Barriers and Enablers to Successful Hyperacute Ischemic Stroke Care

By

Patrick Parfrey

A thesis submitted to the school of graduate studies in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Medicine)

Faculty of Medicine

Memorial University of Newfoundland

October 2024

St. John's Newfoundland and Labrador

Abstract

Stroke is a leading cause of adult disability. Thrombolysis, and Endovascular Therapy (EVT) significantly reduce disability of ischemic stroke patients (85% of strokes). However, in Newfoundland and Labrador (NL), thrombolysis rates were low, and EVT only began in 2022. In addition, NL had a higher incidence of stroke, with worse outcomes than the rest of Canada. Due to the availability of data, this study used a mixed methods approach to investigate stroke care processes in the Eastern Health (EH) region of Newfoundland and Labrador (NL) and three other Canadian regions (Central zone Nova Scotia (NS), Southeastern Ontario (SEO) and Calgary zone Alberta) to identify policy recommendations to improve hyperacute stroke care.

First, two time series analyses compared indicators between stroke centres between each region. In addition, case studies in each region were completed to provide a subjective view of their hyperacute ischemic stroke care. Using literal replication, the case studies recorded semi-structured interviews with stroke care professionals. For data triangulation, stroke care documents and archival data were requested. Through thematic analysis, the goal was to understand critical success factors to optimize efficient hyperacute ischemic stroke care. Finally, using cross-case synthesis, regions were compared using matrices to understand how they differ. The Health Science Centre (HSC) in EH showed impressive improvements from 2016/2017 to 2020/2021 with thrombolysis rates rising from 9.6% to 19.0%, nearing their target of 21.0%. In addition, HSC had similar indicators compared to the three Comprehensive Stroke Centres (CSCs) in the other regions. The four Primary Stroke Centres (PSCs) of EH have not shown the same improvement. However, SEO and Calgary reported Belleville and Red Deer as highly functioning PSCs due to their strong stroke champions, nursing leadership, and team culture. As the cases presented similar care models, I have concluded that EH PSC programs must

standardize and map out processes supporting efficient treatment and improve early communication. Passionate leaders are also required to motivate teams and find time for change management and continuous quality improvement.

The policy implications of the results suggest ways to improve hyperacute stroke care in NL: 1) Develop a provincial stroke program to standardize stroke care across the province, monitor performance, and collaborate with the air and ground ambulance system, 2) Expand EVT to a full-time service serving eligible patients across the province and expand the EVT treatment time window, and 3) Focus on continuous quality improvement with electronic collection of variables that measure the elements of the stroke care pathway, aiming to minimize delays in time to treatment.

Summary

Stroke is the leading cause of adult disability and Newfoundland and Labrador (NL) had a higher incidence of stroke, with worse outcomes than the rest of Canada. Therefore, this study used a mixed methods approach to investigate stroke care indicators (like thrombolysis rates) and stroke care processes within the Eastern Health (EH) region of NL and compare EH with three other Canadian regions (Central zone Nova Scotia (NS), Southeastern Ontario (SEO) and Calgary zone Alberta) to identify policy recommendations to improve hyperacute stroke care. The Health Science Centre (HSC) in EH showed impressive improvements from 2016/2017 to 2020/2021 with thrombolysis rates rising from 9.6% to 19.0%, nearing their target of 21.0%. In addition, HSC had similar indicators to the three Comprehensive Stroke Centres (CSCs) in the other regions. However, the four Primary Stroke Centres (PSCs) of EH have not shown the same improvement. SEO and Calgary reported highly functioning PSCs needing strong stroke champions, nursing leadership, and a team culture. In addition, all four regions presented similar

care models, but some implications emerged from the data. To improve the hyperacute stroke care in NL, I have presented three policy implications. Firstly, NL should develop a provincial stroke program to standardize stroke care across the province, monitor performance, and collaborate with the air and ground ambulance system. Secondly, NL should expand their EVT service to a full-time, treat eligible patients throughout the province, and increase their EVT treatment window. Finally, there must be a focus on continuous quality improvement with electronic collection of variables that measure the elements of the stroke care pathway, aiming to minimize delays in time to treatment.

Acknowledgements

This research project would not have been possible without the support of numerous people and the Memorial University of Newfoundland. First, I want to acknowledge and express my sincere gratitude to my supervisor, Dr. Brendan Barrett, who has provided tremendous support, mentorship, and inspiration. Along with Dr. Barrett, I would like to thank Dr. Victor Maddalena, a member of my supervisory committee, for providing immeasurable support, guidance, and patience to a novice qualitative researcher. Moreover, I would also like to thank Dr. Marsha Eustace, a member of my supervisory committee, for her expertise and support. In addition, I would like to express my appreciation to Dr. Michelle Ploughman and Ms. Brenda Crewe for their help at different points throughout my Ph.D. journey. Both were members of my supervisory committee. Along with my supervisory committee, I would like to thank Ms. Maria Lacey, Terra Nova Transcribing, and Ms. Bonnie Matchem for their help transcribing interviews and Mr. Patrick McNicholas and Mr. Jack Thorburn, two friends and peers who made themselves available to discuss issues throughout this process.

Role of the Author

The role of this author included the conceptualization and design of this research project, data analysis of both quantitative and qualitative components of the thesis, interpretation of the data, and the drafting of this dissertation including policy recommendations that could be implemented to improve stroke care.

As a Ph.D. student studying stroke care, I have read and researched the advancements in care. Firstly, Time is Brain by Saver (2006) discovered that with each minute a stroke victim is untreated, 1.9 million neurons, 14 billion synapses, and 12 km of myelinated fibres are destroyed (Saver, 2006). Therefore, although there are time windows for treatments, it is essential to urgently treat a stroke victim without delay. Secondly, the therapy advancements have shown considerable and statistically significant improvements in functional independence for these victims. Understanding the importance of how quality stroke care can significantly improve the quality of life for stroke victims, I have been motivated to discover how to improve stroke care in Newfoundland and Labrador. As a result, I have worked with Quality-of-Care NL from 2016-2023 by providing analytical work on hyperacute stroke care and publishing my findings in their Knowledge Translation journal Practice Points on seven occasions. In addition, improving the quality of stroke care in the province was an important aspect of Health Accord NL, and I presented my data to this provincial Task Force to inform its recommendations. Subsequently, as policy on the provision of a provincial stroke program was being developed by the Government NL Health Transformation team, I also presented data from this thesis, which was also included in the final stakeholder symposium.

In the development of this thesis, I contributed to the health transformation of the Health Accord NL and Quality-of-Care NL Practice Points. This includes:

- Stroke Care in St. John's Hospitals, Practice Points Volume 2, p.5, 2017
- Stroke Care in St. John's: Impact of a New Stroke Unit at Health Sciences Centre. Practice Points Volume 3, p.7, 2018
- Low Thrombolysis Rates for Ischemic Stroke Persisted in Eastern Health in 2018. Practice Points Volume 5, p.21, 2019
- Questions to Ask to Improve Thrombolysis Rates in Ischemic Stroke in NL. Practice Points Volume 6, p.27-28, 2019
- Special Edition for Health Accord NL, p.73, 2020
- Persistence of poor thrombolysis rates for ischemic stroke in NL. Practice Points Volume 8, 81-83, 2021
- Comparison of stroke care indicators in Eastern Health to 3 regions of Canada. Practice Points Volume 10, 32-33, 2023

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

Abbreviations

Δ = Difference
AA = Anesthesia Assistants
ACA = Anterior Cerebral Artery
ACP = Advanced Care Paramedics
AHS = Alberta Health Services
AI = Artificial Intelligence
ALC = Alternate Level of Care
AMPDS = Advanced Medical Priority Dispatch System
ARD = Absolute Risk Difference
ASP = Acute Stroke Protocol
ASPECTS = Alberta Stroke Program Early CT Score
BAO = Basilar Artery Occlusion
BATMAN = Basilar Artery on Computed Tomography Angiography
BE = Balance Eyes
BGH = Brockville General Hospital
BP = Burin Peninsula Health Centre
CACC = Central Ambulance Communication Centre
CAEP = Canadian Association of Emergency Physicians
CASES = Canadian Alteplase for Stroke Effectiveness Study
CG = Carbonear General Hospital
CI = Confidence Interval
CIHI = Canadian Institute for Health Information
CNS = Central Nervous System
CPSS = Cincinnati Prehospital Stroke Scale
CSBP = Canadian Stroke Best Practice
CSC = Comprehensive Stroke Center
CSP = Calgary Stroke Program
CT = Computed Tomography
CTA = CT Angiogram
CTP = CT Perfusion
DAD = Discharge Abstract Database
DASH = District Acute Stroke Hospital
DIDO = Door-in-Door-out
DTNT = Door-To-Needle-Time
DTPT = Door to Puncture Time
DWI = Diffusion-Weighted Imaging
ECASS = European Cooperative Acute Stroke Study
ED = Emergency Department
EH = Eastern Health
EHS =. Emergency Health Services
EKG = Electrocardiogram
ELOS = Expected Length of Stay
EMR = Emergency Medical Responder
EMS = Emergency Medical Services

ENCHANTED = Enhanced Control of Hypertension and Thrombolysis Stroke Study
ERA = Endovascular Reperfusion Alberta
ETA = Estimated Time of Arrival
EVT = Endovascular Therapy
FAST = Face – is it drooping? Arms – can you raise both? Speech – is it slurred or jumbled? Time to call 9-1-1 right away.
FAST-ED = Field Assessment Stroke Triage for Emergency Destination
FLAIR = Fluid Attenuated Inversion Recovery
FMC = Foothills Medical Centre
FY = Fiscal Year
GBC = Dr. G. B. Cross Memorial Hospital
HI = Halifax Infirmary
HPE = Hasting & Prince Edward Counties
H&S = Heart and Stroke
HSC = Health Sciences Centre
ICA = Internal Carotid Artery
ICH = Intracerebral Hemorrhage
ICU = Intensive Care Unit
INR = International Normalized Ratio
INRad = Neuro-Interventional Radiologists
IPAC = Infection, Protection and Control
IQR = Interquartile Range
IR = Interventional Radiology
Isc = Ischemic stroke
IT = Information Technology
IV = Intravenous Line
KFLA = Kingston, Frontenac, Lennox & Addington Counties
KGH = Kingston General Hospital
KHSC = Kingston Health Sciences Centre
KQI = Key Quality Indicators
LAMS = Los Angeles Motor Scale
LLG = Lanark, Leeds & Grenville Counties
LOS = Length of Stay
LSN = Last Seen Normal
LTC = Long-Term Care
LVO = Large Vessel Occlusion
MCA = Middle Cerebral Artery
MMI = Mass Media Interventions
MRT = Medical Radiation Technologist
N/R = Non-Reportable
MRI = Magnetic Resonance Imaging
mRS = modified Rankin Scale
NC = Non-Contrast
NIHSS = National Institutes of Health Stroke Scale
NL = Newfoundland and Labrador
NNT = Numbers Needed to Treat

NPV = Negative Predictive Value
NS = Nova Scotia
OAGO = Ontario Auditor General's Office
OHS = Oxford Handicap Score
OLMC = Online Medical Control
OR = Odds Ratio
OR = Operating Room
PACS = Picture Archiving and Communication System
PACU = Post Anesthesia Care Unit
Pall = Palliative Care
PC-CS = Posterior Circulation Collateral Score
PCP = Primary Care Paramedic
PEBP = Prehospital Evidence-Based Paramedic
PPV = Positive Predictive Value
PSC = Primary Stroke Center
QA = Quality Assurance
QEII = Queen Elizabeth II Health Science Centre
QHC = Quinte Health Centre
QI = Quality Improvement
QSCIC = Quality of Stroke Care In Canada
QuICR = Quality Improvement & Clinical Research Alberta Stroke Program
RAAPID = Referral, Access, Advice, Placement, Information & Destination
RACE = Rapid Arterial oCclusion Evaluation
RASP = Regional Acute Stroke Protocol Committee
RCT = Randomized Control Trials
RHA = Regional Health Authorities
RN = Registered Nurse
RR = Recurrent Risk
rt-PA = Alteplase
SAH = Subarachnoid Hemorrhage
SC = St. Clare's Mercy Hospital
SCN = Strategic Clinical Network
SEO = Southeastern Ontario
sICH = Symptomatic Intracranial Hemorrhage
SITS = Safe Implementation of Thrombolysis in Stroke
SLSR = South London Stroke Registry
STTC = Stroke Thrombolysis Trialists Collaborative
SUEC = Stroke Unit Equivalent Care
TIA = Transient Ischemic Attack
TLOS = Total Length of Stay
TNK = Tenecteplase
UTI = Urinary Tract Infection
VAN = Vision, Aphasia, Neglect
$\bar{x}$ = median

Chapter 1 – Introduction

A stroke is a neurological deficit of the central nervous system (CNS) caused by vascular disease, resulting in ischemia (blockage), a hemorrhage (bleed) or sometimes proceeded by a Transient Ischemic Attacks (TIAs) (Sacco et al., 2013). In patients experiencing a typical large vessel ischemic stroke, each minute the stroke is untreated, 1.9 million neurons, 14 billion synapses, and 12 km of myelinated fibres are destroyed (Saver, 2006). This has led to strokes and other cerebrovascular diseases being Canada's fifth leading cause of death (Government of Canada, 2022) and the leading cause of adult disability. Each year Canadian hospitals treat approximately sixty-two thousand people due to a stroke or TIA, and fifty-three thousand are admitted to acute care (Boulanger, Gubitz, et al., 2018). In addition, The Heart and Stroke (H&S) 2019 stroke report reported over 405,000 Canadians with long-term disability from stroke (Heart & Stroke, 2019), and The Canadian economy must spend more than $3.6 billion annually on physician services, hospital costs, lost wages, and decreased productivity (Krueger et al., 2012). However, evidence-based stroke care has resulted a decreased number of annual hospital episodes (-3.3%), acute care days (-25.9%), and residential care days (12.8%) resulting in annual cost reduction estimated at 682 million (307.4 million directly, and 374.3 million indirectly) throughout Canada (Krueger et al., 2012).

This thesis analyzed the hyperacute care of ischemic stroke patients within four Canadian regions. Ischemic strokes are caused by a clot in the brain and comprise 85% of all strokes in Canada (Heart & Stroke, 2019). The disruption of blood flow causes an infarction, and "with inadequate blood to the cerebral tissue, there is first reversible loss of tissue function, and given enough time, infarction with loss of neurons and supportive structures" (Feske, 2021, p.1457). A thrombus (blood clot) can develop in the arteries and obstruct the blood supply to the brain (Deb et al., 2010). In addition, Embolisms are blood clots formed elsewhere in the body that travel and block a blood vessel in the brain (Feske, 2021). The most common are cardioembolisms due to cardiac disease, but artery-to-artery embolisms also occur due to cholesterol plaque build-up in a larger artery, with embolic blockage of a smaller downstream vessel (Feske, 2021). Evidence has shown better functional outcomes when ischemic stroke patients are treated with thrombolysis and/or Endovascular Therapy (EVT). As both therapies have specific recommended time to treatment from Last Seen Normal (LSN) windows, the Canadian Stroke Best Practice (CSBP) has recommendations to implement efficient processes to accurately identify eligible ischemic stroke patients.

In Newfoundland and Labrador (NL) there is a higher incidence of stroke, and outcomes of stroke are worse than comparable jurisdictions across the country (Eastern Health Regional Stroke Program and Evaluation Framework, 2014). For example, NL ranked eighth in age-sex standardized stroke death rate per 100,000 population at 41 compared to 33 in Canada (Health Accord NL, 2022). In 2018/2019, the age-standardized mortality rate for cerebrovascular diseases was 44.2/100,000 people in NL compared to 31.4/100,000 in Canada, which is the highest rate of all ten provinces (Quality of Care NL, 2020).

Hyperacute treatment for ischemic stroke includes thrombolysis, intravenous medication to help dissolve the clots within the vessels to restore the blood flow of an ischemic stroke (*Thrombolytic Therapy*, 2021), and Endovascular Therapy (EVT) a non-surgical method using microcatheters inserted from the groin or arm to remove the blood clot guided using X-rays (*Endovascular Treatment of Stroke*, 2022). However, thrombolysis rates (the proportion of ischemic stroke patients who receive thrombolysis), a key indicator for stroke care, remain the lowest in NL compared to all other provinces. In 2018/2019, NL had the lowest provincial rate reported by the Canadian Institute for Health Information (CIHI) at 11% compared to 19% in Canada (Health Accord NL, 2022). Along with the low thrombolysis rates, the Health Sciences Centre (HSC) in St. John's, NL, only began phase one of its EVT program in June 2022, which has been the recommended gold standard of care since 2015 (Casaubon et al., 2015).

On November 5th, 2020, the Health Accord for NL published a ten-year plan comprising actions and recommendations for health care in NL (Health Accord NL, 2022). Based on the recommendation by Health Accord NL the four health authorities merged into a new entity called the NL Health Services on April 1st, 2023 to promote consistent and quality health care across the province. In addition, Health Accord NL recommended implementing a provincial stroke network to improve the province's care of stroke patients. This study investigated the performance of the eastern region of NL Health Services (previously known as Eastern Health).

Stroke is a medical emergency and advances in stroke care are evolving. Therefore, the CSBP guidelines aimed to provide current evidence-based recommendations appropriate for use by healthcare professionals caring for stroke and TIA patients within the population of Canada (Boulanger, Lindsay, et al., 2018). The first Canadian Association of Emergency Physicians (CAEP) stroke guideline was published in 2001 to guide emergency physicians when the literature was developing concerning thrombolysis in acute stroke (Rutledge, 2001). However, those guidelines only recommended using thrombolysis treatment as part of clinical trials or in specialized centers (Rutledge, 2001). In 2015, reflecting on new literature, the CSBP recommendations included thrombolytic therapy administered within three hours from ischemic stroke symptom onset (D. Harris et al., 2015). In 2018, the guidelines reflected significant advances in stroke treatment and prevention (D. R. Harris, 2018).

Improving stroke care begins with public awareness of stroke symptoms since the amount of time it takes to initiate treatment must minimized. Next, developing stroke systems of care is paramount to improved stroke outcomes (D. R. Harris, 2018). This includes the Emergency Medical Services (EMS) management to transition the patient to the closest primary stroke care facility. EMS screening tools help identify an ischemic stroke and the patient's potential eligibility for thrombolysis or EVT, a critical component of the organized stroke systems of care (D. R. Harris, 2018). The 2018 recommendations highlighted (1) the use of EVT, proven to reduce disability and mortality (Rodrigues et al., 2016), (2) the recognition of tissue-based eligibility (not time-based eligibility) for reperfusion (D. R. Harris, 2018). The latter highlights that time is not the only indicator to determine salvageable brain tissue. Therefore, Computed Tomography (CT) scan with perfusion imaging, or multimodal Magnetic Resonance Imaging (MRI), is recommended to evaluate viable tissue for EVT selection (Wintermark et al., 2013).

Currently, the gold standard for stroke care within Canada is in The Canadian Stroke Best Practice Recommendations, 7th Edition (2022). Endorsed by CAEP, Canada's Heart and Stroke Foundation developed the recommendations with input from Canadian stroke experts and emergency physicians with expertise in stroke (Heran et al., 2022). The 7th addition (2022) has noted additional advances in stroke care. Notable updates include the addition of Tenecteplase (TNK) as an alternative medication to rt-PA for acute intravenous thrombolysis (Heran et al., 2022). Furthermore, all disabling acute ischemic stroke patients presenting between six and twenty-four hours of stroke symptom onset should be rapidly screened to determine EVT eligibility (Heran et al., 2022). Patients presenting outside of six hours must have a Computed Tomography (CT) scan with CT Angiogram (CTA) using multiphase CTA or CT perfusion imaging (Heran et al., 2022). CSBP also recommends using software on diagnostic imaging to provide quantifiable measurements of ischemic core and penumbra (Heran et al., 2022).

Ischemic stroke is a significant public health burden for NL and Eastern Health (EH), requiring further investigation. Therefore, I have developed an understanding of the importance of time to treatment and providing the recommended therapy. As NL is my home province, I am motivated to help improve the care processes that support time to treatment of our stroke patients. The aim of this project was to identify barriers and enablers of successful hyperacute treatment in adult patients with ischemic stroke. By using three other Canadian Health regions, this project compared those stroke system with EH and discovered areas to improve. I choose to examine stroke care delivery in Calgary Alberta because it is a national leader in stroke; Southeastern Ontario (SEO) because it is a city reasonably close in population size to urban St. John's; and Central Zone Nova Scotia NS because it has an urban rural divide somewhat similar to NL. In addition, stroke professionals from SEO and NS came to the health sciences center to present on hyper acute stroke best practices. This provided a chance to make contact.

To begin, this thesis conducted an in-depth narrative literature review on the hyperacute treatment of ischemic stroke, and the hyperacute stroke care pathway. The research used a mixed methods approach to investigate EH and the three other health regions within Canada. The mixed methods approach included quantitative and qualitative methods. The quantitative study conducted two time series evaluations and the qualitative study conducted multiple case studies to investigate hyperacute ischemic stroke care within each Health region EH, Central Zone NS, SEO, and Calgary Zone Alberta.

The results begin with a quantitative analysis. First, EH was analyzed using a time series approach to evaluate stroke care indicators, including thrombolysis rates. The objective of the investigation was to determine if the stroke centres in EH improved over time. Next, the quantitative study used the same variables to compare the EH hospitals with stroke centres from Central Zone NS, SEO, and Calgary Zone Alberta. Following the quantitative analysis, the case studies used a thematic analysis aimed to understand and learn from what professionals believed were critical success factors, how to achieve those factors, the barriers and enablers affecting their care process, and how to establish EVT. EH can learn and adapt its' processes by understanding the hyperacute stroke care models of central zone NS, SEO, and Calgary zone Alberta. From the results, I developed three policy recommendations for the NL Health Services to further improve their stroke care. These recommendations include a provincial stroke program encompassing the whole province with an emphasis on Primary Stroke Centres (PSC) and transport functions, a full-time Endovascular Therapy (EVT) service to care for all eligible patients in NL, and a considerable focus on continuous quality improvement (QI) supported by electronic medical records.

1.1 Research Question

What are the barriers and enablers of successful hyperacute treatment in adult patients with ischemic stroke?

1.2 Research Objectives

- To compare the ischemic stroke care indicators of Eastern Health, NL with the care recommended by CSBP guidelines and the three other Canadian regions.
- To understand how the separate processes of stroke care cooperate to help transition the patient along the stroke care pathway.

- To document how hospitals (especially those with EVT) were able to implement key stroke care steps and treatments and identify barriers and enablers they faced.
- Identify keys to success factors from the other Canadian regions.
- Provide policy implications for ischemic stroke care in NL.

Chapter 2 – Literature Review

I conducted a narrative literature review to interpret the literature on hyperacute ischemic stroke care with a primary focus to compile information regarding the research question and my research methods. This review investigates the evolution of hyperacute ischemic stroke therapies (thrombolysis and Endovascular therapy) and the surrounding hyperacute stroke care pathway. Therefore, my literature review included Randomized Controlled Trials (RCTs), meta-analysis and Systematic reviews comparing the efficacy of hyperacute ischemic stroke care. For areas of care that did not have the higher level of control, I reviewed observational studies. Newfoundland and Labrador (NL) will need to understand the health and economic impact of hyperacute best practices to decide if they should invest in the gold standard of care. The economic impact view observational studies and is presented in my discussion.

2.1 Literature Search

I started my search at The National Library of Medicine (through PubMed) with an initial search query of "Ischemic Stroke AND Best Practice". My initial search included a publication date within the last ten years and full text availability. This search discovered Boulanger and colleagues, 2018, Canadian Stroke Best Practice Recommendations for Acute Stroke Management: Prehospital, Emergency Department, and Acute Inpatient Stroke Care, 6th Edition, Update 2018. Canadian Stroke Best Practices (CSBP) helped guide my search through a stroke patient's pathway. Using Medical Terms (MeSH) terms, I narrowed my search to investigate specific topics of interest.

As this project considers multiple fields of stroke care and research, the process was completed numerous times. For example, while searching for relevant publications on ischemic stroke treatment, I began my search using "Ischemic Stroke Treatment" and "Ischemic Stroke

Therapy”. This investigation evolved into searching “Ischemic Stroke AND Thrombolysis”, “Ischemic Stroke AND [Endovascular Therapy OR Thrombectomy]”, and then “Ischemic Stroke AND [Endovascular Therapy OR Thrombectomy] AND [Alteplase OR Tenecteplase]”. Articles of interest from these search parameters provided relevant references and other articles were found in the sidebar “Similar articles” in PubMed. While this project considered the quality of care within Canada, specifically NL, my search parameters included articles from other countries without a date restriction to understand the evolution of stroke care.

In addition, the Cochrane Library was searched to capture systematic reviews and meta-analyses to offer insight into the gold standard of care. Firstly, I initially searched “Ischemic Stroke Care”. Then, I used the advanced search engine combining relevant MeSH terms into the search manager to narrow my search. For example, I added the MeSH terms “Ischemic Stroke”, “Thrombectomy”, and “Thrombolysis” to investigate any systematic reviews and meta-analyses relevant to my advanced search. The World Wide Web was also searched, assessing key sites such as Canadian Stroke Best Practices (CSBP) and The American Stroke Association.

2.2 Emergency Treatment of Ischemic Stroke

The study Time is Brain by Saver (2006) conducted a systematic review and identified consensus estimates of human nervous tissue loss from forebrain, large vessel, supratentorial ischemic strokes (Saver, 2006). In patients experiencing a typical large vessel ischemic stroke, each minute the stroke is untreated, 1.9 million neurons, 14 billion synapses, and 12 km of myelinated fibres are destroyed (Saver, 2006). As a stroke could happen to anyone at any time, the population needs to know the signs and symptoms. Campaigns, specifically the FAST (Face – is it drooping? Arms – can you raise both? Speech – is it slurred or jumbled? Time to call 9-1-1 right away) campaign, have shown benefits in reducing the delays in seeking and receiving medical attention (Wolters et al., 2015). Once identified, the patient must be transferred to a hospital's Emergency Department (ED), which can provide time-sensitive therapy of thrombolysis within four and a half hours from symptom onset or by Endovascular Therapy (EVT) within six hours of symptom onset (Boulanger et al., 2018). In addition to time-based criteria, tissue-based eligibility utilizing neuroimaging has been developed. Therefore, neuroimaging is vital for diagnosing an ischemic stroke and determining the extent of salvageable tissue, which can indicate a patient's eligibility for emergency treatment outside the recommended time windows.

2.2.1 Thrombolysis

For decades, there have been international Randomized Control Trials (RCTs) providing evidence to clearly indicate that treatment with intravenous recombinant tissue plasminogen activator (rt-PA) administered within 4.5-hour of symptom onset improves stroke outcomes by substantially reducing the risk of death and/or disability (Boulanger et al., 2018; Wardlaw et al., 2014; Hill & Buchan, 2005; Wahlgren et al., 2007). Thrombolytics can help dissolve the clots within the vessels to restore the blood flow of an ischemic stroke (*Thrombolytic Therapy*, 2021). This is achieved by "binding to fibrin in clots and converting the entrapped plasminogen to plasmin" (Potla & Ganti, 2022, p.1). Rt-PA has a significant risk of symptomatic intracranial hemorrhage (sICH) (Jauch et al., 2013; Wardlaw et al., 2014; *Thrombolytic Therapy*, 2021). The NINDS rt-PA Stroke Trial reported ICH occurring in 6.4% treated with rt-PA compared to only 0.6% of patients given a placebo (Marler, 1995). However, those ICH rates did not affect the ninety-day (17% vs 20%) and yearly mortality rates (24% vs 28% (Marler, 1995). The trial also showed that ischemic stroke patients who receive rt-PA within three hours after symptom onset had at least a 30% relative increase in the number of patients having minimal to no disability at three months based on the modified Rankin Scale (mRS – Table 2.1) (Marler, 1995; Jauch et al., 2013; Kwiatkowski et al., 1999).

Subgroup analysis showed that the likelihood of a favourable outcome was associated with the severity of deficits and the patient's age. Patients with mild to moderate strokes and patients under 75 years of age were more likely to show excellent outcomes with treatment of rt-PA (The NINDS t-PA Stroke Study Group, 1997). However, based on the combined data and the positive association of the treatment, the study did not recommend withholding rt-PA from any sub-groups (The NINDS t-PA Stroke Study Group, 1997).

Table 2.1: Modified Rankin Scale (mRS) Description

Modified Rankin Scale	
0	No symptoms at all
1	No significant disability despite symptoms: able to carry out all usual duties and activities
2	Slight disability: unable to carry out all previous activities, but able to look after own affairs without assistance
3	Moderate disability: requiring some help, but able to walk without assistance
4	Moderately severe disability: unable to walk without and unable to attend to own bodily needs without assistance
5	Severe disability: bedridden, incontinent, and requiring constant nursing care and attention
6	Dead

(van Swieten et al., 1988)

Wardlaw and colleagues (2014) conducteded a large meta-analysis on the effects of thrombolysis on acute ischemic stroke. When analyzed by time windows, thrombolytic therapy administered up to six hours from symptom onset significantly reduced the proportion of ischemic stroke patients who were dead or disabled at three to six months (Odds Ratio (OR) 0.85, 95% Confidence Interval (CI) 0.78 to 0.93) (Wardlaw et al., 2014). However, using a six-hour time window increased the risk of symptomatic intracranial hemorrhage (OR 3.75, 95% CI 3.11 to 4.51), early death (OR 1.69, 95% CI 1.44 to 1.98) and death by three to six months (OR

1.18, 95% CI 1.06 to 1.30) (Wardlaw et al., 2014). The meta-analysis also examined trials testing different thrombolytic drugs; urokinase, streptokinase, recombinant pro urokinase or desmotoplase. The trials assessing rt-PA administered up to six hours from symptom onset showed a significant reduction in death and disability (OR 0.84, with 95% CI of 0.77 to 0.93), a significant increased risk of symptomatic intracranial hemorrhage (ICH) (OR 3.72, 95% CI of 2.98 to 4.64), and an insignificant change in death at follow-up (OR 1.06, 95% CI 0.94 to 1.20) (Wardlaw et al., 2014). Early death was attributed to ICH after using thrombolytic drugs; antithrombotic drugs increased the risk (Wardlaw et al., 2014).

Using trials that reported data using both time windows of patients receiving thrombolysis before three hours from symptom onset and after three up to six hours, Wardlaw and colleagues provided results of the effect of time to treatment. The results showed a significant reduction in the odds of death and dependence when patients were treated with thrombolysis within three hours of symptom onset compared to controls (OR=0.69, 95% CI=0.55-0.85), but a non-significant change for patients treated between three to six hours (OR=0.99, 95% CI=0.88-1.10) (Wardlaw et al., 2014). Thus, there were more alive and functionally independent ischemic stroke victims when given thrombolysis within the recommended time window. For example, in trials using rt-PA, for every thousand participants given rt-PA within three hours, ninety more would be alive and independent ($P<0.0001$) compared to placebo, and ten more compared to patients treated between three to six hours after stroke symptom onset (Wardlaw et al., 2014).

Other evidence consistently showed that with earlier treatment from symptom onset, there was a higher chance of ischemic stroke patients surviving and being functionally independent (Marler et al., 2000; Jauch et al., 2013; T. Kwiatkowski et al., 2005; Johnston et al., 2004; Saver & Yafeh, 2007). Therefore, every effort should be made to treat each patient as early as possible.

In 2005, a prospective national study led by Hill, Buchan, and the Canadian Alteplase for Stroke Effectiveness Study (CASES) investigators assessed the effectiveness of alteplase (rt-PA) therapy for ischemic stroke in actual practice (Hill & Buchan, 2005). The study invited all hospitals capable of administering thrombolysis therapy to submit patient data into an established registry from Feb. 17, 1999, to June 30, 2001 (Boulanger et al., 2018). This prospective data collection observed excellent outcomes were not significantly lower compared to the NINDS study (36.8% vs. 39.9%, p=0.15), the overall ninety-day mortality was 22.3% (95% CI 20.0%-25.05%), the symptomatic ICH was 4.6% which was lower than previous major trials (Hill & Buchan, 2005) and they reported stroke thrombolysis as a safe and effective therapy in actual practice reflecting the results of clinical trials (Hill & Buchan, 2005).

For over 20 years, many large international trials have provided consistent evidence that thrombolysis treatment reduces the risk of death or disability following an ischemic stroke at three to six months post-treatment (Boulanger et al., 2018). Treatment should be provided as fast as possible, but how long should thrombolysis be administered after symptom onset? As time elapses from symptom onset, the benefits decline, and the risks increase. For years, thrombolysis was limited to three hours after symptom onset and many patients were ineligible from receiving rt-PA as they presented more than three hours after symptom onset (Clark et al., 1999). Therefore, Clark and associates studied the efficacy and safety of rt-PA with acute ischemic stroke patients when administered between three to five hours after symptom onset (Clark et al., 1999). This trial did not support intravenous rt-PA for ischemic stroke treatment beyond three hours, reported no significant benefit of an excellent neurological recovery at ninety days and patients treated with rt-PA in this time window had an increased risk of sICH (Clark et al., 1999).

Therefore, future studies were necessary to investigate the efficacy of rt-PA on ischemic stroke patients after three hours from last seen normal.

The European Cooperative Acute Stroke Study (ECASS) provided three trials (1995, 1998, and 2008) designed around the hypothesis that the efficacy of intravenous thrombolysis with alteplase administered in patients with acute ischemic stroke can be safely extended to a time window above three hours (Hacke et al., 1995; Hacke et al., 1998; Hacke et al., 2008). The first two trials (ECASS and ECASS II) assessed the safety and efficacy within six hours of symptom onset and could not confirm statistical benefit and the authors suggested that the study may have been underpowered (Hacke et al., 1995; Hacke et al., 1998; Boulanger et al., 2018). Alternatively, the third trial (ECASS III) showed the efficacy of intravenous thrombolysis administered between three and 4.5 hours after symptom onset as more patients had a favourable outcome (mRS of 0 or 1) at ninety days when treated with rt-PA compared to placebo, 52.4% vs. 45.2%, OR=1.34, 95% CI=1.02-1.76, p=0.04 (Hacke et al., 2008). The safety endpoints were mortality, which did not differ, and sICH which increased for the rt-PA group, 2.4% vs. 0.2%, p=0.008 (Hacke et al., 2008). The caveat in the three ECASS trials was the increased risk of sICH and, in some cases, short-term mortality due to intravenous thrombolysis treatment (Boulanger et al., 2018). However, there was no difference in ninety-day mortality.

An increased time window to 4.5 hours for rt-PA administration provided benefits. However, early treatment remains a priority. For example, a pooled analysis of the Atlantis, ECASS, and NINDS rt-PA stroke trials showed patients treated within the first 1.5 hours derive nearly twice the benefits compared to patients treated within 1.5 to three hours (Hacke et al., 2008; The ATLANTIS, ECASS, and NINDS rt-PA Study Group Investigators, 2004). In addition, this study showed an increased odds for a favourable outcome at three months of 2.8 (95% CI=1.8-

4.5) for zero to ninety minutes, 1.6 (95% CI=1.1-2.2) for 91-180 minutes, and 1.4 (95% CI=1.1-1.9) for 181-270 minutes, but was non-significant OR=1.2 (95% CI=0.9-1.5) for 271-360 mins (The ATLANTIS, ECASS, and NINDS rt-PA Study Group Investigators, 2004).

Numerous studies were performed under European Union regulations called the Safe Implementation of Thrombolysis in Stroke (SITS) (Wahlgren et al., 2007; Wahlgren et al., 2008; Ahmed et al., 2010; The IST-3 collaborative group, 2012). SITS is a collaboration of more than 700 clinical centers in 35 countries for the documentation of treatments for stroke (Wahlgren et al., 2008). These trials assessed the safety profile of alteplase by monitoring clinical practice. The aim was to discover if the levels of safety and efficacy found in RCTs could be reproduced in routine clinical practice (Wahlgren et al., 2007). The first trial, SITS-MOST (Monitoring Study), confirmed that intravenous alteplase is safe and effective in routine clinical ischemic stroke care within three hours of stroke onset (Wahlgren et al., 2007). Furthermore, SITS-MOST showed a reduction compared to pooled RCTs in sICH (7.3% vs. 8.6%) and in three-month mortality (11.3% vs. 17.3%) (Wahlgren et al., 2007). In addition, functional independence (mRS 0-2) at three months was higher (54.8% vs. 49%) compared to the pooled RCTs (Wahlgren et al., 2007). However, the SITS-MOST trial population had a lower average age (68 years) and a lower median NIHSS score related to stroke severity (Wahlgren et al., 2007).

In 2008, SITS provided a second study using SITS-international Stroke Treatment Registry (SITS-ISTR). The study discovered that alteplase was still safe at three to 4.5 hours from ischemic stroke symptom onset (Wahlgren et al., 2008). The SITS-ISTR compared prospectively collected patients treated with rt-PA between three hours and 4.5 hours with patients treated within three hours. The rates of sICH (2.2% vs. 1.6%, adjusted OR=1.32, 95% CI 1.00-1.75, p=0.052), mortality at three months (12.7% vs. 12.2%, adjusted OR=1.15, 95% CI 1.00-1.33, p=0.053), and an mRS of independence (0-2) at three months (58.0% vs. 56.3%, adjusted OR=1.04, 95% CI 0.95-1.13, p=0.42) were similar between both cohorts (Wahlgren et al., 2008).

Later, Ahmed and colleagues conducted an updated analysis from the SITS-ISTR with alteplase from three to 4.5 hours after an acute ischemic stroke and discussed concerns about increased delays from ED admission to alteplase treatment due to the 2008 implementation of an expanded time window of 4.5 hours. However, they discovered a simultaneous increase in patients treated within three hours, and admission to treatment time did not increase with this extended time window (Ahmed et al., 2010). At three months, sICH and mortality were experienced more frequently and significantly fewer patients were independent (57.5% vs. 60.3%, p=0.005) when treated with rt-PA within 3 to 4.5 hours compared to three hours or less (Ahmed et al., 2010).

After providing evidence for the benefit of intravenous thrombolysis within 4.5 hours, a third study was conducted to see the benefits and risks of intravenous thrombolysis within six hours of acute ischemic stroke symptom onset, called the third international stroke trial (IST-3) (The IST-3 collaborative group, 2012). IST-3 found an increase in patients alive and independent at six months when treated with rt-PA within six hours compared to a placebo control group (37% vs. 35%), but the number was insignificant and smaller than initially anticipated (The IST-3 collaborative group, 2012). IST-3 discovered an increase in early mortality within seven days (11% vs. 7%), mainly due to ICH (4% vs. <1%); however, mortality at six months was equal between the two groups and the degree of disability was lower for the group treated with rt-PA within six hours (The IST-3 collaborative group, 2012).

The IST-3 collaboration group believed their trial was underpowered to reliably detect critical sub-group effects (The IST-3 collaborative group, 2012). This led to the Stroke

Thrombolysis Trialists Collaborative (STTC) Group to conduct a pre-specified meta-analysis to analyze the effects of treatment delay, age, and stroke severity on the effects of intravenous thrombolysis with alteplase (Emberson et al., 2014). The patients from IST-3 almost doubled the population (6756) compared to previous meta-analysis, allowing for a more accurate assessment of the relative impacts (Emberson et al., 2014). The source of individual patient data continued to provide evidence about the extent to which treatment delay alters the beneficial effects of alteplase on acute ischemic stroke patients. The odds of an mRS of 0-1 at three to six months stratified by: treatment time was; ≤ three hours (OR = 1.75, 95% CI 1.35-2.27), three to 4.5 hours (OR = 1.26, 95% CI 1.05-1.51), and > 4.5 hours (OR = 1.15, 95% CI 0.95- 1.40) (Boulanger et al., 2018; Emberson et al., 2014). There were different ORs between groups stratified by age and stroke severity, but all confidence intervals overlapped supporting ischemic stroke guidelines to provide rt-PA within three hours from last seen normal irrespective of age and stroke severity (Emberson et al., 2014). In addition, the average benefit of alteplase might extend beyond 4.5 hours (Emberson et al., 2014).

Emerson and colleagues showed a 2% absolute increase in the risk of early death, but that was non-significant by three-month mortality, with a 10% absolute increase in disability-free survival for patients treated within three hours and about 5% between three to 4.5 hours (Emberson et al., 2014). Framed slightly differently, Lees and colleagues concluded that neither age nor stroke severity significantly influenced the relationship between the benefit of time to treatment initiation and improved levels of function (mRS), where earlier treatment had a more significant benefit (Lees et al., 2016). Using an ordinal logistic regression model adjusting for treatment delay, age, and stroke severity, Lees and colleagues published a net patient per 1000 treated that expressed an improvement of one or more divisions of the mRS (Lees et al., 2016).

Patient treated within three hours (mean = 2 hours and 20 min) had a net benefit of 122 (95% CI= 61-171), within 4.5 hours (mean = 3 hours and 20 mins) was 55 (95% CI=13-91) and beyond 4.5 hours (mean = 5 hours and 20 mins) was 20 (95% CI = (-) 31-75) (Lees et al., 2016).

More recently, trials sought to determine whether ischemic stroke patients with an unknown onset time would benefit from thrombolysis. The time of symptom onset is frequently unknown (14-27% of strokes), usually because about 20% of ischemic strokes occur while the patient is asleep (Thomalla et al., 2012; Thomalla et al., 2018; Fink et al., 2002; Mackey et al., 2011; Rimmele & Thomalla, 2014). Patients with an unknown time of symptom onset were excluded from thrombolysis. However, several imaging approaches have been suggested to identify patients who wake-up with stroke symptoms and would likely benefit from thrombolysis, including using an MRI for diffusion-weighted imaging-fluid attenuated inversion recovery (DWI-FLAIR) (Rimmele & Thomalla, 2014). DWI can detect an acute ischemic lesion within minutes with high contrast (Moseley et al., 1990) but is unable to add conclusions about the acute lesion age (stroke onset) (Thomalla et al., 2009; Aoki et al., 2010; Petkova et al., 2010; Thomalla et al., 2011). FLAIR images have a low sensitivity for detecting early acute ischemic lesions, and sensitivity increases as time from symptom onset increases (Thomalla et al., 2009; Thomalla et al., 2011). Therefore, a pattern of a positive DWI and negative FLAIR identified patients with symptom onset ≤ three hours with high specificity (0.93) and Positive Predictive Value (PPV=0.94) (Thomalla et al., 2009).

MRI DWI-FLAIR results from Aoki and colleagues showed: < three hours had sensitivity = 0.83, specificity = 0.71, PPV = 0.64, and Negative Predictive Value (NPV) = 0.70; < 4.5 hours had sensitivity = 0.74, specificity = 0.85, PPV = 0.87, and NPV = 0.70 (Aoki et al., 2010). Petkova and colleagues concluded that MRI might be a presumable clock for determining stroke age for patients with unknown onset time, indicating signal intensity changes on 1.5-T FLAIR MRI can help provide stroke neurologists with a reliable surrogate marker of stroke age (Petkova et al., 2010). Finally, Thomalla and colleagues believed it was likely that patients with +DWI to -FLAIR (DWI-FLAIR mismatch) are within the time window (4.5 hours) for which thrombolysis is safe and effective, sensitivity of 62%, specificity of 78%, PPV of 83%, and an NPV of 54% (Thomalla et al., 2011). These results supported using DWI-FLAIR mismatch for selecting stroke patients with an unknown symptom onset time for future RCTs.

In 2012, Thomalla and colleagues received approval for a multicenter, randomized, double-blind, placebo-controlled trial to test the efficacy and safety of magnetic resonance imaging-based thrombolysis in wake-up stroke (WAKE-UP), the first clinical trial to use the DWI-FLAIR mismatch to identify unknown symptom onset stroke patients who would likely benefit from thrombolysis (Thomalla et al., 2018). The study was published in 2018, concluding that ischemic stroke patients with an unknown symptom onset time had a significantly better ninety-day functional outcome (defined by mRS 0 or 1) when treated with rt-PA using DWI-FLAIR mismatch eligibility (Thomalla et al., 2018). Although the trial was halted due to funding, 254 patients were treated with rt-PA, and 249 were treated with a placebo (Thomalla et al., 2018). The adjusted odds ratio of the ninety-day favourable outcome was 1.61 (95% CI= 1.09-2.36, p=0.02), where 53.3% of the rt-PA group (vs. 41.8%) was associated with a ninety-day favourable outcome (Thomalla et al., 2018). In addition, the EXTEND trial was stopped early due to loss of equipoise, discontinuing recruitment (Ma et al., 2019). The RCT concluded an higher percentage of patients with no or minor neurological deficits for ischemic stroke patients with a favourable imaging profile upon awakening or between 4.5 to nine hours from symptom onset treated with rt-PA compared to placebo, 35.4% vs. 29.5%, p=0.04 (Ma et al., 2019). Further trials are required in this time window (Ma et al., 2019).

2.2.2 Long Term Outcomes

The STTC group concluded that there is a need for longer-term follow-up to test the effect of thrombolysis on reducing the long-term risk of death and adverse outcomes. Two studies previously mentioned had a longer follow-up. The NINDS stroke trial follow-up (1999) reported no significant differences in mortality with a twelve-month follow-up between rt-PA and standard care (24% vs. 28%, p=0.29), but rt-PA had a significant odds ratio for a favourable twelve-month outcome (OR=1.7, 95% CI=1.2-2.3) (T. G. Kwiatkowski et al., 1999). The IST-3, three-year follow-up (2016) also reported a small but non-significant absolute reduction in risk of death at three years (3.6%) between rt-PA plus standard care and standard care alone (Berge et al., 2016).

Other trials investigating the extended effects of alteplase on ischemic stroke have shown a reduction in longer-term mortality. Schmitz and colleagues conducted a nationwide propensity score-matched follow-up study in Denmark (2014). With a median follow-up of 1.4 years, ischemic stroke patients treated with intravenous thrombolysis had a significantly lower risk of long-term mortality (adjusted HR=0.66, 95% CI 0.49-0.88) (Schmitz et al., 2014). Muruet and colleagues reported another propensity score-matched study analyzing long-term survival up to a ten-year follow-up. Using the South London Stroke Register (SLSR), the study achieved a median follow-up time of 5.45 years showing that, on average, an ischemic stroke patient treated with thrombolysis lives around a year longer (5.72 vs. 4.98) than a similar non-thrombolized patient after adjusting for confounders (Muruet et al., 2018). A Cox regression analysis showed that the risk of mortality was reduced by 37% (HR=0.63, 95% CI 0.48-0.82), and the NNT 12 to prevent 1 death in 5 years and 20 to prevent 1 death in 10 years (Muruet et al., 2018). The authors suggested that the observed benefit in survival was driven by older patients and patients with NIHSS ≥ 16 (moderate-severe strokes), but in some categories patient numbers were low (Muruet et al., 2018). When using rt-PA compared to controls, the data have shown an increased risk in sICH which can lead to an increase in early mortality. However, the ninety-day mortality showed no significant differences between rt-PA and controls, and those patients had increased odds of achieving ninety-day functional independence. Now, trials conducting more extended follow-up periods have shown how rt-PA can reduce the long-term mortality risk after stroke.

Another nationwide Danish study by Yafasova and associates (2021) analyzed the association of time to thrombolysis and long-term outcomes. Yafasova and associates examined a three year outcome of a composite outcome that combined all-cause mortality and recurrent ischemic stroke. The outcome was lower in patients who received thrombolysis earlier: 19% (95% CI 16.4%-21.8%) in the 0-90 minute group, 23.3% (95% CI 21.8%-24.9%) in the 91-180 minute group, and 23.8% (95% CI 21.6%-26.1%) in the 181-270 group (Yafasova et al., 2021). Yafasova and associates (2021) highlighted how thrombolysis leads to better functional outcomes, which may be the mechanism behind the reduction in long-term mortality, as better function results will likely lead to fewer post-stroke complications with a higher quality of life\. However, it is unfortunate this trial does not separate the composite outcome as thrombolysis is associated with improved functional outcomes, which may be associated with delayed death, but the mechanism of thrombolysis would not be expected to impact risk of recurrent stroke.

While public awareness and EMS contribute to earlier treatment, hospitals can focus on reducing their door-to-needle time (DTNT – a time measurement from when a patient enters the ED to when they receive thrombolysis). Man and colleagues (2020) published a study that concluded shorter DTNTs for acute ischemic stroke patients treated with rt-PA (within 4.5 hours) were associated with lower all-cause mortality and lower all-cause readmission at 1 year. This study emphasizes the importance of speed to treatment within the hospital. Every fifteen-minute increase in DTNT was significantly associated with higher all-cause mortality (adjusted HR=1.04, 95% CI 1.01-1.05) and all-cause readmission (adjusted HR=1.02, 95% CI 1.01-1.03) (Man et al., 2020). These findings are fascinating and apply to the efficacy of hospital stroke care processes. DTNT can be enhanced through organized stroke care, with protocols and checklists to help the hospital's stroke team.

2.2.3 Alteplase Dose

The standard dose for thrombolytic therapy is 0.9 mg of intravenous alteplase (recombinant tissue-type plasminogen activator - rt-PA) per kilogram (kg) of body weight, with a maximum amount of 90mg (Boulanger et al., 2018; Powers et al., 2018; Anderson et al., 2016). However, as previously mentioned, thrombolytic therapy has the associated risk of intracerebral hemorrhage, especially as the time to treatment extends. Therefore, approaches to improve therapy by reducing risks and maintaining benefits are currently ongoing in non-inferiority trials. The Japanese drug and safety authority approved the use of alteplase at a lower dose of 0.6 mg/kg after a 2006 study (Anderson et al., 2016; Yamaguchi et al., 2006). Yamaguchi and colleagues (2006) conducted an uncontrolled, open-label study that evaluated 0.6 mg/kg of rt-PA and compared to a meta-analysis published on standard-dose rt-PA. The endpoints were set at > 33.9% for the proportion of patients with an mRS score of 0-1 at three months and < 9.6% for the proportion of patients with an incidence of sICH within 36 hours. The lower dose was reported as non-inferior. The proportion of patients with a three-month mRS score of 0-1 was 36.9%, exceeding the predetermined threshold, and 5.8% of the patients had sICH within 36 hours, lower than the predetermined threshold (Yamaguchi et al., 2006). However, the sample size was small (103 total patients). Therefore, additional evidence is required to test the non-inferiority of a lower dose of rt-PA compared to the standard dose. Other registries in Asia showed inconsistent results with differing perceived risks, but sICH was a risk for the Asian population treated with the standard dose of rt-PA (Anderson et al., 2016; Toyoda et al., 2009; Nakagawara et al., 2010; Chao et al., 2010; Kim et al., 2015; Sharma et al., 2011).

The Enhanced Control of Hypertension and Thrombolysis Stroke Study (ENCHANTED) was designed with a primary objective to determine the non-inferiority of the 0.6 mg/kg dose to the standard dose concerning death or disability at ninety days (defined by an mRS score of 2-6, where 6=death), and a secondary objective to determine whether the lower dose would be superior to the standard dose for sICH (Anderson et al., 2016). This trial randomly assigned 3310 patients, recruited at 111 clinical centers in 13 countries, eligible for thrombolytic therapy to the low dose of alteplase 0.6 mg/kg (1654) and the standard dose (1643) (Anderson et al., 2016). The trial discovered that in a predominantly Asian population (63%), the low dose did not show non-inferiority to the standard dose concerning death and disability which occurred in 53.2% of the low dose group and 51.1% in the standard group (OR = 1.09, 95% CI 0.95 to 1.25; where the upper boundary exceeded the non-inferiority margin of 1.14, p = 0.51 (Anderson et al., 2016). However, the ENCHANTED trial did show there were significantly fewer proportion of patients who had sICH with the low dose group (1.0%) vs. the standard group (2.1%), p = 0.01, implying that the lower dose reduced the risk of sICH (Anderson et al., 2016).

2.2.4 Tenecteplase

While the standard dose of alteplase remained at 0.9 mg/kg, a newer thrombolytic agent, Tenecteplase (TNK), has emerged with some pharmacological advantages compared to alteplase.

TNK is a modified recombinant tissue plasminogen activator molecule engineered to improve efficacy by increasing its affinity to bind to fibrin, increasing resistance to inactivation without procoagulant effects, and having a longer plasma half-life (Huang et al., 2015; Keyt et al., 1994). TNK could provide greater thrombolytic activity due to its superior specificity to fibrin and may cause less frequent hemorrhagic complications (Baird, 2018). In addition, TNK has a longer half-life which allows the variant to be administered as a bolus (Baird, 2018), as opposed to alteplase which is administered over an hour with an initial 10% dose as a bolus (1 min) and the remaining treatment infused (*Dosing & Administration Guidelines for Activase® (Alteplase)*, 2022). This single dose of TNK is more manageable to administer and reduces the infusion time, which could significantly reduce the time to reperfusion (restoration of blood) and transition for EVT (Baird, 2018).

In acute myocardial infarction, TNK and alteplase showed equivalent thirty-day mortality rates and similar rates of intracranial hemorrhage but a lower risk of non-cerebral bleeding (Van de Werf, 1999). Van der Werf concluded that TNK's ease of administration may facilitate rapid treatment. In 2009, a small pilot trial of 50 non-randomized stroke patients were given 0.1 mg/kg of TNK or 0.9 mg/kg of alteplase between three to six hours from symptom onset (Parsons, 2009). The TNK group had more significant reperfusion (mean 74% vs. 44%, p=0.01), significant neurological improvement at 24 hours (66.7% vs. 20%, p=0.001), and no ICH (0% vs. 11%) (Parsons, 2009). However, no conclusive efficacy comparisons could be made because it was a small non-randomized selected population (Parsons, 2009).

The following year, Haley and colleagues reported on a small multicentered, randomized, double-blind, controlled clinical trial comparing 0.1, 0.25, and 0.4 mg/kg TNK with the standard dose of rt-PA (0.9mg/kg) in patients with acute ischemic stroke within three hours of symptom onset (Haley et al., 2010). This phase II trial was prematurely terminated due to funding and could not provide a convincing conclusion. The trial discarded 0.4 mg/kg TNK as inferior due to increased bleadding risks, but could not distinguish between 0.1 mg/kg and 0.25 mg/kg (Haley et al., 2010). Symptomatic ICH rates were highest in the 0.4 mg/kg TNK group and lowest in the 0.1 mg/kg TNK group (Haley et al., 2010). Parsons and colleagues (2012) published a similar study (phase IIB trial) that randomly assigned ischemic stroke patients within six hours after symptom onset to different doses (0.1mg/kg and 0.25 mg/kg) of TNK or the 0.9 mg/kg of rt-PA. This study used imaging to select eligible patients who would most likely benefit from thrombolytic therapy and surmised that TNK was superior to rt-PA for reperfusions and clinical improvements at 24 hours, assessed using the National Institute of Health Stroke Scale (NIHSS) (Parsons et al., 2012). The higher proportion of reperfusion with TNK did not come at the cost of increased ICH. Outcomes at three months were notably better in the higher dose of TNK (0.25 mg/kg), 72% with excellent recovery, compared to 40% of the rt-PA group ($p=0.02$) (Parsons et al., 2012). In addition, 0.25 mg/kg of TNK was superior to 0.10 mg/kg of TNK on all clinical efficacy and imaging outcomes, including three-month functional outcomes (Parsons et al., 2012). Using a selective sample, Parsons and colleagues found TNK superior to rt-PA and the results suggested the need for phase III trials using the 0.25 mg/kg dose of TNK against rt-PA.

In 2017, a phase III trial called NOR-TEST by Logallo and colleagues (2017) compared TNK (0.4mg/kg, max 40mg) with a standard dose of rt-PA. This phase III trial was a randomized, open-labelled, blinded endpoint, superiority trial on acute ischemic stroke patients (n=1100) who were eligible for thrombolysis and admitted within 4.5 hours of symptom onset, 4.5 hours of awakening or were eligible for bridging therapy before thrombectomy. Using an intention-to-treat analysis, 64% of the TNK group and 63% of the rt-PA group achieved the primary outcome (OR=1.08, 95% CI 0.84-1.38, p=0.52) of an excellent functional outcome at three months (an mRS score of 0-1) (Logallo et al., 2017). For secondary outcomes both groups had the same proportion for any ICH within 24-48 hours (9%) and death at 3 months (5%) (Logallo et al., 2017). The trial could not prove that TNK was superior to alteplase but TNK showed similar rates for excellent outcomes, safety measurements, and the author concluded the need for future trials to establish safety and efficacy in different stroke severities and TNK doses.

Therefore, NOR-TEST published another trial in 2019 to assess the safety and efficacy of TNK in patients with moderate and severe ischemic strokes (Kvistad et al., 2019). In patients with moderate strokes, TNK (0.4mg/kg) and rt-PA had similar results; 49.2% vs. 45.2% for a favourable outcome (p=0.528), 4.1% vs. 2.2% for sICH (p=0.481), and 8.5% vs. 8.3% ninety-day mortality (p=0.1) (Kvistad et al., 2019). Unfortunately, the sample size was inadequate to compare patients with severe strokes (n=40) as the two groups produced somewhat similar results: 9 (23.7%) vs. 7 (15.0%) with a favourable outcome (p=0.41), and 4 (10%) vs. 3 (6.4%) with sICH (p=0.698), but an increase in ninety-day mortality with TNK: 10 (26.3%) vs. 4 (9.1%) (p=0.045) (Kvistad et al., 2019). The trial concluded that future studies to increase power and to monitor safety parameters closely in patients with severe strokes (Kvistad et al., 2019).

A meta-analysis by Burgos and Saver (2019) used five RCTs to analyse the non-inferiority of Tenecteplase to Alteplase for acute ischemic stroke. Overall, the five trials enrolled 1585 patients (828 TNK, 757 alteplase), using varying doses of TNK (0.1 mg/kg, 0.25 mg/kg, and 0.4 mg/kg) and the standard dose for alteplase (0.9 mg/kg) (Burgos & Saver, 2019). The primary outcome was disability-free (mRS 0-1) three-month survival. This occurred in 57.9% TNK vs. 55.4% rt-PA, exceeding all non-inferiority margins (Burgos & Saver, 2019). The high proportion of both groups may be the result due to the milder presenting stroke severities. The safety outcomes used were sICH (3% TNK vs. 3% rt-PA) and three-month mortality (7.6% TNK vs. 8.1% rt-PA), where TNK surpassed two of the three non-inferiority margins (Burgos & Saver, 2019). Therefore, it was concluded that TNK demonstrated non-inferiority to alteplase, and the findings supported the consideration of TNK as an alternative to rt-PA (Burgos & Saver, 2019).

More recently, Potla and Ganti published a systematic review (2022) comparing Tenecteplase to alteplase in acute ischemic stroke patients who present within 4.5 hours from symptom onset. The data consisted of six RCTs where 782 received TNK, 727 received alteplase (Potla & Ganti, 2022). "The results demonstrated that tenecteplase is just as good and in some cases better than alteplase with regard to the outcomes of (1) post thrombolytic bleed, (2) functional outcome at 90 days as measured by mRS, and (3) recanalization/reperfusion rates following thrombectomy" (Potla & Ganti, 2022, p.5).

To address the existing gaps in Canada and assess whether TNK was non-inferior to rt-PA in routine clinical practice, the AcT trial used a multicentre, open-labelled, linked randomized control trial involving ischemic stroke patients eligible for thrombolysis (Menon et al., 2022). The trial enrolled 1600 ischemic stroke patients across Canada, randomly assigned to receive 0.25 mg/kg of TNK (816) or 0.9 mg/kg of rt-PA (784) (Menon et al., 2022). TNK met the pre-specified non-inferiority threshold for their primary outcome (proportion with mRS 0-1 at 90-120 days post-treatment) as 36.8 % of the TNK group and 34.8 % of the rt-PA group met the primary outcome with an unadjusted risk difference of 2.1% (95% CI (-)2.6 – 6.9) (Menon et al., 2022). In addition, their safety analysis produced similarities as 3.4% of the TNK patients compared to 3.2% of the rt-PA patients had sICH at 24 hours, and 15.5% (TNK) compared to 15.4% (rt-PA) died within ninety days (Menon et al., 2022). Due to the ease of TNK, the AcT trial provided robust evidence to support TNK (0.25 mg/kg) as the standard of care for intravenous thrombolysis when treating ischemic stroke. Therefore, a notable update of the CSBP Recommendations, 7th addition (2022) included TNK as an alternative to rt-PA for acute intravenous thrombolysis (Heran et al., 2022). TNK has direct implications for clinical practice by providing desirable advantages over rt-PA. Instead of an hour-long infusion, TNK can be administered in a single bolus that is more comfortable for the patient, easier to administer for the hospital staff, and more convenient when transferring the patient to a different unit or hospital for EVT (Burgos & Saver, 2019).

After reviewing the thrombolysis evidence, I believe all eligible ischemic stroke patients presenting within 4.5 hours from LSN should receive either 0.25 mg/kg of TNK or 0.9 mg/kg of rt-PA. As TNK is easier to administer and has a much shorter administration time, I believe hospitals should transition to from rt-PA to TNK. Stroke hospitals should aim to achieve the CSBP target median Door To Needle Time (DTNT) of 30 minutes for eligible ischemic stroke patients receiving thrombolysis (Heran et al., 2022). DTNT is the time a patient arrives at a stroke hospital to the time a needle is used to administer thrombolysis. DTNT is a process measure for hospitals to use. In addition, evidence has shown that MRI DWI-FLAIR mismatch for patients waking with an ischemic stroke or patients presenting after 4.5 hours from symptom onset benefit from thrombolysis. However, emergent MRIs are not a feasible option in NL and Canada.

2.2.5 Endovascular Therapy (EVT)

A new era of stroke care began in 2018 for Canada. The CSBP recommendations included EVT as a treatment for eligible ischemic stroke patients within six hours of symptom onset (Boulanger et al., 2018). EVT is a non-surgical method using microcatheters inserted from the groin or arm to remove the blood clot guided using X-rays (*Endovascular Treatment of Stroke*, 2022). An interventional radiologist will perform the procedure called a thrombectomy (removal of the clot) by trapping the blood clot within a stent to be pulled out or using a catheter to suck out the blood clot (*Endovascular Treatment of Stroke*, 2022). Many major RCTs have published their findings supporting rapid EVT as safe and more effective than thrombolysis alone for eligible patients (Boulanger, et al., 2018). Imaging and time to treatment are essential inclusion criteria for EVT. As of now, EVT is recommended for Large Vessel Occlusions (LVOs), which include intracranial artery occlusions internal carotid artery (ICA) or proximal middle cerebral artery (MCA) in the anterior circulation and the immediate branches (Boulanger et al., 2018).

Along with the importance of the occlusion location, EVT considers the ischemic core, which can “differentiate between areas of potentially viable and irreversibly injured ischemic tissue” (Kaufmann et al., 1999, p.93). The Alberta Stroke Program Early CT Score (ASPECTS) is a ten-point quantitative score (lower score = more significant infarction) that measures early ischemic changes in the anterior circulation (Mokin et al., 2017). This score has shown reliability for prognostic value on functional outcomes and sICH before thrombolysis (Barber et al., 2000) and EVT (Schröder & Thomalla, 2017). The ASPECTS score was initially designed to identify patients eligible for thrombolysis who would likely benefit and is now applied to EVT (Mokin et al., 2017). EVT is recommended in LVOs with small-to-moderate ischemic core, an ASPECTS score of six or higher (Boulanger et al., 2018). In patients who show basilar artery occlusions or have a sizeable ischemic core (ASPECTS score less than six), a decision based on the potential benefits and risks must be made by a physician with stroke expertise, the neuro-interventionist, and the patient/decision makers (Boulanger et al., 2018).

In conjunction with the imaging criteria, time from symptom onset is essential. With EVT, there is a recommended time window of treating up to six hours from symptom onset, slightly longer than thrombolysis (Boulanger et al., 2018). For patients who present outside this time window between six hours and 24 hours or have wake-up strokes, highly selected patients may be treated if they meet appropriate clinical and imaging criteria (Albers et al., 2018; Nogueira et al., 2018; Boulanger et al., 2018). In addition, the 7th edition of CSBP recommends all disabling acute ischemic stroke patients presenting between six and 24 hours of stroke symptom onset should be rapidly screened to determine EVT eligibility (Heran et al., 2022). Positively screened ischemic stroke patients presenting outside of six hours must have access to a CT scanner with equipment and trained technicians capable of administering contrast for multiphase CTA or CT perfusion imaging, a large gap between sites throughout Canada (Heran et al., 2022). CSBP also recommends using "software that provides quantifiable measurements of ischemic core and penumbra" (Heran et al., 2022, p.50).

Thrombolysis is effective but less effective than EVT at opening proximal occlusions of the major arteries, which accounts for more than one-third of the acute anterior-circulation strokes (Berkhemer et al., 2015; Heldner et al., 2013). The prognosis of large vessel occluded ischemic strokes without revascularization is generally poor (Lima et al., 2014). Sixty to eighty percent of LVO patients with proximal vessel occlusion in the anterior circulation die or do not regain functional independence within ninety days, even with thrombolysis (Broderick et al., 2013). LVOs often remain occluded after rt-PA, especially the MCA (67%), leading to poor outcomes (Christou et al., 2001). The modest reperfusion rate for LVO patients treated with thrombolysis is the primary reason for its limited efficacy (Bhatia et al., 2010). This modest reperfusion rates may be due to the difficulty in breaking down the large occlusion.

Initial RCTs provided neutral results contributing to uncertainty about the efficacy of catheter-based treatment (Broderick et al., 2013; Kidwell et al., 2013; Ciccone et al., 2013).

However, since 2015, several RCTs have been published that demonstrated how ischemic stroke patients with LVOs of the intracranial carotid artery or MCA have benefited from EVT up to six hours after a stroke compared with intravenous rt-PA alone (Berkhemer et al., 2015; Goyal et al., 2015; Campbell et al., 2015; Saver et al., 2015; Jovin et al., 2015; Bracard et al., 2016).

The MR CLEAN trial compared intraarterial treatment (defined as intraarterial thrombolysis, mechanical treatment, or both) plus standard care (rt-PA) with rt-PA alone (Berkhemer et al., 2015). The inclusion criteria were an occlusion of the distal intracranial carotid artery, proximal MCA, or anterior cerebral artery (ACA) within six hours after symptom onset (Berkhemer et al., 2015). The MR CLEAN results show the benefit of intraarterial treatment, where there was a significant increase in ninety-day functional independence (mRS 0-2), with an absolute difference of 13.5% (adjusted OR=2.16, 95% CI=1.39-3.38), without an increase in mortality or sICH (Berkhemer et al., 2015). The release of the MR CLEAN results prompted the ESCAPE, EXTEND IA, and SWIFT PRIME trials to stop early because of efficacy (Goyal et al., 2015; Campbell et al., 2015; Saver et al., 2015).

The ESCAPE trial was a worldwide study that included Canada (11 out of 22 centers), randomly assigned ischemic stroke patients with a small infarct core and occlusion of the proximal artery in the anterior circulation with moderate-to-good collateral circulation to receive endovascular treatment plus standard care or standard care alone (Goyal et al., 2015). Although the results of the MR CLEAN trial caused the ESCAPE trial to stop early (n=316), the unplanned interim analysis found that rapid EVT improved clinical outcomes with a ninety-day mRS score favouring EVT (common OR=2.6, 95% CI=1.7-3.8, $p<0.001$), the rate of ninety-day functional independence was significantly increased by EVT (53.0% vs. 29.3%, $p<0.001$), and the rate of mortality was reduced by EVT (10.4% vs. 19.0%, p=0.04), confirming the benefits of the MR CLEAN trial (Goyal et al., 2015).

The EXTEND IA, SWIFT PRIME and REVASCAT trials all focused on the Solitaire FR Revascularization Device, an overlapping stent retriever to retrieve clots from occluded vessels to retore blood flow. The EXTEND IA trial randomized patients with an occlusions of the ICA or the first or second segment of the MCA who received rt-PA, and had CT perfusion imaging showing evidence of salvageable brain tissue and an ischemic core of fewer than 70 ml to either undergo EVT or not (Campbell et al., 2015). The study was stopped early with only a population of 70, EVT was associated with a greater reperfusion rate at 24 hours (100% vs. 37%, p<0.001), better early neurological improvement – 8 or more-point reduction on the NIHSS scale at day three, or an mRS score of 0 or 1 – (80% vs. 37%, p=0.002), achievement of functional independence (71% vs. 40%, p=0.01), and no significant differences in sICH or mortality (Campbell et al., 2015). The EXTEND IA trial concluded that future studies are required to clarify uncertainties regarding more distal occlusions, the influence of the device type, the variability of the endovascular technique and extended time windows (Campbell et al., 2015).

The SWIFT PRIME trial randomly assigned patients with an occlusion of the intracranial ICA and/or the first MCA segment to receive EVT plus rt-PA or rt-PA alone (Saver et al., 2015). Like the ESCAPE and EXTEND IA trial, the SWIFT PRIME trial was stopped early with a sample of 196 patients and concluded that EVT "was safe and effective in achieving reperfusion and substantially reduced the degree of disability and increased the proportion of patients with functional independence 3 months after stroke" (Saver et al., 2015, p.2294) in ischemic stroke patients with LVOs of the anterior circulation. The proportion of patients with functional independence at ninety days favoured EVT, 60% vs. 35% (risk ratio (RR) = 1.70, 95% CI=1.23-

2.33, p<0.001), as well as the proportion with successful reperfusion, 83% vs. 40% (RR=2.05, 95% CI=1.45-2.91, p<0.001) (Saver et al., 2015). There was no significant difference in ninety-day mortality (p=0.5) (Saver et al., 2015).

The REVASCAT trial randomized 206 patients with a confirmed proximal anterior circulation occlusion and an absence of a large infarct core (based on neuroimaging) who could be treated within eight hours of symptom onset to receive EVT (Solitaire device) and standard therapy (including rt-PA if eligible) or standard treatment alone (Jovin et al., 2015). Based on guidelines, the proportion of patients treated with rt-PA patients was 68.0% in the EVT group and 77.7% in the controls (Jovin et al., 2015). The study findings are consistent with the above trials, providing evidence that EVT was safe and decreased post-stroke disability when treating ischemic stroke patients with proximal LVOs (Jovin et al., 2015). The primary outcome of ninety-day disability (using mRS) favoured the EVT group (adjusted OR=1.7, 95% CI=1.05-2.8), an increased proportion had ninety-day functional independence (mRS 0-2) (43.7% vs. 28.2%, adjusted OR=2.1, 95% CI=1.1-4.0), and sICH and mortality did not significantly differ between EVT and the control group (Jovin et al., 2015).

The THRACE trial included broader eligibility criteria to examine the impact of EVT on moderate to severe strokes (NIHSS 10-25). The trial included occlusions from the superior third of the basilar artery and occlusions in the intracranial ICA, or M1 segment of the MCA (Bracard et al., 2016). The trial randomly assigned 414 patients to receive either rt-PA and EVT or rt-PA alone, where EVT had to be started within five hours of symptom onset (Bracard et al., 2016). Again, the results confirm that EVT improved functional independence (53% vs. 42%, OR=1.55, 95% CI=1.05-2.30, p=0.028) in patients with proximal intracranial arterial occlusions (Bracard et al., 2016). However, future studies are required to determine the efficacy of EVT on occlusions of the basilar artery as only two patients were available for inclusion (Bracard et al., 2016).

Basilar artery occlusions (BAO) are rare, but they are a devastating sub-type of ischemic stroke, resulting in high mortality and disability rates (Mattle et al., 2011). The Basilar Artery on Computed Tomography Angiography (BATMAN) score evaluates both the extent of the occlusion and the presence of collaterals (Alemseged et al., 2017). The BATMAN score showed good interrater reliability and prognostic accuracy for functional outcome and mortality (Alemseged et al., 2017). Kwak & Park (2020) suggested distal BAO and good initial collateral status may qualify the patient as a good candidate for EVT because good collateral circulation is an independent predictor of good clinical outcomes after EVT (Kwak & Park, 2020). Pasarikovski and colleagues (2020) reported time to treatment and successful reperfusion was not associated with improved outcomes of BAOs and they suggested utilizing tissue imaging because of the variability of collaterals in the posterior circulation.

While CSBP recommends EVT in LVOs of the anterior circulation with small-to-moderate ischemic core (defined as an ASPECTS score of 6 or higher) (Boulanger et al., 2018). Three studies analyzed the efficacy of EVT in ischemic stroke patients with an ASPECTS of three to five (larger infarction). A study in Japan by Yoshimura and colleagues (2022) randomized 203 to receive EVT with medical care or medical care alone within six hours of symptom onset. The trial reported patients treated with EVT had better ninety-day functional outcomes (mRS 0-3) with 31.0% compared to 12.7%, (RR=2.43, 95% CI=1.35-4.37, p=0.002), but EVT had a higher risk ICH in the first 48 hours (58.0% vs. 31.4%, RR=1.85, 95% CI=1.33-2.58, p<0.001) (Yoshimura et al., 2022). However, there were no significant differences in sICH at 48 hours or ninety-day mortality (Yoshimura et al., 2022). The ANGEL-ASPECT trail (2023) in China randomized 456 ischemic stroke patients presenting 24 hours from symptom. Stopped due to efficacy, ischemic stroke patients presenting within 24 hours had better odds of a lower mRS (OR = 1.37, 95% CI = 1.11-1.69, p = 0.004) when treated with EVT compared to medical management (Huo et al., 2023). The EVT group had more intracranial hemorrhages. Finally, the SELECT 2 trial was an international trial that randomized 352 patients to receive EVT or medical care. Stopped early for efficacy, EVT was associated with and generalized odds ratio of 1.51 (95% CI = 1.20-1.89, p<0.001) to have a better outcome using mRS compared to medical care (Sarraj et al., 2023). There was no difference in mortality, but the EVT group was associated with vascular complications.

The patient population eligible for EVT is increasing. Along with larger infarction cores, trials have investigated Medium Vessel Occlusions (MVOs). Further studies should investigate the efficacy of EVT on moderate to large ischemic core.

2.2.6 EVT Treatment Window

The DAWN and DEFUSE-3 trials provided evidence that suggested expanded treatment windows. The DAWN trial randomized 206 patients last known well between six to 24 hours from symptom onset, with occlusions of the intracranial ICA or the proximal MCA, to receive EVT plus standard medical care vs. standard care alone (Nogueira et al., 2018). With the extended time window, these patients required a mismatch between the severity of the clinical deficit (NIHSS score) and the infarct volume (assessed by diffusion-weighted MRI or perfusion CT and measured with RAPID software) (Nogueira et al., 2018). The superiority trial was stopped early because the prescribed interim analysis suggested that EVT plus standard care was superior to standard care alone for selected ischemic stroke patients from six to 24 hours from symptom onset (Nogueira et al., 2018). EVT increased the rate of ninety-day functional independence (mRS of 0-2) (49% vs. 13%, adjusted difference of 33%, 95% CI=24%-44%, posterior probability of superiority >0.999), and showed no significant difference in sICH and ninety-day mortality (Nogueira et al., 2018).

The DEFUSE-3 trial had slightly different inclusion criteria where 182 patients with occlusions to the intracranial ICA or the proximal MCA were randomized to undergo EVT plus standard care from six to 16 hours post-stroke or standard care alone (Albers et al., 2018). Again, patients with LVOs who have favourable findings on perfusion imaging treated with EVT have been shown to have less disability (OR=2.77, 95% CI=1.63-4.70, p<0.001), a higher rate of ninety-day functional independence (45% vs. 17%, RR=2.67, 95% CI=1.60-4.48, p<0.001), decreased proportion of ninety-day mortality (14% vs. 26%, p=0.05), and no significant increase in sICH (7% vs. 4%, p=0.75) (Albers et al., 2018).

In BAO patients, Alemseged and colleagues (2019) reported patients with a baseline CTA reporting a low thrombus burden and good collaterals were associated with good outcomes and revascularization (Alemseged et al., 2019). This trend continued regardless of time to treatment, including patients beyond six hours (Alemseged et al., 2019). The BATMAN score and the Posterior Circulation Collateral Score (PC-CS) may help identify eligible patients for EVT beyond six hours (Alemseged et al., 2019).

Although evidence has shown the benefits of an extended time window for EVT for patients selected using imaging, it is still a priority to treat the patient as fast as it is safely possible. The HERMES meta-analysis (n=1287) aimed to identify a time from symptom onset in which EVT remains associated with benefits and to discover how treatment delay is related to the degree of disability, functional independence, mortality, and sICH (Saver et al., 2016). According to Saver and colleagues, “Compared to the best medical therapy alone, endovascular thrombectomy therapy was associated with improved outcomes when procedure start (arterial puncture) could be performed within the first 7.3 hours after symptom onset" (Saver et al., 2016, p.1285). However, the longer time from symptom onset to arterial puncture (EVT initiation) resulted in a decline in the degree of benefit on disability (mRS score): at three hours, the common OR was 2.79 (95% CI=1.96-3.98), with an absolute risk difference (ARD) of 39.2%; at six hours the common OR was 1.98 (95% CI=1.30-3.00), ARD=30.2%; and at eight hours the common OR was 1.57 (95% CI=0.86-2.88), ARD=15.7% (Saver et al., 2016). At seven hours and 18 minutes, the lower 95% CI crosses 1.0, indicating EVT is no longer beneficial for all eligible LVOs (Saver et al., 2016). However, the DAWN and DEFUSE trials suggested that imaing selected patients may benefit from EVT.

In addition, setting targets like door-to-reperfusion (restoring blood flow) time can drive change in clinical practice which can improve the functional outcomes of ischemic sroke patients. For example, Saver and colleagues reported 39 per 1000 patients will have a decreased three-month disability score, and 25 more can achieve functional independence for every 15 minutes saved by the emergency department (ED) in door-to-reperfusion time (Saver et al., 2016). These findings support efficient in-hospital process and are consistent with the door-to-needle time (DTNT) results for rt-PA trials (Saver et al., 2013; Emberson et al., 2014).

Mulder and colleagues conducted an observational, prospective study using the MR CLEAN Registry to assess the association of time from symptom onset to EVT and successful reperfusion (Mulder et al., 2018). By analyzing EVT in current clinical practice, every hour delay in starting EVT reduced functional independence by 5.3% and a decrease of 7.7% for every hour delayed to successful reperfusion reduced functional independence by 7.7% (Mulder et al., 2018). The HERMES meta-analysis emphasized how imaging selection can affect the time to treatment

(Mulder et al., 2018; Saver et al., 2016). These studies described how additional imaging selection may be essential for patients outside the six-hour recommended time window (Mulder et al., 2018). It is important to emphasize the clinical importance of policies to accelerate door-to-treatment times.

2.2.7 EVT With Thrombolysis Versus EVT Alone

The previous studies investigated the efficacy of EVT combined with rt-PA compared to rt-PA alone. Now EVT is the recommended treatment for ischemic stroke patients with LVOs in the anterior circulation. There is some uncertainty about the efficacy of thrombolysis when treating LVOs as thrombolysis may potentially complicate EVT by fragmenting the thrombus, increase the risk of cerebral hemorrhage, or thrombolysis could potentially dissolve residual thrombi left behind by EVT (Christou et al., 2001; Yang et al., 2020). In 2017, Coutinho and colleagues reported a patient-level (n=346) pooled post-hoc-analysis from two prospective studies, examining whether rt-PA is beneficial in patients undergoing EVT (Coutinho et al., 2017). Additionally, Phan and colleagues published a systematic review, including prospective and retrospective studies (Phan et al., 2017). These studies did not report statistically significant differences in benefits or harm between the two groups. Coutinho and colleagues (n=291) reported ninety-day functional independence of 57.7% in the EVT+rt-PA group and 47.7% in the EVT alone group (OR=1.48, 95% CI=0.75-2.74, p=0.10), and ninety-day mortality of 8.1% and 12.2% (p=0.32) (Coutinho et al., 2017). The study did not show a statistically significant difference (suggesting the study may be underpowered), but an absolute risk difference of 10% is clinically important, supporting rt-PA before EVT. However, due to the post-hoc analysis, further investigation is required. Phan and colleagues (n=2615) reported ninety-day functional independence in 43.9% of the EVT group vs. 48.4% in the EVT+rt-PA group (OR=0.8, 95%

CI=0.64-1.002, p=0.052) (Phan et al., 2017). Both studies concluded that the findings warrant RCTs comparing these interventions in groups of ischemic stroke patients with LVOs.

From 2020-2021, two RCTs from China and one from Japan were published, comparing EVT with rt-PA and without. In the Chinese trials, Yang and colleagues randomly assigned 656 ischemic stroke patients, and Zi and colleagues randomized 234 using similar criteria (Yang et al., 2020; Zi et al., 2021). In Japan, Suzuki and colleagues randomized 204 LVO ischemic stroke patients eligible for EVT and rt-PA therapy (Suzuki et al., 2021). All three RCTs used a non-inferiority analysis comparing EVT alone to the recommended care of rt-PA before EVT using ninety-day mRS distribution as their primary outcome. Care must be taken when interpreting non-inferiority designs, as choosing large margins may not demonstrate non-inferiority even when significant differences exist.

Yang and colleagues (2020) set a non-inferiority margin of 0.8 for a common OR on a ninety-day mRS score. The ninety-day mRS for EVT vs. EVT + rt-PA resulted in an adjusted OR of 1.07 (95% CI=0.81-1.40, p=0.04), with no significant difference in ninety-day mortality (17.7% vs. 18.8%, p=0.71) (Yang et al., 2020). Zi and colleagues (2021) set a margin of -10.0% as the clinically relevant limit for the rate of ninety-day functional independence. Results showed 54.3% of the EVT group compared to 46.6% of the EVT + rt-PA group achieving ninety-day functional independence (7.7% difference, noninferiority=0.003), with no significant difference in sICH (6.1% vs. 6.8%) and ninety-day mortality (17.2% vs. 17.8%) (Zi et al., 2021). Suzuki and colleagues (2021) used an OR of 0.74 as their non-inferiority margin for ninety-day functional independence, which was derived from a previous meta-analysis. However, the trial reported a failure to achieve non-inferior results due to wide confidence intervals: ninety-day functional independence of 59.4% vs. 57.3% (OR=1.09, 1-sided 97.5% CI=0.63-∞, p=0.18 for non-inferiority) (Suzuki et al., 2021). In conclusion, EVT alone was non-inferior to rt-PA before EVT for two of the three trials. However, wide non-inferiority margins lead to bias and incorrect claims. The studies shows substantial differences, but reported non-inferiority. Therefore, the authors recommended future trials to investigate other populations to increase the generalizability of their results.

Using an ischemic stroke population from Europe (Netherlands, Belgium, and France), LeCouffe and colleagues reported contrasting results where patients eligible for EVT and rt-PA were randomized to receive EVT alone or rt-PA before EVT (LeCouffe et al., 2021). This study analyzed the data first for superiority and then for non-inferiority. The results reported that the median ninety-day mRS score for patients receiving EVT alone was inferior to those receiving rt-PA before EVT (LeCouffe et al., 2021). However, the adjusted odds ratio was 0.84 (95% CI=0.62-1.15, p=0.28), where the EVT group was not non-inferior as the 95% CI lower boundary crossed the set margin of 0.8 (LeCouffe et al., 2021).

In addition, two meta-analyses were published using the four RCTs above. Zhang and colleagues (2022) concluded that EVT alone was not significantly different from rt-PA before EVT, yielding similar efficacy and safety outcomes in ischemic stroke patients who had LVOs of the anterior circulation. Lin and colleagues (2022) reported that direct EVT was demonstrated to be non-inferior to rt-PA before EVT for ninety-day functional independence (mRS 0-2), with 46.0% of the EVT alone group compared to 45.5% of the rt-PA before EVT group. The risk difference was 1% (95% CI= -4% to 5%), where the lower boundary fell within most of the non-inferiority margins but not the most stringent of –1.3% (Lin et al., 2022). Both studies reported the need for future investigations and bigger sample sizes.

Finally, four major RCTs failed to demonstrate the non-inferiority of EVT without thrombolysis compared to recommended thrombolysis then EVT. The SKIP trial randomised 204 patients in Japan. Using a favourable outcome of mRS 0-2 at 90 days, the EVT alone group produced an OR of 1.09, p = 0.18 for non-inferiority (Suzuki et al., 2021). The DIRECT-SAFE trial randomized 295 international LVO ischemic stroke patients. Also using an primary outcome of mRS 0-2 at 90 days, functional independence occurred in 55% of the direct EVT group and 61% of the thrombolysis before EVT group (Mitchell et al., 2022). The MR CLEAN-NO IV trial investigated thrombolysis before EVT by randomizing 145 patients with CTP results in the Netherlands and did not produce statistically significant differences in infarct evolution at follow-up (Hoving et al., 2023). Using a European and Canadian population, Fischer and colleagues randomly assigned 423 ischemic stroke patients with LVOs. Using a primary outcome of mRS 0-2 at 90-days, 57% of the EVT alone patients had a favourable outcome compared to 65% in the thrombolysis plus EVT (Fischer et al., 2022). As EVT alone did not demonstrate non-inferiority, thrombolysis should not be delayed before EVT.

2.2.8 Tenecteplase Compared to Alteplase Prior to EVT

We discussed the clinical advantages of TNK, but using a single bolus could save valuable time to EVT compared to the hour-long infusion of rt-PA. The EXTEND-IA TNK trial randomized patients to compare TNK (0.25mg/kg) with rt-PA in establishing reperfusion when administered within 4.5 hours of symptom onset before EVT. The primary outcome was defined as "… reperfusion of greater than 50% of the involved territory or an absence of retrievable thrombus at the time of initial angiographic assessment.", and if this outcome occurred, the patients would not undergo EVT (Campbell et al., 2018, p. 1576). This outcome occurred in 22% (22/101) of the patients who received TNK compared to 10% (10/101) who received rt-PA, with an incidence difference of 12% (95% CI=2%-21%, noninferiority margin of -2.3%, p=0.002 for noninferiority) (Campbell et al., 2018). In addition, there was a significantly better function favouring TNK before EVT in the ninety-day mRS median score (common OR=1.7, 95% CI=1.0-2.8, p=0.04), but no significant differences in the ninety-day independent function (mRS 0-2, 64% TNK vs. 51% rt-PA, adjusted OR=1.8, 95% CI=1.0-3.4, p=0.06), and mortality (10% vs. 18%, adjusted OR=0.4, 95% CI 0.2-1.1, p=0.08) (Campbell et al., 2018). The results supported TNK as non-inferior to rt-PA in establishing reperfusion and achieving better functional outcomes. Campbell and colleagues did highlight that the increased reperfusion rate from TNK before EVT may have contributed to the improved median mRS scores (Campbell et al., 2018). The AcT trial provided empirical evidence to support switching the standard-of-care for thrombolysis from rt-PA to a TNK dose of 0.25 mg/kg (Menon et al., 2022). Therefore, TNK is recommended as the standard of care for all eligible hyperacute ischemic stroke patients and thrombolysis decision should ideally be made before the EVT (Heran et al., 2022). In addition, Alemseged and colleagues reported that TNK may be associated with an increased reperfusion rate (26% vs. 7%, RR=4.0, 95% CI=1.3-12, p=0.004) compared to rt-PA before EVT in BAO patients (Alemseged et al., 2021) warranting further investigation in BAOs.

2.3 Hyper Acute Ischemic Stroke Care

Ischemic stroke patients require an efficient, organized response with interprofessional care. Hyperacute stroke care consist of stroke patients presenting within six hours from symptom onset (Bader and Palmer., 2006). For eligible ischemic stroke patients, emergency therapy with thrombolysis and/or EVT have shown significant benefits for a patient's functional independence. From the onset of stroke signs and symptoms, the first minutes and hours are critical and strongly linked to patient outcomes (Boulanger et al., 2018). Each patient will have different circumstances, and their geographical location may delay their access to certain resources. This will affect the specific steps in early stroke management to support each patient. However, the steps outlined in Figure 2.1 reflect stroke best practices for stroke patients (Boulanger et al., 2018). Rapid application of these steps could significantly impact time to treatment resulting in reduced odds of mortality, improved odds of long-term recovery and quality of life.

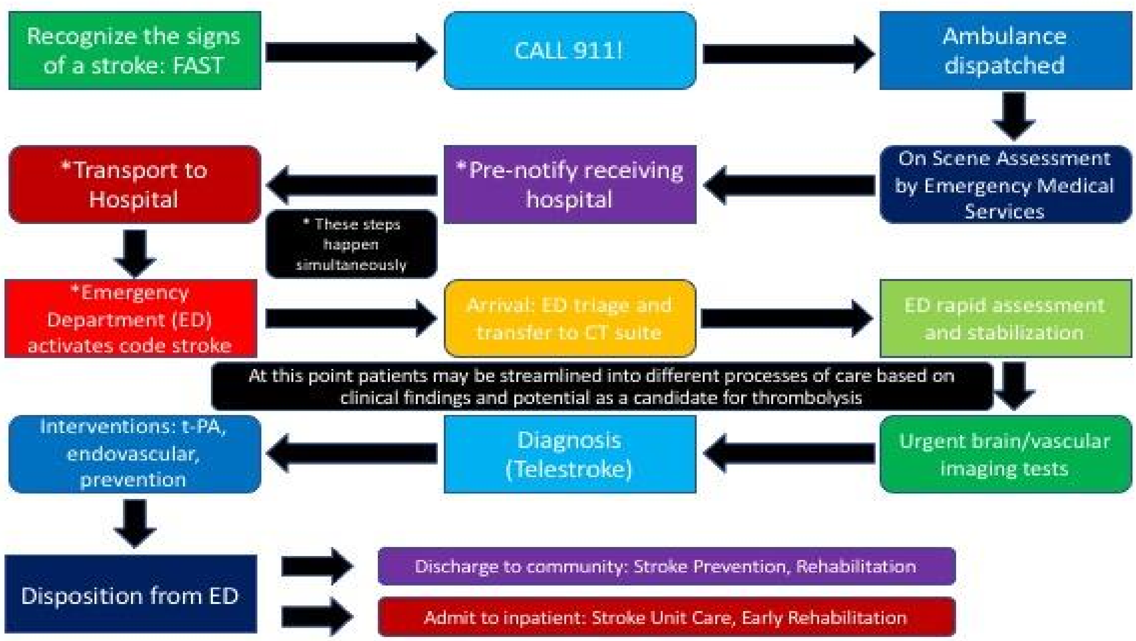
Efficiency through these steps is essential as brain cells are dying at an alarming rate. Ischemic strokes can be treated effectively within the recommended time from symptom onset of 4.5 hours for thrombolysis and up to 24 hours for EVT (with the aid of advanced imaging techniques). While time windows exist, the benefit is more significant when patients are treated as soon as possible (Prabhakaran et al., 2015; Emberson et al., 2014; Saver et al., 2013) (Saver et al., 2016). As time progresses, the benefit-to-risk ratio begins to diminish, where risks might outweigh benefits, especially for thrombolysis (Lees & Bluhmki, 2010). Therefore, efficiencies through the processes in Figure 2.1 can significantly affect a stroke victim's outcome.

Two timelines can be established within the 4.5 hour-window from symptom onset to administration of thrombolytic therapy to facilitate an effective and efficient response to a stroke in Canada. Eligibility for EVT also occurs in this pathway but has an increased time window.

1. The pre-hospital phase begins with stroke symptom recognition, calling 9-1-1, rapid dispatch, paramedic on-scene management and transport time. (Boulanger et al., 2018).
2. The Emergency Department (ED) phase begins when the stroke patient arrives at the hospital and includes diagnostic evaluation, diagnosis, consideration of treatment options, and the initiation of treatment options (Boulanger et al., 2018). The CSBP set a target

Door To Needle Time (DTNT) for thrombolysis at a median of 30 minutes and a Door To Puncture Time (DTPT) for EVT at a median of 60 minutes (Kamal et al., 2014).

Figure 2.1: Hyper Acute Management of Stroke



Through the CSBP Recommendations, I have developed a process map of the recommended care pathway of a stroke patient.

2.3.1 Pre-Hospital Phase

The pre-hospital phase presented in Figure 2.2 encompasses the first seven steps of Figure 2.1. When the signs of a stroke are recognized, 9-1-1 must be called, immediately. By calling 9-1-1 an ambulance will be dispatched, an on-scene assessment by Emergency Medical Services (EMS) will be conducted, EMS will transfer to the appropriate hospital and the receiving hospital will be pre-notified of the incoming stroke patient, allowing the hospital to activate its stroke protocol to prepare for the patient's arrival. It is important to understand that around a third of acute stroke patients fail to arrive by ambulance (Heran et al. 2022).rmf

2.3.1.1 Recognition

Public awareness and education about the signs of stroke play a vital role in the patient's overall potential for a positive outcome. Time is a significant factor for stroke victims. As each minute passes untreated, a typical stroke patient will lose 1.9 million neurons (Saver, 2006). The responsibility for public education is shared by many, with decisions, funding and actions taken by government and health system leaders, healthcare providers, educators, community services and health organizations. Over the past decade, numerous public health campaigns have been designed to increase the recognition of the signs and symptoms of stroke (Boulanger et al., 2018). In Canada, FAST (Figure 2.3) is the Heart and Stroke Foundation's national campaign to raise awareness of the signs of stroke (Heart & Stroke, 2022). FAST stands for Face – is it drooping? Arms – can you raise both? Speech – is it slurred or jumbled? And Time – to call 9-1-1 or your local emergency service immediately (Heart & Stroke, 2022).

Figure 2.2: Pre-Hospital Pathway

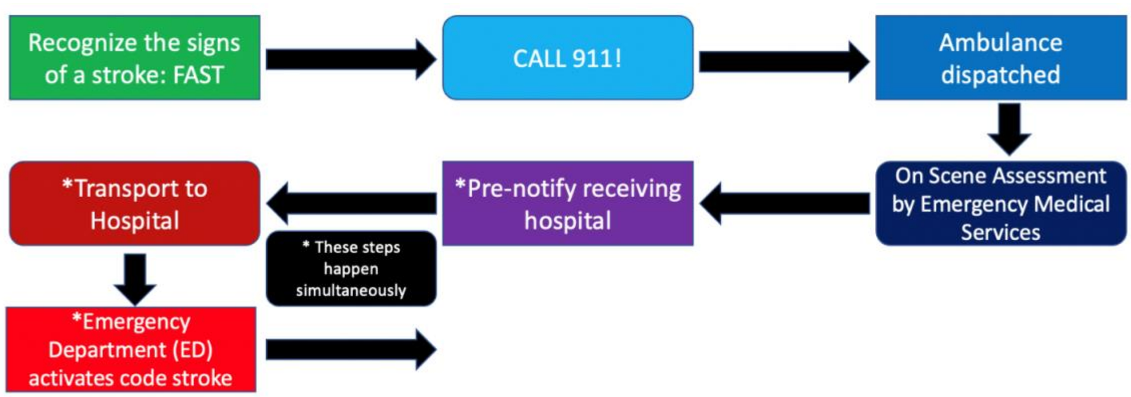


Fig. 2.2. Highlights the pre-hospital care pathway of a stroke patients from recognition of stroke signs and symptoms to the response of EMS to get the patient to the closest stroke care facility.

Exposure to these public health campaigns, especially with the three most common features in the FAST campaign (Face, Arms, and Speech), has significantly increased awareness and increased the proportion of respondents that recall stroke warning signs (Bray et al., 2013).

Figure 2.3: Heart and Stroke Foundation FAST Signs of Stroke Campaign

The H&S FAST Campaign is designed to increase the publics recognition of stroke symptoms and once recognized, to call 9-1-1 as fast as possible. The Heart and Stroke Foundation granted copyright approval.

FAST was also associated with an increase in the number of people who indicated they would call 9-1-1 in response to witnessing specific stroke symptoms (T – Time to call 9-1-1) (Jurkowski et al., 2010). However, even though campaigns are effective, a recent public poll conducted by the Heart and Stroke Foundation showed that 40% of Canadians, who responded, did not know any of the FAST signs of stroke (Boulanger et al., 2018). In 2019, Quality of Care NL reported 26% were not very familiar or not at all familiar with FAST (Quality of Care NL, 2019a). This failure to recognize stroke symptoms as a witness or patient will decrease the patient's opportunity to receive time-sensitive treatment.

Mass Media Interventions (MMI) of mnemonics like FAST were proven to increase intravenous thrombolysis use (Advani et al., 2016). Advani and colleagues reported that in Norway, the average number of patients treated with rt-PA increased by 54.7% ($p = 0.002$), and the number of patients treated in the ED increased by 95.7% ($p < 0.0001$) after a 6-month MMI (Advani et al., 2016). The FAST ideas were used, but the acronym was avoided. Instead, vivid imagery and actors acting out the symptoms were used for advertising on television, posters, social media, and healthcare trust websites to increase awareness (Advani et al., 2016). The increased rt-PA rate was believed to be due to the increase in ED admissions (Advani et al., 2016). Although the results showed some longer-lasting effects, campaigns often require repetition at regular intervals to be remembered (Advani et al., 2016).

Investigating a different strategy, Dombrowski and colleagues looked at the impact of the 'Act FAST' campaign in Newcastle, UK (Dombrowski et al., 2015). This campaign only provided an Act Fast leaflet (using the FAST symptoms) where participants were randomized to either receive a leaflet and a questionnaire or just a questionnaire (Dombrowski et al., 2015). The results showed more significant levels of recall of specific Act FAST elements for those who received the leaflet (66.1% vs. 45.3%, $p<0.001$) (Dombrowski et al., 2015). However, there was no impact on stroke recognition and response measures (Dombrowski et al., 2015). Therefore, if FAST is continued, more research is required to develop alternative methods that effectively deliver the appropriate message to the general public (Dombrowski et al., 2015).

Aroor, Singh, and Goldstein (2017) investigated broadening the aspects of the FAST mnemonic by adding Balance and Eyes to create BE-FAST (Aroor et al., 2017). Using retrospective data, they reported that 14.1% of patients with ischemic stroke had no FAST symptoms at presentations (Aroor et al., 2017). However, with the addition of gait imbalance or leg weakness (Balance) and visual symptoms (Eyes), the proportion of patients without symptoms was reduced to 4.4% (Aroor et al., 2017). Therefore, if the BE-FAST mnemonic can be validated prospectively, a revision of the FAST mnemonic may be warranted.

Additional research is required as BE (Balance and Eyes) is associated with many non-stroke symptoms. This may create an influx of false positive stroke cases, but patients should still call

9-1-1. In addition, high-risk patients and patients who have experienced a TIA must be educated on the risk of a stroke, particularly the signs and symptoms of stroke, and stroke prevention to lower their risk.

2.3.1.2 Response

If stroke symptoms are recognized, 9-1-1 or the local emergency number must be called to place the stroke patient in the care of the Emergency Medical Services (EMS). A well-functioning stroke system will essentialize the role of paramedics and emphasize speed. For example, the CSBP recommends an on-scene time to be at a median of under twenty minutes (Heran et al., 2022). Once 9-1-1 is contacted, EMS are sent to the scene and should transfer the patient to the closest stroke care facility (Boulanger et al., 2018). NL has many rural regions where their health centers are ill-equipped to treat stroke. Therefore, EMS has a vital role within these regions. If they recognize stroke symptoms, they must bypass to the closest stroke centre. In 2016, about 37% of Canadian stroke patients did not arrive at the ED by ambulance, and CIHI reported a higher proportion in NL (43%) (Information (CIHI), 2016). This wastes valuable time and result in falling outside treatment windows. Patients arriving using EMS experience fewer delays as paramedics create an appropriate triage, proceed to a proper stroke centre, and notify the ED of their arrival (Boulanger et al., 2018). This results in fewer delays to appropriate diagnostic imaging and potential thrombolysis and/or EVT treatment.

As soon as the EMS arrive, they should be trained to recognize the stroke symptoms and mobilize those patients as fast as possible to the most appropriate stroke centre for diagnostic imaging and hyperacute therapy (The Heart and Stroke Foundation 2015 Report, 2015). For stroke recognition, EMS must use two-step stroke screening tools while on scene (Heran et al., 2022). It is recommended that paramedics include a standard screening for signs of stroke using a tool like FAST or the Cincinnati Prehospital Stroke Scale (CPSS) (Kothari et al., 1999). The CPSS is a 3-item scale (arm weakness, speech, and facial droop), simplifying the National Institutes of Health Stroke Scale (NIHSS) (Kothari et al., 1999). CPSS is easily administered among prehospital personnel and physicians showing validity in identifying patients with ischemic stroke eligible for thrombolysis (Kothari et al., 1999). If positive, a secondary screen for stroke severity, LVO recognition and EVT eligibility is recommended (Heran et al., 2022). Stroke vision, aphasia, neglect (VAN) (Teleb et al., 2017), and the Field Assessment Stroke Triage for Emergency Destination (FAST-ED) (Lima et al., 2016) are both validated scales used by paramedics. These screening tools accurately identified emergent LVO strokes in the prehospital setting, enabling rapid patient triage and allowing hospitals to mobilize resources to expect EVT-eligible patients (Teleb et al., 2017; Lima et al., 2016).

In NL, paramedics use a Rapid Arterial oCclusion Evaluation (RACE) Stroke Scale presented in Appendix I. If the patient has a five or higher RACE score, they may be a candidate for EVT. However, the current model excludes pregnant patients and patients on anti-coagulants. These patients are potential EVT candidates even if they meet thrombolysis exclusion criteria. Not all thrombolysis exclusions are applicable to EVT eligibility. Therefore, NL may miss eligible EVT candidates using the current model.

Another study (2018) considered a three-step ambulance clinical triage for acute stroke (ACT-FAST), designed as an algorithmic identification tool (Zhao et al., 2018). They found that the three-step ACT-FAST algorithm showed higher specificity and reliability than existing scales for clinical LVO recognition (Zhao et al., 2018). The three steps involved; 1) unilateral arm drift to stretcher <10 seconds, 2) severe language deficit (if the right arm is weak) or gaze deviation/hemineglect assessed by a simple shoulder tap test (if the left arm is weak), and 3) eligibility and stroke mimic screen (Zhao et al., 2018). Including a stroke mimic screen increased the accuracy of recognizing EVT eligibility, and the sequential steps eliminated scoring confusion and reduced assessment time (Zhao et al., 2018).

Along with the screening tools, CSBP recommends that EMS personnel obtain information from the patient, family member, or witness about the suspected stroke event (Boulanger et al., 2018). For example, they should determine when the first signs began (or when the patient was last known well), current medications (especially anticoagulants), medical allergies, and comorbid conditions (Boulanger et al., 2018). It is also recommended that a family member or decision maker accompany the stroke patient to the hospital or be accessible by phone to provide other urgent information (Boulanger et al., 2018). Additional treatment can be completed enroute to the hospital, for example, CSBP recommends a capillary blood glucose measurement because blood glucose levels can present stroke like symptoms affecting transport decisions (Heran et al., 2022; Fugate & Rabinstein, 2015). Hypoglycemia, low glucose levels, mimic stroke symptoms and is a primary exclusion factor for thrombolysis (Fugate & Rabinstein, 2015). In severe cases, hyperglycemia (high glucose levels) can also produce focal neurological deficits but is omitted as an exclusion (Fugate & Rabinstein, 2015). In addition, hypoglycemia and hyperglycemia can worsen brain ischemia (Fugate & Rabinstein, 2015). Hyperglycemia is associated with a decreased chance of recanalization and an increased risk of ICH (Ribo et al., 2007; Bruno et al., 2002; Demchuk et al., 1999).

2.3.1.3 Dispatch Communication

To assist with EMS and hospital communication are EMS dispatchers. An EMS dispatcher typically involves informing relevant personnel, such as Neurology, Internal medicine (if no neurology), ED physicians, Radiologists, CT technologists, and blood and electrocardiogram

(EKG) technicians of the arrival of the potential stroke patient (Boulanger et al., 2018). In addition, dispatchers can identify strokes that EMS crews missed during their prehospital diagnosis (Jia et al., 2017). Several studies have shown a significant increase in patients treated with rt-PA after EMS dispatchers completed training to improve their ability to detect suspected ischemic stroke patients (Berglund et al., 2012; Caceres et al., 2013). Caceres and colleagues reported that arrival time to a hospital was decreased by the dispatcher's recognition and diagnosis of a potential stroke (Caceres et al., 2013). Finally, The HASTA study used an increased priority level for stroke patients, from level two to one, where an increased priority level resulted in a more significant proportion of ischemic stroke patients receiving thrombolysis (24% vs. 10%, $p<0.001$) and this group reached the stroke unit 26 minutes earlier ($p<0.001$) (Berglund et al., 2012). Therefore, all suspected stroke patients should be treated at a higher priority level to get a CT/MRI scan immediately.

Dispatchers can also hasten the process by providing pre-arrival instructions to the stroke witness to optimize prehospital care, including: unlocking the door, moving pets, determining the stroke symptom onset time, and determining the current medications the patient is taking (Boulanger et al., 2018). This may be a problem if the stroke victim contacts EMS, as they may have trouble complying with the requests, but calling is a major step to receiving efficient care (Boulanger et al., 2018).

2.3.1.4 Transport

Suspected stroke patients must have direct transport protocols. Potentially eligible patients for thrombolysis and/or EVT must be transferred directly to the closest stroke centre capable of diagnosing and treating acute ischemic strokes (Boulanger et al., 2018). There are different levels of acute stroke care hospitals. First are the Primary stroke centres (PSC) that provide good stroke care, use of a CT scanner and thrombolysis (National Association EMS Physicians, 2018). Next is a thrombectomy-capable or EVT-capable PSC, which has the same capabilities as a PSC but also can perform EVT (National Association EMS Physicians, 2018). Lastly is the Comprehensive Stroke Centres (CSC). These facilities have all the above resources but are better equipped to provide state-of-the-art care for patients with severe ischemic and hemorrhagic stroke, including advanced diagnostic imaging, continuous availability to in-hospital neuro-surgery, and neurocritical care with a dedicated neurological intensive care unit (ICU) (National Association EMS Physicians, 2018). In addition, acute stroke care can be provided without a hospital through Mobile Stroke Units (MSU).

Evidence shows that EMS should have bypass protocols to bypass non-stroke centers in favour of PSCs or a center capable of providing thrombolysis (E. C. Jauch et al., 2013; Schuberg et al., 2013; Higashida et al., 2013; Fargen et al., 2015). NL has many rural and remote regions where hospitals and health centers cannot provide thrombolysis. Therefore, EMS has a vital role within these regions. If they recognize a patient is undergoing stroke symptoms, they must bypass the non-PSCs and go to a PSC as fast and safely as possible. In NL there are many PSCs and recently the Health Sciences Centre (HSC) in St. John’s has become an EVT-capable PSC. With the advances implemented at the HSC, it should be a priority to develop a CSC.

For patients who are believed to be eligible for EVT, the concept of bypassing a PSC for a CSC has been considered but has yet to be widely adopted (Katz et al., 2015; Higashida et al., 2013). Bypassing directly to a CSC is associated with time savings and possibly a reduced time to receive EVT (Goyal et al., 2014). However, results have shown longer travel times extending the reperfusion time past ninety minutes (McMullan et al., 2012; McMullan et al., 2011). Therefore, The American Stroke Association only recommends bypassing to a CSC if the transportation time is no more than twenty minutes (Katz et al., 2017). If eligible, patients should receive thrombolysis as fast as possible, then transition for EVT.

Another method of transportation used in rural areas is the “Drip and Ship” model. The “Drip and Ship” model is designed to transport the assumed ischemic stroke patient to the nearest hospital that provides thrombolysis. If eligible, the patient receives thrombolysis and is then transferred to the nearest hospital that provides EVT (Holodinsky et al., 2017; Sheth et al., 2015; Deguchi et al., 2018; Kijpaisalratana et al., 2020). This system can work very well with rural communities farther away from a CSC (Kijpaisalratana et al., 2020). In addition, evidence has shown the benefit of EVT up to 24 hours from symptom onset based on imaging and clinical criteria. (Albers et al., 2018; Nogueira et al., 2018). If regions extend that EVT time window, EVT will be more accessible for eligible rural patients. However, earlier treatment is associated with an improved odds of retaining functional independence.

In NL, all CT scanners can perform a CTA. However, patients presenting in the later time windows require software and trained technologists to do timed contrast injections for CT perfusion imaging or a multiphase CTA. CT perfusion imaging has been used to identify salvageable brain tissue for patients outside of six hours from last seen normal and should be accessible if the EVT treatment window is extended. Drip and ship could still be applied without CTA and CT perfusion based on LVO screening by paramedics. These patients could go for thrombolysis, then transfer for additional imaging and potentially EVT.

Finally, large geographic rural regions should investigate MSUs as an option for their acute stroke patients. A MSU is an ambulance equipped with a CT scanner, a point-of-care laboratory, and a stroke team to diagnose, triage, provide pre-hospital care and administer thrombolysis (Højslev Lund et al., 2022). Some MSUs have a lightweight design to reduce costs, facilitate speed and navigate narrow roads (Fassbender et al., 2021). Larger vehicles can provide extra space, incorporate larger scanners, and allow relatives to accompany and provide history and informed consent for thrombolysis and EVT (Fassbender et al., 2021)

The BEST-MSU trial (2021) compared MSUs to EMS using an observational, prospective trial that enrolled 1047 patients eligible for thrombolysis. The MSU group had a higher proportion of their eligible patients receiving thrombolysis (97.1% vs. 79.5%), a shorter median time from symptom onset to thrombolysis (72 minutes vs. 108 minutes), a higher proportion were functionally independent (mRS 0-1) (53.5% vs. 45.5%), and a lower proportion died within 90 days (8.9% vs. 11.9%) (Grotta et al., 2021).

In 2022, a systematic review and meta-analysis by Turc and Colleagues questioned if MSUs led to better functional outcomes than usual care. Using five studies ($n = 3228$), MSUs were associated with an increased odds of an excellent outcome (mRS 0-1) with an adjusted OR of 1.64 (95% CI = 1.27-2.13, $p < 0.001$) (Turc et al., 2022). Turcs and colleagues also identified a median reduction of 31 minutes (95% CI = 23-39), $p < 0.001$) in stroke onset to thrombolysis, and there were no safety concerns associated with MSUs. From symptom onset to EVT, Zhao and colleagues (2020) reported a median reduction of 51 minutes (95% CI = 30.1-71.9, $p < 0.001$) in Melbourne, Australia with MSUs compared to standard ambulance during MSU hours. In addition, Czap and colleagues (2020) identified a reduction of 53.5 minutes (95% CI = 35-67) from symptom onset to EVT with a CTA on board an MSU and a direct EVT team notification compared to MSUs without CTAs.

While MSUs have shown substantial benefits for their stroke patients, implementation requires a substantial investment. The costs of an MSU include an initial investment of around one million Canadian dollars, and then the ongoing operating, maintenance, and staffing costs

(Mason, 2017). Therefore, many articles have explored the potential cost effectiveness of MSUs. In 2022, Chen and colleagues published a systematic review, and four studies provided an economic analysis. MSUs displayed favourable cost effectiveness using an Incremental Cost-Effectiveness Ratio (ICER) for Quality-Adjusted Life Years (QALY) and Disability-Adjusted Life Years (DALY). The incremental cost-effectiveness per QALY was $31,911 and $38,731 per DALY (Chen et al., 2022). Buzby (2017), reported an ICER of $33,537 per QALY. When using the WHOs $190,000 (U.S gross domestic product) threshold for cost-effectiveness, MSUs would need to treat between 100–150 ischemic patients with thrombolysis per year (Buzby., 2017). However, the yearly costs of operating an MSU must be taken in consideration. Reimer and colleagues (2020) reported that MSUs when treating the same populations would cost an additional $70,613 per year compared to standard transport. However, a sensitive analysis to address direct transfers of MSUs to CSCs, the increased costs of MSUs was $336,331 per year (Reimer et al., 2020). Operating an MSU near a CSC appears to be an insufficient use of resources. In rural health zone, stroke resources may need to be reduced at smaller sites to prioritize an MSU. In addition, cost-effectiveness and the size of the catchment area should be considered.

2.3.1.5 Pre-notifying the Receiving Emergency Department

If a stroke victim or a witness can call EMS immediately, they save valuable minutes, leading to a higher chance of retaining functional independence and decreased disability. In addition, EMS can provide FAST information on-scene to the clinical communications/ dispatcher, who dispatches information to the receiving hospital to activate an acute stroke protocol. This allows the hospital to prepare and quickly treat the patient. Upon arrival, EMS will hand the patient to the ED. Pre-notification is critical to ensure the availability of stroke teams when the stroke patient arrives (Boulanger et al., 2018). Upon arrival, the stroke team immediately initiates patient triage, registration, time-sensitive investigations, and treatments (Boulanger et al., 2018). With the ability to transmit information on route, hospitals can complete patient histories and pre-register patients in preparation for CT scans (Sadeghi-Hokmabadi et al., 2018). This pre-notification system reduces intra-hospital processing times, which leads to an increased rate of thrombolysis and a decreased door-to-needle time (DTNT) (S. K. Kim et al., 2009; Bae et al., 2010). These pre-notification reports should include the last known normal time, stroke screen results, vital signs, blood glucose, current medications, and any acute interventions (E. Jauch et al., 2015). In addition, pre-notification can facilitate pre-registration which will reduce in hospital processes and the time to treatment (Heran et al., 2022).

2.3.2 Emergency Department Phase

The Emergency Department (ED) phase presented in Figure 2.4 encompasses the remainder of the stroke care pathway steps from Figure 2.1. This stage of the stroke treatment pathway must minimize the time to treatment. Evaluations of DTNT are sought out when using thrombolysis, as well as Door to Puncture time (DTPT) for EVT. Other key outcome variables include patient outcome measurements (functional independence) and thrombolysis rates.

Figure 2.4: Emergency Department Pathway

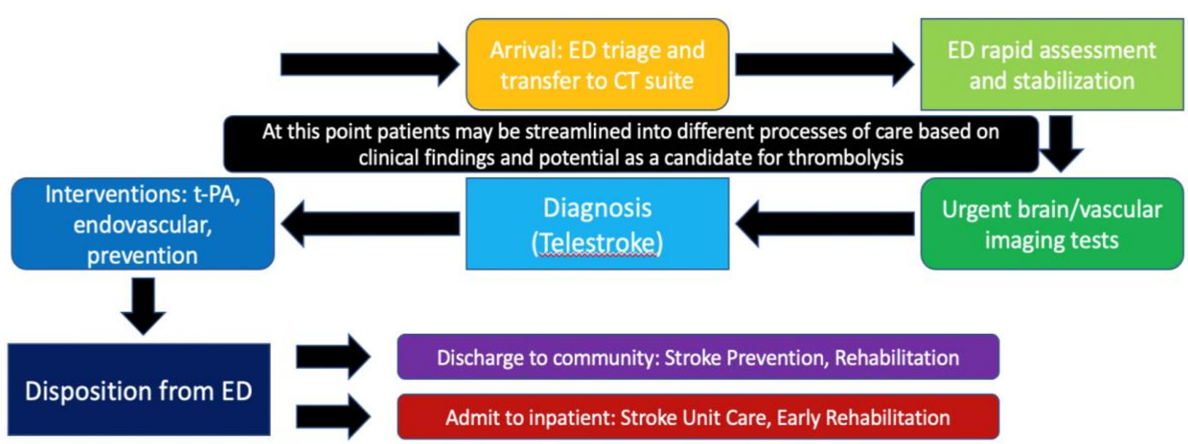


Fig. 2.4. Highlights the emergency department care pathway for an ischemic stroke patient. This care pathway has regimented processes within a stroke facility to treat a stroke patient as fast as safely possible.

2.3.2.1 Patient Handover

Upon arrival, the job of the EMS is still ongoing. EMS has collected vital information that will help the treatment decision of the neurologist/most responsible physician. With the help of pre-notification, code stroke should be activated, the stroke team should be ready to go, and the patient can be pre-registered. The patient should remain on the EMS stretcher and go straight to the CT suite instead of transferring to an ED bed. Evidence has shown that staying on the EMS stretcher reduces DTNT (Meretoja et al., 2012; Busby et al., 2016; Ajmi et al., 2019). If medically stable, the stroke physician can perform a swift neurological evaluation and send the patient swiftly to the CT scanner (Busby et al., 2016).

2.3.2.2 Rapid Assessment

Ischemic stroke has a narrow therapeutic window from symptom onset. Therefore, timely ED evaluation and diagnosis are essential (Marler et al., 2000; Powers et al., 2018). The initial assessment of a potential stroke patient involves an emergency physician's immediate stabilization of the patient's airway, breathing and circulation, quickly followed by a neurological examination (Powers et al., 2018; Boulanger et al., 2018). The CSBP and American Stroke Association recommend the National Institute of Health Stroke Scale (NIHSS) to determine focal neurological deficits to assess stroke severity (Boulanger et al., 2018; Powers et al., 2018). NIHSS has demonstrated its utility, accuracy, and reliability when performed rapidly by trained healthcare providers (Josephson et al., 2006; Lyden et al., 2009). The rapid assessment scores from these scales can provide important prognostic information, help quantify the degree of neurological deficit/stroke severity, help identify patients eligible for thrombolysis and/or

EVT, and identify those at higher risk for complications (Powers et al., 2018; Fonarow et al., 2012; Wahlgren, Ahmed, Eriksson, et al., 2008). The overall goal of the initial assessment is to stabilize the patient, exclude stroke mimics, and identify the stroke patient's severity (Boulanger et al., 2018).

2.3.2.3 Urgent Diagnostic Imaging

Other assessments must be undertaken, such as heart rate and rhythm, blood pressure, temperature, oxygen saturation, hydration status, and seizure activity, but it is essential to highlight that these tests should not delay imaging, treatment decisions and the initiation of thrombolysis and EVT (Boulanger et al., 2018). Brain imaging is necessary to reliably differentiate an ischemic infarct from a hemorrhage. Although CT scanning is expensive, Wardlaw and colleagues (2004) reported immediate CT scanning for acute stroke patients as the most cost-effective strategy. The cost-effectiveness was achieved by having a correct early diagnosis to ensure appropriate treatment decisions, leading to increased independent survival, which reduced the cost of stroke and increased quality-adjusted life years (Wardlaw et al., 2004).

A Non-contrast (NC) CT scan is the initial standard of imaging to identify an acute ischemic stroke. It is very reliable in excluding a hemorrhage, the main contraindication of thrombolysis (Boulanger et al., 2018; Wintermark et al., 2013). With an emphasis on fast DTNTs, thrombolysis decisions should be made immediately after the NCCT scan, and before other imaging techniques (Wintermark et al., 2013).

Along with the NC-CT scan, multiphase CT angiography (CTA) can be performed within the same imaging session (Wintermark et al., 2013). Obtaining a CTA can characterize the ischemic tissue and the occlusion site before deciding on EVT (Wintermark et al., 2013). Another advanced imaging technique is CT perfusion (CTP). CTP can determine the infarct core size and ischemic penumbra (Boulanger et al., 2018). However, CTPs can take time to interpret (Menon et al., 2015). Therefore, standardized software like RAPID AI, with trained technicians and protocols have efficiently changed CT Imaging.

Information gathered through imaging is critical for diagnosing a stroke patient and supporting appropriate treatment decisions. Therefore, it is crucial that PSCs can conduct an NC-CT scan to make decisions to treat using thrombolysis and a CTA to diagnose EVT eligibility. For patients outside of six hours, advanced imaging techniques (multiphase CTA or CT perfusion) are required. Menon and colleagues described how multiphase CTA is a quick and easy-to-use imaging tool that reduces uncertainty in clinical decision-making (Menon et al., 2015). In addition, CSBP recommends using "software that provides quantifiable measurements of ischemic core and penumbra" (Heran et al., 2022, p.50).

2.3.2.4 Contraindications

As discussed, any hemorrhage on imaging results is an absolute exclusion for thrombolysis. In addition, any source of active hemorrhage or a condition that increases the risk of major hemorrhage post thrombolysis is an absolute exclusion. While hemorrhage is an exclusion for EVT, certain scenarios that are remote from the LVO may not contraindicate.

Relative exclusion criteria requires "…clinical judgement based upon the specific situation" (Heran et al., 2022, p. 67). There are four categories of relative exclusion including historical, clinical, CT or MRI findings, and laboratory. The decision-makers will need to determine the patient's history and assess clinical symptoms to make a clinical judgment when using thrombolysis and EVT. History assessment includes a history of ICH, a stroke or serious head or spinal trauma in the past three months, major surgery in the preceding 14 days, and arterial puncture at a non-compressible site in the previous seven days (Heran et al., 2022). Clinical factors include stroke symptoms due to another acute neurological condition (seizure with post-ictal Todd's paralysis) or focal neurological signs due to severe hypoglycemia or hyperglycemia, refractory hypertension with a target blood pressure < 180/105, and prescribed and taking a direct non-vitamin K oral anticoagulant (Heran et al., 2022). Exclusion may occur if CT or MRI findings show early signs of extensive infarction (ASPECTS < 6) (Heran et al., 2022). Finally, decision makers must monitor laboratory results including blood glucose concentration < 2.7 mmol/L or > 22.2 mmol/L, Elevated activated partial-thromboplastin time, international normalized ration > 1.7, and platelet count < 100,000 per cubic millimetre (Heran et al., 2022).

Clinicians need the appropriate information to make an emergency treatment decision. Time from symptom onset, urgent imaging, patient history, and the patient's clinical symptoms will drive those decisions. Appropriate protocols and checklists may help with decision-making and increase the proportion of ischemic stroke patients receiving thrombolysis and/or EVT.

2.3.2.5 Antiplatelet Therapy

Antiplatelet therapy includes several drugs that work via different mechanisms to inhibit platelet adhesion and aggregation decreasing your body's ability to form a thrombus (Minhas et al., 2022). Antiplatelet therapy does not lyse a thrombus but are significantly effective for secondary prevention of stroke by inhibiting the extension of clots (Minhas et al., 2022). These drugs include aspirin (acetylsalicylic acid), thienopyridine derivatives (ticlopidine, clopidogrel), phosphodiesterase inhibitors (dipyridamole, cilostazol), and thromboxane A2 antagonists (ozagrel). CSBP recommends using aspirin (160 mg) immediately after imaging if imaging shows no ICH and the patient is ineligible for thrombolysis or EVT (Boulanger et al., 2018). Although the net benefit of aspirin is relatively small compared to thrombolysis and EVT, it is still effective at reducing patient death and dependency compared to placebo (OR=0.95, 95%

CI=0.91-0.99, p=0.008, 13/1000 treated avoid death or dependency) (Minhas et al., 2022). In addition, aspirin is inexpensive, easy and safe to administer (Minhas et al., 2022).

A Cochrane meta-analysis by Minhas and colleagues stated that starting antiplatelet therapy immediately after an ischemic stroke or TIA and continuing long-term treatment avoids about 36 vascular events for every 1000 patients treated (Minhas et al., 2022). CSBP recommends minor stroke or high-risk TIA patients begin dual antiplatelet therapy (300 mg-600 mg of clopidogrel and 160 mg of aspirin) for 21 to 30 days with a loading dose of 160 mg of aspirin after brain imaging has excluded hemorrhage (Boulanger et al., 2018). If patients receive thrombolysis, the initiation of antiplatelet therapy should be delayed until the 24-hour post-thrombolysis scan excludes ICH (Boulanger et al., 2018). If the patients are dysphagic, daily use of an enteral tube (80 mg of aspirin with 75 mg of clopidogrel) or a rectal suppository (325 mg daily of aspirin) are the recommended replacements (Boulanger et al., 2018).

A meta-analysis by Greengage and colleagues showed that dual antiplatelet therapy significantly reduces the risk of recurrent stroke (RR=0.67, 95% CI=0.49-0.93, p=0.02), 3.3% of stroke recurrence compared to 5.0% on mono-antiplatelet therapy (Geeganage et al., 2012). Wong and colleagues provided another meta-analysis that also demonstrated in the reduction of stroke recurrence with dual antiplatelet therapy compared to monotherapy (RR=0.69, 95% CI=0.60-0.80, p<0.001) (Wong et al., 2013).

The CSBP recommends short term Dual AntiPlatelet Therapy (DAPT) for secondary stroke prevention for patients not at a high bleeding risk (Heran et al., 2022). CSBP suggest two regimens with a loading dose of 162 mg of Aspirin followed by a daily dose of 81 mg with either clopidrel for 21 days (loading dose of 300-600 mg followed by 75 mg daily) or ticagrelor for 30 days (loading dose of 180 mg followed by 90 mg daily) (Heran et al., 2022). It is not recommended to use DAPT longer than prescribed due to an increased risk of bleeding, unless there is a specific indication (symptomatic intracranial artery stenosis) (Heran et al., 2022).

2.3.2.6 Acute Stroke Units

Following hyperacute therapy, substantial evidence supports that acute stroke patients should be admitted and consistently monitored in a designated stroke unit, which refers to an organized inpatient hospital unit dedicated to the management of stroke patients and staffed by a specialized, experienced interdisciplinary stroke team (Langhorne & Ramachandra, 2020; Stroke Unit Trialists' Collaboration, 2013; Boulanger et al., 2018). The core elements of a comprehensive stroke unit include dedicated stroke beds, a team with broad stroke expertise (neurology, nursing, neurosurgery, physiatry, rehabilitation, pharmacy, occupational therapy, physiotherapy, and speech language pathology), availability of 24/7 imaging and interventional neuroradiology, access to emergent neurovascular surgery, implementation of protocols for seamless management and transition of care (hyperacute care, acute care, pre-hospital, ED, inpatient care), dysphagia screening protocols, post-acute rehabilitation availability, early discharge planning after admission, daily/bi-weekly patient care rounds, patient and family education, provision of palliative care, ongoing professional development, and the involvement of clinical research (Boulanger et al., 2018).

CSBP recognized that it is difficult for hospitals to implement all the elements of a stroke unit, and hospitals should act to "… establish protocols and processes of care to implement as many elements as possible to achieve optimal stroke care delivery within their geographic location, hospital volumes and resource availability" (Boulanger et al., 2018, p. 81).

Over the past 30 years, the value of stroke units has been debated (Langhorne & Ramachandra, 2020). However, a Cochrane systematic review by the Stroke Unit Trailists'

Collaboration (2020) selected 29 RCTs comparing organised inpatient stroke unit care with an alternative service (typically conventional care. This trial reported that patients receiving organized stroke unit care were more likely to return home, regain independence and survive than an alternate service (Langhorne & Ramachandra, 2020). The summary results indicated a significant reduction in the odds of death or dependency (24 trials) on follow-up (median of 12 months) with stroke unit care (OR=0.75, 95% CI=0.66-0.85) compared to an alternate service (Langhorne & Ramachandra, 2020). In addition, three trials suggested sustained benefits among stroke unit patients with an extended follow-up of five and ten years.

Seenan and colleagues conducted a systematic review to determine the benefits of stroke unit care in clinical practice using 25 observational studies comparing stroke unit care to non-stroke unit care (Seenan et al., 2007). The primary outcome was death within one year of a stroke, and poor results (death, dependency, or institutional care) were also recorded (Seenan et al., 2007). It was reported that the observed benefit of stroke unit care was comparable to clinical trials, where the results showed a significant reduction in the odds of death at one year (OR=0.79, 95% CI=0.73-0.86, $p<0.00001$) and poor functional outcomes (OR=0.87, 95% CI=0.80-0.95, $p=0.002$) (Seenan et al., 2007).

2.4 Best Practice

"The Canadian Stroke Best Practice Recommendations present high-quality, evidence-based stroke guidelines in a standardized framework to support healthcare administrators and professionals across all disciplines" (Boulanger et al., 2018, p.9). The recommendations target health professionals within the health system caring for those affected by stroke (Boulanger et al., 2018). The CSBP has a rigorous, twelve-step methodology before updating recommendations (Boulanger et al., 2018). CSBP debates the value of the evidence and those values are presented as levels in Table 2.2, ranging from A-C and an additional category for clinical considerations (Boulanger et al., 2018). By implementing these recommendations, NL can reduce the variations in practice and close the gap between evidence and practice. As a result, I am researching how the recommendations are applied in Eastern Health, NL and three other regions across Canada, intending to improve stroke care in NL and provide policy recommendations.

Table 2.2: CSBP Levels of Evidence Summary

Levels of Evidence	Criteria
A	Evidence from a meta-analysis of RCTs or consistent findings from two or more RCTs. Desirable Effects clearly outweigh undesirable effects or vice versa
B	Evidence from a single RCT or consistent findings from two or more well-designed non-controlled trials, and large observational studies. Meta analysis of non-randomized and/or observational studies. Desirable effects outweigh or are closely balanced with undesirable effects or vice versa
C	Writing group consensus on topics supported by limited research evidence. Desirable effects outweigh or are closely balanced with undesirable effects or vice versa, as determined by writing group consensus.
Clinical Considerations	Reasonable practical advice provided by consensus of the writing group on specific clinical issues that are common and/or controversial and lack research evidence to guide practice.

(Boulanger et al., 2018, p. 10)

2.5 Change Management

To provide policy recommendations to assist the newly formed NL Health Services, change management strategies need to be understood and applied. Stroke care has been rapidly evolving, and change is expected. Managers and decision-makers are in a challenging position to adopt new processes and technology and must implement quality initiatives to improve their programs and assist their healthcare providers (R. J. Campbell, 2020). There are emotional and situational components for policy change, and Kotter’s change management model is expressed through three phases: 1) Create a climate for change, 2) engage and enable the program, and 3) implement and sustain change (R. J. Campbell, 2020). First, leaders must create a compelling argument to instill a feeling of action that will drive change while presenting facts to bolster their argument (R. J. Campbell, 2020).

For stroke care, data collection and analysis provide a significant opportunity to identify areas of improvement. Hyperacute stroke literature emphasizes interventions to reduce the time to present at a hospital and the efficiency within a hospital (LaBresh, 2006). To establish system change, a stroke program must have a continuous quality improvement (QI) model (LaBresh 2006). A model refined for healthcare applications asked three questions: 1) What are we trying to accomplish? 2) How will we know that change resulted in improvement? 3) What change will result in improvement? (LaBresh, 2006). To answer these questions and create a continuous QI model, a stroke program must establish a multidisciplinary team with leaders (clinical, system, day-to-day) to define their goals (LaBresh, 2006). After defining and testing policy change, implementation requires widespread communication, support and continuous monitoring through data collection of key performance measures (adapted as needed) (LaBresh, 2006). Stroke is in a fortunate position having clear answers. Stroke care is trying to improve survival and independence after stroke, these outcomes are measurable. The literature has provided evidence on what to change (increasing ischemic stroke patient access to thrombolysis, EVT, and improving the process metrics) to achieve these outcomes.

Everett Rogers provided five criteria to predict a successful adoption of policy change (Rogers, 1995). First, did the policy change demonstrate a relative advantage? Was it overly complex? Were there observable advantages? Is there trialability? Is it compatible? (Rogers, 1995). Relative advantage implies the new policy performs better than the old policy. In addition, having observable outcomes to show higher performance levels that are achievable bestows confidence in other hospitals attempting to change the same processes, especially within the same region. Finally, trialability and compatibility work together to test system change and identify the adaptability of the new policy to a specific hospital's environment and culture (Rogers, 1995).

Change management strategies need communication with the necessary stakeholders and engagement with clinical leaders and professional teams (Hamilton et al., 2007). Effective leadership works across organizational boundaries to create an effective team, vital to facilitate change (Hamilton et al., 2007). As stroke programs commit to evidence-based medicine, a multidisciplinary working group must focus on education/outreach (Hamilton et al., 2007).

For a system-wide change, multiple organizations and care providers are affected (Turner et al., 2016). Therefore, "… system leadership with authority is necessary to align multiple organizations across a large scale" (Turner et al., 2016. P. 163). Assisting the system leader are the distributed stroke physicians and other key stakeholders interested in the policy change (Turner et al., 2016). While planning, a wide range of stakeholders should be included to cover "… clinical, financial, logistical and public interest considerations" (Turner et al., 2016, p.163). By having a wide range of local stakeholders, planning ensures the policy is relevant and motivates the group, while public and patient involvement, can create support to help develop the recommended proposal (Turner et al., 2016). Finally, many health systems are under financial pressure and must prioritize cost effectiveness over others (Turner et al., 2016).

2.6 Thesis Relevance

As ischemic stroke care evolves, there is still investigation and research needed to identify how NL can provide best practice. Therefore, this study identified inefficiencies in Eastern Health's (EH) stroke system and, through the information gathered, provided policy recommendations to improve hyperacute stroke care. Using knowledge supported by the literature, this study collected comparable stroke outcomes from EH and three other Canadian regions and conducted multiple case studies to create a holistic view on how each region conducts hyperacute care, the barriers each region faces, and the factors contributing to successful care. This study identified barriers and enablers of successful hyperacute treatment in adult patients with ischemic stroke and then provides policy recommendations for the newly formed NL Health Services to aid hyperacute stroke care. In addition, this study provides Canadian stroke centres a resource to identify how other regions care for their ischemic stroke patients. From the results, I developed three policy recommendations for the NL Health Services to further improve their stroke care. These recommendations include a provincial stroke program encompassing the whole province with an emphasis on Primary Stroke Centres (PSC) and transport functions, a full-time Endovascular Therapy (EVT) service to care for all eligible patients in NL, and a considerable focus on continuous quality improvement (QI) supported by electronic medical records.

Chapter 3 – Research Methods

This study used a mixed methods approach using quantitative and qualitative methods. The quantitative research presents two-time series analyses: (1) de-identified individual data on stroke care in Eastern Health (EH) Newfoundland and Labrador (NL), analyzed by hospital from fiscal year (FY) 2012/2013 to FY 2020/2021 with the evaluation of stroke care indicators, including thrombolysis rates; (2) Aggregate de-identified data from the Canadian Institute for Health Information (CIHI) for three other health regions within Canada (Central zone Nova Scotia (NS), Southeastern Ontario (SEO), and Alberta health's Calgary zone) for the FY 2016/2017 to 2020/2021. This retrospective stroke data was used to compare important stroke care indicators and CSBP targets over time between stroke centres in each region.

I choose to examine stroke care delivery in Calgary because it is a national leader in stroke; SEO because it is a city reasonably close in population size to urban St. John's.; and NS because it has an urban rural divide somewhat similar to NL. In addition, stroke professionals from SEO and NS came to the health sciences center to present on hyper acute stroke best practices. This provided a chance to make contact.

In the qualitative section I used replication logic to conduct four explanatory case studies. The cases were designed to investigate hyperacute ischemic stroke care in the four Canadian health regions (EH, Central Health NS, SEO, and Calgary Zone Alberta) to provide a holistic view of hyperacute stroke care around each region's Comprehensive Stroke Centre (CSC) and peripheral Primary Stroke Centres (PSC). Using literal replication, the case studies recorded semi-structured interviews. Using a purposeful sample, stroke professionals within the stroke care pathway were selected as interviewees. Along with the interview data, documentary and archival documents were requested for further understanding and provide data triangulation. The intention was to understand what professionals believe are critical success factors to optimize efficient hyperacute ischemic stroke care, how to achieve success, barriers and enablers affecting the care process, how to overcome specific barriers, and how to establish EVT. In addition, each case has an embedded case study design, as hyperacute stroke care has many integrated steps. Finally, using cross-case synthesis, I compared the hyperacute stroke care of EH with the three other Canadian regions using matrices to understand whether EH provides the same efficiency processes, faces similar barriers, conducts similar quality initiatives, and has similar future directions.

3.1 Ethics Approval

To begin this mixed methods approach, I needed to complete two separate research proposals for Newfoundland and Labrador's (NL) Health Research Ethics Board (HREB) to review health research involving human subjects that is being conducted in NL. In addition, ethical proposals had to be submitted to the Eastern Health (EH) Research Proposals Approval Committee (RPAC) to review and grant access to EH resources.

The time series analysis study applied for HREB approval using HREB Secondary Use/Chart Audit Application to analyze individual de-identified stroke patient data from CIHI special stroke project 340. After approval, this application underwent three separate amendments: 1) the sample size of the data base went from 6186 to 7531, 2) Include the request of aggregate stroke data from CIHI for stroke hospitals within Central Zone Nova Scotia, Southeastern Ontario, and Calgary Zone Alberta and the addition of Discharge Abstract Databases (DADs) for additional stroke outcome variables, and 3) Include variables from CIHI special stroke project 440, 640, and 740. Appendix II presents the HREB ethical approval letter and Appendix III presents the RPAC ethical approval Letter.

For the case studies application, I applied for HREB approval using HREB Application for General Research (Certification/Human Ethics) to record and interview stroke professionals, request documentary and archival evidence, and submit a questionnaire to Emergency Medical Services (EMS). In addition, this request required a consent form for all interviewees to sign.

After approval, this study applied for two amendments, 1) The removal of the EMS questionnaire, to include EMS professionals in my interview sample, change in the consent form to increase the interview length, and the inclusion of documentary and archival evidence to support the results of the interviews, 2) After analyzing the interview data, it was apparent that follow up questions/interviews were required to achieve data saturation. Therefore, this amendment included follow up interviews. Also, the sample size was increased as the original application had a sample of six to eight participants. The second amendment required an updated consent form including the follow-up information, and a consent addendum for follow-up participants who signed the original consent form. Appendix IV presents the HREB ethical approval letter, Appendix V presents the RPAC approval letter, Appendix VI presents the consent form, and Appendix VII presents the Consent Addendum.

3.2 Research Paradigms

Knowledge of a researcher's ontological and epistemological beliefs will help better understand the importance and relevance of the study (Abdul Rehman & Alharthi, 2016). With a mixed methods approach, each study has its own paradigm, including ontology (the nature of reality), epistemology (the nature of knowledge), methodology, and methods (Crotty, 1998; Al-

Ababneh, 2020). The results from each study are presented individually. Both approaches will aim to collect complementary data, allowing the researcher to gather a more comprehensive and robust array of evidence (Yin, 2014). As my two methods had different paradigms, I used a paradigm of pragmatism in my discussion to provide the best policies to improve hyperacute ischemic stroke care in NL. A paradigm of pragmatism was the best method to solve problems and states that reality is constantly renegotiated, debated, and interpreted (Yvonne Feilzer, 2010). Greene described mixing paradigms for mixed methods research. This approach aims to deepen our understanding of the phenomena and generate fruitful interactions (Greene, 2007).

The quantitative time series study has a research paradigm of post-positivism in which "… positivism assumes reality exists independently of humans... not mediated by our senses and is governed by immutable laws" (Abdul Rehman & Alharthi, 2016, p. 53). Post-positivism has an ontological position of critical realism, which "assumes a reality exists independent of the observer, but which can only be represented imperfectly because of the complexity of the social phenomenon; it also recognizes the possibility of the researcher's own beliefs and values affecting what is being observed" (Abdul Rehman & Alharthi, 2016, p.53). In addition, paradigm had an epistemological position of objectivism to keep the researcher focused on observable data that can provide credible facts (Al-Ababneh, 2020). Using large samples, the researcher reduces the data to its simplest element, aiming to generalize the results and discover associations between variables (Al-Ababneh, 2020).

Since 2009, the Canadian Institute for Health Information (CIHI) have been collecting key indicators on stroke care through the Special stroke project series (340, 440, 640, and 740). In conjunction with stroke patient Discharge Abstract Databases (DADs), data were used to examine actual practice ischemic stroke indicators (thrombolysis rates) relative to CSBP recommendations, and to compare those indicators between hospital sites. This study assumes the data collected hold objective truths that are generalizable and replicable. However, there are limits to capturing it perfectly. Different settings, populations, and geography may influence the quality of data collection. The use of secondary data, and the time series methodology make it impossible to address cause and effect and can examine only associations.

The qualitative multiple case studies are a descriptive method to understand and compare hyperacute stroke care within four Canadian health regions. I used a naturalistic paradigm, where research is focused on how people behave in their natural setting (Given, 2008). The overall goal is to "… understand the social phenomenon in their context" (Abdul Rehman & Alharthi, 2016, p.56). Al-Ababneh described the social world as too complex to follow law-like generalizations due to the changing state of organizations and individual interpretations (Al-Ababneh, 2020). Therefore, this philosophy developed knowledge using a descriptive method to deal with complicated situations (Al-Ababneh, 2020). Guba and Lincoln believed the appropriate epistemological position for qualitative research was constructivism, where our understanding of reality is a social construction, not an objective truth, and that there exist multiple realities associated with different groups and perspectives (Guba & Lincoln, 1994; Soini et al., 2011).

It is not possible to achieve pure objectivity as Grix described how researchers are not detached, but are part of the social reality (Grix, 2004). This addresses reflexivity, as the researcher also influences the co-creation of knowledge. Through my literature review, I understood the importance of how quality stroke care can significantly improve the quality of life for stroke victims. Therefore, I have been motivated to discover how to improve stroke care in NL. Throughout these cases, I interacted with each health region and stroke program to identify areas NL stroke care could improve.

These case studies sought to understand how different areas across Canada provide hyperacute stroke care, how they achieved specific steps and milestones, barriers they have faced and are currently facing, and the keys to success. Applying a naturalistic paradigm, stroke care was examined and described throughout the four health regions using the point of view of stroke care professionals and provided documents. Through these case studies, the barriers and enablers in other sites were identified, and consideration was given to how they might relate to success.

A realist perspective, in dialogue with a constructivist, can be of value for qualitative researchers (Soini et al., 2011). My mixed methods approach combined my quantitative study's objectivist position (critical realism) with the constructivist position of my qualitative study.The objective of these studies were to combine the realities derived from the quantitative study with the descriptions of the qualitative studies to assist in policies to improve the delivery of hyperacute stroke care in NL.

3.3 Research Approach

I employed a time series analysis to identify improvement over time and collect stroke care indicator to compare with Central Zone Nova Scotia (NS), Southeastern Ontario (SEO) and Calgary Alberta. In addition, I conducted multiple case studies to describe how various health regions attend to hyper acute ischemic stroke care. I choose Calgary because they were a national leader in stroke; SEO because it is a city reasonably close in population size to urban St. John's.; and NS because it has an urban rural divide somewhat similar to NL.

First, serial retrospective cohorts were evaluated over time in a time series approach. In EH, the cohorts were determined by the availability of individual de-identified patient data collected from a federal stroke outcome study (special stroke project series) and stroke patient Discharge

Abstract Databases (DADs). Similar cohorts provided aggregate de-identified data from CIHI for three other regions within Canada (Central zone NS, SEO, and Calgary zone Alberta). Small cells (less than five) have been suppressed to facilitate de-identification. This study provided hyperacute stroke care outcomes to identify if EH improved over time and were comparable to the three other health regions. I used a repeated measure t-test to analyze change over time. In addition, when comparing proportion outcomes of EH with the other health regions, I used a Pearson chi-test. When comparing median outcomes, I used the median test.

Then I conducted multiple case studies. A case study can be defined as a research approach that explores an event or phenomenon in depth and in its natural context, often referred to as a naturalistic design (Crowe et al., 2011). In general, case studies can discover exploratory "what" questions and investigate "how" or "why/why not" questions (Yin, 2014). I conducted multiple case studies designed to investigate hyperacute ischemic stroke care within four Canadian health regions to provide a holistic view of hyperacute stroke care around each region's CSC and peripheral PSCs. The intention was to understand what professionals believed were critical success factors to optimize efficient hyperacute ischemic stroke care, how to achieve success, barriers and enablers affecting the care process, how to overcome specific barriers, and how to establish EVT. The case studies used an inductive approach, "…for analyzing qualitative data in which the analysis is likely to be guided by specific evaluation objectives" (Thomas, 2006, p.238). Without the restraints of structured methodologies, I used the inductive approach to analyze the raw data to identify concepts and significant themes (Thomas, 2006).

By using various health authorities, these cases provided data to contribute to recommendations for EH and NL aimed to improve hyperacute ischemic stroke care. Using multiple cases is often more compelling, and the overall study is more robust (Yin, 2014). Unlike sampling logic, the multiple case designs used replication logic, analogous to that used in multiple experiments (Yin, 2014). Literal replication predicts similar results and theoretical replication predicts contrasting results for anticipated reasons (Yin, 2014). For this study, literal replication logic was chosen and has helped bolster the analytic generalization in the form of lessons learned (Yin, 2014). The boundaries associated with each case included the onset of stroke signs and symptoms to rapid treatment and early monitoring of the stroke patient. Each case had an embedded case study design based around the hyperacute stroke care pathway investigating public awareness, pre-hospital care, emergency hospital care, endovascular therapy, and stroke care units. Along with the care pathway, I investigated quality improvement initiatives, non-clinical factors that contribute to success and barriers affecting care processes.

3.4 Data Collection

3.4.1 Quantitative

The Heart and Stroke (H&S) Foundation has worked with the Canadian Institute for Health Information (CIHI) to create a special project for stroke patients called "Project 340". Acute care facilities in all provinces and territories that provide care to acute stroke patients were invited to participate in the stroke project. Along with Project 340, adult stroke patient data was reported to other special stroke project series (440, 640, and 740), and Discharge Abstract Databases (DAD) were used to provide more depth and essential variable information. Unfortunately, the data quality I received from project 640 and 740 was low due to missing and non-reportable cells, and only one site reported to project 440 was Kingston Health Science Centre of SEO. Therefore, I removed those variables from my analysis.

In a joint effort between H&S and CIHI, the Stroke Special Projects enable the capture of essential process and outcome information based on the H&S Foundation Canadian Stroke Best Practice (CSBP) Recommendations and support stroke surveillance, quality improvement, benchmarking, and Accreditation Canada's Stroke Distinction Program (Gould et al., 2017). In addition, patients admitted from their Emergency Department (ED) to an acute care facility will have information entered the DAD. In cases where a patient is transferred to another facility for the same continuous care, only the final receiving ED facility should complete the project. Finally, stroke populations were retrospective samples of adult stroke hospitalization.

Special Project 340: Canadian Stroke Strategy Performance Improvement began in 2009, Project 340 is an optional Canada-wide collection of clinically significant stroke care indicators that can be used to prepare annual stroke report cards to monitor hospital and regional care (Canadian Institute for Health Information, 2018b).

Core review elements collected in Project 340 include:

1. CT Scan / MRI within 24 hours
2. Admission to a Stroke Unit
3. Administration of Acute thrombolysis
4. Date and Time of Acute thrombolysis administration
5. Antithrombotic Medication prescribed at Discharge.
6. Date and Time of Stroke Onset

Special Project 640: Canadian Stroke Strategy Performance Improvement II Began in 2015, additional stroke best practices emerged to be captured and connected to the Special Project 340 cohort and in line with the reporting requirements for Stroke Distinction awarded by Accreditation Canada (Canadian Institute for Health Information, 2018c).

Special Project 740: Alpha FIM**:** The AlphaFim instrument (FIM = Functional Independence Measure) is a standardized method of assessing a patient's functional status in acute care to quantify the functional impact of stroke (Ontario Stroke Network, 2014).

Special Project 440: Endovascular Thrombectomy Project 440 collects additional data on patients who undergo endovascular thrombectomy for LVOs causing acute ischemia (Canadian Institute for Health Information, 2018a).

Part 1: Eastern Health Time Series

De-identified data on stroke care in Eastern Health NL was analyzed by hospital from fiscal year (FY) 2012/2013 to FY 2020/2021 with an evaluation of stroke care indicators, including thrombolysis rates. The inclusion criteria were: Stroke patients (18 years and older) admitted from FY 2012/2013 – 2020/2021. De-identified stroke patient data for EH was uploaded to SPSS, and the stroke care key indicators analyzed are presented in table 3.1.

Table 3.1: Stroke Care Indicators

1. Number of Stroke Hospitalizations
2. Stroke Type
3. Total Hospital Length of Stay (TLOS), Acute Days Length of Stay (-ALC days), Alternate Level of Care Length of Stay (ALC-LOS), Expected Length of Stay (ELOS)
4. 7-day in-hospital all cause of death, 30-day in-hospital all cause of death
5. CT Scan/MRI Scan within 24 hours of ED Arrival
6. Referral to stroke prevention service at ED Discharge
7. Administration of acute thrombolytic therapy (rt-PA)
8. Prescription of antithrombotics at discharge
9. Discharge Locations/Discharge Disposition
10. Mode of arrival
11. Dysphagia screening
12. Alpha-Fim Test/Modified Rankin Scale at discharge
13. Telestroke consultation

Data on baseline characteristics, interventions undertaken, and clinical outcomes was recorded by health record clerks into DADs. Discharge disposition (patients discharge location) comprised of multiple outcomes presented in Table 3.2. Patient characteristics collected include age, gender, presence of diabetes, hypertension, symptomatic coronary artery disease, cardiac failure, chronic kidney disease, and prior stroke.

Table 3.2 Discharge Disposition Outcomes

Died, expired • Died in facility • Died while on pass/leave
Discharged home (no support service required)
Discharged to home or a home setting with support services
Transferred to an ACUTE care inpatient institution
Transferred to CONTINUING care (facility provides supervisory care by medical or allied staff)
Transferred to another hospital for inpatient care, including specialty hospitals
Transfer to reporting or another facility for ED, day surgery or ambulatory care
Transferred to Long Term Care home (24-hour nursing)
Transferred to assisted living/supportive housing or transitional housing, including shelters (these settings do not have 24-hour nursing care)
Transferred to OTHER care (incl Ambulatory, palliative, jails etc.)
Left against medical advice (with or without signout, AWOL, LAMA)
Other

Part 2: Stroke Care in Three Canadian Stroke Regions

Indicators in EH were compared to Central Zone NS, SEO, and Alberta Health's Calgary zone. For these three regions, CIHI provided de-identified aggregate stroke data covering five years (FY 2016/2017 – FY 2020/2021). In addition to the variables requested for EH, aggregate project 440 data on EVT was requested from CIHI for the 3 regions outside of NL. EH just began this treatment on June 20th, 2022. I requested stroke data for large hospital list from CIHI, but only a few centres treat stroke patients.

3.4.2 Multiple Case Studies

The four case studies used literal replication by conducting semi-structured interviews and collecting stroke care documents to further understand each region's protocols, goals, and outcomes. As the researcher, I used a semi structured interview script, presented in Appendix VIII, and recorded each interview for transcription and analysis. Each case used a purposeful sample to include personnel involved in the critical steps of the stroke care pathway as they were able to provide appropriate information to answer the research questions. The personnel include stroke care leaders, emergency medical services, neurologists, emergency physicians, radiologists, intervention neuroradiologists, anesthesiologists, stroke program coordinators, decision-makers, registered nurses, and CT technologists. As a PhD candidate, my experience in quantitative research was low. Therefore, I requested follow-up interviews for specific participants for further investigation to achieve data saturation.

The stroke care professionals in NL helped coordinate first contact at Halifax, Kingston, and Calgary. Once identified, emails were sent with a brief description of the study, the researcher, and a request to participate. If they were interested, an available date was requested with a consent form and interview script. The interview script allowed the participant to look at the topics of interest and determine the areas to which they could contribute. Next, the researcher scheduled a recorded audio interview via Zoom or phone. As the recording device captures most of the information, I could jot down notes and highlight areas of interest to investigate. Once completed, the audio recordings were transcribed and analyzed. This procedure continued until the needs of the inquiry were satisfied (Yin, 2014).

Table 3.3 presents information about the total interviews, occupations interviewed, start date, and if there was a follow-up for each case. The SEO stroke program and Calgary stroke program became very busy due to accreditation Canada's Stroke Distinction evaluation. Therefore, the total interviewees were lower in both regions compared to EH and NS. However, the contacts I had made, were available to provide any requested information. In addition, some personnel and occupations did not respond to my inquiries. Upon follow up, SEO requested I not reach out to front line workers due to staffing strains and re-applying for stroke distinction.

Table 3.3 Case Characteristics

Case	Total Interviewees	Occupations	Start Date	Follow-up
Eastern Health Newfoundland and Labrador	13	Neurology, emergency physician, PSC physician, director of paramedicine, division manager, radiology, charge nurse, program manager, director, and a VP	Began 02/05/2020	03/01/2023 – 03/28/2023
Central Health Nova Scotia	11	Neurologist, health care optimization, ACP, paramedicine manager, registered nurse, stroke coordinator, research coordinator, emergency physician, CT technologist, anesthesiologist, clinical lead	10/23/2021 – 02/09/2022	NA
Southeastern Ontario	6	Neurologist, director, interventional radiologist, registered nurse, best practices coordinator, general surgeon, critical care specialist	Began 10/14/2020	10/07/2022 – 01/23/2023
Calgary Zone Alberta	6	Neurologist, director, emergency physician, charge nurse, unit manager, program manager, special projects lead	Began 10/26/2020	12/14/2022 – 04/06/2023

The semi-structured interview kept track of the topics of interest and helped guide the conversation. There was a consistent line of inquiry, but the conversation avoided rigid questioning to promote a fluid conversation (Yin, 2014). As hyperacute stroke care is multidisciplinary, some topics of interest were inappropriate for certain professionals as they were not involved in that area of care. Therefore, with the understanding of the stroke pathway and communication with the interviewee, the appropriate areas of interest were targeted.

The boundaries associated with each case included the onset of stroke signs and symptoms to the rapid treatment and monitoring of stroke patients. There were two phases established was the Pre-Hospital Phase (onset of stroke symptoms to ED) and Emergency Department Phase (arrival, treatment, and patient monitoring. In addition to processes in these phases, I investigated barriers, enablers, and quality improvement initiatives.

The stroke care professionals in NL helped coordinate first contact at Halifax, Kingston, and Calgary. All communications were beneficial and provided contact with the appropriate personnel. Once identified, emails were sent with a brief description of the study, the researcher, and a request to participate. If they were interested, an available date was requested with a consent form and interview script. The interview script allowed the participant to look at the topics of interest and determine the areas to which they could contribute. Next, the researcher scheduled a recorded audio interview via Zoom or phone. As the recording device captures most of the information, I could jot down notes and highlight areas of interest to investigate. Once completed, the audio recordings were transcribed and analyzed. This procedure continued until the needs of the inquiry were satisfied (Yin, 2014).

A significant strength of a case study is the opportunity to use various sources of data. "Various sources of evidence are highly complementary, and a good case study will therefore rely on as many sources as possible" (Yin, 2014, p.105). The objective of using multiple sources of evidence is triangulation – "the development of converging lines of inquiry" (Yin, 2014, p.120). Triangulation helps provide more accurate and convincing findings and conclusions (Yin, 2014). Along with Yin, Carter describes 4 sources of triangulation: Data triangulation, Investigator triangulation, Theory triangulation, and Methodological triangulation (Yin, 2014; Carter et al., 2014). Data triangulation describes uses multiple sources of evidence. Along with collecting interviews that can provide various perspectives and conclusions (Carter et al., 2014), this study examined documentation and archival records to help triangulate the research findings. These records included protocols, guidelines, chart reviews, checklists, outcome reports, meeting minute reports, quality assurance reports, and significant decision reports. The case studies used data triangulation to support the credibility of the findings and interpretations.

A case study database was created for each region to organize and document the raw data collected from the case studies and to maintain the chain of evidence to allow an external reader to examine the origin of the evidence (Yin, 2014).

3.5 Data Analysis

3.5.1 Quantitative

The individual patient database from EH was transferred into the IBM SPSS Statistics (Version 27) predictive analytics software. From there, all the variables (non-continuous) were transformed into categorical variables. These variables were changed using the different variable method in SPSS. The data were analyzed once the variables were transformed. The descriptive characteristics between the exposure categories (Hospital site) were analyzed to see if there were any statistically significant differences between the groups. Categorical variables were analyzed using cross tabs to show counts and percentages. Continuous numeric variables were analyzed using medians with interquartile ranges. For the three other regions, aggregate patient data were similarly analyzed. If an outcome reported less than five counts, the cell was suppressed.

The Pearson chi-squared test was used to evaluate the likelihood that any observed differences happened because of chance. If the Pearson chi-squared test was $p < 0.05$, then it is fair to reject chance as the reason for any differences and that the variables in the cross tabulation are associates. The Pearson chi-squared test was used to compare 2020/2021 outcomes between HSC with the CSC of the other regions, HSC with EH's combined PSC population, and EH's combined PSC population against each combined PSC population of the other regions.

The time series analysis compared fiscal years (FY) to identify the improvement of variables within hospitals within EH. Linear regression was used to model the effect a change in a year can have on a specific continuous dependent outcome using linear relationship. To analyze the significance of the linear model, the ANOVA test was used. If the ANOVA test produced $p <.05$, the linear regression had a significant relationship.

3.5.2 Case Studies

The multiple case studies are a descriptive method to understand and compare hyperacute stroke care within four Canadian health regions. These case studies sought to understand how different areas across Canada provide hyperacute stroke care, how they achieved specific steps and milestones, barriers they have faced and are currently facing, and the keys to success. Through these case studies, the barriers and enablers in other sites were identified, and consideration was given to how they might relate to success. I used a cross-case synthesis, where each case study was analyzed separately as an individual case. Then the findings were aggregated, and I began pattern matching to discover cross-case similarities, differences, and conclusions. The cross-case synthesis can tell the collective story to identify recommendations to improve the hyperacute stroke care of NL. The analytical strategy of the case studies was to identify themes from the data reflecting the study's research questions, objectives, design, and reviewed literature (Yin, 2014). I attempted to adhere to the following principles: attend to all the evidence, address all plausible rival interpretations, focus on the most important/significant issues, and use prior knowledge (Yin, 2014).

To describe the hyperacute stroke care within each health region, I used a thematic analysis, "… a method for systematically identifying, organizing and offering insight into patterns of meaning (themes) across a data set" (Braun & Clarke, 2012, p.57). Thematic analysis has the flexibility to allow the researcher to focus on the data in numerous ways and to make sense of the data and experiences by identifying commonalities related to the research question(s) being explored (Braun & Clarke, 2012). The interview script, my line of questioning, and my knowledge of the stroke care pathway helped identify the themes within each case. Themes within the data were manually generated using the five phases of Braun and Clarke (2012) thematic analysis presented in Table 3.3. As the researcher, I went through every transcript with the code-recode strategy to identify codes. I manually color-coded codes to link them to an area of care, then I develop themes using those codes. The stroke care pathway already had broken down section of care/themes. Within these sections of care, I developed descriptive themes of how these health regions provided care. In addition, I provided descriptive themes of their barriers, enables and quality improvement initiatives. Throughout chapter 5 and 6, I presented numerous quotes from the participants. Appendix IX presents my descriptive themes with associated codes

Each case followed the stroke care pathway including Pre-hospital, Emergency Medical Services, Emergency Department, and Endovascular Therapy. Chapter 5 describes the commonalities and differences in EH's stroke care pathway compared to the other health regions.

In addition, chapter 6 describes barriers, enablers, and quality improvement initiatives those regions experienced. Using cross-case synthesis, I compared the hyperacute stroke care of EH with the three other Canadian regions. I used matrices to understand whether EH provided the same efficiency processes, faced similar barriers, reported similar enabler, and conducts similar quality initiatives.

Table 3.3: Braun and Clarke's Five Phases of Thematic Analysis

1. Familiarization with the data – reading transcripts/documents and highlighting/making notes on the topics of interest (Braun & Clarke, 2012) and organizing the data in a way that is easy to look at and analyze (O'Connor & Gibson, 2003).
2. Generating initial Codes from a systematic analysis of the data. Codes were the building blocks of the thematic analysis (Braun & Clarke, 2012), and each code was linked with the marked text and participant. In addition, some codes were quotes contributing to a specific theme.
3. Searching for Themes – to "… capture something important about the data in relation to the research question and represents some level of patterned response or meaning within the data set" (Braun & Clarke, 2012, p.63). This attempt to determine concepts or issues that cut across themes provided a unifying framework for telling a coherent story about the overall data. By the end of phase three, a thematic map was provided to outline the proposed themes and the relevant data associated with those themes. In reviewing potential themes, the following key questions were asked that were recommended by Braun and Clarke: • Is this a theme or another code? • If this is a theme, what is the quality of this theme? • What are the boundaries for this theme? • Is there enough support for this to be a theme? • Does this theme lack coherence?
4. Revise themes by finding themes that do not fit the codes (Braun & Clarke, 2012). This included a final re-read of the raw data to check if the thematic map and proposed themes captured the entire data set concerning the propositions (Braun & Clarke, 2012)
5. Defining and Naming Themes – "This phase involved the deep analytic work involved in thematic analysis, the crucial shaping of the analysis into its fine-grained detail …" to provide a coherent overall story about the data and the overarching patterns related to the research questions (Braun & Clarke, 2012, p.67).

In the Discussion, these findings were used in conjunction with the quantitative results to provide policy recommendations for hyperacute stroke care in NL. From the results, I developed three policy recommendations for the NL Health Services to further improve their stroke care. These recommendations include a provincial stroke program encompassing the whole province with an emphasis on Primary Stroke Centres (PSC) and transport functions, a full-time Endovascular Therapy (EVT) service to care for all eligible patients in NL, and a considerable focus on continuous quality improvement (QI) supported by electronic medical records.

3.6 Reliability and Validity

The project 340 database is asking the same reliable questions; however, the consistency of the respondent may vary. For validity, Project 340 was not randomized and will be difficult to claim high internal validity or causation. In addition, this study is focused on improving hyper acute stroke care in Newfoundland and Labrador (NL) and will be difficult to have high external validity. However, this is a national database that will allow for repeatability of this study for other locations within Canada.

3.7 Trustworthiness

Trustworthiness has four key components – credibility, transferability, dependability, and confirmability. Credibility refers to the confidence that can be placed in the research findings of the case studies (Anney, 2014). To improve credibility, triangulation uses multiple sources such as the interview data and documentary evidence to help triangulate the research question, and peer examinations can help test the growing insights. Transferability refers to the generalizability of the cases (Anney, 2014). This study is directed to NL and may be difficult to generalize to other populations. However, smaller cities and emerging stroke centres may benefit from the information provided from this research. In addition, the use of a thick description (how well the research context fits other contexts) and a purposive sample (to find greater in-depth findings) can facilitate transferability (Anney, 2014). Dependability refers to the stability of the findings over time (Anney, 2014). There are also some analysis strategies that have been shown to help with dependability, such as code-recode strategy (researcher coding the same data twice with 1-2 week gestation between each coding), and Peer examination (share findings with researchers with experience in qualitative research to contribute to a deeper reflexive analysis) (Anney, 2014). Confirmability refers to the results of an inquiry being confirmed or corroborated by other researchers (Anney, 2014). I have used triangulation to bolster my confirmability.

3.8 Reflexivity

I conducted an inductive (bottom-up) approach, but "… it is impossible to be purely inductive, as we always bring something to the data when we analyze it" – reflexivity (Braun & Clarke, 2012, p.59). Reflexivity is an "… explicit, self-aware reflection and analysis towards increasing richness and integrity of understanding" (Finlay, 2012, p.317). To assure awareness of personal effects on the research and methodological concerns, reflective notes were recorded with their impact on data interpretation analyzed. There are five lenses that a researcher can use to evaluate their collected data presented in Table: 3.4 (Finlay, 2012).

Table 3.4: Finlay's Five Lenses of Reflexivity (Finlay, 2012)

Strategic Reflexivity	Monitoring the strategic decisions made during the research process, while collecting and analysing data
Contextual-discursive Reflexivity	Considers the social context and world of shared meanings of the collected data, acknowledging its co-creation
Embodied Reflexivity	Refers to body language and non-verbal communication of the interview that may provide significant implicit meaning
Relational Reflexivity	The process of interviewing is engaging, not unbiased or neutral, and these interview relationships need attention
Ethical Reflexivity	As researchers, we must ethically conduct our research to protect the participants

As the researcher, I acknowledge my part in each case study. I understood that I could not separate myself from the creation of knowledge. Throughout these cases, I was interacting with each health region and stroke program to identify areas NL stroke care could improve. To increase the richness and understanding of my results, I used Finlay's five lenses of reflexivity. I employed strategic reflexivity when I recorded and monitored the strategic decisions and the changes made to my thesis. While working with my supervisor committee, there were multiple recommendations to develop a rigorous study. For example, I changed my interview script, consent form, and research methods to help answer my research questions and protect my participants. While self-reflecting during my data collection process and analysis I used contextual-discursive reflexivity to understand the sense of my experiences within each case. This self-reflection created areas of interest I wanted to investigate within a case. These areas of interest affected my relational reflexivity as I would develop a relationship with my participants and discuss areas of care I would like to learn about. At certain occasions I would spend more time discussing a topic I believed I needed to investigate which may have affected other topics. While I had an interview script to keep my discussions on track, I would continue a topic that the interviewee seemed excited to discuss. Using embodied reflexivity, I would reflect on the excitement of the participants tone or body language (if the interviewee was on video). Finally, ethical reflexivity was used to protect my participants. Along with ethical approval and consent forms, I aimed to protect the confidentiality of my participants. Again, my supervisors were helpful with their recommendations to protect my interviewees.

Chapter 4 – Quantitative Results

This chapter presents the outcomes from my retrospective cohort studies. My first objective was to compare ischemic stroke indicators of Eastern Health (EH), Newfoundland and Labrador (NL) with Central Nova Scotia (NS), Southeastern Ontario (SEO), and Calgary Zone Alberta (AB). Using cross-tabulations and the Pearson Chi-Squared test, I compared the Health Sciences Centre (HSC) with the Comprehensive Stroke Centres (CSC) of the three other health regions. I compared the combine results of the primary stroke centres (PSC) in EH with the three other regions, and I compared HSC with the combined EH PSC population. In addition, I analyzed each EH stroke centre to identify tend over time using…

Firstly, de-identified individual data on stroke care outcomes from hospitals in EH was analyzed from fiscal year (FY) 2012/2013 to FY 2020/2021 with the evaluation of stroke care indicators primarily based on the 2020 Provincial Stroke Scorecard and the 2021 CSBP Recommendations "Quality of Stroke Care In Canada (QSCIC): Stroke Key Quality Indicators (KQI) (Canadian Stroke Best Practices Stroke Quality Advisory Committee, 2021). HSC is on its way to becoming a CSC as it began Endovascular therapy (EVT) in 2022 but will need 24/7 access to attain this designation. The four other Category A hospitals are PSCs: The HSC, St. Clare's Mercy Hospital (SC), Carbonear General Hospital (CG), Dr. G. B. Cross Memorial Hospital (GBC) in Clarenville, and Burin Peninsula Health Centre (BP). All other patients sent to category B hospitals within EH will be labelled as Other.

Second, the Canadian Institute for Health Information (CIHI) provided de-identified, aggregate stroke data for three other health regions within Canada (Central Zone Nova Scotia (NS), Southeastern Ontario (SEO), and Alberta Health's Calgary zone) for the FY 2016/2017 to 2020/2021. CIHI has suppressed cells as Non-reportable (N/R) for one to four values. Therefore, many requested hospitals were removed as they are not stroke care facilities. Table 4.1 shows the affiliated hospitals of interest by region with sufficient stroke hospitalizations. Each region has a corresponding CSC of interest: Queen Elizabeth II Health Science Centre (QEII), Foothills Medical Centre (FMC), and Kingston General Hospital (KGH).

Table 4.1: Hospital List by Region

Province	Hospital ID	Hospital Name
Nova Scotia (Central Health)	NS-1	Queen Elizabeth II Health Science Centre
	NS-2	Dartmouth General Hospital
Alberta (Calgary Zone)	AB-1	Foothills Medical Centre (Calgary)
	AB-2	Peter Loughead Centre (Calgary)
	AB-3	Rockyview General Hospital (Calgary)
	AB-4	South Health Campus (Calgary)
Southeastern Ontario	ON-1	Kingston General Hospital (Kingston)
	ON-2	Brockville General Hospital (Brockville)
	ON-3	Belleville General Hospital (Belleville)

A. Stroke Hospitalizations

This section explores the differences in total stroke hospitalizations (including TIA), hospitalizations by stroke type, distribution, the stroke rate and ischemic stroke rate per 1000 population, mean age, and gender proportions.

I. Number of Stroke Hospitalizations including TIA

The CSBPR KQI 53 for health systems recommends measuring the annual acute inpatient admission volume for patients with TIA, ischemic stroke, ICH, and SAH to monitor trends and measure access, process, and system capacity. Table 4.2 presents nine years of stroke hospitalizations within EH by Hospital and each EH hospitals ANOVA test and linear model, Table 4.3 presents stroke hospitalizations by NS, AB, and SEO hospitals from 2016/17 to 2020/2021, Figure 4.1 illustrates five years of stroke hospitalizations by CSCs, including HSC and Figure 4.2 presents 5 years of stroke hospitalizations by Primary Stroke Centers (PSC).

Table 4.2: Number of EH Stroke Hospitalizations by Hospital from 2012/13 to 2020/21 and the ANOVA Test and Linear Model for Year and Change in Stoke Hospitalizations

Hospital	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
HSC	328	337	341	409	364	386	441	447	482
SC	187	168	183	201	212	198	195	167	138
CG	79	95	95	116	131	136	177	160	130
GBC	65	69	51	69	55	56	58	77	90
BPH	49	79	54	65	47	39	46	34	49
Other	24	24	28	15	19	19	18	18	11
Total	732	772	752	875	828	834	935	903	900

Hospital	ANOVA	Coefficients
HSC	p <.001	18.717x + 299.194
SC	p =.34	(-)2.967x + 198.056
CG	p =.002	10.317x + 73.75
GBC	p =.211	2.083x + 55.139
BPH	p =.09	(-)2.95x + 66.083

- HSC and CG were the only sites with a significant relationship and both hospitals reported a significant increase in stroke hospitalizations from 2012/13 to 2020/21.
- From 2012/13 to 2020/21, stroke hospitalizations have increased by 23%. HSC had the largest increase in stroke hospitalization at 47.0%.
- In 2020/2021, 53.6% of acute strokes and TIAs were managed at the HSC, 15.3% at SC, and 31.1% at the remaining hospitals. HSC and SC are both St. John's Hospitals.
- The aging population and population health could be related to the increase in strokes.

Table 4.3: Number of Stroke Hospitalizations in NS, AB, and SEO by Hospital from 2016/17 to 2020/21

Hospital	2016/17	2017/18	2018/19	2019/20	2020/21
NS-1	610	529	719	758	794
NS-2	90	81	98	148	142
AB-1	1463	1415	1688	1719	1715
AB-2	55	65	105	143	129
AB-3	85	90	122	174	130
AB-4	108	109	115	122	151
ON-1	498	537	576	655	670
ON-2	211	200	198	198	168
ON-3	314	389	419	426	439

Figure 4.1: Number of Stroke Hospitalizations by Comprehensive Stroke Center

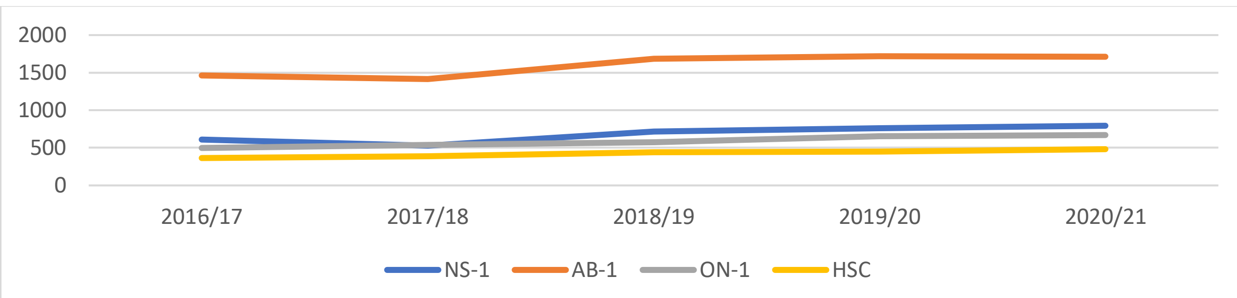


Fig. 4.1. Compares the total number of stroke hospitalization at the HSC with the three CSCs of NS, Calgary, and SEO from 2016/17 to 2020/2021. Since 2016/17 HSC has seen an increase of 32.4% in stroke Hospitalizations. QEII had a rise of 30.2 %, FMC had an increase of 17.2%, and KGH had an increase of 34.5 %.

Figure 4.2: Number of Stroke Hospitalizations by Primary Stroke Center

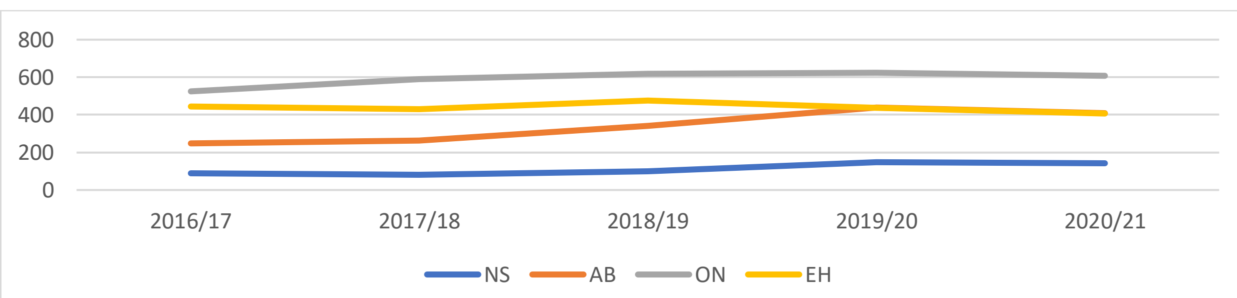


Fig. 4.2. Compares the total number of stroke hospitalization of all PSCs in EH with the PSCs of NS, SEO, and Calgary from 2016/17 to 2020/2021. Of the four regions, EH had the second most stroke hospitalizations going to a PSC, only behind SEO. In 2020/21, there were 407 stroke

hospitalization going to PSCs. This was 45.8% of all the stroke hospitalizations within EH, second to SEO (47.5%) but more than Calgary Zone (19.3%) and Central NS (15.2%). However, EH has spread these stroke hospitalizations over four PSCs compared to one in Central NS, three in Calgary AB, and two in SEO. EH should investigate if all sites should act as PSCs. The literature has recommended annual volumes of stroke hospitalizations to maintain expertise and achieve targets.

II. Total Stroke Rate and Total Ischemic Rate per 1000 Population

Each region should have differing stroke hospitalizations as there are differing population sizes. Therefore, Table 4.4 presents the total stroke and ischemic stroke hospitalizations per 1000 population of the four health regions. The populations for each region used the Stats Canada Census 2016 because the 2021 population for these health regions has yet to be published. Therefore, the rates per 1000 were calculated using the 2016 census population and the 2016/17 stroke hospitalizations. Using the population change from 2011 to 2016, I calculated an estimated population for 2021. For example, Central Health NS had a 2016 census population of 424,037 (+3.1%), Calgary Zone had 1,551,876 (+14%), SEO had 482,391 (+0.9%), and EH had 313,267 (+2.2%).

Table 4.4: Total Strokes and Ischemic Stroke Hospitalizations per 1000 population for Each Health Regions in 2016/2017

CSC	2016 Total	2016 Ischemic	2021 Total	20021 Ischemic
Central Health NS	1.65	1.15	2.14	1.51
Calgary Zone AB	1.10	0.80	1.20	0.88
Southeastern ON	2.12	1.39	2.62	1.93
Eastern Health NL	2.58	1.60	2.81	1.82

- Of the four health regions, EH has the highest total stroke hospitalizations and ischemic stroke hospitalizations per 1000 population. Future research should investigate population health, population lifestyle, and risk reduction to identify strategies to reduce strokes occurrence in EH.

III. Total Number of Stroke Hospitalizations by Stroke Type

The CSBPR KQI 22 for Acute Inpatient Stroke Care recommends measuring the annual TIA, ischemic stroke (Isc), Intracerebral Hemorrhagic (ICH), and Subarachnoid Hemorrhagic (SAH) patients separately to monitor trends and to measure access, process, and system capacity. The patients with ICH and SAH are combined into Hem = Hemorrhagic Strokes. Table 4.5 presents the different types of stroke hospitalization by EH hospital over the nine years and each EH hospitals ANOVA test and linear model, and Figure 4.3 A-D illustrates stroke hospitalizations by stroke type distribution for all CSCs including HSC. Cells are supressed as non-reportable (NR) if there are less the five counts.

Table 4.5: Number of Stroke Hospitalizations by Stroke Type for Eestern Health Hospitals and the ANOVA Test and Linear Model for Year and Change in Ischemic Strokes

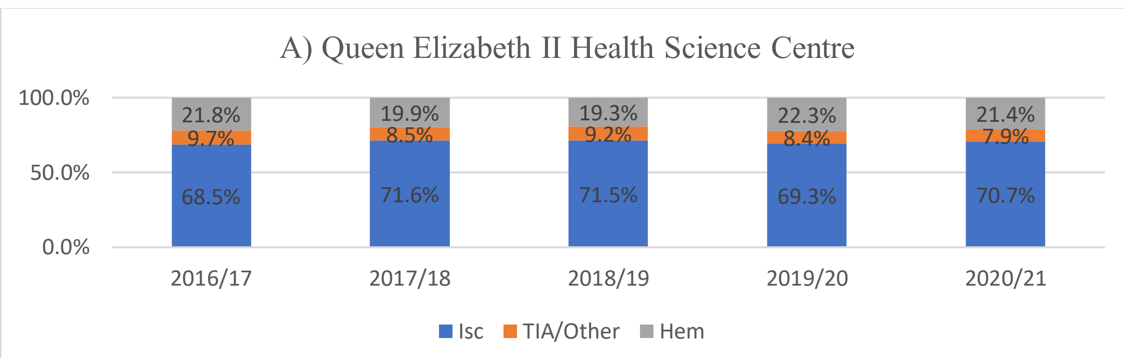
Hospital	2012/13			2013/14			2014/15			2015/16			2016/17		
	Isc	TIA	Hem	Isc	TIA	Hem	Isc	TIA	Hem	Isc	TIA	Hem	Isc	TIA	Hem
HSC	197	57	74	194	58	85	210	55	76	233	66	110	229	70	65
SC	99	71	17	89	66	13	100	70	13	115	67	19	127	71	14
CG	55	16	8	47	39	9	41	41	13	63	45	8	76	42	13
GBC	48	13	NR	51	15	NR	41	5	5	50	11	8	45	10	0
BPH	30	15	NR	64	5	10	38	12	NR	39	22	NR	32	10	5
Other	12	9	NR	9	12	NR	19	8	NR	7	7	NR	15	0	NR
Total	441	181	110	454	195	123	449	191	112	507	218	150	524	203	101

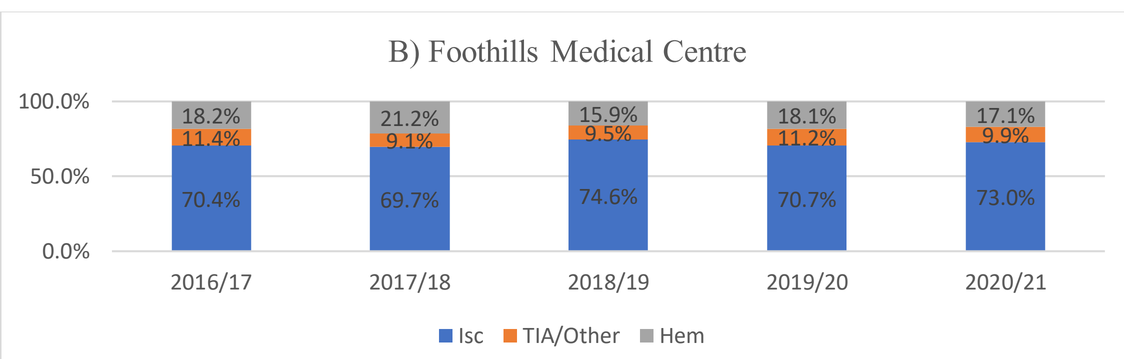
Hospital	2017/18			2018/19			2019/20			2020/21		
	Isc	TIA	Hem	Isc	TIA	Hem	Isc	TIA	Hem	Isc	TIA	Hem
HSC	234	71	81	277	83	81	286	61	100	332	70	80
SC	113	71	14	119	66	10	111	48	8	87	36	15
CG	73	57	6	103	65	9	69	77	14	65	55	10
GBC	35	13	8	42	12	NR	48	21	8	56	24	10
BPH	26	10	NR	21	20	5	20	13	NR	35	11	NR
Other	14	NR	NR	15	0	NR	13	NR	NR	9	NR	NR
Total	495	226	113	577	246	112	547	223	133	584	197	119

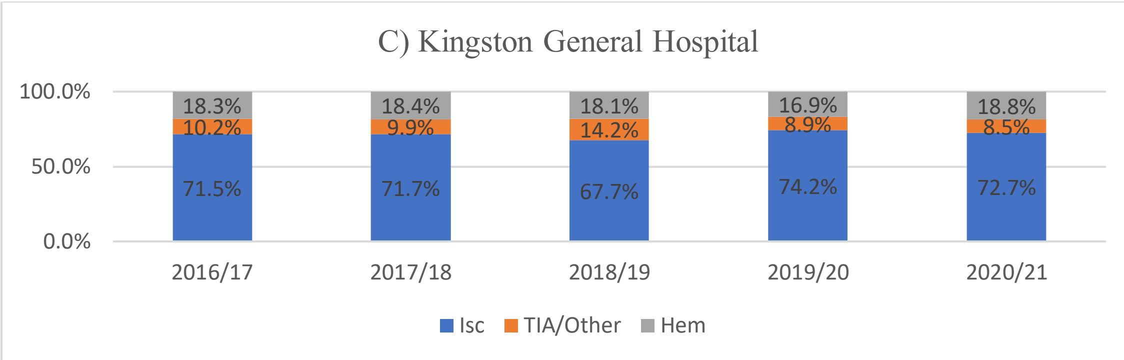
Hospital	ANOVA	Coefficients
HSC	p <.001	15.85x + 164.306
SC	p =.643	.9x + 102.167
CG	p =.086	4x + 45.778
GBC	p =.852	.167x + 45.389
BPH	p =.125	(-)2.65 + 47.139

- HSC reported a significant increase in ischemic stroke hospitalizations from 2012/13 to 2020/21.
- In EH, most stroke hospitalizations resulted from ischemic stroke: in 2020/2021, ischemic stroke comprised 65% of stroke hospitalization, and 87% with TIA included.
- Compared to PSCs, HSC had a higher proportion of patients admitted with hemorrhagic strokes (average: 21.5% vs. 8.0%), and a lower proportion admitted with TIAs (average: 16.5% vs. 32.5%). This distribution was consistent over the years of investigation.
- Like EH, the CSCs in the three other Canadian regions have a larger percentage of Hemorrhagic stroke hospitalizations than the PSCs in their region. This is shown below in Figure 4.3.

Figure 4.3 A-D: Stroke Distribution of the Comprehensive Stroke Centers







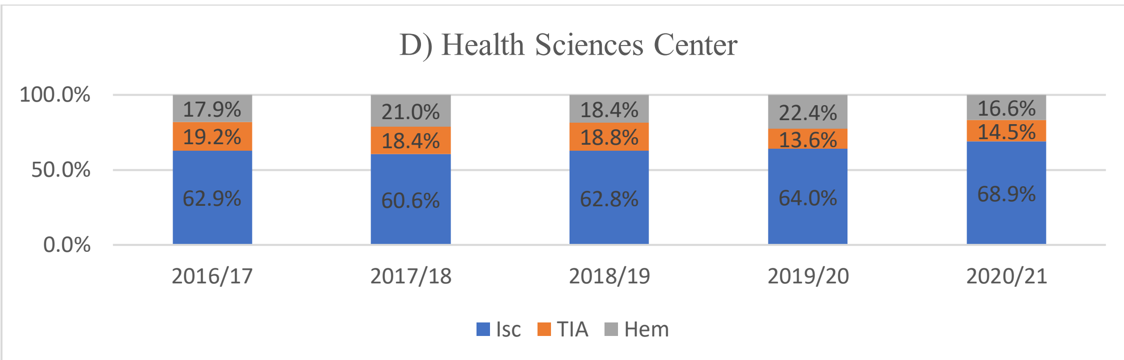


Fig 4.3. Compares the distribution of total stroke hospitalizations by stroke type in the HSC with the distribution at the CSC in NS, Calgary, and SEO. HSC consistently had a lower proportion of ischemic stroke and a higher proportion of TIA hospitalizations. Hospitalized TIAs may be lower in the other CSCs as they may admit their TIA patients into a TIA clinic. Therefore, HSC should maintain a quality TIA clinic to avoid more severe secondary strokes. In addition, if there was les access to timely imaging, ischemic strokes may be labelled as TIAs

IV. Mean Age and Sex Proportions

In 2012/2013, the mean age for all acute stroke and TIA patients in EH was 69.8 ± 14.6 years. When analyzed by stroke type, the mean age was 70.6 ± 13.6 years for ischemic stroke patients, 64.7 ± 16.3 years for hemorrhagic stroke patients, and 71.1 ± 15.2 years for TIA patients. In 2020/21, the mean age for all acute stroke and TIA patients was 70.6 ± 13.3 years. By stroke type, the mean age was 70.4 ± 13.4 years for ischemic stroke patients, 67.0 ± 14.7 years for hemorrhagic stroke patients, and 73.1 ± 11.7 years for TIA patients. In addition, all mean ages for ischemic stroke patients in NS were in the range of 70-75, AB were 69-81 with 70% between 70-75, and SEO were 72-75.

In the database I received, there was no sex specification until 2020/21. Sex refers to an individual's gene expression. This database had a sex classification of female or male. In 2020/21, the proportion of female acute stroke and TIA patients was 45.1% and 54.9% were male. Among ischemic stroke patients, 44.0% were female and 56.0% were male; among hemorrhagic stroke patients, 41.2 % were female and 58.8% were male; and among TIA patients, 50.8% were female and 49.2% were male.

B. Ischemic Stroke

As this thesis focuses on the management of ischemic stroke, the following examines metrics of ischemic stroke care. These metrics have been analyzed to identify a general trend over time for each EH hospital. In addition, HSC is compared to each regions CSC, with patients going to EH PSCs, and patients going to EH PSCs are compared to the combined population going to PSCs in the other regions.

I. Seven Day In-Hospital All-Cause Mortality

The CSBPR KQI 26 for Acute Inpatient Stroke Care recommends calculating the proportion of acute stroke inpatients who died within seven days of hospital admission as an outcome measure for effectiveness. The CSBPR KPI has a target set at < 5% of all acute stroke patients. However, I will focus on ischemic strokes. Table 4.6 presents the seven-day mortality rate of ischemic stroke by EH hospital over nine years and each EH hospitals ANOVA test and linear model, Table 4.7 presents the Pearson chi-squared test between stroke populations, and Figure 4.4 presents the seven-day mortality of ischemic stroke of the CSCs and HSC from 2016/17 to 2020/21. The PSC cells had too many N/R cells to compare seven-day mortality.

Table 4.6: Seven-day In-Hospital Mortality Rate in Ischemic Stroke by EH Hospitals and Each ANOVA Test and Linear Model for Year and Change in Seven Day Mortality

Hospital	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
HSC	6.6%	0.5%	9.0%	10.7%	6.6%	8.5%	7.9%	8.4%	6.3%
SC	5.1%	1.1%	10.0%	6.1%	10.2%	9.7%	11.8%	4.5%	4.6%
CG	10.9%	0.0%	9.8%	14.3%	9.2%	9.6%	10.7%	14.5%	7.5%
GBC	12.5%	3.9%	14.6%	14.0%	4.4%	14.1%	4.8%	8.3%	5.4%
BPH	6.7%	0.0%	13.2%	5.1%	3.1%	11.5%	9.5%	25.0%	5.7%
Other	33.3%	11.1%	21.1%	14.3%	33.3%	14.3%	13.3%	38.5%	11.1%

Hospital	Anova	Coefficients
HSC	p =.708	(-).001x +.085
SC	p =.847	(-).001x +.082
CG	p =.779	(-).001x +.114
GBC	p =.100	(-).01x +.154
BPH	p =.457	.008x +.057

- No hospital saw a significant change in ischemic stroke seven-day mortality.
- The seven-day mortality for 2013/14 was very low at every site for reasons I could not identify.
- There was a high seven-day mortality rate at category B hospitals. However, these hospitals have low populations. Small variances will have a large effect.

Table 4.7: Pearson Chi-Squared Two-Sided Significance Test Between Stroke Populations and Ischemic Stroke Seven Day Mortality

Eastern Health	HSC	HSC	HSC	HSC	EH-PSC	EH-PSC	EH-PSC
Comparison	QEII	Kingston	Foothills	EH-PSC	NS-PSC	SEO-PSC	AB-PSC
Pearson Chi-Squared	p =.121	p =.733	p =.650	p =.780	p =.044	p =.910	p =.093

- When comparing seven-day mortality, the stroke population at HSC was not significantly different to the other CSCs and the population going to PSCs in EH. The population going to PSCs in EH was not significantly different to the other health regions.

Figure 4.4: Ischemic Stroke Seven-Day Mortality Rate by Comprehensive Stroke Center

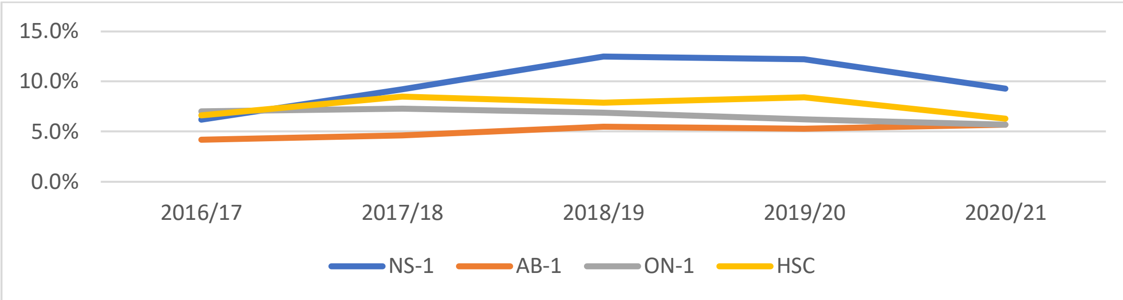


Fig. 4.4. Compares the seven-day mortality rate of ischemic stroke patients from the HSC with those from the CSC in NS, Calgary, and SEO. In 2020/21, the seven-day mortality for ischemic stroke was lower at HSC (6.3%) than QEII (9.3%) and similar to FMC (5.7%) and KGH (5.7%).

II. Thirty-Day In-Hospital All-Cause Mortality Rate

The CSBPR KQI 27 for Acute Inpatient Stroke Care recommends calculating the proportion of acute stroke inpatients who died within thirty days of hospital admission as an outcome measure for effectiveness. Table 4.8 presents the thirty-day mortality rate of ischemic stroke by EH hospital over nine years and each EH hospitals ANOVA test and linear model, Figure 4.5 illustrates the thirty-day mortality of the CSC including HSC from 2016/17 to 2020/21, Figure 4.6 illustrates the thirty-day mortality of PSCs from 2016/17 to 2020/21, and Table 4.9 presents the Pearson chi-squared test between stroke populations. AB-3 had an N/R cell in 2020/21 and was excluded from the 2020/21 combined ischemic stroke thirty-day mortality for PSCs in AB.

Table 4.8: Thirty-day In-Hospital Mortality Rate in Ischemic Stroke by EH Hospitals and Each ANOVA Test and Linear Model for Year and Change in Thirty Day Mortality

Hospital	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
HSC	17.8%	14.4%	17.6%	15.9%	14.8%	14.1%	12.3%	13.6%	13.9%
SC	11.1%	12.4%	16.0%	10.4%	12.6%	15.0%	16.8%	11.7%	12.6%
CG	29.1%	17.0%	24.4%	22.2%	18.4%	11.0%	18.4%	21.7%	15.4%
GBC	22.9%	15.7%	24.4%	18.0%	13.3%	20.0%	7.1%	10.4%	16.1%
BPH	16.7%	7.8%	26.3%	7.7%	9.4%	11.5%	9.5%	30.0%	11.4%
Other	41.7%	33.3%	26.3%	14.3%	46.7%	14.3%	20.0%	38.5%	33.3%

HSC	p = .019	(-).005x + .175
SC	p = .594	.002x +.123
CG	p =.126	(-).011x +.251
GBC	p =.079	(-).013x +.227
BPH	p =.825	.003x +.132

- HSC reported a significant decrease in ischemic stroke thirty-day mortality rate from 2012/13 to 2020/21. Over time there is an overlap between the mortality rate across the five stroke hospitals.

Figure 4.5: Ischemic Stroke Thirty-Day Mortality Rate by Comprehensive Stroke Center

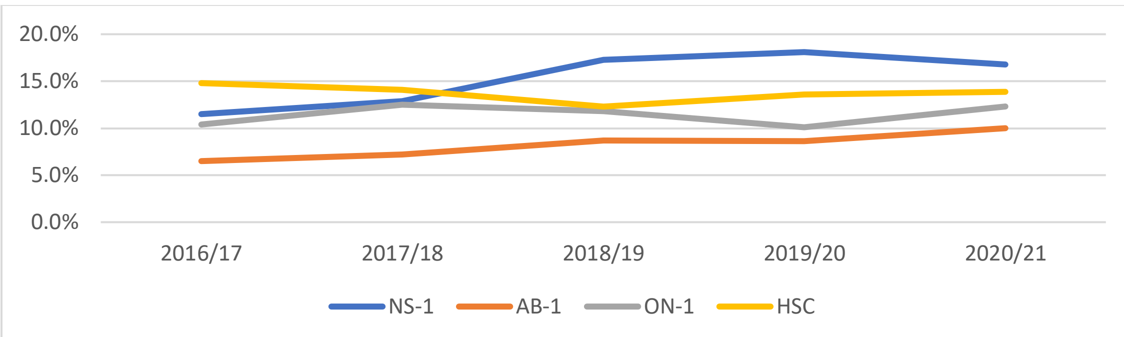


Fig. 4.5. Compares the thirty-day mortality rate of ischemic stroke patients from the HSC with those from the CSC in NS, Calgary, and SEO. In 2020/21, the thirty-day mortality for ischemic stroke was lower at HSC (13.9%) than QEII (16.8%) but higher than FMC (10.0%) and KGH (12.3%).

Figure 4.6: Ischemic Stroke Thirty-Day Mortality Rate by Primary Stroke Center

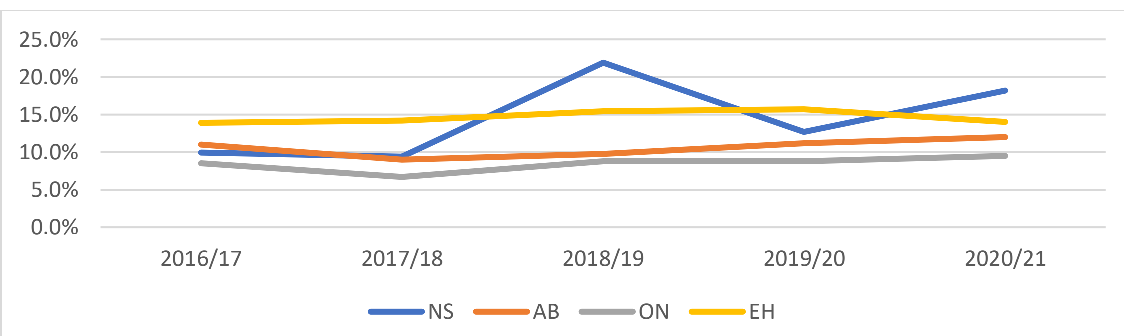


Fig. 4.6. Compares the thirty-day mortality rate of ischemic stroke patients from the PSCs in EH with those from PSCs in NS, Calgary, and SEO. In 2020/21, the thirty-day mortality of ischemic strokes within PSCs was higher in EH (14.0%) than SEO (9.5%) and Calgary Zone (12.0%) but lower than central zone NS (18.2%).

Table 4.9: Pearson Chi-Squared Two-Sided Significance Test Between Stroke Populations and Ischemic Stroke Thirty Day Mortality

Eastern Health	HSC	HSC	HSC	HSC	EH-PSC	EH-PSC	EH-PSC
Comparison	QEII	KGH	FMC	EH-PSC	NS-PSC	SEO-PSC	AB-PSC
Pearson Chi-Squared	p =.249	p =.521	p =.043	p =.963	p =.328	p =.073	p =.464

- HSC reported a significantly higher thirty-day mortality rate when compared to FMC.

III. Median Total Length of Stay (TLOS) for Ischemic Stroke Patients

The CSBPR KQI 24 for Acute Inpatient Stroke Care recommends a median TLOS target of ≤ 8 days for acute stroke patients. TLOS includes active Length of Stay (LOS) and Alternate Level of Care (ALC) day. In 2020/21, the median TLOS within EH was 7.0, and the mean was 15.4 ± 26.9, with skewness of 8.2. Therefore median (med) and interquartile range (IQR) was calculated. There is a lower population size in some of the cells compared to ischemic stroke population sizes in Table 4.5, as some patients had missing LOS data. Table 4.10 present the median TLOS for the various EH hospitals over nine years and each EH hospitals ANOVA test and linear model, Figure 4.7 illustrates the TLOS for each CSC including HSC over 5 years, and Figure 4.8 shows the TLOS for each region's combined PSCs over 5 years.

Table 4.10: Median TLOS for EH Ischemic Stroke Patients from 2012/13 to 2020/21 and each ANOVA Test and Linear Model for Year and Change in Median TLOS

Hospital	2012/13			2013/14			2014/15			2015/16			2016/17		
	N	med	IQR	N	med	IQR	N	med	IQR	N	med	IQR	N	med	IQR
HSC	197	13	22.5	193	12.2	16.5	210	11	21	233	10	17.5	229	10	19
SC	99	12	20	89	11.2	18.1	100	8.5	15.8	115	9	16	127	11	19
CG	55	12	21	47	10.1	10.8	41	11	16	63	7	22	76	7.5	12.5
GBC	48	8	19	51	11.2	18	41	6	8	50	6	18.3	45	12	28.5
BPH	30	10.5	14.5	63	5.4	6.2	38	9	10.5	39	8	17	32	8	19
Other	12	6.5	46	9	7.3	10.7	19	12	20	7	14	50	15	9	55

Hospital	2017/18			2018/19			2019/20			2020/21		
	N	med	IQR	N	med	IQR	N	med	IQR	N	med	IQR
HSC	234	8	14	277	7	14.5	286	9	21	320	7	13
SC	113	9	14	119	7	10	111	9	14	87	9	12
CG	73	7	14	103	7	15	69	8	18.5	65	7	11.5
GBC	35	5	11	42	7.5	12.75	48	6	12	56	8.5	15.5
BPH	26	6.5	8	21	5	10	20	7	23	35	9	14
Other	14	9	16.5	15	5	10	13	5	10	9	7	19.5

Hospital	Anova	Coefficients
HSC	p <0.001	(-).727x + 13.322
SC	p =.069	(-).360x + 11.322
CG	p =.011	(-).572x + 11.369
GBC	p =.574	(-).193x + 8.767
BPH	p =.479	(-).178x + 8.492

- While all sites showed good improvements with a decrease in ischemic stroke median TLOS hospitalization from 2012/13 to 2020/21. Only HSC and CG showed a significant decrease. In 2020/21, HSC and CG were below the recommended TLOS median. Decreasing from 13 to 7 and 12 to 7, respectively.

Figure 4.7: Ischemic Stroke Median TLOS by Comprehensive Stroke Center

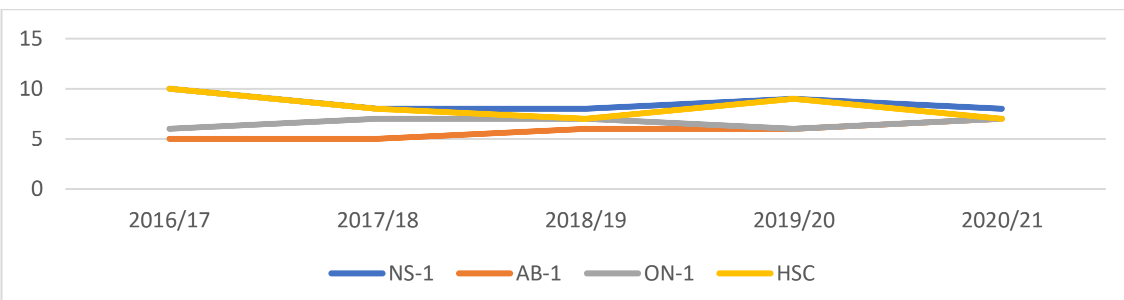


Fig 4.7. Compares the median TLOS of ischemic stroke patients from the HSC with those from the CSC in NS, Calgary, and SEO. By 2020/21, the median TLOS for ischemic stroke was similar in HSC and all three CSCs. In 2020/21, the TLOS at HSC was seven days.

Figure 4.8: Ischemic Stroke Median TLOS by Primary Stroke Centers

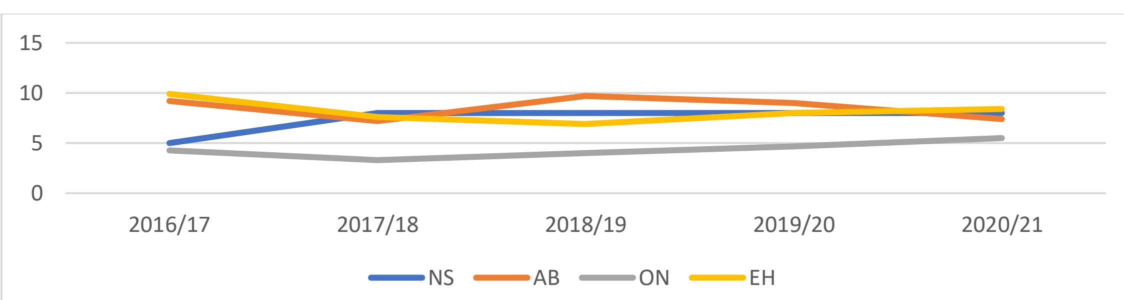


Fig. 4.8. Compares the median TLOS of ischemic stroke patients from EH PSCs with those from PSCs in NS, Calgary, and SEO. In 2020/21, the PSCs in EH had a median TLOS of 8.4 days for their ischemic stroke patients. This was similar to central zone NS (8 days) and Calgary zone AB (7.4 days) but higher than SEO (5.5 days).

IV. Number of ALC Days for Ischemic Stroke Hospitalizations

This indicator is not in the CSBP KPI but is of interest because it suggests using acute care beds and acute care resources while the patient is waiting to be discharged to a more appropriate setting. The median number of ALC days was zero across all hospitals and years. However, the number of ALC days/year attributed to ischemic stroke hospitalizations for EH hospitals is presented in Table 4.11 with each EH hospitals ANOVA test and linear model. To compare sites with different ischemic stroke totals, I used ALC days per 100 ischemic stroke patients. Figure 4.9 illustrates the number of ALC days/year per 100 ischemic stroke patients by CSC and HSC from 2016/17 to 2020/21, and Figure 4.10 shows the number of ALC days/year per 100 ischemic stroke patients by each region's combined PSCs from 2016/17 to 2020/21.

Table 4.11: Total ALC Days for Ischemic Stroke by Hospital from 2012/13 to 2020/21 and Each ANOVA Test and Linear Model for Year and Change in ALC Days

Hospital	2012/13		2013/14		2014/15		2015/16		2016/17	
	N	ALC Days	N	ALC Days	N	ALC Days	N	ALC Days	N	ALC Days
HSC	197	1212	194	1300	210	910	233	500	229	772
SC	99	597	89	1167	100	361	115	525	127	719
CG	55	249	47	177	41	30	63	160	76	267
GBC	48	109	51	450	41	335	50	290	45	280
BPH	30	211	64	64	38	149	39	68	32	204
Other	12	159	9	8	19	45	7	0	15	148

Hospital	2017/18		2018/19		2019/20		2020/21	
	N	ALC Days	N	ALC Days	N	ALC Days	N	ALC Days
HSC	234	502	277	661	286	885	320	366
SC	113	529	119	298	111	583	87	386
CG	73	328	103	422	69	219	65	193
GBC	35	84	42	160	48	250	56	131
BPH	26	42	21	29	20	88	35	78
Other	14	31	15	18	13	14	9	19

Hospital	Anova	Coefficients
HSC	p =.026	(-)85.417x + 1216.861
SC	p =.191	(-)45.3x + 800.389
CG	p =.351	14.233x + 156.056
GBC	p =.281	(-)17.8x +321.111
BPH	p =.182	(-)12.1x +164.167

- HSC reported a significant decrease in ischemic stroke ALC days from 2012/13 to 2020/21. During that time, the number of ischemic stroke patients increased at the HSC from 197 to 320 while the total ALC days decreased from 1212 to 366.
- In the other four hospitals, the total number of ALC days decreased but not to the same extent as HSC.

Figure 4.9: ALC Days per 100 Ischemic Strokes by Comprehensive Stroke Centre

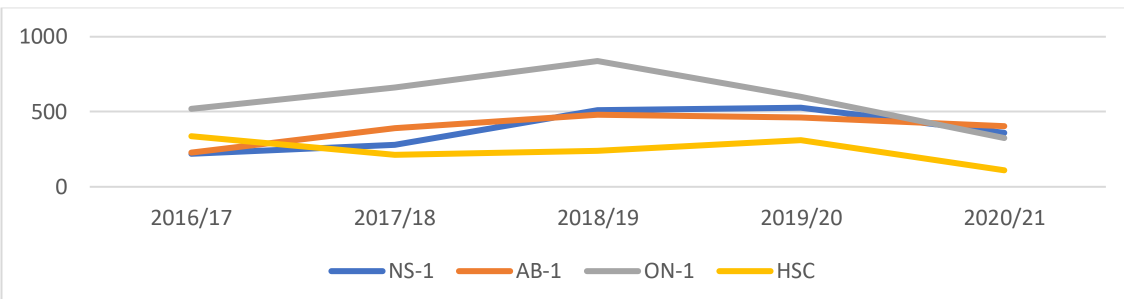


Fig. 4.9. Compares the ALC days per 100 ischemic stroke patients from the HSC with those from the CSC in NS, Calgary, and SEO. Since 2017/18, HSC has had fewer ALC days per 100 ischemic stroke patients than the three CSCs. In 2020/21, the ALC days per 100 patients were 110 days.

Figure 4.10: ALC Days per 100 Ischemic Strokes by Primary Stroke Centers

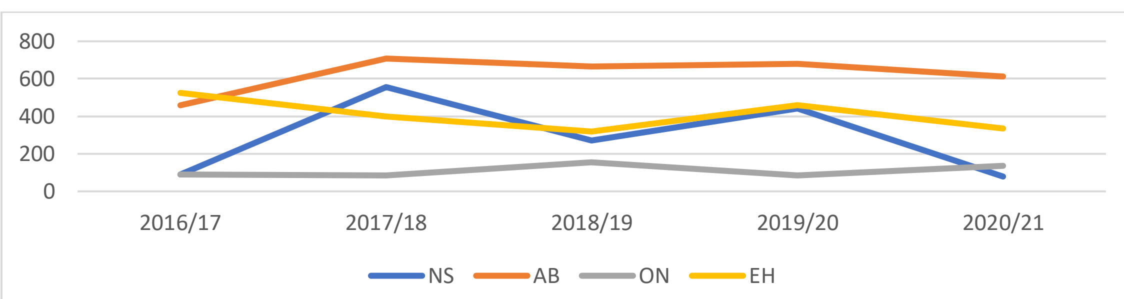


Fig. 4.10. Compares the ALC days per 100 ischemic stroke patients from EH PSCs with those from PSCs in NS, Calgary, and SEO. In 2020/21, The PSCs in EH had 335 ALC days per 100 patients, which was lower than Calgary (614) but higher than NS (79) and SEO (136).

V. Proportion of Ischemic Stroke Inpatients Discharged Home

The CSBPR KQI 29 for Acute Inpatient Stroke Care recommends recording the distribution of discharge locations for acute stroke patients from acute inpatient care to home (with and without services), inpatient rehabilitation (General or specialized), long-term care (LTC) and palliative care (Pall) as a measure of effectiveness processing. Due to missing information, only the proportion of patients discharged home can be accurately calculated. The proportion of ischemic patients discharged “Home” was calculated using Discharge Disposition labelled as either: Discharged to a private home, condo, apartment without support services (2017, 2018); Discharged to a private home, condo, apt, with support services 2017,2018); Discharged home (no support service required); and Discharged to a home or home setting with support services. Table 4.12 presents the proportion of ischemic stroke patients discharged home by EH hospital and each EH hospitals ANOVA test and linear model, Figure 4.11 illustrates the proportion of ischemic stroke patients discharged home by CSC including HSC Figure 4.12 shows the proportion of ischemic stroke patients discharged home by each region's combined PSCs, and Table 4.13 presents the Pearson chi-squared test between stroke populations. Patients discharged to “Rehab” and LTC used the variable called Institution To Type (referring to the level of care). However, the proportion of missing data for the Institution To Type category was between 39.6% - 87.5%. While the proportion of missing data is improving, it remains too high to accurately calculate the proportion of patients going to Rehab or LTC. Therefore, efforts must be made to accurately record data. The CSBPR recommends a target of > 30% of acute stroke patients receiving rehabilitation.

Table 4.12: Proportion of Ischemic Stroke Patients Discharged Home by Hospital and Each ANOVA Test and Linear Model from 2012/13 to 2020/21

Hospital	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
HSC	41.1%	43.8%	45.2%	45.1%	45.9%	47.0%	54.5%	52.1%	54.5%
SC	47.5%	40.4%	38.0%	47.8%	37.8%	46.9%	47.9%	50.5%	55.2%
CG	34.5%	42.6%	41.5%	54.0%	44.7%	56.2%	46.6%	34.8%	53.8%
GBC	62.5%	68.8%	58.5%	60.0%	44.4%	48.6%	54.8%	56.3%	37.5%
BPH	53.3%	79.7%	47.4%	71.8%	46.9%	61.5%	66.7%	40.0%	57.1%
Other	33.3%	33.3%	52.6%	42.9%	13.3%	21.4%	33.3%	30.8%	33.3%

Hospital	Anova	Coefficients
HSC	<.001	.017x + .394
SC	p =.075	.013x +.391
CG	p =319	.011x +.399
GBC	p =.023	(-).026 +.676
BPH	p =.486	(-).013x +.646

- HSC showed a significant increase in the proportion of their ischemic stroke patients going home when discharged from 2012/13 to 2020/2021 (41.1% to 54.5%).
- GBC showed a significant decrease in the proportion of their ischemic stroke patients going home when discharged from 2012/13 to 2020/2021 (62.5% to 37.5%).

Figure 4.11: Proportion of Ischemic Stroke Patients Discharged Home by CSC

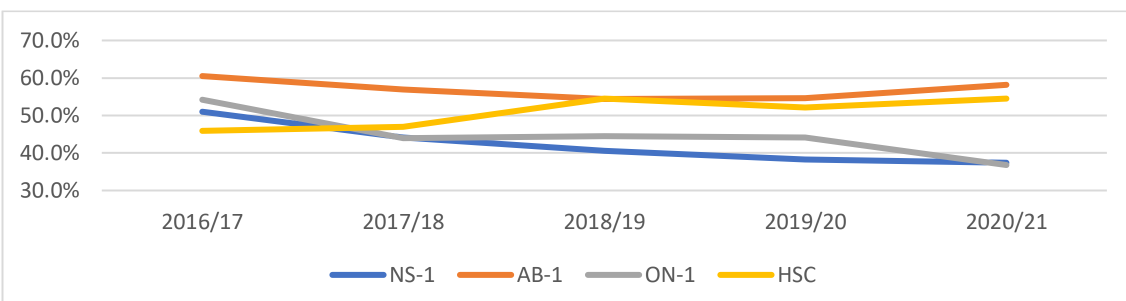


Fig. 4.11. Compares the proportion of ischemic stroke patients discharged home from the HSC with those from the CSC in NS, Calgary, and SEO. By 2020/21, HSC had 54.5% of their ischemic stroke patients discharged home. This proportion was like FMC (58.2%) and higher than QEII (37.4%) and KGH (36.8%). Additional functional dependence indicators should be monitored as other regions may be sending their patients to rehabilitation.

Figure 4.12: Proportion of Ischemic Stroke Patients Discharged Home by Primary Stroke Center From 2016/17 to 2020/21

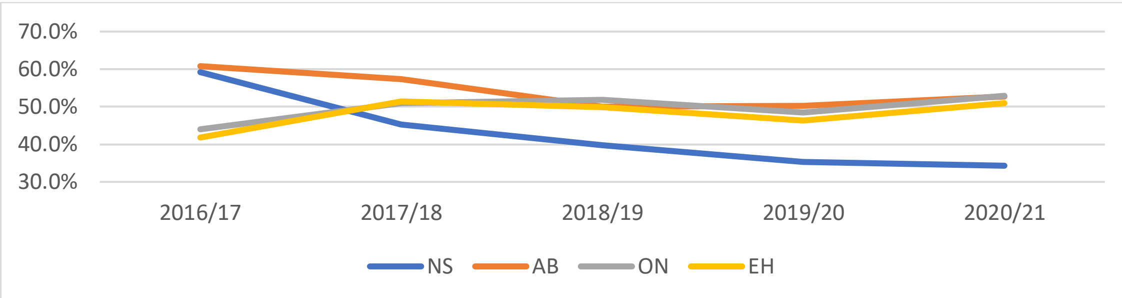


Fig. 4.12. Compares the proportion of ischemic stroke patients discharged home from EH PSCs with those from PCSs in NS, Calgary, and SEO. By 2020/21, the PSCs in EH had 51.0% of their ischemic stroke patients discharged home. This proportion was similar to Calgary zone AB (52.7%) and SEO (52.9%). Central zone NS was lower than the other three regions at 34.3%. This decrease may be the result of a change in policy about patients transferring to rehabilitation facilities. Unfortunately, data on patients discharged to a rehabilitation facility was not requested from CIHI.

Table 4.13: Pearson Chi-Squared Two-Sided Significance Test Between Stroke Populations and the Proportion of Ischemic Strokes Discharged Home

Eastern Health	HSC	HSC	HSC	HSC	EH-PSC	EH-PSC	EH-PSC
Comparison	QEII	KGH	FMC	EH-PSC	NS-PSC	SEO-PSC	AB-PSC
Pearson Chi-Squared	p <.001	p <.001	p =.224	p =.408	p =.005	p =.642	p =.690

- HSC reported a significantly higher proportion of their ischemic stroke patients going home compared to QEII and KGH. In addition, ischemic stroke patients going to EH PSCs higher proportion of their ischemic stroke patients going home compared to ischemic stroke patients going to central NS PSCs.

VI. Proportion of Ischemic Stroke Patients Arriving by Ambulance

Arriving by ambulance is not in the CSBP KPI but is of interest to this project. Hyper acute stroke protocols are inefficient if patients do not arrive by ambulance and pre-notification. Reasons for not arriving by ambulance include making one’s way to the ED by a different mode of transport or by having a stroke in the hospital. Table 4.14 presents the proportion of ischemic stroke patients arriving by ambulance in the EH hospitals over nine years and each EH hospitals

ANOVA test and linear model, Figure 4.13 illustrates the proportion of ischemic strokes arriving by ambulance for CSCs including HSC over five years, and Figure 4.14 shows the proportion of ischemic strokes arriving by ambulance by each region's combined PSCs over five years, and Table 4.15 presents the Pearson chi-squared test between stroke populations.

Table 4.14: Proportion of Ischemic Stroke Patients Arriving by Ambulance and Each ANOVA Test and Linear Model from 2012/13 to 2020/21

Hospital	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
HSC	71.1%	72.2%	64.3%	69.1%	67.2%	64.5%	64.6%	69.6%	75.9%
SC	56.6%	56.2%	61.0%	65.2%	70.1%	62.8%	65.5%	72.1%	71.3%
CG	83.6%	70.2%	78.0%	73.0%	67.1%	64.4%	68.9%	72.5%	75.4%
GBC	68.8%	82.4%	61.0%	70.0%	62.2%	80.0%	59.5%	72.9%	78.6%
BPH	70.0%	50.0%	73.7%	61.5%	59.4%	61.5%	71.4%	85.0%	74.3%
Other	75.0%	66.7%	57.9%	28.6%	100%	92.9%	66.7%	76.9%	77.8%

Hospital	Anova	Coefficients
HSC	p =0.828	.001x +.681
SC	p =.002	.019x +.551
CG	p = .273	(-).009x +.77
GBC	p =.809	.003x +.691
BPH	p =.152	.02x +.576

- SC was the only site that showed a significant increase in the proportion of their ishemic stroke patients arriving by ambulance. In 2020/21, the proportion of ischemic stroke patients arriving by ambulance was similar across EH. Ranging from 71.3% to 78.6%.

Figure 4.13: Proportion of Ischemic Stroke Patients Arriving by Ambulance for Comprehensive Stroke Centers From 2016/17 to 2020/21

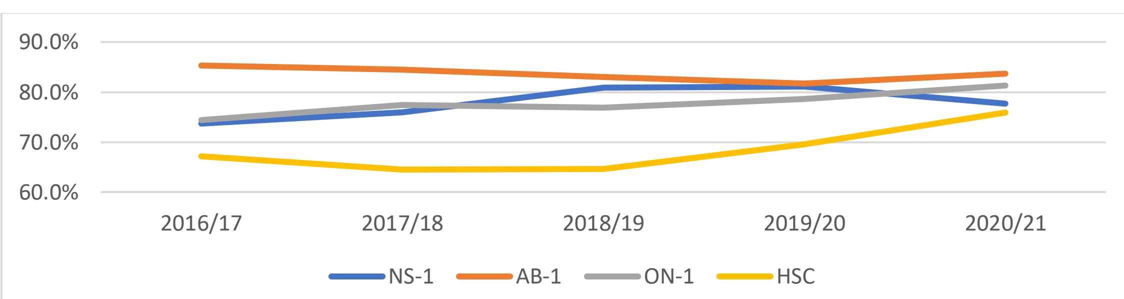


Fig 4.13. Compares the proportion of ischemic stroke patients arriving by ambulance at the HSC with those at the CSC in NS, Calgary, and SEO. By 2020/21, HSC had steadily improved to

75.9% of the ischemic stroke patients arriving by ambulance. This was still lower than the three other CSCs but was close to QEII (77.7%). KGH was 81.3% and FMC was 83.7%. The paramedics are critical for efficient stroke care. Key processes include pre-notification, bypassing to the appropriate hospitals, and beginning treatment.

Figure 4.14: Proportion of Ischemic Stroke Patients Arriving by Ambulance by Primary Stroke Center From 2016/17 to 2020/21

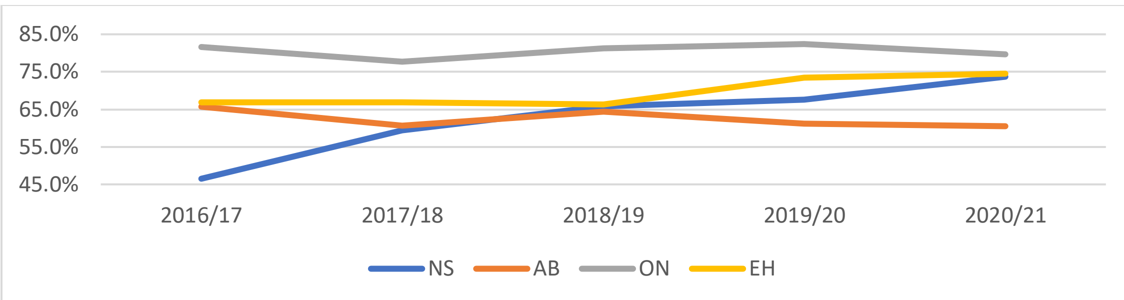


Fig 4.14. Compares the proportion of ischemic stroke patients arriving by ambulance at the EH PSCs with those arriving at PSCs in NS, Calgary, and SEO. EH PSCs have improved the proportion of their ischemic stroke patients arriving by ambulance from 66.8% to 74.5%. In 2020/21, the PSCs in EH were similar to Central Zone NS (73.7%), higher than Calgary Zone AB (60.5%), but lower than SEO (79.6%).

Table 4.15: Pearson Chi-Squared Two-Sided Significance Test Between Stroke Populations and the Proportion of Ischemic Strokes Arriving by Ambulance

Eastern Health	HSC	HSC	HSC	HSC	EH-PSC	EH-PSC	EH-PSC
Comparison	QEII	KGH	FMC	EH-PSC	NS-PSC	SEO-PSC	AB-PSC
Pearson Chi-Squared	p =.533	p =.061	p <.001	p =.697	p =.886	p =.118	p <.001

- In 2020/21, HSC reported a significantly lower proportion if their ischemic stroke patients arriving by ambulance compared to FMC. However, the patients going to EH PSCs had a significantly higher proportion than ischemic patients arriving by ambulance at Calgary zone PSCs. This becomes apparent during the case study as ambulance are instructed to go directly to FMC if patients have a positive stroke screen.

C. Special Stroke Projects

In a joint effort between H&S and CIHI, the Stroke Special Projects enable the capture of essential process and outcome information. There is a large proportion of missing/blank data from 2012/2013 to 2017/2018 compared to 2018/2019 to 2020/2021. For example, see Table 4.16: Percentage of Missing/Blank CT/MRI Scan data. By 2018/19 data collection has vastly improved. Therefore, data is only provided for 2018/19 to 2020/21, with little to no missing data.

Table 4.16: Percentage of Missing/Blank data for CT/MRI Scan

Hospital	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
HSC	27.7%	22.3%	19.4%	12.5%	15.7%	11.7%	0.2%	0.3%	0.0%
SC	21.4%	23.8%	19.7%	10.9%	13.7%	12.6%	0.0%	0.0%	0.0%
CG	39.2%	14.7%	9.5%	11.2%	8.4%	10.3%	0.0%	0.0%	0.0%
GBC	90.8%	13.0%	11.8%	14.5%	12.7%	30.4%	0.0%	0.0%	0.0%
BPH	36.7%	70.9%	20.4%	9.2%	6.4%	7.7%	0.0%	0.0%	0.0%
Other	79.2%	58.3%	50.0%	53.3%	52.6%	63.2%	0.0%	0.0%	0.0%

I. CT/MRL Scan Within 24 Hours of Hospital Arrival

This indicator is not a key indicator in the CSBP KPI but is collected in Project 340 and is of interest to NLCHI. The population of interest is all acute strokes (Ischemic, ICH, SAH) and TIA's. The proportion included were responses of "Yes, at this institution within 24 hrs" and "Completed Prior to transfer to this acute care institution". NLCHI and the provincial stroke scorecard set a target of > 96.5% of all acute stroke and TIA patients who should receive a CT/MRI scan within 24 hours. Table 4.17 presents the proportion of acute stroke and TIA patients receiving a CT/MRI scan within 24 hours at EH hospitals from 2018/19 to 2020/21 and each EH hospitals ANOVA test and linear model, Figure 4.15 illustrates the proportion of acute stroke and TIA patients receiving a CT/MRI scan from 2018/19 to 2020/21 by CSC including HSC, Figure 4.16 shows the proportion of acute stroke and TIA patients receiving a CT/MRI scan from 2018/19 to 2020/21 by each region's combined PSCs, and Table 4.18 presents the Pearson chi-squared test between stroke populations.

Table 4.17: Percentage of Acute Stroke and TIA Patients who Received a CT/MRI Scan Within 24 Hours of Hospital Arrival and Each ANOVA Test and Linear Model

Hospital	2018/19	2019/20	2020/21
HSC	98.4%	98.2%	97.1%
SC	96.4%	96.4%	96.4%
CG	94.9%	98.1%	95.4%
GBC	98.3%	94.8%	93.3%
BPH	100%	97.1%	93.9%
Other	38.9%	83.3%	81.8%

HSC	p =.242	(-).007x + 1.031
SC	Constant	Constant
CG	p =.907	.003x +.941
GBC	p =.144	(-).025x + 1.155
BPH	p =.018	(-).031x + 1.214

- The target of 96.5% of acute stroke and TIA patients receiving a CT/MRI scan within 24 hours of arrival was achieved by HSC and SC. The three rural hospitals were consistently above 93%. BPH reported a significant decrease of their patients receiving scanning.
- Patients arriving outside designated stroke facilities do not achieve the targeted rates.

Figure 4.15: Percentage of Acute Stroke and TIA Patients who Received a CT/MRL Scan Within 24 Hours by CSC From 2018/19 to 2020/21

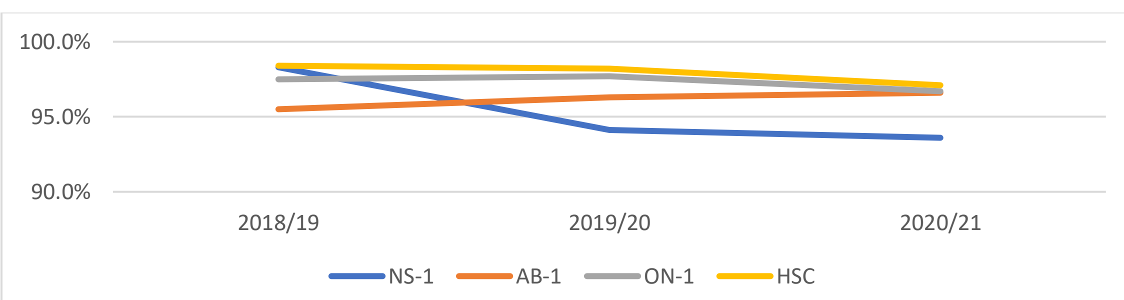


Fig 4.15. Compares the proportion of ischemic stroke patients who received a CT or MRI scan within 24 hours at the HSC with those at the CSC in NS, Calgary, and SEO. By 2020/21, HSC (97.1%), KGH (96.7%), and FMC (96.6%) were all above the target of 96.5%. In 2019/2020, and 2020/21, QEII dipped below that target but still had a proportion of 94.1% and 93.6%, respectively.

Figure 4.16: Percentage of Acute Stroke and TIA Patients who Received a CT/MRL Scan Within 24 Hours by PSC From 2018/19 to 2020/21

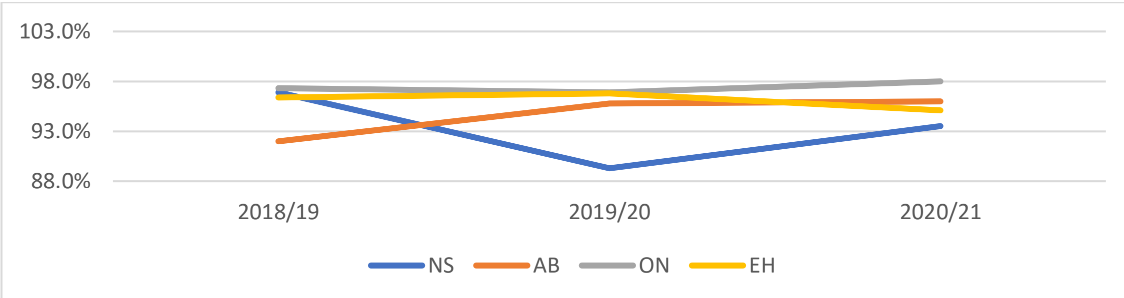


Fig 4.16. Compares the proportion of ischemic stroke patients who received a CT or MRI scan within 24 hours at EH PSCs with those at PSCs in NS, Calgary, and SEO. From 2018/19 to 2020/21, the PSCs in EH achieved the target goal of 96.5%. In 2020/21, EH was 95.1%, which was below SEO (98.0%), Calgary zone AB (96.0%), but above Central zone NS (93.5%). This shows that rural hospitals can still achieve high standards for a critical stroke diagnosis step.

Table 4.18: Pearson Chi-Squared Two-Sided Significance Test Between Stroke Populations and the Proportion of Acute Strokes and TIA Patients Receiving CT/MRI Imaging

Eastern Health	HSC	HSC	HSC	HSC	EH-PSC	EH-PSC	EH-PSC
Comparison	QEII	KGH	FMC	EH-PSC	NS-PSC	SEO-PSC	AB-PSC
Pearson Chi-Squared	p =.006	p =.715	p =.603	p =.120	p =.514	p <.001	p =.481

- In 2020/21, HSC had a significantly higher proportion of their acute stroke and TIA patients receiving CT/MRI imaging within 24 hours. Patients going to SEO PSCs had a significantly higher proportion receiving imaging compared to the EH PSC population.

II. Percentage of Ischemic Stroke In patients who received Thrombolytic Therapy

CSBP 2021 QSCIC stroke KPI 9 for hyperacute and emergency stroke is the proportion of all ischemic stroke patients who receive thrombolytic therapy. The proportion of ischemic strokes who received thrombolytic therapy included the responses of "Yes, received thrombolysis at this facility" and "Yes, received acute thrombolysis at another acute care facility prior to direct transfer". In addition, the CSBP set a target of > 21% at the 25th percentile and > 28% at the 10th percentile of top-performing hospitals. Table 4.18 presents the proportion of ischemic stroke patients who received thrombolysis by EH hospital and each EH hospitals ANOVA test and linear model. As there is missing data before 2018/19, Table 4.19 assumed that any patient receiving thrombolytic therapy was recorded. However, proportions could be higher than observed, and conclusions on years with missing data are challenging. Figure 4.17 illustrates the proportion of ischemic stroke patients who received thrombolysis by CSC including and Figure 4.18 shows the proportion of ischemic stroke patients who received thrombolysis by the combined PSCs from EH and SEO from 2018/19 to 2020/21 and NS-2 in 2018/19. NS-2 presented non-reportable cells (value 1-4) for 2019-2021 and AB either had zero or N/R cells for all years. Therefore, were not included in Figure 4.18. Table 4.20 presents the Pearson chi-squared test between stroke populations.

Table 4.19: Percentage of Ischemic Stroke Patients Who Received Thrombolytic Therapy by Eastern Health Stroke Centre and Each ANOVA Test and Linear Model

Hospital	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
HSC	8.6%	9.8%	6.7%	7.3%	9.6%	9.4%	14.1%	16.1%	19.0%
SC	3.0%	3.4%	12.0%	5.2%	10.2%	8.0%	7.6%	9.0%	10.3%
CG	5.5%	6.4%	19.5%	7.9%	3.9%	5.5%	8.7%	8.7%	4.6%
GBC	0.0%	9.8%	0.0%	18.0%	17.8%	8.6%	2.4%	4.2%	8.9%
BPH	3.3%	3.1%	5.3%	10.3%	15.6%	7.7%	0.0%	5.0%	2.9%
Other	0.0%	11.1%*	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

*Thrombolysis prior to transfer

Hospital	Anova	Coefficients
HSC	p =.005	.013x + .047
SC	p =.104	.007x +.043
CG	p =.604	(-).003x +.096
GBC	p =.808	.002x +.066
BPH	p =.821	(-).002x +.067

- From 2012/12 to 2020/21, HSC was the only EH stroke hospital to report a significant increase in the proportion of their ischemic stroke patients receiving thrombolysis. HSC thrombolysis rates have steadily improved over time to 19%.
- From 2018/19 to 2020/21, rates at SC have ranged from 7.6% to 10.3%. This is expected as EMS are instructed to bypass SC for HSC with an expected hyperacute stroke patient.
- Rates at the three rural PSCs were low from 2018/19 to 2020/21.

- In 2015/16 and 2016/17, Clarenville had two good years at 18.0% and 17.8% but significantly dropped due to variability in decision makers, only having one internist, wait times for on-call support, and patients arriving outside treatment windows.
- Rates at the HSC are steadily rising, whereas the rates of the other four PSCs are < 11%.

Figure 4.17: Thrombolytic Therapy by Comprehensive Stroke Center

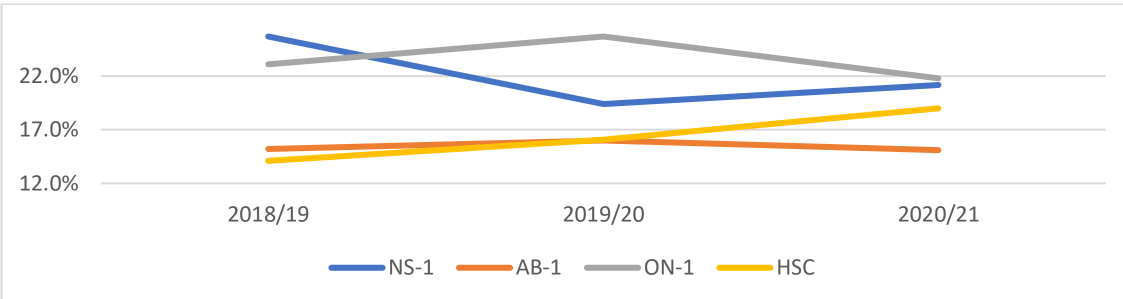


Fig 4.17. Compares the proportion of ischemic stroke patients who were treated with thrombolytic therapy at the HSC with those at the CSC in NS, Calgary, and SEO. HSC has shown that they can improve their ischemic stroke care as they have steadily improved their thrombolysis rates. In 2020/21, HSC had a thrombolysis rate of 19.0%, just below the target of 21%. KGH (21.8%) and QEII (21.2%) were above the target, but FMC (15.1%) was lower.

Figure 4.18: Thrombolytic Therapy by Primary Stroke Center

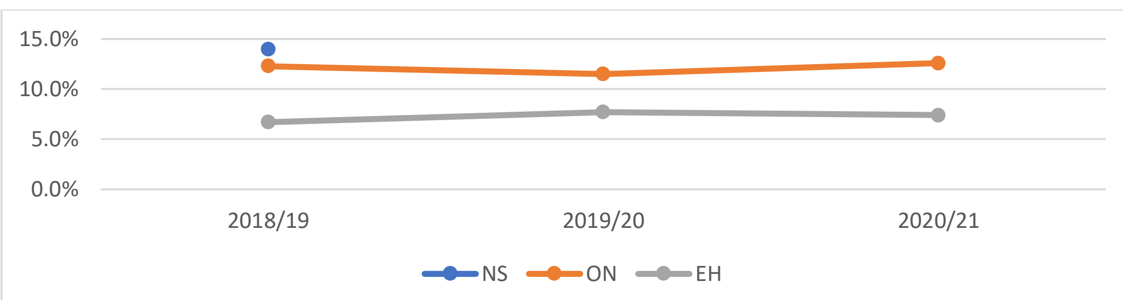


Fig. 4.18. Compares the proportion of ischemic stroke patients who were treated with thrombolytic therapy at EH PSCs with those at the PSCs in NS, Calgary, and SEO. In 2020/21, the combined thrombolysis rate of the PSCs in EH was 7.4%. This rate was much lower than the HSC (19.0%) and the PSCs in southeastern ON (12.6%). Belleville (ON-3) has a similar ischemic stroke population to HSC and had the highest thrombolysis rate of the PSCs at 14.0%. On the other hand, SC, an urban hospital in St. John's, only had 10.3% of their ischemic stroke patients receiving thrombolysis. Many PSCs in other regions had non-Reportable cells.

Table 4.20: Pearson Chi-Squared Two-Sided Significance Test Between Stroke Populations and the Proportion of Ischemic Strokes Receiving Thrombolysis

Eastern Health	HSC	HSC	HSC	HSC	EH-PSC	EH-PSC	EH-PSC
Comparison	QEII	KGH	FMC	EH-PSC	NS-PSC	SEO-PSC	AB-PSC
Pearson Chi-Squared	p =.423	p =.333	p =.086	p <.001	p =.005	p =.035	p <.001

- In 2020/21, HSC reported a non-significant difference in thrombolysis rate compared to the other health regions CSC. When compared to the ischemic stroke population going to EH PSC, HSC was significantly higher.
- In 2020/21, only EH and SEO reported their ischemic stroke patients received thrombolysis when arriving at a PSC. When compared, EH PSCs had a significantly lower proportion of their ischemic patients receiving thrombolysis compared to SEO.

III. Percentage of Ischemic Stroke and ICH Admitted to a Stroke Unit

CSBP 2021 QSCIC stroke KPI 25 for acute inpatient stroke care recommends measuring the proportion of acute stroke patients (excluding TIA and SAH) managed on a designated geographically defined integrated, acute, and/or rehabilitation stroke unit at any point during hospitalization. The three rural PSCs do not have a stroke unit. CSBP has set a target of > 75% of Ischemic and ICH patients admitted to a designated stroke unit. Table 4.21 presents the proportion of ischemic and ICH patients admitted to a designated stroke unit from 2018/19 to 2020/21. Unfortunately, data on the other Canadian regions was unavailable.

Table 4.21: Percentage of Ischemic Stroke and ICH Admitted to a Stroke Unit

Hospital	2018/19	2019/20	2020/21
HSC	80.1%	77.4%	74.75%
SC	80.6%	81.7%	67.3%

- In St. John's HSC implemented a stroke unit in 2016/17
- The target of >75% of ischemic and ICH stroke patients admitted to a stroke unit was achieved in 2018/19 and 2019/20 but was lower at SC in 2020/21.
- Stroke Units have proven their effect on stroke recovery. Therefore, I would recommend developing a strategy to support rural patients in EH. Transporting recovering patients to a stroke unit equivalent able to support the rural region could be beneficial.

IV. Ischemic Stroke and TIA patients Discharged on Anti-Thrombotic Therapy

This indicator is not a KPI in the CSBP but is collected in Project 340 and is of interest to this project. Patients who died before discharge were excluded. Table 4.22 present the proportion of ischemic stroke and TIA patients discharged on anti-thrombotic therapy from 2018/19 to 2020/21 and each EH hospitals ANOVA test and linear model. NLCHI and the provincial stroke scorecard set a target of > 90%. Figure 4.19 illustrates the proportion of ischemic stroke and TIA patients discharged on anti-thrombotic therapy from 2018/19 to 2020/21 by CSC including HSC. Figure 4.20 shows the proportion of ischemic stroke and TIA patients discharged on anti-thrombotic therapy from 2018/19 to 2020/21 by each region's combined PSCs, and Table 4.23 presents the Pearson chi-squared test between stroke populations. Patients who died within thirty days were excluded.

Table 4.22: Percentage of Ischemic Strokes and TIAs Discharged on Anti-Thrombotics and Each ANOVA Test and Linear Model

Hospital	2018/19	2019/20	2020/21
HSC	89.8%	95.7%	95.4%
SC	98.8%	95.8%	91.8%
CG	93.1%	98.4%	100%
GBC	84.3%	96.9%	98.6%
BPH	97.4%	96.3%	100%
Other	83.3%	72.7%	71.4%

Hospital	Anova	Coefficients
HSC	p =.362	.028x +.712
SC	p =.052	(-).035x +1.235
CG	p =.191	.034x +.696
GBC	p =.264	.072x +.361
BPH	p =.52	.013x +.875

- No hospital reported a significant change from 2018/19 to 2020/12.
- The target of 90% discharged on anti-thrombotic therapy was achieved in all the stroke care hospitals but not in the health centres.

Figure 4.19: Percentage of Ischemic Strokes and TIAs Discharged on Anti-Thrombotic Therapy by Comprehensive Stroke Centre From 2016/17 to 2020/21

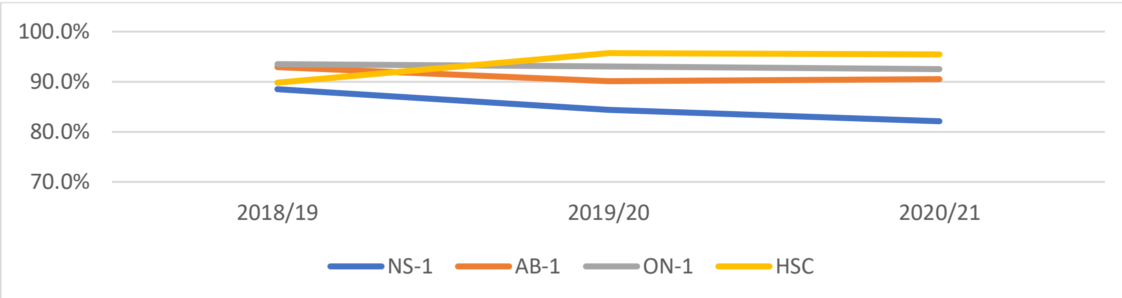


Fig 4.19. Compares the proportion of ischemic stroke and TIA patients discharged with anti-thrombotic therapy at the HSC with those from the CSC in NS, Calgary, and SEO. In 2020/21, HSC had 95.4% of their ischemic stroke and TIA patients receiving anti-thrombotic medication upon discharge, which was higher than the CSCs. In addition, KGH (92.5%) and FMC (90.5%) were above the set target, but QEII (82.1%) was below.

Figure 4.20: Percentage of Ischemic Stroke and TIA Patients Discharged on Anti-Thrombotic Therapy by Primary Stroke Centre From 2016/17 to 2020/21

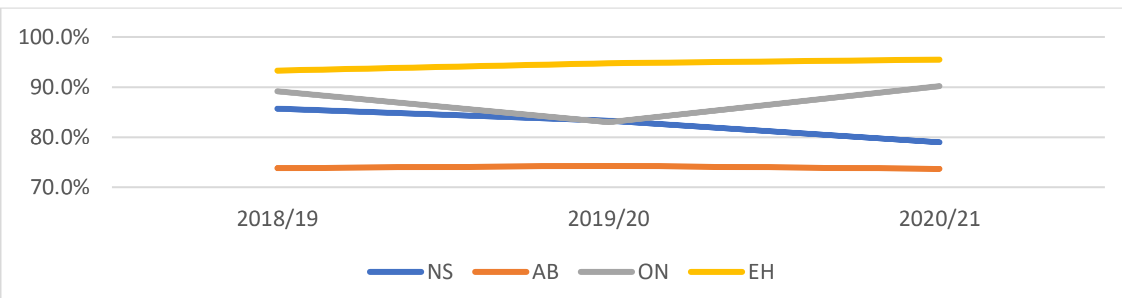


Fig 4.20. Compares the proportion of ischemic stroke and TIA patients discharged with anti-thrombotic therapy at EH PSCs with those from PSCs in NS, Calgary, and SEO. The EH PSCs were above the set target and had the highest proportion of their ischemic and TIA patients receiving anti-thrombotic therapy upon discharge. In 2020/21, the proportion was 95.5% compared to 79.0% in central zone NS, 73.7% in Calgary zone AB, and 90.2% in SEO.

Table 4.23: Pearson Chi-Squared Two-Sided Significance Test Between Stroke Populations and the Proportion of Ischemic Strokes and TIAs Discharged on Anti-Thrombotics

Eastern Health	HSC	HSC	HSC	HSC	EH-PSC	EH-PSC	EH-PSC
Comparison	QEII	KGH	FMC	EH-PSC	NS-PSC	SEO-PSC	AB-PSC
Pearson Chi-Squared	p <.001	p =.091	p =.003	p =.933	p <.001	p =.004	p <.001

- In 2020/21, HSC had a significantly higher proportion of their ischemic stroke and TIA patients discharged on anti-thrombolytic therapy compared to QEII and FMC. When comparing PSC populations, EH had a significantly higher proportion compared to the three other regions.

VII. Endovascular Therapy

CSBP 2021 QSCIC stroke KQI 14 for hyperacute and emergency stroke is the proportion of all ischemic stroke patients who receive acute endovascular treatment. The CSBP set a developmental target of > 10%. ON-01 was the only hospital submitted to Project 440, beginning in 2017/18. As HSC has just implemented EVT, it will be critical to record the proportion of ischemic stroke patients receiving the treatment in order to have the ability to compare their proportion with other hospitals. Table 4.24 presents the proportion of ischemic stroke patients from ON-1 who received EVT from 2016/17 to 2020/21.

Table 4.24: Proportion of Ischemic Stroke Patients Who Received EVT

Hospital	2017/18	2018/19	2019/20	2020/21
ON-1	8.3%	8.0%	11.3%	13.8%

- KGH surpassed the 10% target by 2019/20 and continued to improve in 2020/21.

D. A Summary of Ischemic Stroke Care Indicators

Table 4.25 summarizes nine stroke care indicators from 2020/21, comparing HSC and the three CSCs. Table 4.26 summarizes nine stroke care indicators from 2020/21, comparing the combined PSCs within the four health regions. If a number is highlighted green, the outcome is significantly better than EH. If a number is highlighted red, the outcome is significantly worse than EH.

Table 4.25: A Summary of the 2020/21 Ischemic Stroke Care Indicators for HSC and the Three Comprehensive Stroke Centers

Metrics	QEII	Foothills	Kingston	HSC
Ischemic Strokes	561	1252	487	332
7-day Mortality	9.3%	5.7%	5.7%	6.3%
30-day Mortality	16.8%	10.0%	12.3%	13.9%
TLOS	8	7	7	7
Discharged Home	37.4%	58.2%	36.8%	54.5%
Arriving by Ambulance	77.7%	83.7%	81.3%	75.9%
CT/MRI Scan	93.6%	96.6%	96.7%	97.1%
Thrombolysis Rate	21.2%	15.1%	21.8%	19.0%
Anti-thrombotics	82.1%	90.5%	92.5%	95.4%

- In 2020/21, stroke care at HSC was similar when compared to the three CSCs of Nova Scotia (QEII), Calgary Alberta (FMC), and SEO (KGH) and was significantly better at discharging ischemic patients' home (QEII and KGH), scanning their acute stroke patients (QEII) and prescribing anti-thrombotic therapy (QEII and FMC). Only FMC reported significantly better outcomes - lower 30-day mortality and a higher proportion of ischemic stroke patients arriving by ambulance.

Table 4.26: A Summary of the 2020/21 Ischemic Stroke Care Indicators for the Primary Stroke Centres

Metrics	Central NS	Calgary AB	SEO	EH
Ischemic Strokes	99	311	452	243
7-day Mortality	12.1%	7.6%	6.0%	5.8%
30-day Mortality	18.2%	12.0%	9.5%	14.0%
TLOS	8	7.4	5.5	8.4
Discharged Home	34.3%	52.7%	52.9%	51.0%
Arriving by Ambulance	73.7%	60.5%	79.6%	74.5%
CT/MRI Scan	93.5%	96.0%	98.0%	95.1%
Thrombolysis Rate	N/R	N/R	12.6%	7.4%
Anti-thrombotics	79.0%	73.7%	90.2%	95.5%

- In 2020/21, stroke care at the PSCs in EH was comparable to the other three health regions and was significantly better than NS and AB. SEO reported significantly more of their patients receiving imaging and thrombolysis compared to EH.

E. Time Series Conclusions

By 2020/21, HSC was equivalent in stroke care indicators and outcomes to the Comprehensive Stroke Centres in Central Zone Nova Scotia, southeastern Ontario, and Calgary Zone Alberta. The improvements made have been impressive. HSC has shown a significant linear trend of increasing stroke hospitalizations, increasing ischemic stroke hospitalizations, decreasing the 30-day mortality rate if their ischemic stroke patients, decreasing the median TLOS of ischemic stroke patients, decreasing ALC days of ischemic stroke patients, increasing the proportion of ischemic stroke patients discharged home, and increasing the proportion of their ischemic stroke patients receiving thrombolysis. The thrombolysis rates have risen from 9.6% in 2016/17 to 19.0% in 2020/21, nearing the target goal of 21%. Outside of HSC, primary stroke care facilities have not shown consistent improvements and have a low combined thrombolysis rate of 7.4%. Therefore, the learnings from HSC should be transferred to the PSCs and neurology should be on-call to support PSCs decision making.

After working with this dataset, there are many aspects to improve stroke care monitoring. Regions should properly collect and share data. Charting time of symptom onset or last known well helps understand if the patient was within treatment time windows. Door-to-CT time is an effective process measure. In addition, door-to-needle time (DTNT) for thrombolysis is a vital performance measurement for stroke care hospitals. DTNT is the time it takes from patient arrival to the beginning of thrombolysis. The CSBP target is set at a median of thirty minutes (Canadian Stroke Best Practices Health Systems Quality Advisory Committee, 2022).

With the addition of an EVT program, other stroke care efficiency metrics can be collected. For example, door-to-puncture time (DTPT) is the time from patient arrival to groin puncture of EVT, and door-in-door-out (DIDO) time refers to the time of patient arrival at a PSC to discharge for EVT transfer. DTPT is an outcome for HSC, and DIDO time is important for PSCs. Along with in-hospital efficiency metrics, understanding the process of EMS is essential. For example, if there are long delays in getting a patient from the scene to the appropriate hospital, the stroke system needs to know that information to improve. In addition, EMS need to measure their time on scene.

Additional missing values of interest include a stroke severity scale, reasonings thrombolysis was not provided, and disability scales at discharge and follow-up. The stroke severity scale could be the NIHSS score and can be controlled in future studies. Contraindications should also be captured to understand why an ischemic stroke patient did not receive thrombolysis. This could show that patients are not getting to the hospital in time and would be an aspect of stroke care that needs to improve. Finally, in the literature review, thrombolysis does not improve the mortality rate but impacts a stroke victim's functional independence. Discharged home is not an appropriate outcome measure for functional independence. Therefore, efforts should be made to collect the ninety-day modified Rankin score (mRS) or 90-day home time to measure the level of a patient's disability. 90-day home time is easier to collect and is highly correlated with mRS.

As a country, efforts should be made to easily capture and share quality stroke care indicators to evaluate and compare the performances of stroke care facilities. By 2018/19, data collection vastly improved throughout EH. However, stroke care in NL manually captures their data. This puts a massive strain on resources. Efforts should be made to develop an electronic form to capture and easily submit data into a database. The database should share stroke care information throughout the centres and include additional variables of interest. Especially efficiency outcomes.

Chapter 5 – Stroke Care Pathways

Multiple case studies investigated hyperacute ischemic stroke care within four Canadian Health regions: Eastern Health (EH), Newfoundland and Labrador (NL), Central Health Nova Scotia (NS), Southeastern Ontario (SEO), and Calgary Zone Alberta. These cases aimed to provide a holistic view of hyperacute stroke care around each region's Comprehensive Stroke Centre (CSC) and peripheral Primary Stroke Centres (PSCs). I have used an embedded case study design to mirror a stroke patient's pathway depicted in Figure 2.1, beginning with public awareness, followed by the pre-hospital phase, Emergency Department (ED) phase, Endovascular Therapy (EVT), and patient monitoring. Using a cross-case synthesis, I compared the hyperacute stroke care of EH with the three other Canadian regions. Matrices are provided to compare each health region's structure and hyperacute ischemic stroke care processes.

5.1 Structure of Each Stroke Region

Each region has a Comprehensive Stroke Centre (CSC). EH has the Health Science Centre (HSC) when their EVT program becomes a fulltime service. Halifax has the sole Comprehensive Stroke Centre (CSC) in NS, located at the Halifax Infirmary (HI), one of the buildings of Queen Elizabeth II (QEII) Health Sciences Centre. Kingston General Hospital (KGH) is their regional stroke centre, a CSC with Accreditation Canada Stroke Distinction providing Endovascular Therapy (EVT) (Our Region | Stroke Network of Southeastern Ontario, 2022). The Calgary Stroke Program (CSP) is also one of the eleven recipients of Accreditation Canada's distinction in Stroke Care (Pellerin, 2019). Foothills Medical Centre (FMC) is a "… very well positioned …" (AB-02) CSC allowing all the strokes within the Calgary Zone and the eligible EVT candidates south of Red Deer to go to one centre. To support those regions, there are Primary Stroke Centres (PSCs) to help administer thrombolysis, assist in diagnosis through direct imaging, and transfer EVT patients to CSCs. In the Calgary zone, all stroke patients go directly to the FMC and FMC supports a much larger region and population compared to HSC, QEII and KGH. EH has a similar landmass to SEO but a smaller population. Table 5.1 compare the four regional stroke networks.

Table 5.1: A Comparison of the Four Regional Stroke Networks

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Largest of four (NL) health authorities.	One of the four (NS) Health Regions. Largest population	SEO stroke network is one of eleven in Ontario	One of five health zones in Alberta Health Service (AHS)
Population: 313,267	**Population**: 424,037	**Population**: 482,391	**Population**: 1,551,876
Land Mass:19,395.25 km^2	**Land Mass**: 6901.70 km^2	**Land Mass**:18,252.97 km^2	**Land Mass**:38,752.66 km^2
HSC is NL's only CSC (aside from 24-hour EVT)	QEII is NS's only CSC	KGH is SEO's Regional Stroke Centre	FMC is one of the two CSCs in Alberta
4 PSCs/category A hospitals	Built around major centres	QHC is SEO's District stroke centre	FMC is the only stroke centre in their zone
NL Health Accord: create a provincial stroke network	Lost their strategic command in the 2015 Health Care reorganization	Ontario's health network (CorHealth) focused on cardiac, stroke and vascular care	Strategic Clinical Network to oversee provincial stroke
		Accreditation Canada's Stoke Distinction	Accreditation Canada's Stoke Distinction

SEO and Calgary have a dedicated health network that oversees provincial stroke care and has achieved Accreditation Canada's Stroke Distinction. Their health networks have emphasized continuous quality assurance to maintain CSBP recommendations. NS lost its strategic command in 2015 due to a healthcare reorganization. Since that time, they have struggled with policy change without a network responsible for stroke. Therefore, I would recommend NL to develop a dedicated health network that oversees provincial stroke care. The NL Health Accord has recommended implementing a provincial stroke network to improve their province's care. In addition, striving for stroke distinction will create a framework to raise the quality of care and support quality assurance.

5.2 Public Awareness

Public awareness and education about the signs of stroke contribute to a patient's overall potential for a positive outcome. As each minute passes untreated, a typical stroke patient will lose 1.9 million neurons (Saver, 2006). The responsibility for public awareness is shared by many, with decisions, funding and actions taken by the government, health system leaders, health care providers, educators, community services and health organizations. With recognition, patients should call 9-1-1 immediately, beginning the pre-hospital phase. Public awareness can improve the time to get to an ED. Reducing that time should improve the proportion of patients receiving thrombolysis of EVT. Table 5.2 summarizes public awareness and stroke prevention within the four regions. No region provided an innovative solution to improve the general knowledge of stroke symptoms. As public awareness is the mandate of the Heart & Stroke (H&S) Foundation, stroke systems do not want to invest resources in campaigns they do not know will be effective.

"It's mainly Heart and Stroke, but what happens... they tend to come through us to ask us about some public messaging that we could support as well. I think we've tapped it out with what we currently do. there's opportunity to do more. Unfortunately, as you know, some of that awareness comes at a cost." (NL-11)

"Public awareness is the H&S mandate and we're using the FAST campaign. If they call 9-1-1, the patient Is in our protocol." (ON-01)

"Public Awareness falls in the hands of the Heart and Stroke Foundation and the Heart and Stroke has been doing things with the provincial Heart and Stroke groups to improve awareness of stroke in the community." (NS-02)

"Primary public education is done by the H&S Foundation. We follow the H&S Foundation on this. To a large extent we delegated/vacated the public awareness space to the H&S except when asked." (AB-01).

"CSP is partnered with the H&S foundation" (AB-03).

Table 5.2: Summary of Public Awareness and Stroke Prevention

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Public Awareness - Responsibility of the H&S - FAST campaign: - In EDs - On Ambulances - Monthly communication of Stroke program to communications team - Weekly for Stroke month - Local commercial	**Public Awareness** - Responsibility of the H&S - FAST campaign - On Ambulances - Use different mediums - Social Media - Blogs - Podcasts	**Public Awareness** - Responsibility of the H&S - Work closely with H&S - FAST campaign - On Ambulances - Believe a variety of methods should be used - Help H&S make patient connections for stories	**Public Awareness** - Responsibility of the H&S - Partnered with the Canadian Stroke Consortium - Reactive: help when asked - FAST campaign
Stroke Prevention - Educate high-risk - Carotid Dopplers and CTAs - HSC neurologists educate TIA patients - Stroke education booklet	**Stroke Prevention** - This information was not collected	**Stroke Prevention** - TIA and Minor Disabling Strokes - Care pathway involving ED/stroke clinic/consultation - Patient education package with contact numbers	**Stroke Prevention** - TIAs/minor events - Stroke Prevention Clinic: Canadian guidelines - Delayed Stroke Protocol after 48 hours
Barriers - Public awareness comes at a cost - NL population downplay symptoms/ do not go to hospitals - TIA management is not meeting Canadian Guidelines - Need more TIA Clinics	**Barriers** - FAST does not capture posterior strokes. - Uncertainty in non-FAST campaigns; Ads can be expensive with a short half-life - Slow Process	**Barriers** - Since H&S went national, they have been struggling with funding as Ontario has provided less - A long way to go, especially in rural regions who are not using ambulances	**Barriers** - Language barrier of new immigrants = more walk-in patients/delayed presentation. Have not identified a solution.

Each region uses the FAST campaign throughout their hospitals and on their ambulances. In addition, every month EH's communication team releases of H&S material on their social media platforms. During stroke month (June), they provide information weekly. While they have some collaboration, there is not much more EH can do for free/at a low cost. Unfortunately, EH believe there are a lot of patients arriving late. Elderly patients based in rural regions are the biggest issue. They arrive late and sometimes the next day. They do not want to bother their children or EMS. Other patients rely on their family who may not bring the patient to the appropriate stroke centre. Therefore, NL needs to record these patients to identify what patients are arriving within the time windows and if they are going to the appropriate hospitals. If a patient or witness can call 911, they are in the ASP, present by ambulance, receive timely treatment, and have access to more treatment options.

"The [FAST] campaign is really effective but we [are] not seeing that connect yet with the general public" (NL-01)

NS understood the difficulties of Public Awareness and believed that the public loses interest without variation like social media and television. Stroke can also learn from other campaigns. COVID was an extreme scenario that can teach us a lot on how to reach the population. Smoking has used intergenerational education at schools. For example, teaching children the signs of stroke, who go home and transfer the knowledge to their elders. Finally, investigating other programs (like cardiac) to understand how their strategies could help.

The Ontario Stroke Report FY 2020/21 showed that in SEO, 68.6% (66.2% in Ontario) of stroke and TIA patients arrived at the emergency department (ED) by ambulance. However, ten years ago, only 40% arrived by ambulance. While improving, there is still a long way to go, especially in rural regions. SEO monitors their stroke ambulance arrivals. With a decline in the proportion of patients arriving by ambulance, they often put together a local media campaign.

As public awareness is the mandate of H&S, stroke systems should focus on stroke prevention for TIA, minor events, and high-risk patients to prevent a more significant ischemic event. Participants from EH have recognized that their TIA management is not meeting Canadian Guidelines. EH patients should receive stroke education booklets that are reviewed with them by the allied health team and HSC neurologists will educate their TIA patients. In Clarenville they expedite carotid dopplers (a non-invasive ultrasound of the large carotid arteries that supply blood to the brain) for TIA patients. These ultrasounds are intended to see if the arteries are narrowed due to atherosclerosis. If so, the TIA patients are at a high risk of an ischemic stroke and may benefit from early endarterectomy. However, participant NL-08 is not convinced the provincial management of TIAs meets Canadian guidelines and requires further work. Therefore, NL should investigate stroke prevention and TIA clinics throughout the province.

In Calgary, they have highlighted the effectiveness of their Stroke Prevention Clinic. Their clinic follows the CSBP guidelines in terms of assessing, treating, and educating adults with a TIA or minor stroke. These patients are at a high risk of having an ischemic stroke. If they arrive within forty-eight hours of their event, they receive imaging, have a consult with an FMC stroke fellow, and are usually put on dual antiplatelet therapy. Within the next two days, the patient will receive a carotid doppler, echocardiography, and an MRI. Patients arriving after forty-eight hours from symptom onset would have a delayed stroke protocol and are referred to the stroke prevention clinic. In SEO, they have a care pathway involving their ED, stroke clinic and consultation. Efforts can be made to prevent future more significant and more costly ischemic strokes. NL Health Services has planned to construct a new Cardiovascular and Stroke Institute for HSC. The institute strives to provide an organized hub, including care for TIA patients and stroke prevention. While the institute is a fantastic addition to stroke care in St. John's, additional services will need to be provided for the rest of the province. However, further investigation will need to be applied to identify where clinics can be placed to effectively support patients and optimize resources in that region.

5.3 Emergency Medical Services

Emergency Medical Services (EMS) are vital in hyperacute stroke care. When 9-1-1 is called, dispatch sends an ambulance, and EMS conducts an on-scene assessment and pre-notifies the closest stroke centre of an incoming stroke patient. Therefore, stroke systems have implemented standardized protocols and communication pathways to assist paramedics in making the correct decision. Quick assessment allows EMS to immediately bypass to the most appropriate stroke facility. Pre-notification will enable the stroke team to activate their acute stroke protocol, prepare and wait for the patient, clear a CT suite, and pre-registration enables early orders for a CT scan and medication. Each region has had some difficulty dealing with privacy legislation for pre-identification but all have found solutions to adapt. Table 5.3 compares the description of each EMS system within the four regions. Descriptive themes that presented in the data included differing EMS systems, similar efficiency process, how regions adapt to rural regions with PSCs, and how EVT has affected EMS

Table 5.3: A Summary of Emergency Medical Services from the Four Canadian Regions

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
EMS System - RHA and privately operated services - Provincial Medical Director (for EMS) on	**EMS System** - Centralised ambulance services	**EMS System** - Five different municipally funded providers	**EMS System** - Unified provincial pre-hospital system

the provincial steering committee - Communication Centre, with eDispatch and a ProQA system - Standard model = 50% PCPs/50% ACPs - Activate a code stroke within 4 hours LSN	- Standardize processes with specific and fast rules - EMS guidelines on their learning management system - Clinical app with up-to-date guidelines - Dispatcher communication (AMPDS) - DASH within 3.5 hours for Thrombolysis	- Maintain close contact with each chief - Focus on relationships with EMS and stroke centres - Ministry of Health regulates common standards	- Provincial EMS Medical Control Protocols - Starting point for Stat Stroke - Rely on EMS to coordinate and transfer - Dispatchers use algorithms
Essential Processes - Stroke Screen - LSN time - Bypass - Pre-notification - Pre-identification on secure line - Contraindications - Online medical control to support EMRs	**Essential Processes** - LSN time - Cincinnati Prehospital Stroke Scale (CPSS) - Bypass protocol - Pre-notification with ETA - Pre-identification - Contraindications - 2 IV lines	**Essential Processes** - Early recognition using prompt card - Establish LSN - Bypass using GPS - Pre-notification with ETA - Pre-registration - Start 2 18g IV lines - Second notification for long ETAs	**Essential Processes** - EMS Stroke Screen (CPSS) - Bypass - Pre-notification patch with ETA - Collateral info on baseline function - Patient identifiers - RAAPID can share patient identifiers
EVT roles - RACE score - 6 hours from LSN - Additional communication - MedFlight needed	**EVT roles** - FAST-VAN - Long transfers - LifeFlight - Transfer within 11 hours LSN	**EVT roles** - LAMS - Additional communication and transfers	**EVT roles** - LAMS - RAAPID to coordinate provincial consultations - Air transportation

Barriers
- No centralized provincial system.
- No consensus on the standard criteria
- Differences in provincial care due to EMRs and the "Best efforts clause"
- Must check for contraindications
- Activating a code outside the treatment window
- Air ambulances are often slow to respond and require an hour before transferring
	Barriers
	- CPSS only captures anterior ischemic strokes. 20% are posterior (5 D's)
	- Sometimes IV lines are not patent
	- Privacy concerns were a stumbling block. Took years to get a privacy waiver
	- Un-registered patients cannot be scanned
	- Availability
	- Several hours delay if LifeFlight already on mission
		Barriers
		- Privacy preventing pre-registration
		  - Dispatchers can use a secure phone.
		- Education dependent on region and service
		- No bypass after 6 hours
			Barriers
			- No identifiers over dispatch radio
			  - Register as unknown.
			  - Use RAAPID
			- Long Distances
			- Understaffing
			- Slow repatriation response
			- Challenge for rural communities as ground ambulances are saturated.
			- Relying on STARS who also have limited resources and are expensive.

5.3.1 Emergency Medical System

"If you look at a good program, you need it set from paramedics right through" (NL-03)

EH and NL has a fragmented EMS system with regional health authority (RHA) and privately operated services. The provincial medical director provides recommended guidelines, but the consensus is difficult to acquire with multiple operating services. Calgary and NS have a unified provincial ambulance system to standardize their protocols, and SEO has five different municipally funded providers with regulated standards. Along with a fragmented system, NL rural communities have different care levels due to a dependency on Emergency Medical Responders (EMRs). The Department of Health required the RHAs to staff their ambulances with fifty percent Primary Care Paramedics (PCPs) and fifty percent Advanced Care Paramedics (ACPs). ACPs have a higher level of training. However, outside of St. John's and the metropolitan area, the rural services rely on Emergency Medical Responders (EMRs). Using the best-effort clause, private operators hire EMRs when they cannot find PCPs or ACPs. EMRs have about two weeks of first aid training and know how to drive an ambulance. Dual EMR crews have different guidelines disrupting quality of stroke care. These crews do not bypass, are unable to measure the patient's capillary blood glucose level and cannot manage a patient's airway (addressed before additional care). To assist, EMRs are encouraged to call an online medical control physician for advice to and can be recommended to bypass. In addition, EMRs can request PCPs, who are better suited to treat stroke patients, to intercept their stroke patients.

In addition, there are staffing shortages applying stress on ground and air EMS across the country, disrupting their standard of care. The standard of care in EH was set by the provincial medical director with the help of their neurology group, stroke experts and leaders. The standard protocol begins as soon as 9-1-1 is called. Emergency Medical Dispatchers (EMDs) use a high-quality eDispatch system with a ProQA System. The ProQA system prescribes protocols with a series of validated decision rules and scripts that dispatchers use to collect information, dispatch the appropriate service, and provide pre-arrival instructions. In EH, EMDs are all paramedics who have completed EMD training, including the use of ProQA. ProQA has built-in quality assurance that reviews and provides continuous feedback.

> "Eastern Health has a centralized medical dispatch … The dispatch includes Metro and Carbonear… They have been advocating for a provincial wide centralized medical dispatch but there are complicated reasons for that not occurring" (NL-04)

NS used to have multiple privately owned paramedic services, but now they are centralized around one company. This has been helpful in maintaining standardized protocols. The government's Department of Health worked with the Prehospital Evidence-Based Paramedic (PEBP) program, a repository of prehospital evidence, to standardize guidelines with specific and fast rules. Paramedics can access stroke guidelines on route through their learning management system and clinical app. Dispatching follows the Advanced Medical Priority Dispatch System (AMPDS) to go through some pre-arrival instructions and over the phone tests.

The SEO region has five different municipally funded ambulance providers who maintain close contact. In addition, one of Ontario's provincial stroke strategies was to improve relationships between EMS providers and stroke centres (The Canadian Stroke Strategy, 2010).

> "The level of education is a bit different dependant on region, but the Ministry of Health oversees the standards that all paramedics have to meet." (ON-03)

SEO uses Central Ambulance Communication Centre (CACC) to relay information to the charge nurse at the receiving EDs. The KGH charge nurse activates ASP through their hospital switchboard resulting in a page to the stroke team notifying of an incoming acute stroke with an associated ETA. At QHC, participant ON-06 explained how their code stroke is paged overhead, and repeated when EMS call to say they are five to ten minutes away. Appendix X illustrates the roles and responsibilities of the Acute Stroke Protocol Activation, and Appendix XI lists the ASP team for day hours versus after-hours, weekends, and holidays.

Calgary relies on its EMS service to coordinate and transfer ischemic stroke patients to the Foothills Medical Centre (FMC). The AHS has a unified provincial pre-hospital system which allows their province to create provincial EMS Medical Control Protocols. These protocols provide clear criteria for to maintain a consistent standard of care. When calling 9-1-1, the pre-hospital dispatchers use algorithms to flag stroke signs for the EMS on route.

"I actually think we're pretty good at that within our system because we have such a well-established protocol." (AB-03)

In an ideal world, paramedics would identify a stroke using their prompt card presented in Appendix I, bypass to the closest stroke centre, and notify the receiving hospital to activate Code Stroke. They use a modified Cincinnati stroke screen that participant was described as sensitive but not specific, which has caused some contention with their neurology group. Parties hope to select patients more effectively, but casting a larger net is important. Optimally over twenty percent of ischemic stroke patients are treated with thrombolysis. Therefore, paramedics understand that stroke care is time sensitive. CPSS misses posterior strokes, accounting for 20% of ischemic strokes, that commonly present "five D" symptoms: Dizziness, Diplopia, Dysphagia, Dysarthria and Dystaxia (NS Stroke Network, 2020). On-scene paramedics also conduct a standard history, physical, and identify contraindications such as a patient's low capillary blood-glucose measurement (hypoglycemic patients can present with stroke-like symptoms). In addition, this prompt card is excluding pregnant patients and patients with anticoagulation for thrombolysis. NL should re-evaluate this card to include these patients for Code stroke activation for LVO screening and EVT eligibility.

The Ontario stroke network has developed a prompt card that is easy to learn (paramedics interpret it with 98.8% accuracy), sensitive and reliable that will not overburden the paramedic services (Stiell et al., 2017). With a positive stroke screen, EMS have a GPS directing them to the closest stroke centre (KGH or QHC) within six hours of LSN for proper imaging and treatment. Appendix XII presents the 2021 Paramedic Prompt Card for Acute Stroke Bypass Protocol.

"In fact, it's a better screen for ischemic stroke than we get in, in patient's staff" (ON-06)

The AHS Stroke Screen combines the Cincinnati Stroke Screen and the LAMS score. Appendix XIII presents AHS's EMS Stroke Screen which are available on EMS computer units. Based on the patient's stroke screen, EMS are expected to pre-notify the receiving emergency department (ED) of an incoming stroke patient to activate their stat stroke protocol. If unsure, paramedics can call their Online Medical Control (OLMC). If the stroke is severe enough (LAMS = 4 or 5), the paramedics can activate the Stat Stroke from the field up to six hours from LSN.

With a positive Cincinnati stroke screen, paramedics call the closest stroke centre as soon as possible to provide a stroke alert. HSC requests another notification when the paramedics are closer to allow the patient care facilitator to activate their code stroke. To call for a Code Stroke, EH's current EMS guidelines include four hours from Last Seen Normal (LSN) to get to the closest stroke hospital. This allows the hospital to provide thrombolysis within 4.5 hours from LSN. Table 5.4 presents factors paramedics must monitor, and Figure 5.1 shows Newfoundland and Labrador's 2023 Code Stroke Destination Algorithm with the addition of EVT screening.

Figure 5.1: 2023 Code Stroke Destination Algorithm

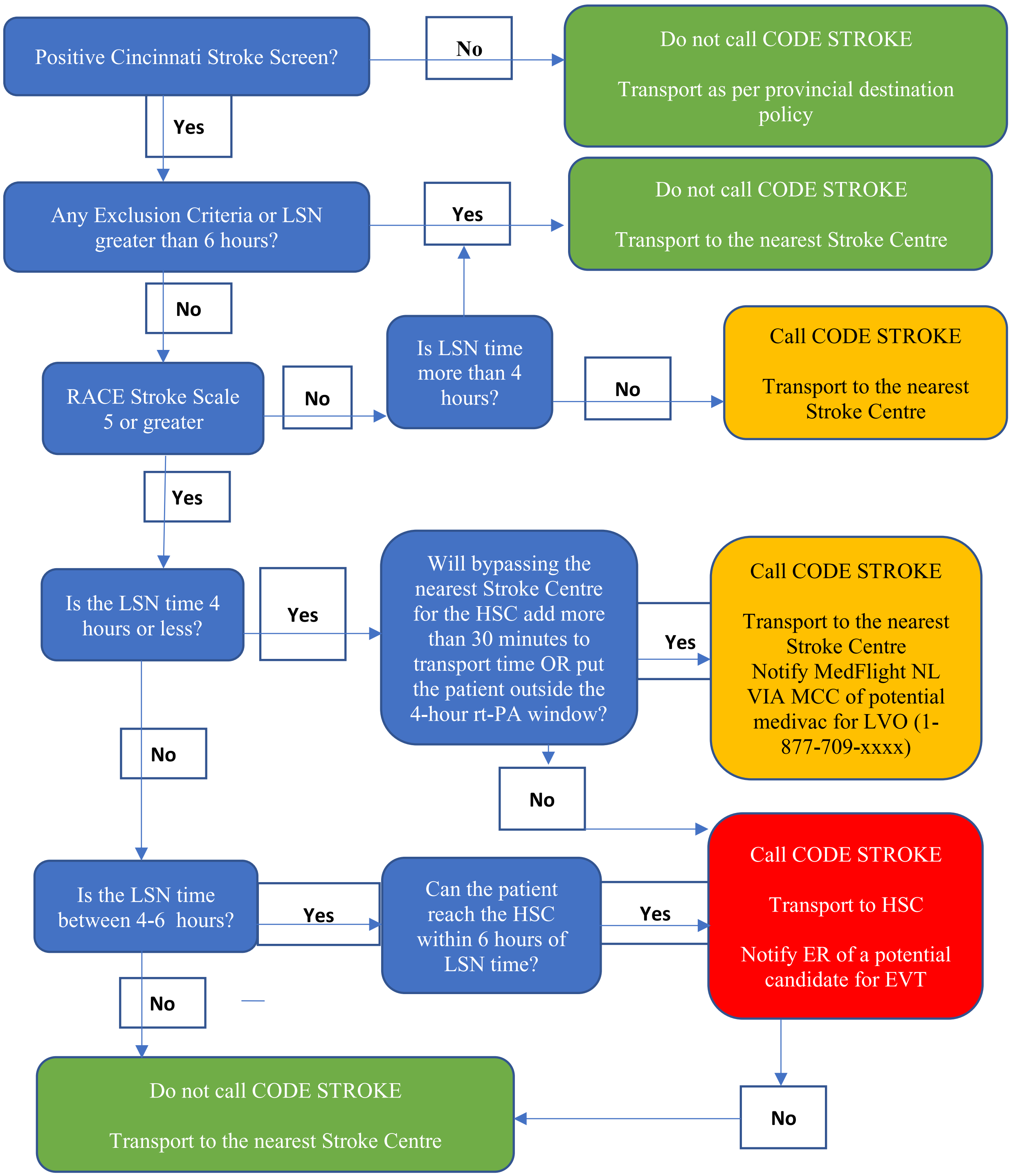


Fig 5.1. Presents the EH Code stroke destination algorithm for Emergency Medical Services. The new EMS algorithm for stroke care has introduced a Large Vessel Occlusion (LVO) screen and an increased time window of six hours for potential EVT candidates.

Table 5.4: EMS Code Stroke – Recognize and Mobilize – Minimize on-scene time, complete interventions during transport, if possible

Initiate Advanced Life Support (ALS) assessment and monitoring
Establish and document accurate Last Seen Normal (LSN) Time The last time a patient was witnessed or confirmed in their usual state of health and without signs or symptoms of stroke. It is critical to get an accurate LSN time
Measure blood glucose Treat hypoglycemia as per Symptomatic Hypoglycemia Protocol
Perform 12 Lead ECG
Complete Paramedic Code Stroke Assessment Form
Follow Code Stroke Destination Algorithm
Establish 2 x 18G or larger IVs during transport, place one in the right antecubital fossa, if possible and not contraindicated
Patients Not Eligible for Thrombolysis Patient with signs and symptoms of an acute stroke who are presenting outside the thrombolysis window or are otherwise not eligible for thrombolysis should still be brought to a Stroke Centre and bypass other facilities, if applicable

*If at any time there is airway compromise or other immediate life-threat that cannot be effectively managed during transport, transport to the closest emergency department, even if it is not a designated Stroke Centre

5.3.2 Efficiency Processes

Efficiency processes include pre-notification, a bypass protocol, and pre-identification. Firstly, pre-notification with an estimated time of arrival (ETA) allows the receiving stroke centre to activate their Code Stroke and notify their stroke team to be ready and waiting. When pre-notified, the receiving emergency department (ED) nurse calls the emergency paging line to inform “We are calling a code stroke at this time” (NL-01). Then their switchboard pages their stroke team indicating a Code Stroke activation with the patient's ETA. Secondly, the bypass protocol is critical to quickly access a hospital with a Computed Tomography (CT) scanner for diagnosis and thrombolysis for urgent therapy. In St. John’s, they bring Code Stroke patients to the HSC instead of St. Clare’s (only minutes from HSC) because HSC has the stroke neurologists, who can significantly reduce the Door to Needle Time (DTNT). Finally, the neurology group pushed for pre-identification in 2020, which included paramedics providing patient identifiers (name, date of birth, and MCP) to pre-register the incoming patient and have access to the patient's medical history and medication. Unfortunately, the EMS radio is not secure. Therefore, their EMS radio the receiving ED of a code stroke and call back on a secure phone to provide the patient identifiers. The receiving ED staff should know to prompt/request a secure phone call with pre-identifiers. Pre-registration allows an earlier CT requisition, improving any delays of a CT and treatment.

"I mean the huge efficiencies for us will be the pre-hospital notifications. Um, the immediate activation of that code stroke" (NL-10)

In NS paramedics arrive and identify the patient's time of Last Seen Normal (LSN), determining signs and symptoms of stroke, bypass to the closest stroke hospital, and notifying that receiving hospital. If EMS can reach a stroke centre within 3.5 hours of LSN, the patient is eligible for thrombolysis (NS Stroke Network, 2020). In addition, paramedics should identify possible risk factors, a medical history, and a physical exam to help guide treatment and transport decisions (NS Stroke Network, 2020). At the HI, the physician may require further information, and will activate the ASP. Table 5.5 identifies the key points from NS EMS, and Appendix XIV presents their prehospital acute stroke protocol.

Table 5.5: Key Points in Stroke Care for Emergency Health Services

Identify a positive Cincinnati Prehospital Stroke Scale early
Use the Last Seen Normal Time to calculate the prehospital reperfusion interval
Consult the nearest District Acute Stroke Hospital as soon as possible if there is a positive Cincinnati Prehospital Stroke Screen within the reperfusion time window
Identify possible posterior circulation strokes
Never bypass the nearest District Acute Stroke Hospital
Bring the patient's family or substitute decision maker or have their contact information
Early Notification and treatment improve outcomes

(NS Stroke Network, 2020)

The SEO stroke network presented what they learned by achieving best practice target times for hyperacute treatment. The vital pre-hospital elements included: “Early recognition of stroke signs, pre-notification of Acute Stroke Protocol (ASP), and Early communication to the stroke team of ASP by ED & Switchboard” (Stroke Network Southeastern Ontario, 2021, p.5). EMS must pre-notify the receiving ED as soon as possible, stating their estimated arrival time. Approximately sixty percent of patients are outside Kingston, ETA helps establish when their stroke team needs to gather (Stroke Network Southeastern Ontario, 2021). The longest pre-notification for KGH is about sixty minutes, within one hundred kilometres.

“The bigger the lead time, the faster we’re going to be able to treat.” (ON-01)

Additional efficiency learnings included EMS starting two 18 g Intravenous Lines (IVs) on route (if possible), notifying that the IVs are patent, and providing a second notification for longer transport time with a fifteen-minute ETA (Stroke Network Southeastern Ontario, 2021). In 2020, health information privacy was one of the issues KGH was figuring out and working to rectify. privacy rules are odd in Ontario and KGH required clarification from the Ministry of Health and their privacy officer. Their privacy rules suggested that privacy is second to preserving life. To work around these privacy concerns, their dispatchers would call back on a secure phone line. However, QHC ethics cleared paramedics to provide only health card numbers over their radios. When the health card comes through, admitting activate the patient into the system. Most of the time, there is access to the patient’s electronic record through Ontario Connect, which helps to efficiently treat and check the medical history.

“Privacy is second to preserving life” (ON-01)

Alberta’s EMS provide pre-notification with their ETA and a rough summary on the patient (gender, age, significant deficits). Next, the receiving hospital will activate its Stat Stroke, which has been streamlined by lots of Quality Improvement (QI) work. Finally, a page is fanned out to the necessary Stroke team, ED, radiology to prepare their team, meet the patient upon arrival, and clear a Computed Tomography (CT) bed for imaging. Upon arrival, stroke physicians have difficulty getting collateral history about baseline function. Therefore, their EMS are trained to ask specific questions. For legal reasons, Calgary cannot provide patient identifiers over the EMS pre-notification call. Therefore, FMC registers their Stat Stroke patients as unknowns, which has helped their treatment times, as collecting identifiers upon arrival prevented early orders for CT imaging/treatments. Unknown registration does not occur for all their patients as they like to register using their ID name, which is more accessible through their Referral, Access, Advice, Placement, Information & Destination (RAAPID) communication system. RAAPID is a province-wide initiative acting as a centralized access point for emergency patient transfers within Alberta. When contacted, a 24/7 operator would immediately page the attending stroke physician at FMC and a transport physician to get on a conference call with the physicians/EMS crew who are with the patient. During the call, the RAAPID operator will provide real-time updateson transportation resources and pull in our [Shock Trauma Air Rescue Service] STARS Air Ambulance to aid in longer transportation decisions. RAAPID calls can also provide patient identifiers. With patient identifiers, Alberta use Connect Care to provide provincial electronic medical records that are essential when making thrombolysis and EVT decisions.

5.3.3 Rural Regions

For the rural hospitals, EMS go to the closest stroke centre for a CT scan if they question stroke-like symptoms. In Clarenville, EMS pre-notifies but they wait to activate their code stroke until the triage RN or ED physician confirms to patient is having a stroke. While they attempted to change to pre-hospital calls, numerous aspects prevented that change. Firstly, ambulance providers are challenged regarding crew staffing resulting in dual EMR ambulance teams who are unable to bypass. However, this has essentially become irrelevant as category B hospitals are closed more often than open due to staffing challenges. Secondly, Clarenville only has three internists (rotate call 24/7 for a week at a time) and two radiologists (on call 24/7 for up to two-three weeks at a time). Therefore, Clarenville cannot burn out their specialists due to false Code Stroke activations. While they wait to activate their Code Stroke, participant NL-08 believes they can still achieve DTNTs of under thirty minutes during their working hours of 8am-4pm and until 11pm if they have a radiographer dual CT technologist trained. If there is no dual CT technologist or the patient comes in after 11pm, thirty to forty-five-minute DTNT is achievable by pre-warning a CT tech while EMS in enroute. Like Clarenville, Burin has their ED physician examine the suspected stroke patient before activating a code stroke. When EMS calls ahead, Burin often advises appropriate personnel of a potential code stroke to prepare for activation.

Ontario's The Ministry of Health regulates a common set of standards, but education level depends on region and paramedic service. Some services have basic paramedics instead of PCP or ACP. There have been issues with these different levels of certification, competencies, and experience between different services and regions.

If a patient has a stroke in a rural Albertan community, the transportation physician and stroke teams would send the patient and a helicopter to the closest PSC to properly check for thrombolysis and/or EVT eligibility. If eligible for thrombolysis, the patient can begin therapy at the PSC, then transfer to a CSC for EVT, or receive thrombolysis in the air as their STARS helicopters carry thrombolytics.

5.3.4 Endovascular Therapy

With the implementation of EVT, Figure 5.1 presents two key processes that EMS must include. First, EVT has an extended treatment window from LSN compared to thrombolysis. NL is currently using a six-hour time window. However, evidence has shown patients can qualify for EVT up to 24 hours from LSN using advanced imaging techniques. This extended window will put additional strain and responsibility on the EMS system.

Secondly, if a patient has a positive Cincinnati Stroke Scale and no exclusion criteria, paramedics must conduct a Large Vessel Occlusion (LVO) screen to check for EVT eligibility. In NL, paramedics use a Rapid Arterial oCclusion Evaluation (RACE) Stroke Scale presented in Appendix I. If the patient has a five or higher RACE score, they may be a candidate for EVT. However, it is still essential for rural patients to go to the closest stroke centre if they are less than four hours from LSN. This allows patients to be assessed, receive CT imaging to determine EVT and thrombolysis eligibility, and potentially receive thrombolysis before transferring to HSC for EVT (if eligible). This method is called Drip and Ship. LVO screening tools can be used to determine if patients should bypass to an EVT centre. NL is not doing this because of large distances between stroke centres. Paramedics can only bypass directly to St. John's if that distance does not add more than thirty minutes of transport time. There is only a small sliver of land between Carbonear and St. John's where that decision is made.

Therefore, NL is using the RACE screen to help pre-notify MedFlight NL (air ambulance) and HSC. Participant NL-04 hopes pre-notification will allow their MedFlight team to avoid going on a less urgent mission and prepare their resources to transfer an EVT candidate to St. John's. Pre-notification is valuable for HSC too. HSC needs to approve the eligible EVT patient and confirm with MedFlight and the sending hospital to transfer the patient. In the early stages, HSC is often the last to be notified, which can delay transfer decisions. EVT was expanded to rural EH on March 13th, 2023, and at the time of our discussion, there is excitement to see how pre-notification will work with the rest of the province. They have brought in stakeholders and front-line workers to understand and improve this process.

All regions have their paramedics conduct a secondary stroke severity screen to identify patients who likely have an LVO. In SEO, if a patient has a positive stroke prompt card, EMS use a second assessment measure called the Los Angeles Motor Scale (LAMS), which is a brief three-item stroke severity assessment to identify a possible Large Vessel Occlusions (LVO) which are potentially eligible for EVT (Southeastern Ontario Stroke Network, 2021). With a score of 4 or greater, the patient is considered positive and may benefit from EVT. Appendix XXII illustrates the LAMS Scorecard used in SEO with key messages from SEO when introducing the LAMS assessment. Alberta also uses LAMS and NS uses the FAST-VAN.

EVT also introduces extended protocols, longer transfers, additional communication/ consultation, and the need for air transportation. EVT adds extra strain on a system that is already under pressure. The geography of NL adds additional pressure. In the EVT section, I discuss EMS systems and initiatives implemented by the other regions to increase access to EVT and assist their paramedics.

Overall, Health Accord NL has recommended a centralized provincial ambulance system. This will require an extensive investment in ground and air paramedicine to provide their paramedics with the appropriate education and ensure a quality system with enough medics and ambulances. A significant aspect supporting their system is the multi-year plan to expand PCPs and ACPs throughout NL. This will address staffing shortages and EMRs. In addition, most of the province is better served with fixed-winged airplanes, but inefficiencies must be addressed to get their patients to HSC quickly. For example, their fixed-winged ambulances require "a one-hour wheels-up time" (NL-04) before transferring patients.

5.4 Acute Stroke Protocol

The Emergency Department (ED) phase begins upon arrival and includes diagnostic evaluation, diagnosis, and the initiation of treatment options. Hospitals have an Acute Stroke Protocol (ASP) to efficiently treat their stroke patients. For ischemic stroke patients, the Canadian Stroke Best Practices (CSBP) set a Door to Needle Time (DTNT) target at a median of thirty minutes from Last Seen Normal (LSN) (Canadian Stroke Best Practices Health Systems Quality Advisory Committee, 2022). The DTNT is a stroke care efficiency metric used for thrombolysis referring to the time it takes from patient arrival to intravenous thrombolysis. With the help of an EMS pre-notification, hospitals can properly prepare for the incoming patient and efficiently treat. Table 5.6 compares the ASP until thrombolysis for each region. The descriptive themes included ASP activation, an interprofessional protocol, efficiency process, and strategies to support PSCs.

> "Stroke is a provincial program, a multidisciplinary issue where the protocols require multidisciplinary input for coordinated care." (NL-04)

Table 5.6: A Summary of the Acute Stroke Protocol for the Four Canadian Regions

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Activation - Pre-notification - ED nurse calls emergency paging - Switchboard pages Stroke team with ETA - HSC request a second page as EMS get closer	**Activation** - Pre-notification - May require further information (checklist) - Physician activates ASP - ED calls locating who calls each stroke team member individually	**Activation** - EMS call CACC who relays information - Charge nurse activates stroke protocol through hospital switchboard who pages stroke team - Stroke team confirm,	**Activation** - Streamlined - Pre-notification - Unsure call OLMC - LAMS ≥ 4, EMS can activate - A single page number is fanned out to necessary stakeholders

- Prepare team - Clear CT - Rural PSCs wait to activate until ED physician can verify	- Prepares stroke team - Clear CT scanner - Some sites want at least fifteen minutes notification	- Switchboard notifies ED of confirmation - CT technologist prepares the CT suite - ED nurse readies portable monitor and ASP package - **QHC** pages overhead	- Stroke team prepare to meet patient in trauma bay - CT technologists clear a CT bed
<u>Code Stroke</u> - Coordinated care, teamwork, and communication - Multi-program response - Working in tandem - Neurology Leads - Stroke champions at PSCs - Nursing leadership - Change in culture and attitudes towards efficient care - Include Radiology	**<u>Acute Stroke Protocol</u>** - Standardized approach - Numerous groups working together - Keep good relationships - Culture that is patient centered and focused on urgency. - Balanced with safety (checklists) - Need leaders	**<u>Acute Stroke Protocol</u>** - Centred around KHSC and QHC - Launched TNK - Culture using clinical knowledge, patient centered, focused on urgency - Organized protocols - Defined roles - Working simultaneously - Highly choreographed to avoid chaos	**<u>Stat Stroke</u>** - Multidisciplinary Team led by Stroke neurology - Protocols are designed to minimize time to the CT - Team understand the need for urgency - Frenetic choreography - Joint care model allows flexibility - Well-defined roles and hand-off points - TNK
<u>Efficient Processes</u> - Immediate activation - Pre-registration - Quick assessment in tandem - Direct to the CT scanner. Target < 10 minutes - Remain on the paramedic stretcher - Stroke box with all required resources - Administer thrombolytics in the CT suite. - Start infusion before CTA - Making change to TNK	**<u>Efficient Processes</u>** - Stroke team waiting - Parallel process and simultaneous work. - Limit ED time - Remain on the paramedic stretcher - Direct to CT Suite - Do not wait for the full imaging report. Review images as they come up. - Gather relevant information - Stroke kit available - Thrombolysis just outside the CT suite - Targets: DTNT < 30 mins, Door to CT < 15 mins	**<u>Efficient Processes</u>** - Early activation - Use ETA to meet the patient on arrival - Simultaneous work - Remain on the paramedic stretcher - Forgo waiting on lab work unless clinically relevant - Bring equipment and TNK - Early consent - Neurologist receives paramedic report and family information - Thrombolysis in the CT suite Targets: Assessment < 4 mins, 30 min DTNT	**<u>Efficient Processes</u>** - Register as an unknown or Identifiers through RAAPID and Netcare - Meet patient in their trauma bay - Bring stroke bucket - Dual Assessment - Remain on the EMS stretcher - Go to CT scanner - Immediately read CT scans as they come up - Administer thrombolysis just outside the CT suite - 24/7 stroke nurse trained to thrombolyze
<u>Supporting PSCs</u> - On-call Neurology and Radiology are paged to consult and review the PACS images	**<u>Supporting PSCs</u>** - On-call stroke neurologists support PSCs	**<u>Supporting PSCs</u>** - Race Car Pit Stop model and use Telestroke neurologists for support - Establish the most responsible nurse	**<u>Supporting PSCs</u>** - PSCs use RAAPID to facilitate their consults - FMC supports PSCs in the south and central parts of Alberta - Stroke Champions

Barriers - Standardize protocols across the province - Rare to thrombolyze without pre-notification	**Barriers** - Need Patent IV lines - Walk-in patients - In-hospital patients - PSC Care providers using on-call support have increased DTNT	**Barriers** - Slower without pre-notification. - Night shift delays - Telestroke tends to increase DTNT - Patients on warfarin (15 mins) - Speed of first CT	**Barriers** - Getting collateral history about baseline function - Relying on EMS - No pre-notification and preparation. Walk-in and Inpatient strokes

5.4.1 Activation

An acute stroke protocol (ASP) begins when the patient arrives at the Emergency Department (ED). Calgary explained how EMS is the starting point as EMS recognizes the stroke and notifies the hospital to activate their protocol. ASP activation at HSC is like SEO and Calgary. A page is fanned to their stroke team with an Estimated Time of Arrival (ETA), allowing their team to prepare, pre-register the patient and organize a CT suite. However, EH PSCs are waiting for the ED to confirm a stroke before activating their protocols.

5.4.2 Interprofessional protocol

HSC is the top-performing hospital in EH and has a robust team-based approach, quality leadership, and efficient processes. To help all patients across NL a standardized protocol would be great. HSCs ideal Code Stroke includes an activation with pre-notification to allow their stroke team to await patient arrival, keeping their patients on the paramedic stretcher to go to the CT scanner that is cleared by the CT technologist (from activation), and working in tandem through the roles presented in Appendix XVI: Health Science Centre Standard Operation Procedure for Code Stroke Activation and Administration of rt-PA Protocol, and/or Endovascular Thrombectomy. In addition, there must be an ED physician with the stroke team in case the patient is unstable or having a false stroke. A necessary component to diagnose thrombolysis and EVT eligibility are the CT scanners.

For thrombolysis, the protocol at HSC is similar to the three other CSCs. A stroke patient must have a Non-Contrast (NC) CT scan to eliminate a hemorrhagic stroke. NL uses radiologists to help with CT imaging. Ideally, neurologists at high-volume centres become comfortable enough to read the scans independently, to make thrombolysis and EVT decisions. This reduces the need to wait for radiology clearance/interpretation. Then the neurologist will make the decision to treat with thrombolysis. Once a Code Stroke is activated, HSC have a stroke box follow their patients containing all the required resources (thrombolysis medication and instructions, IV's, Syringes, Needles, Blood tubes, Tourniquet, Vented set, Alcohol swabs, Opsites, and Tape). Once the neurologist decides to treat using thrombolysis, the nurse will begin mixing the medication (about a minute). In addition, HSC changed their process to administer thrombolysis in the CT suite which improved their DTNT. DTNT depends on the hospital's process and how quickly neurologists (or stroke physicians can make a decision. Some are much more enthusiastic than others. When deciding to provide thrombolysis, Appendix XVII presents the thrombolysis order sheet with inclusion and exclusion criteria.

"You need to have protocols in place to figure out what are you going to do" (NS-01)

Throughout all regions, participants believed ASPs required clinical leadership, multi-program teamwork, communication, simultaneous care, and a protocol promoting efficiency.

"If you develop a good coherent policy with role relationships, then it becomes less dependent on the physician and the team just flows and brings everything along with them" (ON-06)

Requiring a multi-program response, HSC stroke care includes EMS, ED, neurology, radiology, CT technologists, nurses, and laboratory staff. An efficient response requires working in tandem to urgently care for and gather the appropriate information required to make the appropriate treatment decisions. While working in tandem, departments are close in proximity, and communication is critical. For example, a CT technologist must receive the appropriate ETA and even small minor delays must be communicated appropriately. In addition, all centres must have leadership to drive their stroke teams and processes. HSC and the other CSCs are very fortunate to have the neurologists. HSC have that advantage compared to the other stroke sites across the province. Therefore, other sites require leaders who are passionate about stroke, such as emergency or internal medicine physicians. Along with leaders, it is essential to have champions on staff, such as a charge nurse lead, who will control the situation. These champions act like an access point who are well-versed in the hospital's stroke care process, know where the patient should go, can activate their Code Stroke, and look for a patient bed post-therapy. Every shift should have a champion.

Finally, on June 29th, 2022, Menon and colleagues published a Canadian non-inferiority trial where they interpreted Tenecteplase (0.25mg/kg) as a reasonable alternative to alteplase for all patients presenting with acute ischemic stroke (Menon et al., 2022). The stroke neurologists from KGH participated in the trial and launched TNK on September 1st, 2022, as the first organization in Ontario. The transition from rt-PA to TNK is a significant change as TNK only requires an initial bolus without the hour-long infusion that requires monitoring. Participant ON-03 believes the transition has likely reduced their DTNT and decreased the time from thrombolysis to EVT. NL began this transition. Without the long infusion, TNK will be easier for patients eligible for EVT, and ambulances will not have to worry about the rt-PA infusions during transfers for EVT.

5.4.3 Efficiency Processes

For an ASP directed toward thrombolysis, HSC is comparable to the other CSCs. The ASP at HSC provides the efficiency processes required for a quality DTNT. While discussing DTNTs, HSC had a culture change. In 2021, HSC began the ACT EAST Project, which aims to improve access and efficiency of treatment for ischemic stroke across all four provinces in Atlantic Canada (ACTEAST, 2022). Their mindset was engaged to improve their stroke program. ACT EAST discussed gaining efficiencies from the simplest things. Discussing points of entry, communication roles, where to transport the patient, and not taking the patient off the paramedic stretcher. Now their DTNTs are consistently under the target time of thirty minutes.

ACTEAST was where they discovered how pushing the thrombolytic in the CT scanner would make their care more efficient. Initially, there was resistance, but their team culture and attitudes changed. Now the HSC stroke team understands the importance. Their group began to question what else they can improve and their DTNTs have improved substantially as a result. However, ACT EAST was focused on HSC, and those learnings must be translated to the other stroke centres who are not picking it up. The stroke committee is attempting to replicate those learning, but the other stroke centres require true engagement and accountability to change their culture. Successful translation has occurred in Clarenville with reports of improvements over the last year after adopting similar efficiency processes from HSC. However, each stroke centre has different resources requiring a different approach.

For efficiency processes, HSC is doing everything the other regions are recommending. This includes a quick simultaneous assessment, keeping the patient on the paramedic stretcher, going directly to the CT scanner, bringing a stroke kit to the CT suite, and immediately interpreting images. HSC has even begun administering thrombolysis in their CT suite after a non-contrast (NC) CT and before the CT angiogram (CTA), yet to be widely adopted. Clareville has followed in HSCs steps. They have administered thrombolysis in the CT suite before the CTA. Burin is looking to make that change.

"We try to cut out all the middlemen and as much stuff in tandem as we possibly can" (NL-10).

"Minimize the amount of time it takes to get the patient to the scanner" (AB-03).

To promote efficiency, SEO highlighted the importance of highly choreographing the first few minutes to quickly assess their patient and get them to a CT scanner. Calgary believed thirty-minute DTNT are achievable with well-defined hand-off points and designated roles. NS emphasized keeping good relationships to maintain a quality culture to help each other. In addition, Table 5.7 critical elements in the CT suite identified by the SEO stroke network to achieve performance targets, Appendix XVIII lists the roles and responsibilities from patient registration to the administration of thrombolysis, Appendix XIX presents the Stroke/TIA Consult History and Physical Assessment, Appendix XX shows the inclusion and exclusion criteria for thrombolysis (TNK or rt-PA). Appendix XXI presents the inclusion and exclusion criteria for thrombolysis and Appendix XXII presents FMC's TNK Order and Administration form. These appendices highlight the ability to standardize protocols and order sets through a provincial body.

One difference at the HSC compared to other CSCs is their reliance on radiology for imaging interpretation. However, it does not appear to affect their DTNTs. The CT scans and RAPID AI report are interpreted by neurology with radiology. To ensure efficiency, the radiology resident has a stroke pager and immediately responds and reports to the neurologist. For efficient use of resources and staff, neurologists can become comfortable enough to independently read scans and make thrombolysis and EVT decisions. In Calgary, their stroke physicians have a great relationship with radiology and will reach out if they require a second opinion.

In addition, SEO recommended an early consent process at the ED, and Calgary emphasized the importance of a 24/7 stroke nurse. Their stroke nurse comes down from their stroke unit with a stroke kit, completes documentation, charts the time stamps, provides bedside nursing support, and helps administer thrombolysis. Most of their thrombolysis is administered by their stroke nurse as soon as the treatment decision is made. In NS they use a research nurse who acts as a stroke nurse during day hours, but they applied to have full time stroke nurses help their program. This role should be investigated for all stroke centres.

Table 5.7: Key Elements Within the CT Suite to Achieve Performance Targets

Neurologist always stays with patient and actively participates to expedite care (keeping track of communication and patient flow, helping transfer patient onto CT table, and assisting in any way they can while maintaining oversight of the entire process)
Patient remains on paramedic stretcher through to CT suite
Next on CT scan policy for ASP
IV rt-PA (or TNK) administered in CT suite
Use RAPID CT perfusion protocol to rapidly identify patients for EVT
Streamlined consent process for CT including administration of contrast

(Stroke Network Southeastern Ontario, 2021)

5.4.4 Primary Stroke Centres

With a provincial stroke network, protocols should be standardized and adjusted to fit the resources of each region. As HSC functions at a high level, EH and NL must translate those successes to PSCs across the province. St. John's and metropolitan patients are supposed to go to HSC, but St. Clare's gets a significant number present as walk-in patients or inpatient strokes. These strokes do not have the pre-notification and pre-identification to prepare. Therefore, when the patient arrives, St. Clare's must quickly register their patient and clear a CT table. In addition, HSC is the only site with neurology. St. Clare's and the rural PSCs require other physicians (internal medicine, emergency, or family medicine) for stroke care influencing thrombolytic decision-making. EH internal medicine physicians (if available) are comfortable with thrombolysis, but the other physicians want aid from neurology or internists. Clarenville has three outstanding internists responding to Code Strokes, resulting in improved outcomes.

Carbonear has a mixture of family medicine, hospitalists, and occasional access to internists. Burin relies on emergency room physicians unless an internist arrives to assume patient care.

As stroke care is a specialty, it is a challenge to make thrombolytic decisions. Therefore, stroke neurologists are on-call to support their treatment decisions. If the acting physician is not confident, they can page switchboard, which will page the on-call neurologist with “code Stroke outside the city”, and the neurologist will respond immediately. NL does not use a video Telestroke service, but their neurologists provide telephone support and review the Picture Archiving and Communication System (PACS) images”.

> “We [have] tried to put some processes in place to make it easier for them to contact Neurology for support” (NL-02)

With the use of RAPID imaging software, neurologists can efficiently view the CT scans on their phones. Rural sites believe the on-call process has had a dramatic improvement. Now, these hospitals have 24/7 direct access to the on-call Stroke Neurologist by paging and bypassing HSCs public switchboard. In addition, EH provides a monthly schedule to notify rural sites for which neurologist is on-call and contact numbers. In addition, Burin identified the need for efficient stroke recognition, quality EMS system, Code Stroke activation, quick response times, clear protocols, and efficient imaging to support efficient decision making.

In Clarenville, translation is ongoing as they have reported quality DTNTs in the past six months and administer thrombolysis in their CT suite. However, I did not see this in the quantitative data. Burin currently brings their patients back to their ED to administer thrombolysis, slowing down DTNT, but have looked at administering in the CT suite, especially with CTAs becoming part of their imaging protocol for EVT. Rural regions also have lower availability of ambulances. Therefore, Clarenville must transfer their patients from the ambulance gurney onto an ED bed to allow the ambulance to go back into the community. However, Burin keeps their patients on their paramedic stretcher to go directly to the CT scanner. This should change with as EVT-eligible patients within rural EH will be transferred to St. John's as of March 13th, 2023. If so, ambulances may need to stay for patients with a five or higher RACE score. This will continue to stress the already short staffing for their EMS.

Like EH, every region uses on-call stroke neurology for consultation. However, the early communication/transfer pathway stages of the RAAPID system in Calgary seems the most effective pre-hospital communication system. RAAPID allows efficient and effective communication between the stroke physician, transport physician, and EMS to determine the patient's destination and treatment scenario (Direct for EVT or drip and ship). Calgary uses a LAMS score for stroke severity. With a LAMS of ≥ four, EMS or a hospital with a walk-in patient will immediately call RAAPID to organize a consultation. In addition, RAAPID will bring in their STARS (air ambulance) service for long distances. Appendix XXIII presents the AHS EVT Pre-hospital Communication Strategy from 2016.

SEO and Calgary reported QHC of Belleville, Ontario, and Red Deer Regional Hospital Centre of Alberta as highly functioning PSCs. These centres have strong stroke champions, strong nursing leadership, and a good team culture. QHC, which underwent a LEAN process to improve DTNT, was the first PSC to have a median DTNT under thirty minutes in Ontario and Red Deer has occasionally shown better results than FMC in Calgary. In addition, NS believes each hospital or region needs a stroke coordinator to find the time for improvement.

PSCs can learn from the two YouTube videos explaining the QHC Code Stroke process in SEO (Fraiberg, 2015; Fraiberg, 2016). With pre-notification and pre-registration, the nurse will then page overhead "code stroke, double emergency, ETA x minutes" allowing the stroke team to wait for the patient's arrival, the CT technologist to clear the CT table, notify radiology to immediately interpret the scans, notify the laboratory for urgent blood work, and notify their porters to pre-position the Code Stroke stretcher/gurney by the CT (Fraiberg, 2016). QHC use the Race Car Pit Stop Model (Fraiberg, 2016). Like a pit crew, the stroke team members will each do a different job working together to limit time to treatment. Their team includes an emergency physician, an ICU physician (decision-maker), a triage nurse, an emergency nurse, and an ICU nurse (act as the navigator and chart). It was essential to establish the most responsible nurse who is with the patient throughout their journey. Upon arrival, the patient is quickly assessed, and their goal is to get a CT as quickly as possible. If eligible for thrombolysis, the patient will be moved to the Code stroke gurney, which has a scale allowing the patient to be weighed for tPA assessment. QHC strives for a DTNT under 30 minutes (median).

I recommend NL to develop a provincial stroke network to standardize care across the province, provide protocols to support care, have on-call neurology available for consultation, and monitor performance to keep centres accountable.

5.5 Endovascular Therapy

EVT is an extension of the ED phase requiring the same urgency and additional teamwork. As stroke care involves multiple programs, EVT adds Interventional Radiology (IR) and in some cases anesthesiology. When comparing each region, the initiation date of EVT is the most identifiable difference. NL was slow to implement an EVT program. In June 2022, HSC began treating ischemic stroke patients with EVT. As of March 13th, 2023, they expanded the program to capture the patients of rural EH. The EVT service is provided Monday to Friday, 8am to 4pm. Although they hope to expand their service hours, expansion has taken longer than expected.

Table 5.8 compares the EVT programs of the four health regions. The descriptive themes included the additional roles and processes of EVT, HSCs initial roll out of EVT, and the expansion of an EVT program.

Table 5.8: A Summary of Endovascular Therapy for the Four Canadian Regions

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Began June 2022 - Very important to prepare before EVT. - Included all the stakeholders - Generated excitement - Mon-Fri, 8am-4pm for patients in the St. Johns/Metropolitan area - March 13th, 2023, rural Eastern Health. - Debrief every case to look for improvements - Treatment window of 6 hours from LSN	**Involved in the ESCAPE trial (2015),** continued after - Planning should involve experts - Mon-Fri, 8am-4pm, then expanded their hours and extended to all NS - 12-hour treatment window from LSN (11-hours for EHS) - Additional teamwork on QEII's ASP	**Began May 2016. Expanded region-wide 24/7 Sept 2017** - Extension of ASP - Protocol includes CTA, and CTP - 24-hour treatment window - CTP and RAPID for patient selection - Avoiding general anesthesia to speed DTPT - EVT working group focused on QI - Well-Designed Implementation Plan	**Led the ESCAPE Trial (2015)** - Protocols to quickly identify eligible patients - Emphasis on efficiency - EVT is an extension of Stat Stroke - Stat stroke is based on a 6-hour time window from LSN. - FMC has extended to 24 hours to demonstrate efficacy for Alberta.
Additional Roles - RACE screen - NC-CT and CTA within 6 hours - RAPID AI for interpretation - Neurologist/ Radiologist must confirm RAPID - Must call in INRad, EVT team, and anaesthesiology with expected LVO/EVT candidate	**Additional Roles** - Need leadership: king or queen (INRad) - Communication - Create relationship, and be respectful - All patients must receive a CTA - INRad view scans with neurology - Prepare the angiography suite. - Anesthesiology check list	**Additional Roles** - Neurology interprets imaging - Call IR to confirm, check imaging and get the patient's story - Prepare IR suite - MRTs and IR team assist in preparation - Neurologist/resident assist IR team - EVT typically < 30 minutes - Combined stent retriever/ aspiration technique	**Additional Roles** - Page INRad - Joint decision - Night: INRad view scans from home - Within 6 hours: NC-CT CTA - Outside 6 hours: Imaging is used in a directed way, including CTP and multiphase CTA - Go directly to EVT suite (right next to radiology).
Anesthesia - Anesthesiologists called for all EVT candidates	**Anesthesia** - As a group, they believe EVT needs anesthesiology. - Contact for all EVT cases	**Anesthesia** - Use procedural conscious sedation with IR nurses to certain Ramsey score. Over score, call anesthesia	**Anesthesia** - Each patient is managed differently - The stroke nurse will be able to give procedural sedation

	- 24/7 AA coverage	- Anesthesiologist to ED for intubation	- Anesthesiologists are called in separately
<u>Rural Support</u> - Identify their transfer processes - RACE score ≥ 5, contact on-call neurologists, and transport team - Push images to neurology and radiology - Drip and Ship - Early notification of MedFlight NL (air ambulance)	**<u>Rural Support</u>** - FAST-VAN screen - Standardized transfer process - Never bypass the nearest DASH - Need immediate imaging - Thrombolysis, if eligible - Call AMTCO for consultation and transportation - Neurologist will review with neuro-radiologist - Transport by ground ambulance, helicopter, or fixed winged airplane - AMTCO notifies QEII	**<u>Rural Support</u>** - Telestroke every EVT candidate - Purchased CTP imaging/RAPID AI - Telestroke neuro makes EVT decision and contacts KGH - Possible drip and ship - Faster with ground ambulance - DIDO < 60 mins - ACT-FAST Protocol to screen up to 24 hours LSN - ACT-FAST in all EDs - ACT-FAST positive -> contact KGH to consult about patient transfer	**<u>Rural Support</u>** **<u>- ERA</u>** resources for their transport, emergency, and stroke teams to increase EVT access - Mothership or Drip and Ship scenarios - Non-Stroke Centres use LAMS - LAMS ≥ 4; immediately contact RAAPID for consult and coordination - Closest CSC/PSC for imaging/ thrombolysis **<u>- STARS</u>** – Air ambulance can meet for transfers and provide thrombolysis

<u>Barriers</u>
- Must understand their transfer process
- Work with INRad group to expand working hours of care. Only 3 INRads
- Expansion is slower than hoped
- INRads need experience.
- Drip and Ship (rt-PA), nurses (or APCs) for patient transfer. APCs can monitor, but there are not enough in the province.
  - TNK
- Not enough ACPs
  - New program
- Staffing
- Need additional angiography suite
- Communication
- One designated unit in Eastern Health
	<u>Barriers</u>
	- Still a lot of debate on the EVT window/ who they'll except
	- For drip and ship, DASH facilities must send a critical care nurse for transfers
	- Increase in patient transfers
	- Never really recognized as a program causing funding issues
	- Role of Anesthesiology. AA's and chrcklists has helped
	- Some centres forget to complete a CTA
	- Need CTPs to aid in EVT selection for later time windows
	- Angio suite is not staffed 24/7
	- Need another centre?
		<u>Barriers</u>
		- Patient selection, especially after 6-hours from LSN
		  - CTP/RAPID AI helped
		- RAPID cost $25,000/year
		  - Totally worth it
		- Drip and ship escort
		- EMS bypass end at 6-hours LSN
		  - ACT-FAST
		<u>Implementing EVT</u>
		- No INRads = a lot of criticism. Could not find mentorship.
		- Leadership had a lot of work
		- Needed a culture change
		- No funding until successful Pilot
		- Painful but necessary data collection
			<u>Barriers</u>
			- STARS availability
			- Weather prevent STARS
			- Available resources and complaints about using resources
			- Funding
			- Pressure on their staff: Not enough nurses
			- How EVT is introduced. A lot of disagreement throughout Canada
			  - ESCAPE trial helped FMC
			- Expanding their treatment window may overwhelm the CSCs
			- Blockages in EDs.
			- Stroke unit saturation

		- 24/7 required additional staff = more funding	

The three other regions have had a region-wide, 24/7 EVT service for many years. Calgary was the leader of the ESCAPE trial (2015) that produced significant evidence for EVT in increasing functional outcomes and reducing mortality for ischemic stroke patients with LVOs (Goyal et al., 2015). The Queen Elizabeth II (QEII) Health Sciences Centre in Halifax was also involved in the ESCAPE trial. Both Foothills Medical Centre (FMC) in Calgary and QEII continued their EVT program after the trial's positive results. SEO began EVT in May 2016 and expanded to a region-wide full-time service in September 2017. SEO faced much criticism at the beginning of their program as they did not have an Interventional Neuro-Radiologist (INRad). However, their leadership understood the need for EVT in their region and worked hard with clinical leadership to change the culture of its program and find funding for a ten-case pilot. Due to their successful implementation plan, they received full-time service funding and are one of Ontario's best-performing stroke hospitals. Based on imaging selection, the SEO region expanded their EVT treatment window to 24 hours from LSN. To help with efficiency, SEO explained using their radiation technicians and IR nurses to help set up the angiography suite and their neurologist and/or resident to assist their INRad team during EVT cases. They have the fastest door to reperfusion (return of blood supply) time in the province.

5.5.1 Additional Roles

Currently, HSC has three neuro-interventional radiologists (INRad) as procedural physicians and the leaders of EVT. Their group is engaged, but they worry that one in three calls will be quite onerous. Currently, patients within EH and six hours from Last Seen Normal (LSN) must have an NC-CT and a CT Angiogram (CTA). A CTA uses a contrast injection to visualize the blood vessels and help identify LVOs eligible for EVT. To help analyze their CT scans, NL uses an application called RAPID, which is software that uses artificial intelligence to automatically analyze an NC-CT for a hemorrhage, provide an Alberta Stroke Program Early CT Score (ASPECTS) to identify regions of early ischemic change, and analyze a CTA to identify an LVO. As soon as a scan is analyzed, the application notifies the appropriate personnel (through their phones) of the generated image results. While the results are not perfect, the on-call neurologist and radiologist must go over the scans to confirm the AI's generated response. The AI is a nice time saver as the application shows the location of the stroke. In SEO, the neurology team are comfortable with reading the acute stroke scans. If unsure, they will contact IR. Their clinical and administrative leaders affirmed the need for advanced CTP imaging with RAPID software to enable patient selection and expedited access to EVT (Stroke Network of Southeast Ontario, 2021).

In addition, HSC had to introduce angiography suite nurses, technologists, and anesthesiology to their processes. Table 5.8 shows a split decision across the regions for anesthesia. SEO and Calgary decided to use procedural sedation provided by trained nurses, IR nurses (SEO) and stroke nurses (Calgary). SEO explained how general sedation was faster for their Door to Puncture Times (DTPTs). DTPT is an efficiency metric for EVT and measures the time a patient arrives to EVT initiation. The CSBP set a median target of less than 60 minutes. While procedural sedation is their standard practice, each patient is treated differently and will call an anesthesiologist if required. Participant The SEO IR nurses are trained in procedural sedation to a specific Ramsey score (sedation scale). Once the patient requires sedation beyond the set Ramsey score, they use on-call anesthesia, which is uncommon.

HSC and QEII have decided to call an anesthesiologist for every EVT case. If HSC continues using anesthesiologists for every EVT case, they must learn from QEII. QEII had a lot of difficulty in the beginning with communication and support for their anesthesiology group. By working together, they created an anesthesia checklist presented in Appendix XXIV and have 24/7 anesthesia assistants to quickly respond and prepare. AAs are all former respiratory therapists who have taken an extra year of anesthesia training and work in the Operating Rooms (ORs) outside of stroke protocols. These additions have improved the efficiency of QEII anesthesiology who are off site. Their anesthesia also wanted to find a balance and did not believe they had to be called for all EVT cases. They believed other providers could provide minor sedation, and anesthesiologists could come in for the more severe cases.

Therefore, it was crucial to do a lot of pre-EVT work. The early preparation got all the stakeholders on board allowing the stroke team to come together as all their programs made decisions on processes to understand their expected roles and responsibilities. Figure 5.2 presents HSC's process map for Code Stroke including EVT, and Appendix XXV shows the Endovascular Thrombectomy (EVT) adult order sheet.

"We really hashed out a lot of the kind of bumps in the road before it even started" (NL-09)

In 2021, the SEO stroke network identified four critical elements for achieving performance targets within the IR suite, presented in table 5.9. Appendix XXVI presents the additional roles and responsibilities at KHSC-KGH for EVT, Appendix XXVII presents EVT's inclusion and exclusion criteria, and Appendix XXVIII offers SEO's highlighted benefits for RAPID software.

Figure 5.2: Code Stroke Process Map – Including EVT

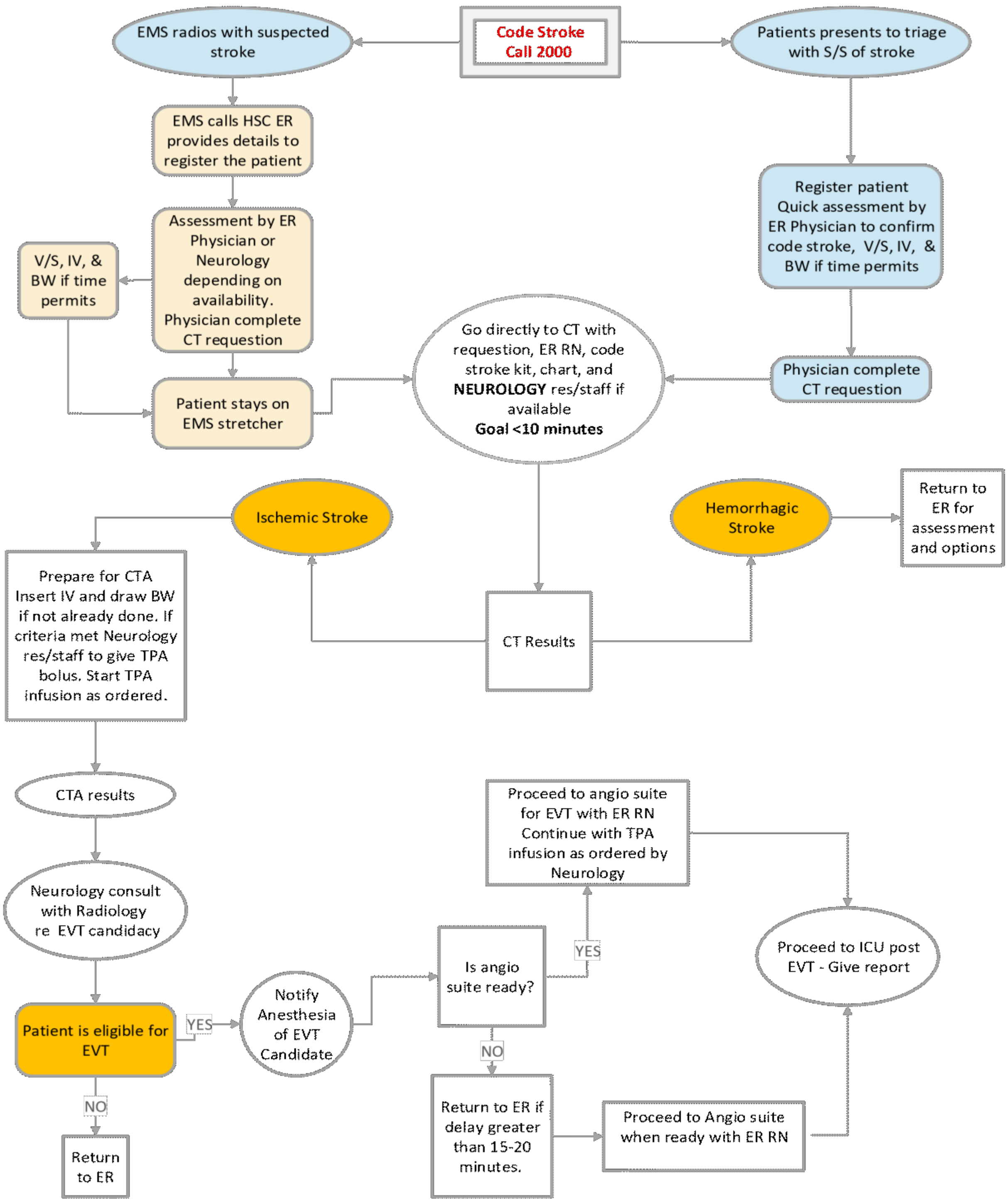


Fig 5.2. Presents a copy of HSC's Code Stroke process map. The process map includes key roles from EMS, Physicians, Neurology, Nurses, and CT Technologists. HSC includes a goal of patient arrival to CT scan of less than 10 minutes. From the CT results, the map includes a pathway for ischemic and hemorrhagic stroke patient. The new process map now includes processes to check for EVT eligibility, prepare for EVT, and proceed to ICU post EVT

Table 5.9: Four Critical Elements in the IR Suite

Medical Radiation Technologists (MRTs) and the IR team assist with setting up the angiography suite
Neurologist and/or resident work as part of the IR team and remain in the angiography suite to assist directly with care (e.g., procedural sedation, discussion of care with IR as EVT proceeds, coaching patient through the procedure)
Use procedural conscious sedation vs. general anesthetic whenever possible
use a combined stent retriever/aspiration technique (e.g., Solumbra and BADASS)

(Stroke Network Southeastern Ontario, 2021)

5.5.2 Initial Roll-out

HSC began phase one of their provincial EVT program in June 2022, and participant NL-09 believes their EVT program is going well. As of March 2023, phase one is ongoing from Monday to Friday, 8am to 4pm, for patients in St. John's and the metropolitan area. However, increasing their process and expanding to phase two is going slower than. To expand, HSC agreed to do ten cases but have only completed eight. In addition, one of the INRads had performed most of the EVT cases and the group hoped to get more experience before expanding. However, INRad have indicated that they may be willing to extend the hours from 4pm into the evening. Table 5.10 presents IR's planned approach to expanding their working hours.

Table 5.10: Plan to Expand EVT Hours

Phase 1	8am – 4pm, Monday to Friday
Phase 2	8am – 10pm, Monday to Friday
Phase 3	8am – 10pm, Seven days a week
Phase 4	24 hours a day

As HSC expands their hours of care, NL is testing their provincial expansion of transferring patients for EVT. Phase two, began on March 13th, included the catchment area of rural EH. Pre-EVT engagement was necessary for their INRads to feel confident. To develop and include all of NL, NL will need to figure out the transport process.

There is still a lot to learn, as participant NL-02 explained how they will need to find efficiencies in their process and learn to effectively work together. HSC has been doing debriefs after every case to identify areas to improve. Although there have not been many cases, through debriefing, there have been major improvements to their processes. The debriefs allowed their team to focus on improving efficient treatment.

"With every debrief, we learned something new" (NL-10).

5.5.3 Expansion

While HSC was late to initiate EVT, the new service has generated a lot of excitement. HSC has seen a culture change and an eagerness to improve. However, there is a long way to go. Therefore, I recommend a full-time Endovascular Therapy (EVT) service to care for all eligible patients in NL.

1. **HSC must identify how they can expand the service hours for EVT.**

Table 5.10 presents a four-phased planned approach to moving HSC to a full-time EVT service. First, HSC believe additional INRad (or EVT-trained physicians) must be trained or recruited, and an appropriate schedule must be made. However, there is likely not enough non-EVT work to keep four or five dedicated interventionalists busy. In 2020/2021 584 ischemic stroke were hospitalized in EH. If 10% are eligible for EVT, that would be ~58/year. A little over one per week. Is that too onerous for three INRads with 24/7 call. Further investigation should be made. In Calgary, most of their interventional service is in radiology, but they also have two neurosurgeons and one interventional neurologist. In addition, HSC must consider other staff (nurses, technologists, neurologists, and anesthesiologists) required to increase their service hours and potential patient volume. Table 5.8 shows a split decision across the regions for anesthesia.

2. **Expand EVT service to the whole province.**

This expansion will require a multidisciplinary education rollout and a standardized communication, transfer, and imaging protocol. Education is required to notify and educate all departments and EMS of additional roles and responsibilities. EMS and ambulances have a vital role in patient transport and communication. PSCs will have an additional flow of patients and must conduct CT angiograms (CTAs) for diagnosis and thrombolysis for possible drip and ship patients. With the expansion to rural EH, NL is trialling their transfer protocol. As Figure 5.2 presents, EMS who have a patient with a positive Cincinnati Stroke Screen, a RACE score of five or higher (positive screen of an LVO), and a LSN time of under four hours should activate code stroke at the closest Stroke Centre (unless HSC is less than thirty minutes of extra transport time). With a positive LVO screen an immediate call to HSC allows them to prepare for a possible EVT candidate and the transport team to organize resources.

Getting to the nearest stroke facility is vital to receive the appropriate imaging to diagnose thrombolytic and EVT eligibility. For EVT, rural physicians would call neurology to view the patient images and discuss with INRad if the patient should be transferred to HSC for EVT. The on-call neurologists will confirm with the rural hospital that the patient is a candidate. Then the rural hospital and transport team figures out how to get the patient to HSC as fast as possible. They should notify HSC of the patient's ETA. For longer transfers, NL must bring in their MedFlight (air ambulance) team. Therefore, additional work into efficient air ambulance travel can help EVT expansion. It has been reported that the air ambulance service has been slow to respond and has a long preparation time (about an hour) before transferring.

If the patient is also eligible for thrombolysis, alteplase (rt-PA) requires an initial IV bolus followed by a sixty-minute continuous infusion, or "drip". While the drip occurs, EMS can transfer the patient for EVT. Appendix XXIX presents this thrombolytic infusion and patient transfer procedure. However, Drip and Ship can create resource issues for the sending hospital and paramedics. For example, thrombolytics are not within PCP scope. Therefore, nurses must accompany and monitor the patient. As staffing is already under pressure, hospitals can't afford to lose nurses. Appendix XXIX is specific to ACPs who can monitor and transfer thrombolytic patients, but there are not enough throughout the province. To assist low staffing, NL have been doing a lot of work to try to expand ACPs throughout the province. NL started a program at the College of the North Atlantic four years ago. This program allows paramedics to train to become ACPs and the Department of Health is willing to fund ambulance operators looking to hire ACPs. In addition, EMS secured a million dollars' worth of equipmentto support their ground and air ambulance programs in 2022. This equipment can allow ACPs keep nurses in their hospitals during drip and ship protocols. ACPs require some practice and education to feel comfortable with these transfers.

"Hopefully, that [is] a moot point as time goes on and people get more comfortable with using TNK" (NL-04).

With the new CSBP recommendation to use Tenecteplase (TNK) as an alternative to rt-PA, monitoring guidelines may relieve that challenge (Heran et al., 2022). In addition, TNK avoids the sixty-minute infusion of rt-PA, which should allow for shorter DTPTs. Non-stroke centres can still receive patients who have stroke symptoms. Therefore, they can be educated in LVO screening and communication pathway.

Outside EH, Participant NL-12 explained how Western Health (WH) is interested in HSC's EVT program expanding to capture their patients. HSC has already started the groundwork with, but there is a long way to go. Appendix XII presents the planned steps and communication for EVT transfers, and Appendix XIII shows the designed secondary site process map.

The three other regions have set up communication pathways to support all their patients. SEO uses telestroke for every EVT patient, NS uses AMTCO, but the early communication/ transfer pathway stages of the RAAPID system in Calgary is the most effective pre-hospital communication system. RAAPID allows efficient and effective communication between the stroke physician, transport physician, and EMS to determine the patient's destination and treatment scenario (Direct for EVT or drip and ship). Calgary uses a LAMS score for stroke severity. With a LAMS of ≥ four, EMS or a hospital with a walk-in patient will immediately call RAAPID to organize a consultation. RAAPID will bring in their STARS (air ambulance) service for long distances. Appendix XXIII presents the AHS EVT Pre-hospital Communication Strategy from 2016. In addition to RAAPID, Appendix XXXII presents Nova Scotia's EVT protocol.

To adapt its provincial stroke system to ensure increased access to EVT throughout their province Alberta created a package called Endovascular Reperfusion Alberta (ERA). The ERA package provided resources for their transport, emergency, and stroke teams to understand the processes and protocols of EVT in Alberta (Alberta Health Services, 2016). to make EVT more accessible Alberta made revisions of EMS triage and transportation pathways (including inter-hospital), implemented appropriate imaging in remote areas, and improves care processes to reduce the time to treatment (Alberta Health Services, 2016).

Two scenarios impact Comprehensive Stroke Centres (CSC) and Primary Stroke Centres (PSC). EMS can bypass all hospitals and go directly to a CSC (the **Mothership** Scenario) or the patient goes through the **Drip and Ship** Scenario (Alberta Health Services, 2016). Figure 5.3 presents the scenarios an EVT-eligible stroke patient could face. Non-stroke centres are only impacted by an in-hospital stroke or a patient presenting directly to the centre (walk-in). For these patients, the centre should conduct a LAMS assessment and immediately contact RAAPID to ensure appropriate transport and timely care. Table 5.11 lists the impact of EVT on Alberta's CSC, PSC, and non-stroke centres and the strategies implemented to help those hospitals.

Figure 5.3: EVT Transport and Transfer Decisions

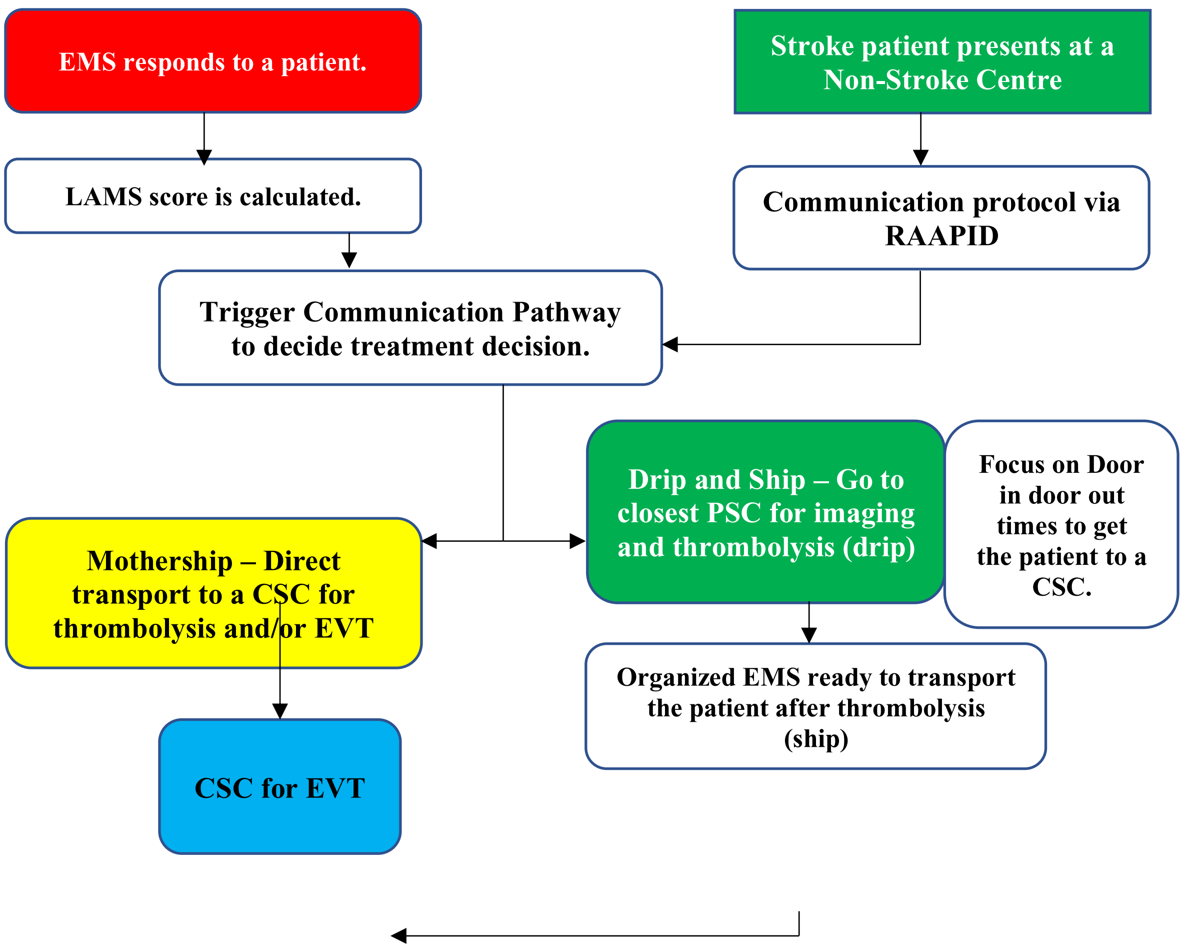


Fig. 5.4. Presents the two scenarios' patients eligible for EVT could face. By using RAAPID a communication pathway is created to transport the patient using Mothership or Drip and Ship.

Table 5.11: EVT Impact on CSCs, PSCs, and Non-Stroke Centres and Strategies to Help

Comprehensive Stroke Centres	
- Increased volume of calls for consultation - Increased volume of patients for EVT - Potential false positive referrals resulting in increased volumes to ED	Education has been developed by QuICR with modification to various protocols to accommodate needs (repatriation)
Primary Stroke Centres	
If the patient follows the Drip and Ship scenario – PSC follows normal Stat Stroke protocol	QuICR has worked with PSCs to improve their processes, and DTNTs = faster EVT treatment times for eligible patients.
Non-Stroke Centres	
Centre must contact RAAPID and conduct a LAMS assessment for walk-in or in-hospital strokes to ensure fast identification and appropriate transfer	

*QuICR = Quality Improvement & Clinical Research Alberta Stroke Program
(Alberta Health Services, 2016)

Alberta explained another solution for rural patients. In certain situations, the transportation physician and stroke team would send the patient and a helicopter to the closest PSC to properly check for thrombolysis and/or EVT eligibility. If eligible for thrombolysis, the patient can begin therapy at the PSC, then transfer to a CSC for EVT, or receive thrombolysis in the air as their STARS helicopters carry thrombolytics.

Finally, Mobile Stroke Units (MSU) should be investigated as an option for rural regions in NL. Instead of multiple stroke centres, regions could have MSUs support their population. A MSU is an ambulance equipped with a CT scanner, a point-of-care laboratory, and a stroke team to diagnose, triage, provide pre-hospital care and administer thrombolysis (Højslev Lund et al., 2022). MSUs have shown substantial benefits for their stroke patients, but implementation requires a substantial investment. The costs of an MSU include an initial investment of around one million Canadian dollars, and then the ongoing operating, maintenance, and staffing costs (Mason, 2017). Threshold for cost-effectiveness, MSUs would need to treat between 100–150 ischemic patients with thrombolysis per year (Buzby., 2017).

3. **Expand the EVT treatment time window.**

For HSCs EVT treatment window, they are staying at six hours from LSN until they expand to a 24/7 service. They want to ensure their capacity and readiness. Then they will begin to start looking at increasing their time window. CSBP has recommended patients with disabling ischemic stroke beyond six hours up to 24 hours from LSN should be rapidly screened using advanced imaging to determine EVT eligibility (Heran et al., 2022). For the other three regions, they had issues extending their treatment windows.

Alberta's provincial protocol is six hours from LSN or wake-up symptoms with severe deficits (LAMS ≥ 4). Alberta has an initiative to expand their EVT time treatment window up to 24 hours province-wide but has not received approval yet. FMC has been using the 24-hour time window to demonstrate efficacy while the province addresses logistical considerations on load management (EMS system, transport calls, CSC patient load). NS continues to have debates on their EVT treatment window and who they should accept. NS has an increased treatment window of twelve hours from LSN. This increase has challenged the QEII staff and resources, as the QEIIs emergency department is already under pressure. Finally, SEO has expanded their treatment window to 24 hours from LSN. Implementing CTP imaging and RAPID AI software to assist was the first step to enable patient selection for those extended EVT treatment windows. However, SEO has faced an area of resistance: their EMS bypass and EVT screening (LAMS) ends six hours from LSN. Therefore, patients go to the closest health centre from six hours LSN. SEO is working to extend their EMS bypass protocol. To work around this issue, SEO has an ACT-FAST protocol. ACT-FAST is a screening tool used in every ED to educate on quick triage and appropriate EVT transfer. Their ACT-FAST protocol has contributed to many EVT transfers for KGH, and the patients treated from six to 24 hours have done well. Appendix XXXIII illustrates the ACT-FAST triage tool, Appendix XXXIV presents the SEO emergency transfer guide to KHSC-KGH for EVT ischemic stroke patients (including ACT-FAST).

The increased treatment window to 24 hours LSN is vital for long transfer distances of eligible EVT patients. CSBP recommends advanced CT scanners with CTA programming and the ability to perform multiphase CTA's or CT Perfusion (CTP) imaging for EVT selection criteria of ischemic stroke patients arriving from six to 24 hours since LSN (Heran et al., 2022). Software should be used to provide quantifiable measurements of the ischemic core and penumbra from CTP imaging to determine whether an area is already completely infarcted and dead (Heran et al., 2022). RAPID AI software is already built into every scanner at every PSC in EH and can send the images to the on-call neurologist and radiologists. Therefore, PSCs are already equipped to identify eligible EVT patients in the extended time window and NL can make sure that software is working, tested and consistent before expanding and consistently treating those patients in the later time window. It may be challenging to use CTP and multiphase CTA on every stroke patient who presents within 24 hours (extended code stroke). Therefore, their EMS RACE score could potentially identify patients with LVOs who could benefit from an extended Code EVT. However, using their RACE score in rural regions is challenging as some paramedics or EMRs have a lower level of training.

5.6 Patient Monitoring

Thrombolysis and EVT greatly benefit eligible patients, but stroke units help a much broader portion of the stroke population. CSBP highlights stroke unit care as the gold standard of care following an acute stroke (Heran et al., 2022). In EH, the only place with the recommended resources and staffing ratios for a stroke unit is the HSC. However, due to staffing shortages, the

HSC-designated stroke unit has had challenges to maintain. As stroke units are shown to improve the odds of functional independence and decrease mortality, rural patients are disadvantaged as they are not admitted in a stroke unit. Therefore, facilities without units should strive to implement alternate models with elements of a designated stroke unit. Following thrombolysis and/or EVT, patients must have ongoing neurological monitoring which is summarized for each region in Table 5.12

Table 5.12: A Summary of Patient Monitoring Responses for the Four Canadian Regions

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
- Proceed to ICU post care for 24-hour monitoring - After critical care, patient should be admitted onto a designated stroke unit	- During EVT, neurology organizes a patient bed on their stroke unit, - Repatriate agreement to a local stroke unit - No return policy for QEII ED after EVT (Pod 7 while waiting on ambulance)	- Make sure an ICU bed is available - Transferred to local stroke unit within 24-72 hours - Repatriation agreement is important to manage patient volume - Full flow office and case managers to help with repatriation - SEO has 3 stroke units - Fast Track for acute care to rehab with stroke hospitalists	- Directly to a stroke unit for frequent neuro monitoring - FMC stroke unit holds a bed for stat stroke patients - Patient remains at FMC until stable and repatriate if their system is full - SUEC for PSCs - Follow-up at 90 days to check in and collect data - Rural patients can use telehealth at closest PSC
Barriers - HSCs capacity - Challenge to maintain - Disadvantaged if they are not admitted onto a designated stroke unit	**Barriers** - QEII cannot house all stroke patients on their stroke unit - Repatriation - Acute care bed while waiting for an ambulance	**Barriers** - Time explaining repatriation - Without stroke units, a lot can go wrong - Long delays to get to rehab (Fast Track)	**Barriers** - SUEC do not have the same resources but standardized care. - Rare delays for stroke unit but FMC holds a bed for Stat strokes

SUEC = Stroke Unit Equivalent Care

At HSC, patients proceed to an ICU bed for 24 hours and are subsequently admitted to HSCs designated stroke unit. In SEO, patients are monitored at KGH in an ICU bed for 24 to 72 hours and repatriated to one of their three stroke units. At FMC and QEII, patients go directly to their designated stroke unit. Therefore, patients can go directly to a stroke unit with the appropriate resources and staff and does not need to go to ICU post-treatment. The QEII neurologists are responsible for the patient’s destination while they are in the angiography suite and will call the bed managers to identify post-treatment management.

HSC does not currently treat many stroke patients with EVT and does not need to use immediate repatriation. However, with a 24/7 provincial-wide service, repatriation may need to be considered, especially since HSC is already having capacity issues. Calgary only repatriates if their unit is full and the patient is stable, but SEO and NS have repatriation agreements. NS sends patients directly back to their local stroke unit and SEO monitors for 24-72 hours before repatriating to the patient’s local stroke unit. SEO has three stroke units to service their region. With a lot of hard work and organization, the SEO stroke network was able to establish three stroke units within their region: Kingston (central), Belleville (west), and Brockville (east). Their most effort went into installing a stroke unit in Brockville. They needed the unit as many smaller communities were presenting higher mortality rates after repatriation. Therefore, they used all the patients throughout the eastern region hit the minimum patient volume set by the government (120 per year). This patient volume was enough to create a four-bed stroke unit in Brockville allowing patients from these smaller communities to repatriate to Brockville and preserve the benefits of thrombolysis and/or EVT.

“People have to get back to their local hospital” (ON-03)

Some regions will have difficulty sourcing the volumes and resources to create a stroke unit. For example, Alberta created Stroke Unit Equivalent Care (SUEC) units to cluster their stroke patients in the same unit and provide a similar level of care as their designated stroke units.

Although the resources differ, AHS has tried to standardize SUEC care with stroke rehabilitation and nursing care guidelines to help with equity throughout their province.

To help ensure a bed for a patient: i) NS use neurologists to organize the patient's bed while the patient is in the angiography suite, ii) SEO case managers and flow office help with repatriation and bed availability, iii) Calgary hold a bed on their unit for a Stat Stroke patient.

After stroke unit care, patients should have rehabilitation available and a follow-up to check in and collect functional outcomes. SEO used a Fast Track initiative to improve the length of stay (LOS) for patients going from acute care to rehabilitation centres. They explained how stroke hospitalists improved medical transition and management across the two centres, reducing their stroke unit LOS from 18.5 days to 8.5 days, and they are still trying to improve. In addition, Calgary has a stroke follow-up clinic as part of its routine care. It is a great way to check in on patients and collect their 90-day functional score. This follow-up can also be done through telehealth, as the patient can go to their closest health centre and consult with the on-call neurologist with the help of a nurse.

In addition, Clarenville has doubts about developing a designated stroke unit to support the rural stroke patients due to healthcare staffing and alternate level of care backlogs occupying acute beds long term care access. Participant NL-08 believed this year has been the most challenging on their staff. With the stress these rural hospitals are under, strategies to discover where to have a local stroke unit or SUEC could really help. Participant NL-13 believed the best model to support their rural patients would be to upscale the multidisciplinary stroke teams at PSCs to include more intensive rehabilitation. Upscaling would require additional support for their allied health providers and additional education, such as, virtual care to support rural regions by connecting rehabilitation teams, HSC neurology team, and the Miller Centre.

Chapter 6 – Barriers, Enablers, and Quality Improvement Initiatives

Along with the stroke care pathway, each case investigated barriers faced/currently facing, enablers to break through barriers, quality improvement (QI) initiatives, and directions participants hoped their programs would take. Each section will have corresponding themes presented during the analysis as subsections that were derived using a thematic analysis of the raw data. Identifying barriers, enablers, QI initiatives, and future directions can help the NL stroke care system by understanding and learning from other stroke care systems. As stroke care is constantly evolving, stroke programs must maintain methods and strategies focused on continuous QI. Efficiencies in the first few hours from symptom onset have significantly improved a stroke victim's functional outcome. Along with QI, it is essential to discover critical success factors for an efficient hyperacute stroke system. In addition, knowing what issues arise while developing a quality stroke program can help EH prepare for potential barriers they may face and understand what enablers, if applicable, overcame each barrier.

A range of professionals providing and implementing hyperacute stroke care were interviewed and stroke care documents were requested to discover how their system cares for their patients. Each interviewee corresponds to a number labelled NL-01 – NL-13, NS-01 – NS-12, ON-01 – ON-06, and AB-01 – AB-06. In addition, the Office of the Auditor General of Ontario (OAGO) investigated KGH (July 2021) intending to learn and understand their strong performance. The OAGO inquired about explanations from KGH on their success; Initiatives, protocols, and structure to facilitate performance, and other important aspects for success.

6.1 Barriers

By understanding Barrier and Enabler, NL can learn from issues that arise while developing a quality stroke program, prepare for potential barriers and establish the appropriate enablers. Table 6.1 summarizes those barriers and the associated themes from my case studies. The descriptive themes included resource management, the disparity between rural and urban stroke care, process barriers, and issues with data collection and analytics.

Table 6.1: A Summary of Barriers Affecting Hyper Acute Stroke Care for Four Canadian Health Regions

<table>
<tr><th>Eastern Health Newfoundland</th><th>Central Zone Nova Scotia</th><th>Southeastern Ontario</th><th>Calgary Zone Alberta</th></tr>
<tr><td><u>Resources Management</u>
- Must review their system
- EMS staffing shortages across the province, especially in rural regions
- ACPs are a limited resource
- EMS quality assurance is understaffed
- Nursing shortages
- Only 3 INRads
- 1 angiography suite
- Need additional stroke units across their province
- QI requires resources.</td><td><u>Resource Management</u>
- Demand for resources, funding, and staff
- Competing priorities/ coinciding emergencies
- EVT Increased strain on EHS/QEII
- Want a 24/7 stroke nurse
- Administration only see dollar signs associated
- Need support for large scale changes
- Lost strategic command after health care reorganization
- Engagement of Sr management for EVT</td><td><u>Resource Management</u>
- Frontline availability for QI
- Finding speakers
- Funding for Actual EVT Volumes was based on the previous year's volumes. Not aligned with actual volumes
- Adjusted
- Growth in patient selection with advanced technology
- IR Suite Capacity has many demands
- Planning to expand INRad for a 3rd suite</td><td><u>Resource Management</u>
- Understaffing of EMS
- Complaints about diagnostic imaging and EVT suite material
- Budget
- Pressure on their staff: Not enough nurses
- Meetings to adapt.
- Blockages in EDs.
- Stroke unit is saturated
- Priority
- Hold a bed.
- Need quality scanners at PSCs</td></tr>
<tr><td><u>Processes</u>
- Imaging interpretations delays (residents)
- Delays on laboratory values. INR (30-60 mins) and platelets (10 mins)
- Point of care testing.</td><td><u>Thrombolysis reluctancy of Emergency Physicians</u>
- Do not support thrombolytics in stroke
- Nothing more controversial
- Afraid of litigation
- Telestroke
<u>On-call System</u></td><td><u>Teamwork</u>
- Changes to key roles cause disruptions and need to be replaced
- Breakdowns in communication due to the time pressures
- Cement roles
- Debrief issues.</td><td><u>Efficiency</u>
- DTNTs > 30-min
- Outliers when managing symptoms
- No pre-notification with In-hospital and walk-in strokes
- Waiting on laboratory results when required
- Flagged vessels</td></tr>
</table>

- Differences in decision makers = longer DTNTs - Walk-in patients = no pre-notification - Night strokes tend to take longer.	_- Video technology is terrible - Slower DTNTs - Physicians become out of practice	- Must have communication redundancies - No pre-notification - No pre-identification - Delayed transitions increases the odds of something going wrong - Constant work	- Capacity barriers can interfere with a fast flow of patients - Early Reluctancy on Thrombolysis, but initiatives created building blocks
Disparity between Rural and Urban - ED confirms and activates Code Stroke - CTAs add up to ten minutes in CT suite - Thrombolysis after NC-CT - Expecting difficulty with rapid transfers. - MedFlight - Carbonear have longer delays when their internists are unavailable	**Disparity between Rural and Urban** - Large gap in care - Bypass protocol had resistance - EMS training level - Groundwork for provincial protocols. - Slower/ hesitant thrombolytic decisions at PSCs - Outreach to help improve. - Differences in on-call neurologists - Stroke unit availability	**Disparity between Rural and Urban** - Do not have decision support team - No neurology - Telestroke - Physician resistance - Need leaders. - Small communities are not comfortable - Education - ACT-FAST - Extend Window - Need Stroke Units	**Disparity between Rural and Urban** - A lot of room for improvement due to poor team culture and no stroke champion - Red Deer is terrific. - Alteplase created resource issues due to drip and ship monitoring - TNK - PSCs do not have the expertise - RAAPID
Emergency Medical Services (EMS) - Need a full review of ground and air paramedicine - Geography may be Newfoundland's biggest barrier. Especially for timely EVT access - HSC location is far from most of NL - Landing strips far from stroke centres - Weather disrupts air travel	**Geography and Transportation** - Can take hours to get to DASH centres - EVT increased this barrier - One EVT centre - Poor road conditions disrupt paramedic care - Little control over transport time. - Weather disrupts air transport - LifeFlight are already on mission	**EMS** - Ground versus air transport - SEO have a lot of delays with their helicopter system, so they use ground ambulances - By-pass only from 6-hour LSN - Huge resources issue - Re-organize drip and ship with TNK - Different level of certification. Need IV starts.	**EMS Geography** - Understaffing - Slow repatriation - Saturated ground ambulances have challenged rural AB - Relying on STARS which also has limited resources and is expensive - Need perfect scenario. - STARS is frequently unavailable due to weather
Education - Bringing people to the table. Mandatory? - Needs a provincial lens - Provincial paramedic education. Regular	**Research** - Ethics and legal aspects are important but they can become very rigid with a lot of hurdles	**Ongoing Training** - Must continue to advance skills - Turnover requires education to focus on the basics and not improvement.	**Simulations** - would love to see simulations used more frequently

education is the responsibility of private operators. Some regions do not have funding. - Educators to provide hands-on education - Continuous education	- Many research advances that could be years away	**COVID – Latent effect** - Telestroke due to Neurology absences - Staffing shortages, cannot fill positions. - Sick days create overworked staff and closed hospital sections - Cannot locate beds	

6.1.1 Resource Management

Programs must be prepared for advances in stroke care which have increased the patient population. For example, extended time window for EVT. SEO is using the ACT-FAST screening at non-stroke centres to capture presenting patients and there are advances in IR technology and equipment to treat previously irretrievable distal cerebral artery occlusions. These advances in equipment have also led to shorter procedural times. While Code strokes are the responsibility of neurology, neurology call in IR and additional staff for EVT. However, every region faces resource issues due to the demanding needs of hyperacute stroke care. As the stroke system develops, there is an increase in demand for resources, funding, and staff. EMS and nursing are understaffed and have been under a lot of pressure. SEO believed this to be the latent effect of COVID. Nurses have chosen a different career choice. This has also affected their education plan as they must revert to teaching the basics instead of advancing. SEO has funding for staff but must wait for new graduates or recruitment from other places. Calgary has explained how they are still providing a quality service under stress. By meeting as a group, they have adjusted to support their staff.

"The understaffing of our EMS system has been a huge issue" (AB-03)

As EVT grows availability for unpredictable ASPs is difficult due to many demands and increased patient volume on the IR suite (Stroke Network of Southeast Ontario, 2021). NL only have one angiography suite which could create issues if the program continues to grow. In KGH they are planning for a third angiography suite with equipment upgrades (biplane imaging). This is a five-year process and should be of consideration for NL.

In rural communities or peripheral sites, having an available ambulance unit is often quite challenging. Their ground ambulances have become saturated and there is a limited number of air assets. It has become challenging to deal with the increased volume of stroke patients that require immediate transportation.

As the system becomes busier, there are competing priorities. Many healthcare programs rely on the pre-hospital team and paramedic beds, but there can only be so many priorities. Therefore, it is crucial to find a balance and get all the stakeholders and the heads of the programs to discuss priority. Competing priorities also effect anesthesia and CT technologists. Participant NS-10 explained how anesthesia are delaying other surgeries for code stroke. The CT technologists receive pressure from many multiple areas. Therefore, accurate ETA and communication are critical. It is unfair to hold the CT table if the stroke patient is delayed, preventing another critically ill patient from using it.

EMS may be unavailable, on another job or a crew may have to take a patient out of their community to a hospital further away. EVT continues to strain the EMS system with longer transfers. Long transfers may require air ambulance teams who bring in additional complications. Participant NS-04 recommended having planes on either end of the province instead of being based in Halifax which creates two trips. Go to the patient and bring them back for EVT.

"That would be double the time" (NS-04).

For EVT, NL and NS have one centre. For NS, issues arise for patients who are far away. Therefore, they debated adding EVT in Sydney who had interested INRads. However, "It would be a massive job to recruit enough people" (NS-04)

Unfortunately, their resources and funding were not there. Therefore, there is a lot of strain on HI as the sole centre for the province. Their increased time window of twelve-hour LSN increased the number of eligible patients transported which is. NL should prepare for this increase in eligible patients when EVT expands and increases their treatment window.

"It's almost overwhelming" (NS-10).

In addition, other emergencies happen simultaneously create situations where required resources are lacking. For example, Halifax Infirmary only have a few transportable cardiac monitors and sometimes they are all gone with other patients. That is why they had to start repatriating patients after EVT. This repatriation agreement helped relieve some strain on their hospital.

"Every place has got unique challenges" (AB-01)

FMC faced some unavoidable barriers. Challenges on the money side including complaints about using too many resources in diagnostic imaging and endovascular suite material, but those resources must be used. To understand resource requirements, AHS used formal mechanisms for incorporating EVT into their operational budget. Now they want to increase the EVT time to treat window but are worried the volume of calls will be overwhelming. However, FMC does not want to miss eligible patients who could benefit. Unfortunately, FMC do not have enough nurses on the neurology unit. Their program continues to provide quality service by meeting to adapt. In addition, FMC has been dealing with overcrowding in the emergency rooms causing patients to be held in the hallways and inappropriate care spaces.

"Where do you even put them physically?" (AB-03).

The biggest challenge KHSC presented was the need for funding to be aligned with actual volumes (Stroke Network of Southeast Ontario, 2021). Their program was concerned as they were funded using the previous year's volumes. However, the KHSC stroke program was in a growth phase, and it is essential to ensure funding to continue to grow and provide a consistent service (Stroke Network of Southeast Ontario, 2021). KHSC adjusted their funding request by predicting their volumes in the upcoming year. They found it hard to predict and estimates can be more or less than expected, but they have closed the gap. They must show how those estimates are wrong because they will underpay.

"We'll probably still be underfunded, but at least there's less of a gap." (ON-03)

"Now we're at the point where I can say our funding is an enabler, 'cuz we're able to hire staff." (ON-03)

6.1.2 Disparity Between Rural and Urban Stroke Care

NS highlighted a need that all of Canada must address: The disparity between Rural and Urban stroke care. Health regions should address this disparity to ensure that more rural patients receive thrombolysis and efficient transfers for EVT. Rural regions with fewer resources have different paramedic training, which further disadvantages the rural population. Therefore, NS put in a lot of work to develop its provincial protocols. Along with those protocols, PSCs require stroke champions and coordinators to drive change and create a team culture. These aspects are described in QHC in SEO and Red Deer in Alberta, both highly functioning PSCs. In addition, I recommend NL to develop a provincial stroke network to standardize care across the province, provide protocols to support care, have on-call neurology available for consultation, and monitor performance to keep centres accountable. At the moment, NL have too many emergency medical responders (EMRs) servicing their rural patients. These EMRs impact their protocols as EMRs are unable to care as PCP or ACPs. Therefore, this provincial network can look at standardizing their EMS system. NL hopes to increase their PCPs and ACPs, a multi-year education plan.

“Our biggest barrier is just the layout of the province” (NL-10)

“Geography is definitely a barrier” (NS-03)

Geography may be NL’s most significant barrier. Many roads are far from main highways and stroke centres. Therefore, rural patients have difficulty getting to PSCs which prevents early access to urgent imaging and additional treatment. In some areas, getting to a PSC facility can take hours, evaporating the 4.5-hour treatment window for thrombolysis. In addition, St. John’s is on the east coast of NL, making it difficult to service the whole province. It would be easier to service the whole province if HSC was in Central NL. Transporting EVT patients beyond Clarenville begins to stretch out the limits of ground transportation. Due to uncontrollable logistics, air and ground time are similar as of Gander (Central NL). Pilots and air control need to do their checks before transporting a patient. The Halifax Infirmary cannot accept some EVT patients because it will take too long to transfer and arrive within eleven hours from LSN.

“Even for critical missions, a one-hour wheels-up time is required” (NL-04)

“Part of the problem is that we have very little control over transport time” (NS-01)

Therefore, Stroke care should investigate address air transportation for EVT access. NL’s weather also disrupts transport times, preventing air travel, and the landing strips are generally not close to the stroke centres, which was not poor planning, just geography. In Alberta, STARS air ambulance service has been effective for longer transport distances, but it has to be the perfect scenario. STARS is unavailable half of the time due to weather. In addition, STARS is not cheap, but patients need ambulances to get immediate imaging for time-sensitive treatment.

Further disadvantaging the rural population is the availability to cover large catchment areas. Organizing efficient transportation with no ground and/or air service available create delays that can prove critical for their patients. In addition, bad roads disrupting the EHS's ability to put in IVs, especially if the patient has poor vessels.

Another significant barrier affecting rural facilities is the reluctance to provide thrombolysis. Peripheral sites do not have neurology and the most responsible physician tends to be a little bit slower and hesitant. In NS, there is nothing more controversial, emergency physicians do not support thrombolysis in stroke and believe the neurology community is in bed with the pharmaceutical companies. Participant NS-06 continued to explain how Canadians worry that if something terrible happened by giving thrombolytics, they might be sued. However, they would be sued in the USA if they did not provide thrombolytics.

"Emergency physicians think it [is} completely black and white" (NS-06)

This is not an issue at larger CSCs because neurology decides to use thrombolytics that an emergency physician may disagree with. However, PSCs do not have neurology and use emergency or family medicine physicians to make the thrombolytic decision. Therefore, health regions should implement a on-call communication pathway like Telestroke.

Using video technology, Telestroke allows the on-call neurologists to provide advice and make treatment decisions. However, due to the terrible video technology, NS uses a cheaper version using a telephone call, where the on-call neurologist can access their provincial PACS system to view images, receive a description of the patient, and help decide the treatment option.

"I'm actually not a big proponent of Telestroke" (NS-02).

While Telestroke is often required, DTNTs are often increased, but may increase the proportion of those thrombolyzed. When the emergency physician makes the decision, there are faster DTNTs. However, due to the reluctance to use thrombolytics, an on-call system may be necessary. Support was supposed to help with education, but physicians rely on the on-call system and are out of practice. For complex cases neurology are required. However, there can be differences in the comfortability and efficiency of neurologists.

Participant NS-02 explained that New Brunswick uses a provincial Telehealth system with video. So instead of a quick phone call, they set up the video system.

> "Their Door-to-needle-times are more than double Nova Scotia" (NS-02).

This may or may not be related to the telestroke system, but it almost seems like a structural barrier for efficient treatment. The NS stroke neurology team are providing education and outreach to help improve, but there remains a difference in comfort level. Calgary also faced debates about thrombolytics, but their quality initiatives created building blocks to support their stroke network. NL should identify any reluctance issues so they can help those providers.

Instead of resisting, these centres need stroke leaders/champions to guide the process. The most efficient enabler is having good standard operating procedures, protocols, policy, and rehearsed roles to allow their stroke care to be less dependent on the physician. In addition, establishing the most responsible nurse.

To assist non stroke centres, education is impactful and the SEOs ACT-FAST's protocol for EVT was big for the rural patients in SEO. ACT-FAST is a screening tool used in every ED to educate on quick triage and appropriate EVT transfer presented in Appendix XXXIII. Their ACT-FAST protocol has contributed to many EVT transfers, and the patients treated from six to 24 hours have done well. ACT-FAST could be a useful tool for NL.

Finally, there are issues that patients admitted to other facilities may not get into a stroke unit. Stroke unit care is essential to maintain the benefits of hyperacute care and only the HSC has a designated stroke unit in NL. With a lot of hard work and organization, the SEO stroke network was able to establish a third stroke unit within their region. They used all the patients throughout the eastern region hit the minimum patient volume set by the government (120 per year. Alternatively, Alberta created Stroke Unit Equivalent Care (SUEC) units to cluster their stroke patients in the same unit and provide a similar level of care as their designated stroke units. Although the resources differ, AHS has tried to standardize SUEC care with stroke rehabilitation and nursing care guidelines to help with equity throughout their province.

6.1.3 Process Barriers

Hyperacute stroke care is very much operational. Therefore, hospitals face barriers around processes in a stroke patient's pathway. This theme relates to any barrier disrupting the stroke care pathway including teamwork, communication, transitions, slow processes, culture, and management. Stroke care services require complex interactions between several hospital teams and units (Stroke Network of Southeast Ontario, 2021). To properly operate, there must be cooperation to simultaneously care for their patients. SEO has engaged these teams to include representatives in their EVT workgroup to meet, review, and share ideas.

Along with teamwork, significant delays can occur without pre-notification, pre-identification, pre-registration, and ASP communication (Stroke Network of Southeast Ontario, 2021). KHSC-KGH has noticed breakdowns in communication due to the time pressures and moments when team members were unclear about their roles. Therefore, it was essential to cement the process about roles and responsibilities. To help reinforce the communication processes, teams can implement reminders, huddles, and posters. When requested, it is important to debrief cases with breakdowns to take away critical learnings (Stroke Network of Southeast Ontario, 2021). To provide overall coordination, a stroke team should have one clinical leader (stroke neurologist) and multiple communication redundancies to support their leaders (Stroke Network of Southeast Ontario, 2021). In addition, NS had patients showing up outside the CT scanner with no notice or inaccurate ETA. They had to get everyone on the same page, especially when EVT was introduced. It was difficult as they had to launch things simultaneously.

“If you do [not] have good flow and transitions, it really blocks things up, and it makes it difficult to do a good job” (ON-03).

When patient transitions are delayed, the likelihood of something going wrong increases. Therefore, success relies on an efficient patient flow with smooth transitions (Stroke Network of Southeast Ontario, 2021). For example, KGH has one critical care flex bed as a backup to help the flow of stroke patients. The overall flow will improve through timely access to stroke units, repatriation agreements, inpatient rehabilitation, stroke prevention clinics, and outpatient rehabilitation (Stroke Network of Southeast Ontario, 2021). However, patient flow constantly need work and may never be perfect. In addition, there are inefficiencies waiting for the next level of care like rehabilitation. The Fast Track quality initiative has improved those delays, but SEO hopes to see those improvements continue. Fast Track is an initiative NL can investigate.

When looking at actual steps in the pathway, hospitals, regions, and provinces can differ in what delays patients will face. Even the time a patient has a stroke can affect the quality of care. Table 6.2 presents issues that affect stroke care processes within the HSC.

A major disruption to efficient care are in-hospital or walk-in stroke patients. These patients do not have the pre-notification of EMS. Therefore, stroke systems must plan for these protocols However, NL should think to educate inpatient staff to recognize stroke symptoms as SEO highlighted their paramedic prompt card as a better screen than their inpatient support staff. Strokes were missed. Therefore, anyone can activate their stroke protocol.

Table 6.2: Barriers in Stroke Care Processes for HSC

Code Stroke - Residents are quicker than staff to arrive on scene. Residents can begin the neurological assessment
Imaging - Radiology residents are in-house to get on-scene immediately but there can be delays in their interpretation of the CT scans. It is a training program.
Thrombolysis - There is a significant amount of Code Stroke patients who do not get thrombolysis. However, HSC has largely improved. - Many code stroke patients are TIAs, bleeds, or stroke mimics. Therefore, the code strokes who do not receive thrombolysis, likely shouldn't. - Provincial review required. Why are patients not receiving thrombolysis.
Laboratory - There have been delays waiting on laboratory values. Especially around international normalized ratio (INR) test (thirty minutes to an hour) for patients on warfarin or who have liver failure. - Pushing the idea that the standard of care is not to wait for blood work results unless abnormalities are expected. - Looking at using point of care testing to hasten INR testing but that is an investment that requires calibration and monitoring. - If the patient has a history of low platelets, then you must wait for the platelets to come back (ten minutes)
Door to Needle Time - Outliers tend to require INR testing or have blood pressure issues. Should record and monitor. - Delays in decision making – Are we going to give thrombolysis or not? - Differences between decision makers
Walk in Patients - The stroke team does not receive the pre-notification to prepare for the patient's arrival. As a result, there is a delay in the door to CT and treatment time. - The triage nurse must recognize the stroke symptoms. If they don't, the process is further delayed as the emergency physician must diagnose the symptoms and activate a Code Stroke.
Day versus Night Hours - Code Stroke tends to be quicker during the day. - After a Code Stroke notification, the patient may be closer to the hospital than the providers. - If the patient arrives first, the ED physician will begin the Code Stroke process while they wait for the neurologist to arrive. The ED physician will make sure the patient is stable, complete a neurological examination, and check for contraindications.

"If you see somebody with any signs or symptoms of stroke, activate the stroke protocol. Period"

(ON-03)

Usually, they will notify the nurse who contacts the neurology resident, who will activate the stroke protocol notifying the appropriate care providers from Appendix XI. Figure 6.1 illustrates the QEII-protected internal protocol. Walk-in patients have a very similar process, but have a slower, less efficient response. In addition, KGH frequently receives walk-in stroke patients that the triage nurse identifies. If they identify a deficit (or something feels wrong), they activate a stroke protocol, and everyone rushes in.

"There's a clear delay of about 10 minutes" (ON-01)

Figure 6.1: Protected Internal Stroke Protocol

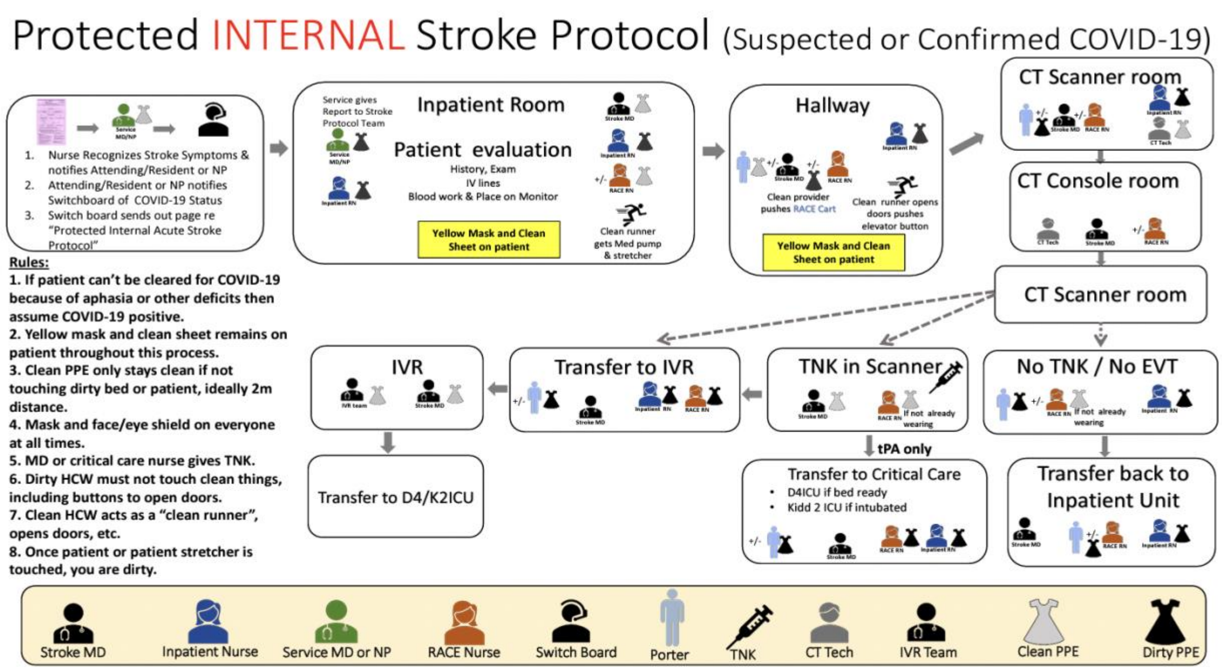


Fig. 6.1. Presents the protected (COVID) internal stroke protocol at the KGH. Aside from the protective gear, the internal protocol is different from having EMS as a nurse must recognize the signs of a stroke and begin the stroke protocol.

All EH PSCs differ, but Code Stroke is not activated until the nurse, or ED physician confirms a stroke due to concerns regarding false stroke activations combined with a strained staff. In Carbonear, the most considerable time delay revolves around having an internist available and waiting for on-call consultations. However, dramatic improvements to reach on-call stroke neurologists have occurred in EH. In addition, patients arriving at Carbonear tend to fall outside the thrombolysis treatment window, preventing effective hyperacute stroke therapy. Outside working hours, Clarenville face a fifteen-minute delay to call in a CT technologist. Internists also have varying DTNTs based on their decision making. This has been addressed by ongoing motivation/modification feedback loops and direct communication with the radiologist to confirm no bleed. With the addition of EVT, the CTA to diagnose EVT eligibility is potentially adding ten minutes in the CT suite. Therefore, Clarenville has made thrombolysis available in the CT suite. After the NC-CT confirms no hemorrhage, thrombolysis is delivered before the CTA is performed. However, rapid/efficient transport will create a challenge for EVT eligible patients. Participant NL-08 believes NL's Medical Flight resources and transport are inadequate for effective EVT transport.

"Training is a big one… Hospitals are losing a lot of that experience" (NS-05)

As professionals leaving hospitals acquire a lot of junior staff creating growing pains. Even when everyone is on the same page, people work at different speeds. For paramedics, experience can introduce bias that can prevent the use of stroke scales. These include older aphasic patients, slurred speech attributed to drunkenness with younger or First Nation patients, and younger patients are often believed to be too young to have a stroke.

In NS, the Escape trial moved everything forward as it provided funding and legitimacy for EVT. However, they had difficulty getting the provincial senior management to engage in developing their EVT protocol. After rolling over from the ESCAPE trial, their EVT program was never really recognized as an official program, causing struggles in acquiring extra funding.

This occurred because NS underwent a health care rearrangement in 2015 that created a problem for their stroke System. Before the rearrangement, NS had a network of free-flowing knowledge led by Cardiovascular Health NS, a provincial program that implemented policy on the ground with the assistance of stroke coordinators and local physician champions. The program was highly functioning and accomplished a lot. However, provincial programs (like Cardiovascular Health) were removed from the Department of Health and made the responsibility of the NS Health Authority. As a result, the stroke system lost its strategic command structure and had no administrative link for stroke. Their network began to wither.

"The immediate thing is to re-institute the network we had, that we built" (NS-09).

SEO and Calgary have a dedicated health network that oversees provincial stroke care and has achieved Accreditation Canada's Stroke Distinction. Their health networks have emphasized continuous quality assurance to maintain CSBP recommendations. Therefore, I would recommend NL to develop a dedicated health network that oversees provincial stroke care.

Finally, stroke Care is a 24/7 service but doesn't work the same 24/7. Outside of daytime hours and on weekends, time to treatment can be longer. NS believed this to occur more often for EVT, as their angiography suite is not staffed 24/7 and will need to be called in. As time to treatment is correlated with better recovery, Participant NS-10 believed patient arriving after hours are discriminated against. To impact 24/7 organization, HI created an application to their administration justifying the role of a 24/7 stroke nurse for just shy of a million dollars. They showed how a stroke nurse improves efficiency, outcomes, and cuts down on Length of Stay (LOS), resulting in future savings. However, the administration only saw the associated dollar signs. Both Calgary and Kingston have full time stroke nurses to support their patients. Their stroke nurses come down from their stroke unit with a stroke kit, completes documentation, charts the time stamps, provides bedside nursing support, and helps administer thrombolysis.

6.1.4 Data Collection and Analytics

To ensure continuous QI, stroke systems must collect and analyze data, but EH does not believe they are where they would like it to be. There are a lot of time-consuming issues due to manual data entry, which also adds additional human error. Data also takes a long time to be coded and analyzed. Therefore, hospitals and regions must wait six to twelve months for their outcomes.

"It [is] one hundred percent a resource issue" (NL-04).

Participant NL-01 explained that they have been working through humps to make it as automated as possible, such as pulling reliable time stamps from their Meditech and PACS systems. However, their provincial reports do not present the efficiency outcomes from those time stamps, such as DTNT.

Extensive manual data collection requires hard, tedious work to identify immediate areas for focused improvements (Stroke Network of Southeast Ontario, 2021). Therefore, KHSC-KGH aims to gradually streamline their data collection. Like NL, they have long wait periods to compare between hospitals and provincial reports.

"Typically, 18 months behind, so it [is] archeological evidence, it [is] useless" (ON-01).

Participant ON-03 explained how the long wait time is due to standardizing for a mixed case which requires a lot of work and expertise. Therefore, they must keep track of their own data to quickly make improvements (minimizing differences between their daytime and nighttime shifts). Quality improvement requires staff and resources, but they do not have staff to solve all their problems. Unlike the CSCs, smaller hospitals do not have decision support teams. Therefore, the managers and patient record department are working to analyze the information.

EMS managers in NL argue for quality assurance. When facing complaints about false positives, they want to understand what ambulance services need training. It is a resource issue. They are brutally understaffed. In addition, EMS work with private ambulance operators who sometimes are not friendly and cooperative when it comes to quality assurance. Those private services are the custodians of their own charts, so the provincial system relies on private services to report.

"If we had electronic patient records, it would be great" (NL-04)

Electronic records would not be wasting so much time trying to collect and analyze data from other sites. However, in rural areas like Carbonear, participant NL-07 said they still work with an older system of signing off on old sheets to get scanned to the patient's chart. They do not use Meditech for Code Stroke.

Finally, it is essential to be clear with data collection definitions. When analyzing, programs must not choose a denominator favourable to your numbers. Selecting outcome measures and denominators also affects the centre's ability to compare with other sites. In addition, questions arise when discussing resource utilization capacity. AHS provided their cost savings estimate. However,

"How do you quantify life years?" (AB-02)

Therefore, I recommend NL having a considerable focus on continuous quality improvement (QI) supported by electronic medical records.

6.2 Enabler and Keys to Success

This section looks additional enablers and keys to a successful stroke program. Each region reported similar enablers and success factors that are summarize in Table 6.3. The descriptive themes included the importance of carious leadership roles, a well-coordinated team response based on a culture that understands Time is Brain, continuous review, and continuous education.

Table 6.3: A Summary of Success Factor for the Four Canadian Regions

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Leadership - To engage/motivate/ encourage - VP with a primary responsibility for stroke care (recommendation) - Need a passionate program manager - Didn't feel a coordinator was sufficient - Hospitals need stroke champions. - Lead charge nurse to act as an access point to organize their team.	**Leadership** - Make improvements - Neurology were instrumental - Clinical leadership to drive processes - Stroke Coordinators responsible for the entire spectrum of stroke care, to find time for improvement and help with large system change - Coordinators at each stroke centre/ region and part-time co-ordinators at smaller centres to organize and find time for improvement	**Leadership** - Regional Stroke Team to work with all stakeholders - Collaborative - Impact on culture - Supportive senior leadership for QI - Neurologists are clinical leaders for efficiency - IR leads EVT - Key charge nurses - District Sites need physician champions - Learn from each other - Neurological expertise in critical care/monitoring	**Leadership** - Unified system that created protocols across Alberta with slight differences between centres. - Led by clinical leadership - Stroke champion at PSCs - Stroke coordinators at each site - Engaged - Help develop protocols - Created a culture supporting QI - Motivated on continuous improvement
Teamwork - Multidisciplinary teamwork with coordinated care - Collaborative approach to improve their protocol - Must include all stakeholders - Provide recognition for their whole team.	**Teamwork** - Improvement Collaboration - Communication - Maintain good relationships - Make sure all stakeholders are involved - Come to a consensus	**Teamwork** - A well-coordinated team response - Culture of Time is Brain - Communication - Cooperate and work simultaneously - Recognize the excellent work of their whole team	**Teamwork** - Quality teamwork and a team culture around efficiency - Highly experienced stroke team (FMC) - Intentionally built team with established relationships - Include all departments
Review - Provincial Stroke Committee	**Review** - Weekly stroke rounds at QEII. Include all stakeholders	**Review** - EVT working group focused on QI.	**Review** - Stroke Working Group reviews the literature, comes to a

- Debrief for improvements - Debrief after every EVT case - Include all stakeholders. - Include frontline workers. - Respectful environment with open communication - Improvements carry onward - Trickle-down effect - Monitor to keep sites accountable (recommend)	- Monthly meeting are important for smaller DASH facilities (An acute stroke working group) - Provincial stroke network meet monthly to maintain their stroke network and keep everyone motivated	Debriefing was very important - Hundreds of data points to review upon EVT launch - Continuous workflow improvements - DTNT improved from 41-19 minutes - Weekly Stroke rounds (18-20 participants) - Monthly rounds at QHC - EVT committee meet every 4 months (30-40) - Provincial Stroke rounds	consensus and implements stroke best practices through position statements. - Representation of all fields - Local teams to implement - Collaborate nationally to assist other regions - Weekly Stroke meeting to review and identify issues - Stroke Improvement Committee review every quarter
Education - Never enough education - Robust on-boarding system - HSC educated all the departments at once - Code Stroke simulations and department simulations. - EH has a lot of on-going education - Manager - Neurology offer their expertise to help - EMS have a great EVT module - ACP program at the College of the North Atlantic.	**Education** - Extensive training for EHS - EHS Learning management system - Teachable moments to give feedback or praise to EHS - Leadership encourage people to keep up to date - Physicians have provided video education sessions - Educational sessions with local and outside experts - Participate in Clinical Trials. - Trials provide funding and legitimacy - Practice and run simulations	**Education** - Government funded education work plan - Work at an organizational level - Continuous process - Huge educational roll-out for process changes - Experts for workshops - Participate in trials - Trials provide training - Must reinforce their messaging/ check-in - Virtual meetings to share information - Education to ensure quality data - Map protocols - MOCK simulations, videotaped, and rehearsed - Document issues	**Education** - Focus on educating themselves and their colleagues - CME training - Routine educational events by their stroke physicians - 4-6 trials at a time to advance care - 4 stroke trial nurses who support these trials - Mapping processes, include all stakeholder to prepare their program - Separate mapped-out processes for each department - Simulations are the best way to get their system moving quickly and discover issues unidentified during meetings
Culture - Buy in from all - There is a ton of room to grow - ACTEAST helped change their mindset - Look for process changes to save minutes	**Culture** - Programs need to standardize processes - Always something to improve - Implement evidence-based research	**Culture** - Time is Brain - To collect data - Decreasing DTNT validates change - Cannot improve without data - If you can measure it, you can fix it	**Culture** - Team culture around efficiently treating patients - Team really believes in quality improvement

6.2.1 Leadership

Firstly, stroke systems require passionate leaders who want to motivate their teams, improve their system, and support QI. Leadership requires a collaborative approach, including performance measurement, knowledge translation, and system change (Stroke Network of Southeast Ontario, 2021). These leaders include senior leaders to provide support, clinical leaders who are the experts and drive change, stroke champions in PSC, stroke coordinators at each site who find time for improvement, and nursing leadership to keep everything together. In addition, these leaders create a necessary culture around time is brain.

One of the recommended positions of the new NL health authority is a Vice President with stroke care in their primary portfolio of responsibilities. The goal is to make stroke care its own entity by creating a comprehensive provincial stroke strategy and engaging stroke centres to understand their needs. In SEO, he Regional Stroke Team (Regional Stroke Director, Regional Stroke Medical Director, and Regional Stroke Best Practice Coordinator) strive for a collaborative approach working with all stakeholders to improve access to best-practice across the continuum, supporting the EVT workgroup to sustain and update best practices, and share learnings (Stroke Network of Southeast Ontario, 2021). In addition, KHSC-KGH and the Calgary Stroke program have been awarded the Accreditation Canada Stroke Distinction, which has helped keep them focused on what's really needed to make those improvements.

The Calgary Stroke Program (CSP) is mostly ler by the clinical leadership. The engagement of their clinical leadership has created a great culture to improve their system and overcome barriers. For EVT, Calgary's service works so well because of their fantastic INRads group. Of course, they had issues, but their INRads have been absolutely essential.

“The champions of leading change would probably be the stroke neurologists” (NS-05)

HSC and CSCs are very fortunate to have the neurologists. As the clinical experts in stroke care, neurologists provide a clear advantage to drive the code stroke processes. They are aware of research evidence and know what other stroke centres are doing. That is why stroke neurologists are instrumental in driving change, developing best practice guidelines, and applying for studies to advance their processes. For centres without neurology, stroke leaders and local champions passionate about stroke care will provide great benefits by driving their processes.

“Having strong nursing leadership is critical” (NS-02)

In addition, a hospital’s lead charge nurse can be a stroke champion on staff who acts as an access point. They control the protocols, know where the patient is going, communicate between departments, and ensures the patient has an ICU/stroke bed. While recommended for all sites, smaller centres would find the most benefits. Smaller centres tend to have higher physician turnover, locums, and international medical graduates.

“For large system change, what you really need is a stroke coordinator” (NS-02).

Ideally, each stroke hospital would have a coordinator. If not, one for each health would be beneficial. Alberta has coordinators at each site who are very well positioned to influence care, run reports, and provide feedback to their frontline. They help develop a culture that every team member has ownership and pride in the work. From participant NS-02’s experience, regions without a stroke coordinator are doing much worse than those with one. Therefore, NS has a stroke coordinator in every area of the province, who are responsible for the entire spectrum of stroke care within their region. As each region has different resources and requirements, they customize and tweak the stroke care pathway to suit their system. For smaller centres, even a part time coordinator is helpful. They set up improvement meetings and look through the data. This should be someone interested in stroke, like an emergency department nurse, clinical nurse educator, or an emergency physician.

Within EH, the stroke program manager is necessary to drive quality care. EH did not feel stroke coordinator was sufficient and created a program manager role. The program manager is passionate about stroke and provides constant reinforcement and education to keep stroke care at the forefront of their healthcare providers' minds. That is why EH's program manager has driven a lot of great things. There needs to be stroke specific leadership within the other regions of NL.

For EVT, SEO has an interprofessional, multidisciplinary EVT working group that focuses on reviewing processes, outcome data, and overseeing ongoing QI initiatives (Stroke Network of Southeast Ontario, 2021). Led by the regional stroke team, the EVT workgroup also included Stroke Neurology, ED, Neuroradiology, IR, Critical Care, the Neurosciences unit, decision support, and ethics leads (Stroke Network of Southeast Ontario, 2021). In addition, their Regional Acute Stroke (RASP) Protocol Committee includes paramedic chiefs and ED leaders and meet annually with the EVT workgroup to review the hyperacute stroke data linking to the regional stroke work plan (Stroke Network of Southeast Ontario, 2021).

6.2.2 Teamwork and Culture

Second, stroke systems need a well-coordinated team response based on a culture that understands Time is Brain. This culture provides a fast, coordinated process while maintaining safety standards. This requires interprofessional teamwork, coordinated care, and communication. Healthcare providers must work together and communicate to coordinate care processes. The KGH stroke team have learned from each other, they have expanded their capacity to deliver a consistent service and are highly skilled at making assessments, carrying out procedural tasks, and have experience working together (Stroke Network of Southeast Ontario, 2021). In addition, there must be positive feedback loops to recognize the excellent work of the whole team.

"Improvement collaborative is about creating a team of multi-disciplinary people" (NS-02)

Stroke care requires interprofessional teamwork to provide coordinated care for a hyper acute stroke patient. HSC believe they have great teamwork and their departments have become close. By working together, HSC has been able to alter protocols to avoid wasting time. Teamwork has been HSC's biggest key to success. As they developed, relationships were created, and now they should take the time to develop relationships with a provincial approach. Therefore, it is essential to include all stakeholders. For EVT, they needed all the stakeholders including the frontline staff to understand each department's roles and responsibilities, develop protocols, and resolve any issues before starting. In Calgary, each department has its own mapped-out processes to illustrate their responsibilities and how they all integrate together.

However, all stakeholders need to buy in and develop a culture around time is brain, promoting efficient and safe treatment. HSCs commitment to improve their stroke care suddenly changed after and ACT EAST presentation. Now they constantly question areas to improve. These learnings should be transitioned across the province. That is why the new NL Health Services hopes to bring a more comprehensive provincial stroke strategy. To understand the full picture in NLs stroke care, a provincial stroke committee can develop provincial relationships. For PSCs, the "Race Car Model" at QHC in Ontario highlights quality teamwork by operating roles concurrently.

By including all stakeholders, regions have highlighted the importance of recognizing the great work of all members on their stroke teams. Therefore, their staff want to achieve their performance targets and be recognized. SEO include their patient record and decision support teams to ensure quality data.

“We make a big deal out of it” (NL-09).

HSC sends emails to highlight great work and provide pins for achievements that staff proudly wear. Recognizing their staff has been a driving force. When teams were getting faster DTNTs, those teams would receive pins. The faster times were being advertised and the program began to understand that these times were achievable. It has spread and became more efficient. Currently, the shortest DTNT pin at HSC is under fifteen minutes.

SEO highlighted their stroke physicians and management representatives recognizing the excellent work of their whole team as an enabler (Stroke Network of Southeast Ontario, 2021). This included the extended partners (paramedics, support staff, and data abstractors). For example, when KHSC-KGH received the Accreditation Canada Stroke Distinction award, they made sure that all were involved. They gave awards to all their data abstractors to ensure they knew they were noticed. EDs have a stressful environment, so celebrating successes can positively affect morale, creating energy to work through the areas that require improvement.

6.2.3 Review

Thirdly, continuous review is required, including weekly stroke rounds at CSCs and HSC, a monthly meeting for PSCs organized by the stroke coordinator, provincial stroke rounds to connect and keep everyone motivated, and working groups that analyze the literature to identify areas of improvement. These meetings should include all stakeholders and have a respectful environment with open communication to bring about change. These Interprofessional debriefs are “… carried out as needed with a problem-solving collaborative approach engaging all who participated in the case to facilitate learning, safety, and continuous improvement” (Stroke

Network of Southeast Ontario, 2021, p.2). For example, KGH improved their DTNT from 41 to 19 minutes through continuous workflow improvements.

"It's a huge component of the entire service because you learn a ton from these cases" (ON-02).

HSC has not had many cases for EVT, but they have been doing debriefs after every case and identified major improvements to their process. The debriefs have created a respectful environment to freely communicate, discuss issues, and the improvements carry on to the next case. HSC aim to include all stakeholders and highlighted how frontline involvement provides the best feedback as they can explain how the case went.

"With every debrief, we learn something new" (NL-10).

If one of the health care providers working that case cannot join, get feedback, and you provide it. This can create a trickle-down effect. Everyone begins to find time because it is right for the patient. Code Strokes are one of the only cases where they debrief, look at the outcome, and get some feedback. It is a great way to monitor their care.

These stroke rounds are a great tool because everyone's on the same path, everyone's getting the same updates. Stroke rounds are pretty informal and can lead to discussions about process issues or data that needs to be collected. These discussions can identify pressure points.

Provincial stroke care is like maintaining a network. CSCs are at the center and the PSCs are dispersed to provide diagnostic imaging and thrombolysis. The network requires a free flow of knowledge to ensure the knowledge is distributed and adapted locally. By incorporating provincial stroke rounds NL can keep the rural sites motivated and provide continuous education

Alberta has an Acute Stroke Expert Working Group with stroke representation from all the different fields of stroke, including budgeting, and literature review around stroke best practices and how to implement them. The working group comes to a consensus to provide position statements on the direction of provincial stroke care, and then it is up to the local teams to decide how best to implement the recommendation in a way that is tailored to fit their program best.

Every four months, SEO has an entire EVT committee (30-40 professionals) formally meet to review outcome data, issues, and change. Participant ON-01 highlighted that there are only three to four physicians involved, and the nurses and technologists are the ones who provide valuable insight on process change. In addition, their chief financial officer and administrators attend the meetings to strategize on funding to expand their program.

NS also put in a lot of groundwork when they implemented their Code Stroke. Cardiovascular Health NS sponsored a one-day conference to improve DTNTs. They required representation of all involved to sit around a large table sketching out their early acute stroke protocol. As it is a 24-hour business, it was important to include the providers that work in the evenings (like nurses and CT technologists) to discuss issues that may arise. In addition, provincial protocols may need to be alter for smaller hospitals who should share what they are doing so others can learn.

"Again, it was getting the right people in the room together" (NS-04).

When developing protocols, SEO mapped out the processes from pre-hospital care, through ED, Imaging, IR, ICU, to the acute stroke unit. KHSC-KGH also mapped out all their transitions and communication processes to understand where the patient must go from ED -> CT -> EVT -> ICU -> Stroke Unit (Stroke Network of Southeast Ontario, 2021). Then they video recorded MOCK simulations and reviewed to identify delays. While rehearsing, any issues or concerns were documented and discussed.

"We run simulation after simulation" (ON-01)

Participant AB-03 explained how simulations helped their team discover issues that were unidentified during meetings. From their experience, their meetings anticipated the ideal flow. Then simulations will inevitably find unanticipated problems. Simulations allow healthcare providers to understand their roles and act quickly. Through participant AB-01's worldwide experiences, centres suggest that simulations are the best way to get their system moving swiftly and would love to see simulations used more frequently.

6.2.4 Education

Finally, continuous education must be provided to all departments. Mapping out their processes and conducting simulations can be very beneficial to understanding protocols. Process change requires large education rollouts and continuous education to reinforce messaging. The SEO stroke network has a regional education work plan funded by the government that covers the entire continuum of stroke care.

"We go wherever the need is" (ON-05).

Their work plan is set based on identified gaps, and their education work is directed to change management and process. Their ministry provides a funding package but do not directly influence what is done and are interested in regions hitting the set standards. Of the eleven stroke networks within Ontario, each regions education plan will differ.

"We advance them individually" (ON-05).

For hyperacute care, the keys to success are working at the organizational level rather than trying to do a lot of regional work. Virtual events can be great for sharing information, allowing rural healthcare providers to attend, and sharing information with non-thrombolytic centres.

"There is never enough education" (NL-11).

There is a lot of work that goes into process change and education is one part. To support, hospitals require a large education roll-out. SEO delivers multiple in-person education workshops. The education team must cooperate with the managers to determine the process change needs. For example, the introduction of TNK would require pharmacy education for the new drug. Then in-person sessions should involve a lot of layers and lots of repetition. Nurses require multiple sessions due to the numerous shift lines.

As stroke care constantly evolves, education is necessary to maintain quality care. Calgary has a lot of Continuing Medical Education (CME) training and their stroke physicians will routinely go and do educational events with all of their PSC providers. The education work plan of SEO must continue to educate EDs and nurses especially with staffing turnaround. In addition, EVT programs require highly trained IRs and advances in technology and equipment require professionals to advance their skills by taking courses to receive training (Stroke Network of Southeast Ontario, 2021).

EH has a lot of ongoing education because their stroke manager takes the lead. For HSC's Code Stroke, all departments got educated at the same time and HSC conducted department simulations to understand roles and responsibilities. In addition, the expertise and leadership of neurologists have offered all kinds of education throughout the province.

"The problem is getting people to come to the table" (NL-11)

If you care for stroke patients throughout the province, these education sessions should be under your requirements as an employee. Therefore, HSC monitors to ensure all their providers have received the required education to maintain their competency. Stroke education exists, but NL should have a provincial lens on it. This includes EMS. EMS has a well-received module to educate their teams on EVT's extra care, including the RACE screening tool for LVOs. NS highlighted the need to get their EMS on board. Therefore, they provided extensive training and encourage the supervisors to keep updated on guidelines and push important information.

However, NL still needs a provincial system for paramedic education. Regular education has fallen to the employer). The province provides modular courses on an online learning management system, but employers need educators to ensure skills are learned and practiced. In addition, private services do not have funding and are not contractually obligated to provide certain education. Therefore, continuous education with hands-on educators who can physically walk through important processes can complement the modules and maintain standards. In addition, physicians have helped educate NS paramedics through video education sessions Neurologists are acknowledging and really incorporating the role that the paramedics play by providing teachable moments to give feedback and encouragement.

When providing educational support, there is a fair bit of outreach. For educational sessions it is helpful to include local experts who understand the system and data. However, outside experts are also beneficial to challenge and give advice. Guidelines and best practices are available. Therefore, health regions can provide the information and conduct meetings. Once it is time to follow-up, it can be done using virtual meetings. The education team will review their performance indicators and ask: "How the changes are going? What are the challenges? What support do you need" (ON-05). If needed, the education team can return in person to offer more education which tends to be small sessions, educators joining nurse huddles, and putting up posters about upcoming education to reinforce and build their messaging.

"The information is out there" (NS-05)

Along with meeting and providing information, practice and simulations can be another form of education. Regions can map out protocols and summarize roles. St. Martha's Hospital, Antigonish NS, did a fantastic job with simulations and flow charts. St. Martha's outlined what gets done, who is involved in the first five minutes, and then the next ten minutes. These simulations helped the professionals understand their roles throughout the patient's pathway. In addition, the QEII leadership conduct dry runs to continue to look for improvements.

6.3 Quality Improvement

Kaplan and colleagues defined Quality Improvement (QI) using the Hastings Center's definition as "… systematic, data-guided activities designed to bring about immediate, positive changes in the delivery of health care" (Kaplan et al., 2010, p.502). As stroke care is constantly evolving, stroke programs must maintain methods and strategies focused on continuous QI. Efficiencies in the first few hours from symptom onset have significantly improved a stroke victim's functional outcome. Therefore, data collection and analysis can provide a significant opportunity to identify areas of improvement. A continuous QI model can improve a stroke system. Therefore, I recommend NL having a considerable focus on continuous quality improvement (QI) supported by electronic medical records. Table 6.4 summarizes each regions QI model.

All four regions believed continuous QI and ongoing data collection was vital to their success. In 2018, the Department of Health requested to keep track of stroke care outcomes. Therefore, NL began a provincial stroke scorecard and publishes the scorecard comparing four health regions. Table 6.5 summarizes 2021/2022 ischemic stroke care information.

NL has had difficulty collecting paper charted data and manual data entry. Manual entry is time consuming and adds in additional human error. They are working to make it as automated as possible but have a lot of work to go. However, regions must wait a year for the data to be coded and analyzed. KGH can get their own data within an hour, but they must wait up to 18 months for CorHealth's annual Ontario stroke report (all stroke care) and biannual EVT reports.

Table 6.4: A Summary of Quality Improvement Initiatives for the Four Canadian Regions

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
- Ongoing Data collection and analysis are major reasons why HSC has been successful - Created a positive feedback loop. - Also benefited rural sites - Share data with Provincial Stroke Scorecard and Practice Points - It is important to have reliable data - HSC review their Code Stroke data Monthly. **Barriers** - Resource issue - Time consuming - Manual data entry. - Often 6-12 months for data reporting - Should adjust targets for PSCs. - Efficiency outcomes (time to treat) are not provincially compared - The Provincial Scorecard does not compare stroke outcomes by hospital - Difficulty collecting data from private operators - Need accountability - Need electronic patient records	- Indicators must be informative and feasible to collect - Monitor time stamps to analyse efficiency. - Must define what you measure and the denominators - Optimize Registry collects acute stroke variables – compare with sites across Canada - QEII have their own registry - Provincial Stroke registry - Want to hit targets - QEII has reduced their DTNT - Must act on outcomes - Free flow of knowledge **Barriers** - Systems rarely publish outcomes on a hospital level - Unable to get data quickly enough for feedback and rewards - When EHS was a different organization, they couldn't share information as easily.	- Incorporate emerging evidence with QI initiatives - Data collection is their top activity. - Organized approach - Frequent updates Informed by regular review of data - Visualize strengths or opportunities - Set Targets - Real time monitoring - Efficiency metrics - Share data - Resource nurse follows data - Required by the ministry of health, CorHealth, and CIHI - Implement promising results from trials **- LEAN Kaizen by QHC** - improved productivity by eliminating wasteful practices. Included all Stakeholders **Barriers** - Manually collecting data consumes time but is necessary - Collaboration and effort to maintain quality data collection - Long wait periods for provincial reports	**QuICR** - Live Database - Process and outcome data with time points - Set definitions - Monthly reports - Compare Facilities - Important to share - Paved the way for QI improving care - Emphasis on the speed - Set targets and objectives - Estimated annual cost avoidance of 37.8 million dollars based on the best-in-class stroke care ***QuICR grant is finished*:** Legacy initiatives - The SCN has taken on its primary mandate - Tableau Dashboard provide outcome measures for hospitals to compare **Barriers** - Must invest resources - Clear definitions - Careful selecting denominators - How to quantify life years

"It takes us a long time to actually have to go through and sift through the data pieces" (NL-09)

Since HSC developed a fully functional Code Stroke, they have monthly reviews and can efficiently access their own data. Appendix XXXV presents HSC's Code Stroke data record, which includes EVT and is manually collected by a nurse practitioner (or physician). While data collection is a significant reason HSC has succeeded, it is not where they would want it to be. However, there have been improvements.

Table 6.5: 2021/2022 Provincial Scorecard Ischemic Stroke Summary

Metrics	Eastern Health	Central Health	Western Health	Labrador-Grenfell Health
Ischemic Strokes	539	145	155	52
7-day Mortality	9.2%	14.8%	11.7%	4.4%
30-day Mortality	15.1%	21.9%	17.7%	11.6%
TLOS	6	7	6	4
Discharged Home	59.5%	/	76.9%	/
CT/MRI Scan	96.3%	87.2%	87.3%	97.7%
Thrombolysis Rate	18.8%	14.6%	12.8%	13.5%
rt-PA patients arriving by ambulance	84.2%	69.6%	90.5%	57.1%
Stroke Unit Admission	58.7%	0.0%	61.3%	0.0%
Anti-thrombotics	95.4%	99.1%	95.9%	93.5%

*Visualizing individual stroke centres within health regions would be great for identifying which hospitals are performing. Also, CSCs should have better outcomes than PSCs. Therefore, performance targets can be adjusted. *

Improvements at HSC has created a positive feedback loop that has helped engage the rural hospital sites. The more HSC improve, the more that other sites want to improve. For example, in Clarenville, they structured a time process audits, with feedback to frontline for modifications and motivation. Clarenville reported improvement over their last six months. In addition, sharing data throughout the province with Practice Points and stroke scorecards is excellent for showing performance indicators and comparing regions.

“How do you hold people accountable?” (NL-12)

Participants NL-11 and 12 believed a provincial health authority should standardize the required practice, provide the evidence with performance indicators attached, and follow up educationally. There should be quality data to understand what stroke centres need to improve.

Therefore, it is essential to be clear and define outcomes of interest. Time stamps are crucial to understanding the efficiencies within the hospital. However, those efficiency outcomes are not used in the Provincial Scorecard. HSC’s Code Stroke Record collects time stamps, but they are not reported or compared in the provincial stroke card. These time stamps should be used and compared between sites. In addition, the scorecard should provide outcome measurements for each stroke centre, not just the region. Certain hospitals may be performing well, and others may need improvement.

To make this happen, frequent updates informed by a regular data review allows hospitals to view strengths and identify areas to improve. NL can learn from Alberta. Alberta created an initiative called QuICR, that has become Tableau dashboard, as a live database comparing stroke centres on process and outcome data, including efficiency outcomes. They believe it is vital to share data between their centres. By sharing data, stroke systems can create a friendly competition centred around a culture of Time is Brain. It is not necessarily a competition but a Dashboard for teams to learn from each other with a rewards system to promote the successes of specific hospitals and even certain groups producing great times (such as DTNT). DTNT is a fast way to visualize how engaged a centre is in hyper acute stroke care.

“The QuICR Initiative has paved the way for improving stroke processes in Alberta” (Alberta Health Services, 2016, p.2). QuICR emphasized how early thrombolysis treatment reduces ninety-day death and disability. Therefore, they have asked their stroke program to achieve the best practice with a median thirty-minute DTNTs and ninety percent of their patients treated under sixty minutes. Since their DTNT initiative, Alberta has reduced their median DTNT from 68 minutes to 37 minutes and increased the proportion of their ischemic stroke patients treated with thrombolysis within sixty minutes from 39% to 78%. For EVT, QuICR provided formal estimates for cost avoidance. QuICR estimated an annual cost avoidance of 37.8 million dollars with best-in-class stroke care (Alberta Health Services, 2016). In addition, AHS valued impact of EVT estimating saving of $42,287 per patient treated. Appendix XXXVI presents ERA and QuICR's reasoning for increasing access to EVT, which includes financial cost, the efficacy of EVT, additional transport considerations/communication, the number of patients who would be eligible for EVT, and five objectives for ERA.

In addition, a stroke outcome dashboard can keep hospitals accountable. However, there will be a need for statistical process control to aid the interpretation of PSCs with smaller volumes to explain random variation over time. When constructing a dashboard, it is essential to gather the appropriate stakeholders to identify the critical variables all programs would like to see. This should include variables specified in the provincial scorecard but must consist of time to CT, DTNT, door in door out times for PSCs transferring EVT patients, and door to groin/puncture time for EVT (HSC). In addition, why patients did not receive thrombolysis and/or EVT should be captured, especially if that patient was within the treatment window time from LSN. Finally, including EMS variables would help identify paramedic time on scene and how long paramedics take to get to the appropriate facility.

Across all four regions, data collection and analysis are recognized to be critical. However, every region understands that it is time-consuming, takes a lot of resources, and requires a long time to report, thus limiting the opportunity for feedback and rewards. No region has yet to figure out an Information Technology (IT) solution to capture stroke outcomes electronically. That can be a goal for NL. They are collecting the data, but it is too labour-intensive to manually input it into a portal. An IT initiative could focus on an electronic tool with the variables identified by the stakeholders that can immediately capture the data and submit it to a database for analysis. Immediate data collection can create a clear picture of how hospitals are operating, creating a transparent process where hospitals can collaborate and learn from each other. NL Health Services have announced a planned new hospital Information system to bring various existing health information systems together to establish an integrated and comprehensive information technology system for health and social services. This is an opportunity to build in stroke data capture from clinical process documentation.

In Ontario, KGH reported the highest proportion of ischemic stroke patients receiving EVT/thrombolysis, and the lowest Door to Needle Time (DTNT), which is sustained below the thirty-minute median target (Stroke Network of Southeast Ontario, 2021). KGH believed the main contributor to their success involved a well-designed coordinated process using a continuous QI approach informed by regular review of process and outcome data (Stroke Network of Southeast Ontario, 2021). Data collection is likely their top activity to improve. It has created an excellent culture to constantly track what they are doing.

"If you can measure it, you can fix it" (ON-01).

When they began EVT, they collected about hundred data points per patient as they has a lot to figure out. They have reduced, but still collect a certain amount of manual data (door-to-reperfusion time, discharge and ninety-day mRS score) remains important.

"It was painful, but it was really necessary" (ON-01)

QHC also has a very robust report card system where their stroke resource nurse follows data to send it to KGH for the issued report cards. For EVT transfer decisions, it is useful recording times when deciding between ground or air emergency transport. For example, SEO has a lot of delays with their helicopter system, so they use ground ambulances.

Outside of their own data collection, stroke centres are required by the minister of health, CorHealth (Provincial health network focused on cardiac, stroke and vascular care), and the Canadian Institute for Health Information (CIHI) to keep track of key stroke care metrics. SEO stroke network website (www.strokenetworkseo.ca) includes all the most recent stroke reports under performance. These performance reports include provincial reports, SEO reports and local sub-region reports. KGH can get their own data "… within an hour" (ON-01), but they must wait for CorHealth's annual provincial stroke report (all stroke care) and biannual EVT reports, "… typically 18 months behind" (ON-01). Overall, the hyperacute care of SEO is more efficient with better outcomes than the whole province of Ontario. Along with continuous QI, Table 4.31 presents ten contributors KHSC believe make their hospital a high-performing stroke centre.

In addition, QHC conducted a The LEAN kaizen initiative to improve productivity by eliminating wasteful practices. QHC brought in all stakeholders and mapped out every aspect, minute, and role of their code stroke using sticky notes. The event took four full days, with over a hundred professionals providing ideas to streamline the process and implement effective strategies from KGH. As a result, QHC improved their DTNT, resulting in a median DTNT of 29-minutes for the first quarter of the 2022/2023 Fiscal Year (FY). This made QHC the first PSC in Ontario to achieve a median DTNT of under thirty minutes. QHC brought in all the stakeholders and mapped out every aspect, minute, and role of their code stroke. They managed to take twenty minutes off their DTNT and are the first PSC in ON to have a median DTNT under thirty minutes. LEAN has shown great results, but the lack resources may prevent all centres from being involved. Therefore, translating successful strategies, and developed literature to other centres is important.

"Going forward, there [is] always something that can be done differently" (NS-01)

Like EH, NS is involved in the ACTEAST program. ACTEAST has an engineering background used to analyze systems and efficiencies. As simple efficiency changes make a difference, HI agreed to have students shadow and watch their stroke care process. Those students have provided quality suggestions as participant NS-01 discussed saving five minutes on their DTNT by simply moving a piece of machinery because they walked back and forth multiple times. In addition, NS provide roles for providers when they aren't involved can also improve efficiency. Everyone should be doing something to help.

It has been demonstrated in the literature that hospitals in clinical trials are the first hospitals to implement the findings. Calgary and QEII were involved in the ESCAPE trial (EVT) and continued treating eligible EVT patients after. In addition, Calgary and NS were in the AcT study (2022) that published 0.25mg/kg of Tenecteplase as an alternative to Alteplase for ischemic stroke patients who meet thrombolysis criteria (Menon et al., 2022). Nationally, Alberta assists and collaborates with a lot of different places.

"The key to having initiatives be successful really relies on having that champion to make sure the stroke agenda is at the forefront" (AB-06).

In Calgary, their program is really motivated on continuous improvement. FMC unequivocally provides excellent stroke care. CSP has Stroke Distinction, other programs attempt to re-create AHS's provincial model, and they have internationally known stroke physicians. However, they are never truly satisfied and strive for perfection. They want to push the boundaries. While pushing the boundaries of its own processes, Calgary participates in and organizes many major stroke trials to progress international stroke care. These trials are advancing the field. To support these trials, Calgary has a team of four-stroke trial nurses who rotate calls, recruit patients, collect consent, and know the details of the studies. These nurses allow the physicians to focus on the clinical care of their patients.

Chapter 7 – Discussion

This study identified potential barriers and enablers of hyperacute stroke care and provides policy recommendations to improve the quality of this care in Newfoundland and Labrador (NL). I used a mixed methods approach including a time series analysis that investigated change over time and multiple case studies to provide a holistic view of hyperacute stroke care in four regions. From the results of this study, I formulated three policy recommendations. These recommendations include a provincial stroke program encompassing the whole province with an emphasis on Primary Stroke Centres (PSC) and transport functions, a full-time Endovascular Therapy (EVT) service to care for all eligible patients in NL, and a considerable focus on continuous quality improvement (QI) supported by electronic medical records.

The time series analyzed the five stroke centres of Eastern Health (EH) NL to determine whether they met stroke best practice targets and compared those EH centres to stroke centres from three other regions in Canada: Central zone Nova Scotia (NS), Southeastern Ontario (SEO), and Calgary zone Alberta. The multiple case reviews created a holistic view of the hyperacute stroke care systems of four Canadian Health regions. A cross case synthesis allowed me to compare the hyperacute stroke care of EH with the three other Canadian regions to understand whether EH provides the same efficiency processes, faces similar barriers, conducts similar quality initiatives, and has identical future directions. In addition, the cases identified some barriers that regions already faced with associated enablers to help solve those issues.

From the data I analyzed, Health Science Centre (HSC) in St. John's, NL, has shown impressive improvements from 2016/2017 to 2020/2021. During that time, HSC's thrombolysis rates increased from 9.6% to 19.0%, nearing their target of 21.0%. HSC was comparable to all three Comprehensive Stroke Centres (CSC) (Table 4.25). These results should encourage the stroke system to implement change and improve its processes. In addition, the case studies showed how HSC are conducting similar Code Stroke protocols, and efficiency processes correlating to the results from Table 4.25. HSC are even administering thrombolysis within the CT suite, yet to be adapted in the other regions. However, HSC was slow to initiate EVT, and expansion took longer than anticipated.

Table 4.26 compared the 2020/21 stroke care outcomes at the PSCs in EH, central zone NS, SEO, and Calgary zone Alberta. EH was comparable to the other three health regions. EH was significantly better than NS PSCs in 7-day mortality, discharging patients home, and prescribing anti-thrombotics. EH was significantly better than Calgary zone in patients arriving by ambulance and prescribing thrombotic. However, SEO reported a significantly higher proportion of their patients receiving imaging and thrombolysis compared to EH. For Calgary, the case study highlighted that there are no PSCs in their region and all patients go to Foothills Medical Centre (FMC). They did emphasize the great care in Red Deer, outside the Calgary zone.

While producing similar results to the other PSCs, the PSCs in EH did not show the same improvement over time as HSC. This may be the disparity between Urban and rural regions. However, work can be done to get the advancements at the HSC mirrored in PSCs. The observable outcomes at HSC could bestow confidence in other hospitals attempting to hit those goals (Rogers, 1995). In addition, a provincial stroke network could standardize protocols and provide support. Approaches and targets (thrombolysis rates) can differ for PSCs compared to CSCs due to their contrasting resources and geography. SEO and Calgary reported QHC of Belleville, Ontario, and Red Deer Regional Hospital Centre of Alberta as highly functioning PSCs due to strong stroke champions, nursing leadership, and a good team culture. Another aspect to consider when having a provincial lens. These regions require leaders who are passionate in stroke care.

When comparing case studies, no region was perfect. While each region reported a similar care model, all have faced barriers caring for ischemic stroke patients. All four regions reported the need for additional staff and resources to support quick transfers and treatment. In addition, stroke programs must standardize their processes (including Emergency medical services), improve early communication, and map out processes to support efficient treatment. Passionate leaders are required to motivate teams, improve systems, and must find time for change management and continuous quality improvement.

From the stroke outcome data and the descriptive data of the case studies, the hyperacute stroke care in EH has improved. However, this study has shown there is much EH and the newly appointed NL Health Services can do to improve. From the information gathered, I have developed three policy recommendations for the NL Health Services to improve their hyperacute stroke care. First, a provincial stroke program must standardize care across their province, monitor performance to keep centres accountable and address their ground and air ambulance system. Second, EH must expand EVT to a full-time service, capture patients throughout the whole province of NL, and expand its treatment time window. Finally, there must be a considerable focus on continuous QI supported by electronic health records and the collection of additional variables. These recommendations are summarized in Table 7.1

Table 7.1: Hyperacute Stroke Care Policy Recommendations for Newfoundland and Labrador Health Services

Create a Provincial Stroke Network
- Passionate leaders
    - Senior leadership: Vice President (VP) of Health Transformation.
    - Clinical Leaders: Experts to drive change.
    - Stroke champions at PSCs.
    - Stroke coordinators.
- Leadership Training
- Coordination between regions and stroke centres
    - Stroke coordinators to report to VP.
- Provincial Stroke Committee
- Standardize Protocols
- Monitor Performance
- Accountability – Continuous Quality Assurance
- Provincial Ambulance System

Develop a Full-Time Provincial EVT Service - Expand EVT service hours 24/7. - Expand EVT service to the whole province. - Expand the EVT treatment time window.
Create Continuous Quality Assurance with Electronic Medical Records - Implement Electronic Forms for data capture. - Stakeholders design a form containing their recommended variables – Must include efficiency outcomes (i.e., DTNT) - Use new hospital Information system in development to. - Aggregate data on a stroke network dashboard for all centres to learn and compare. - Knowledge Translation to Implement Change

I. Create a Provincial Stroke Network

To understand the complete picture of the province's hyperacute stroke care, I recommend the NL Health Services to have a coordinated provincial stroke network. The provincial stroke network would be a network that can standardize care across the province, provide on-call neurology assistance for decision making for PSCs, create a free flow of knowledge to share learnings and educational material, monitor performance to keep centres accountable, and address their ground and air ambulance system. Protocols can implement strategies for efficient transition of care throughout the hyperacute stroke care pathway presented in Figure 2.1.

The success of a provincial network requires passionate leaders who want to motivate their teams, improve their system, and support QI. These include senior leaders to provide support and make necessary decisions (including human and other resource procurement), clinical leaders who are the experts and drive change, stroke champions in each PSC, stroke coordinators who find time for improvement, and nursing leadership to keep everything together. These leaders can create a necessary team culture that understands Time is Brain, have effective coordination to standardize protocols and develop effective teams. From the information gathered, each region would find a stroke coordinator/manager useful to continuously review their program and processes. They can assist by keeping the province aligned. These coordinators can report to a Vice President responsible for stroke system change. For additional support, the stroke network can embed the existing provincial stroke committee, which can understand the complete picture of NLs stroke system.

While a provincial stroke network can implement a lot of great initiative and processes. Each comes at a substantial investment. Therefore, tough decisions will have to be made. The Canadian economy spends more than $3.6 billion annually on physician services, hospital costs, lost wages, and decreased productivity (Krueger et al., 2012). However, evidence-based stroke care has resulted fewer annual hospital episodes (-3.3%), acute care days (-25.9%), and residential care days (12.8%) resulting in annual cost reduction estimated at 682 million (307.4 million directly, and 374.3 million indirectly) throughout Canada (Krueger et al., 2012). In 2021, stroke was the second leading cause of death and third leading cause of disability globally (Bettger & Cadilhac, 2022). The direct and indirect costs of stroke was highest in the US at

$59,900 per patient (Bettger & Cadilhac, 2022). Compared to standard care, comprehensive ischemic stroke care (Guidelines) was associated with a 9.8% reduction in risk of death and dependency and a cost-effectiveness ratio of $6900 (Bettger & Cadilhac, 2022). However, Lucas-Noll and colleagues did not believe acute stroke care has been evaluated with enough complexity (Lucas-Noll et al., 2023). When analysing EVT in ischemic stroke patients with LVOs, EVT was associated with societal cost savings between $22,502 to $86 164 and a gain of 1.62 to 2.21 Quality Adjusted Life Years (QALY) compared to medical management (Sarraj et al., 2021). For the patients EVT can treat, there are large benefits.

Standardizing protocols across the province will not come at a cost. Unfortunately, sites may need to alter how they provide care based on resources. This should be shared so all other sites can learn how others are adapting. NL has already been assisting their PSCs with on-call neurology. However, I would recommend learning from Alberta's RAAPID system to assist in quality communication and transfer assistance. While there may be some up-front cost to educate hospitals and EMS, QuICR estimated an annual cost avoidance of 37.8 million dollars with best-in-class stroke care (Alberta Health Services, 2016). In addition, AHS valued impact of EVT estimating saving of $42,287 per patient treated. EVT would have additional EMS investment as patients would require long transfer distance.

Health Accord NL has recommended a centralized provincial ambulance system to appropriately service the whole province. This will require an extensive investment in ground and air paramedicine with enough medics and ambulances and appropriate education to ensure a quality system. To address staffing shortages and the limitations associated with EMRs, NL has the multi-year plan to expand PCPs and ACPs across the province. For long distances, Air ambulance transportation should be investigated. Most of the province is better served with fixed-winged airplanes, but inefficiencies must be addressed to get their patients to HSC quickly. For example, their fixed-winged ambulances require a one-hour wheels-up time before transferring patients. In addition, the provincial network should investigate the use of MSUs.

Finally, this thesis is focused on the hyperacute care of ischemic stroke. Therefore, most conclusion are directed towards efficiencies in treating thrombolysis and EVT. However, these treatments are only available to a relatively small proportion of the population. The provincial network would need to look at TIA/stroke prevention clinics, stroke units, and overall population health. While overall population health may not be in the spectrum of a provincial stroke network, it could provide the largest cost benefit by preventing severe strokes. Coordinating with the department of health to provide information could help assist the whole population. In 2019, NL spent three billion health care, 40% was for acute hospitals. In addition, compared to Canada, NL spent 43% more per capita due to 25% more bed per 100,000 population, 8% higher age and sex standardized hospitalization rates, 15% higher length of stay percentage, and 25% higher alternate level of care percentage (Quality of Care NL, 2019). The quantitative study showed significant decrease in ischemic stroke thirty-day mortality rate at HSC, a significant decrease in LOS at HSC and CG, and a significant decrease in ischemic stroke ALC days at HSC. However, stroke hospitalizations are going up. Therefore, population health should be addressed.

In Calgary, they highlighted the effectiveness of their Stroke Prevention Clinic to prevent future more significant and more costly ischemic strokes. TIAs need rapid access to a dedicated clinic with rapid testing for modifiable risks including echocardiogram and carotid imaging. NL Health Services has planned to construct a new Cardiovascular and Stroke Institute for HSC. The institute strives to provide an organized hub, including care for TIA patients and stroke prevention. While the institute is a fantastic addition to stroke care in St. John’s, the rest of the province is disadvantaged. However, further investigation will need to be applied to identify where clinics can be placed to effectively support patients and optimize resources in that region.

CSBP highlighted stroke unit care as the gold standard of care following an acute stroke (Heran et al., 2022). Stroke units are shown to improve the odds of functional independence, decrease mortality, and help a much broader portion of the stroke population. Some regions will have difficulty sourcing the volumes and resources to create a stroke unit. For example, Ontario set a minimum patient volume at 120, and SEO used surrounding regions to develop their third unit. Alberta created Stroke Unit Equivalent Care (SUEC) units to cluster their stroke patients in the same unit and provide a similar level of care as their designated stroke units. Although the resources differ, AHS has tried to standardize SUEC care with stroke rehabilitation and nursing care guidelines to help with equity throughout their province.

II. Develop a Full time provincial EVT service.

There are three significant steps the NL stroke network would have to manage for their provincial EVT care. First, HSC believe additional INRad (or EVT-trained physicians) must be trained or recruited, and an appropriate schedule must be made. However, there is likely not enough non-EVT work to keep four or five dedicated interventionalists busy. In 2020/2021 584 ischemic stroke were hospitalized in EH. If 10% are eligible for EVT, that would be ~58/year. A little over one per week. Is that too onerous for three INRads with 24/7 call. Further investigation should be made. For example, it may be more enticing for the INRads to commit to the one in three call if the INRads are paid additional fee for 24/7 EVT service, or if an increase in pay occurred if volume targets were met. In addition, Due to increased service hours and patient volume, other staff (nurses, technologists, neurologists, and anesthesiologists) requirements may need to be addressed. Finally, as their program grows, HSC should decide whether Anesthesiologists should be included in every EVT case. SEO and Calgary commonly use procedural sedation and call-in anesthesiology if necessary.

Second, the NL stroke network would need to consider expanding their reach to capture EVT-eligible patients throughout the whole province. This expansion will require a interprofessional education rollout and a standardized communication, transfer, and imaging protocol. Education is required to notify and educate all departments of additional roles and responsibilities required for EVT. In addition, NL are trialling their transfer protocol in rural EH. The early communication/transfer pathway stages reflect the RAAPID system in Alberta. In my opinion RAAPID was the best communication model of the four regions. RAAPID allows efficient and effective communication between the stroke physician, transport physician, and EMS to determine the patient's destination and treatment scenario (Direct for EVT or drip and ship). NL should learn from Alberta's RAAPID system and Alberta's EVT communication system presented in Appendix XXIII.

Finally, CSBP has recommended patients with disabling ischemic stroke beyond six hours up to 24 hours from LSN should be rapidly screened using advanced imaging to determine EVT eligibility (Heran et al., 2022). When the EVT program at HSC is a full-time service, NL should look to expand past the treatment window of six hours. When that time comes, NL should make sure the RAPID AI software and CT perfusion imaging are working, tested and consistent throughout NL to treat those patients in the later time window. RAPID AI software is built into every scanner at every PSC in EH and can send the images to the on-call neurologist and radiologists for efficient decision making. An initiative to remember is the ACT-FAST initiative from SEO. ACT-FAST is used in non-stroke centres and assists in recognizing eligible EVT patients after six hours from LSN. This time window will help many patients who live far away from HSC. With those distances, the air ambulances should be addressed.

III. Create a continuous quality improvement system with electronic data capture.

For stroke care, data collection and analysis provide a significant opportunity to identify areas of improvement, monitor stroke centres, and understand efficient processes. However, data collection and analysis are time-consuming, take a lot of resources, and this can lead to delays in reporting. This reduces the opportunity for feedback and rewards. While all four regions believed continuous QI and ongoing data collection was vital to their success, none have identified an IT solution to capture stroke care processes and outcomes electronically.

Therefore, NL can identify an IT solution NL Health Services have announced a planned new hospital Information system to bring various existing health information systems together. This is an opportunity to build in stroke data capture from electronic medical records. An IT initiative should focus on an electronic tool with the variables identified by the stakeholders that can immediately capture the data and submit it to a database for analysis within the provincial health information system. With electronic records, the NL stroke network can create a dashboard to actively compare every stroke centre in the province. It is essential to be clear, define outcomes of interest, and gather the appropriate stakeholders to identify the critical variables all programs want to see.

From my literature review, I have gained an understanding about the importance of efficiency in hyperacute care. Time to treatment has been proven to improve functional recovery and reduce mortality (Boulanger, Gubitz, et al., 2018; Emberson et al., 2014; Lees et al., 2016; Saver et al., 2016; Saver et al., 2013; Emberson et al., 2014; Mulder et al., 2018). Therefore, these variables must be included in the electronic collection. This should include variables specified in the provincial scorecard and consist of time to CT, DTNT, door in door out times for PSCs transferring EVT patients, and door to groin/puncture time for EVT (HSC). If ischemic patients did not receive hyperacute treatment, reasons should be captured, especially if that patient was within the treatment window time from LSN. In addition, EMS variables would help identify important outcomes, including EMS time on scene and time to get to the appropriate facility. Finally, patient follow up would be a useful variable. Trials use ninety-day mRS score, but that can be difficult to collect. Therefore, ninety-day home time has been an emerging outcome and is very system dependent. Health cards are linked to emergency departments, acute care hospitals, rehab hospitals, and long-term care. Any day spent in one of these facilities from the day of the stroke is subtracted from ninety days, with the assumption that they are at home if they are not in those facilities. There is a correlation that patients are less disabled when they spend more time at home in the first ninety days after their stroke. However, getting private systems to join the linkage is an issue as the government-funded facilities are where the health card numbers are being tracked.

A provincial stroke dashboard could compare their results to CSBP targets, which reflects evidence in stroke care and could be a framework for how each region is developing. These targets and processes can create a transparent resource where hospitals can collaborate and learn from each other. Alberta created an initiative called QuICR, that has become Tableau dashboard, as a live database comparing stroke centres on process and outcome data, including efficiency outcomes. They believe it is vital to share data between their centres. By sharing data, stroke systems can create a friendly competition centred around a culture of Time is Brain. Therefore, the NL stroke program could use this dashboard to monitor and keep their stroke centres accountable. Accountability includes ensuring that the electronic form is completed for all patients and that stroke centres maintain quality care. This includes system leaders who show due diligence in providing the necessary resources, education, and support to their program. For centres performing well, the stroke network can have a rewards system to promote the success of specific hospitals and even certain groups. Accountability also includes the senior leaders showing diligence in providing the necessary resources, education and support to the programs and hospitals.

In addition, this accountability and continuous QI would be enticing to our government. This can provide a framework for decision makers to visualize the importance of quality stroke care and understand where they can input funding.

Chapter 8 – Limitations and Future Directions

While I this study has collected a vast amount of descriptive data, there are a lot of limitations. Firstly, the retrospective data was pre-existing. I did not have control over confounding and some critical statistics I would have liked to collect were unavailable. Those statistics were time to treatment metrics, such as DTNT. In addition, this dada is four years old. It is difficult to make recommendation on old data. While HSC showed positive trend, implementing my recommendation of continuous quality improvement with electronic data capture would allow the stroke system to quickly act on their outcome measures. With this data, future studies should collect and compare outcomes between sites to analyze efficiency of Newfoundland and Labradors (NL)hyperacute ischemic stroke care.

The case studies relied on my collection and interpretation of the data. Each case interviewed different sample sizes and collected various degrees of documentary evidence. However, the purposeful sample was set to achieve data saturation. With the interviews and documentary evidence, I collected the necessary data to draw conclusions and did not believe additional information was required. As this study is directed to NL, the cases may have low transferability. However, smaller cities and emerging stroke centres may benefit from the information provided from this research. The use of a thick description (how well the research context fits other contexts) and a purposive sample (to find greater in-depth findings) can facilitate transferability (Anney, 2014). For dependability of these results, I conducted the code-recode strategy. However, I did not complete the peer examination strategy or an Audit trail. An audit trail could have improved the dependability and confirmability of my results. In addition, there was a large gap between Nova Scotia's (NS) data collection and the follow-up interviews of the other regions (Table 3.3). I did not follow-up in NS because I achieved data saturation. However, this large gap could have affected my findings. Finally, the passage of time since my data collection could affect my recommendation. However, if no progress towards these recommendations has happened, then the passage of time has reinforced them.

When conducting, collecting, and analyzing my interviews there may have been various biases introduced. Researcher bias may have been introduced as I want to improve stroke care in NL, and believed these regions provided better care. Through reflexivity and data triangulation, I limited this bias. When treating ischemic stroke patients with thrombolysis, my results have shown that HSC is comparable to the other three CSCs. Participation and response bias could have been introduced during my interviews. There is a possibility that the participants distorted their authenticity or responded inaccurately. These participants may not want to discuss faults within their stroke care system.

While my cases reflect the hyper acute ischemic stroke care within Eastern Health NL, further studies should investigate hyperacute stroke care across the province. This would assist the rural regions of NL. As HSC has improved, NL can identify ways to translate those learnings. In addition, this study provided recommendations for a provincial stroke network. However, these treatments are only available to a relatively small proportion of the population. The provincial network would need to look at TIA/stroke prevention clinics, stroke units, and overall population health. While overall population health may not be in the spectrum of a provincial stroke network, it could provide the largest cost benefit by preventing severe strokes. Finally, there were no allied health databases searched, such as CINAHL, ProQuest, SCOPUS. I also did not include allied health as part of my interview pool. In the future, process improvement for teams should include the perspectives of all team members and allied health may have been underrepresented by not searching nursing and allied health literature.

Chapter 9 – Conclusions

When I began my thesis, I set out to discover areas to improve Eastern Health (EH) and the newly appointed NL Health Services hyperacute ischemic stroke care. I sought to explore the barriers and enablers of successful hyperacute ischemic stroke treatment. First, I looked within the NL health services to analyze outcome measures to see if the stroke hospitals in EH were hitting their targets, and I identified important processes, barriers, and quality improvement initiatives. Then, I used the same methods to learn from Central zone Nova Scotia, Southeastern Ontario, and Calgary Alberta and translate those learnings to help NL. I used a mixed methods approach using quantitative and qualitative sections to analyze the hyperacute stroke care of each Canadian region. The quantitative research comprises two time series analyses: (1) the evaluation of stroke care indicators, including thrombolysis rates, of the stroke centres in EH; (2) Evaluation of stroke care indicators of the three other Canadian regions with a comparison against EH. This retrospective stroke data allowed for the comparison of important stroke care indicators and Canadian Stroke Best Practice (CSBP) targets over time between stroke centres in each region.

In addition, multiple case studies investigated the hyperacute ischemic stroke care within EH and the three other regions. These cases aimed to provide a holistic view of hyperacute stroke care around each region's stroke care centre and peripheral sites. Using literal replication, the case studies recorded semi-structured interviews of stroke professionals and requested documentary and archival data. Through thematic analysis, my goal was to understand critical success factors to optimize efficient hyperacute ischemic stroke care, how regions achieved success, identifying barriers and enablers affecting care processes, how regions overcome specific barriers, and how regions established EVT.

This project discovered that hyperacute stroke care in EH is improving. For acute stroke protocols using thrombolysis, HSC is currently providing its ischemic stroke patients with a level of care that is comparable to central Nova Scotia, Southeastern Ontario, and Calgary, Alberta. However, this study has shown that there is still a great deal EH and the newly appointed NL Health Services can do to increase their performance. From the information gathered, I have developed three policy recommendations for the NL Health Services to further improve their stroke care. My first recommendation is to develop a provincial stroke program that standardizes care across NL, monitors performance to keep centres accountable and addresses NLs ground and air ambulance system. Second, Endovascular therapy (EVT) must be expanded to a full-time service, capture patients throughout the whole province of NL, and expand the EVT treatment window. Finally, there must be a considerable focus on continuous quality assurance supported by electronic medical records and the collection of additional variables.

References

Abdul Rehman, A., & Alharthi, K. (2016). *An introduction to research paradigms*. *3*.

ACTEAST: Atlantic Canada Together Enhancing Acute Stroke Treatment. (2022). ACTEAST. https://www.dal.ca/sites/acteast.html

Advani, R., Naess, H., & Kurz, M. (2016). Mass Media Intervention in Western Norway Aimed at Improving Public Recognition of Stroke, Emergency Response, and Acute Treatment. *Journal of Stroke and Cerebrovascular Diseases*, *25*(6), 1467–1472. https://doi.org/10.1016/j.jstrokecerebrovasdis.2016.02.026

Ahmed, N., Wahlgren, N., Grond, M., Hennerici, M., Lees, K. R., Mikulik, R., Parsons, M., Roine, R. O., Toni, D., & Ringleb, P. (2010). Implementation and outcome of thrombolysis with alteplase 3–4·5 h after an acute stroke: An updated analysis from SITS-ISTR. *The Lancet Neurology*, *9*(9), 866–874. https://doi.org/10.1016/S1474-4422(10)70165-4

Ajmi, S. C., Advani, R., Fjetland, L., Kurz, K. D., Lindner, T., Qvindesland, S. A., Ersdal, H., Goyal, M., Kvaløy, J. T., & Kurz, M. (2019). Reducing door-to-needle times in stroke thrombolysis to 13 min through protocol revision and simulation training: A quality improvement project in a Norwegian stroke centre. *BMJ Quality & Safety*, *28*(11), 939–948. https://doi.org/10.1136/bmjqs-2018-009117

Al-Ababneh, M. M. (2020). Linking Ontology, Epistemology And Research Methodology. *Science & Philosophy*, *8*(1). https://doi.org/10.23756/sp.v8i1.500

Albers, G. W., Marks, M. P., Kemp, S., Christensen, S., Tsai, J. P., Ortega-Gutierrez, S., McTaggart, R. A., Torbey, M. T., Kim-Tenser, M., Leslie-Mazwi, T., Sarraj, A., Kasner, S. E., Ansari, S. A., Yeatts, S. D., Hamilton, S., Mlynash, M., Heit, J. J., Zaharchuk, G., Kim, S., … Lansberg, M. G. (2018). Thrombectomy for Stroke at 6 to 16 Hours with Selection by Perfusion Imaging. *The New England Journal of Medicine*, *378*(8), 708–718. https://doi.org/10.1056/NEJMoa1713973

Alberta Health Services. (2016). *Endovascular Reperfusion Alberta (ERA)*.

Alemseged, F., Ng, F. C., Williams, C., Puetz, V., Boulouis, G., Kleinig, T. J., Rocco, A., Wu, T. Y., Shah, D., Arba, F., Kaiser, D., Di Giuliano, F., Morotti, A., Sallustio, F., Dewey, H. M., Bailey, P., O'Brien, B., Sharma, G., Bush, S., … Campbell, B. C. V. (2021). Tenecteplase vs Alteplase Before Endovascular Therapy in Basilar Artery Occlusion. *Neurology*, *96*(9), e1272–e1277. https://doi.org/10.1212/WNL.0000000000011520

Alemseged, F., Shah, D. G., Diomedi, M., Sallustio, F., Bivard, A., Sharma, G., Mitchell, P. J., Dowling, R. J., Bush, S., Yan, B., Caltagirone, C., Floris, R., Parsons, M. W., Levi, C. R., Davis, S. M., & Campbell, B. C. V. (2017). The Basilar Artery on Computed Tomography Angiography Prognostic Score for Basilar Artery Occlusion. *Stroke*, *48*(3), 631–637. https://doi.org/10.1161/STROKEAHA.116.015492

Alemseged, F., Van der Hoeven, E., Di Giuliano, F., Shah, D., Sallustio, F., Arba, F., Kleinig, T. J., Bush, S., Dowling, R. J., Yan, B., Sharma, G., Limbucci, N., Floris, R., Donnan, G. A., Puetz, V., Diomedi, M., Parsons, M. W., Mitchell, P. J., Davis, S. M., … Fifi, J. T. (2019). Response to Late-Window Endovascular Revascularization Is Associated With Collateral Status in Basilar Artery Occlusion. *Stroke*, *50*(6), 1415–1422. https://doi.org/10.1161/STROKEAHA.118.023361

Andersen, K. K., Olsen, T. S., Dehlendorff, C., & Kammersgaard, L. P. (2009). Hemorrhagic and Ischemic Strokes Compared: Stroke Severity, Mortality, and Risk Factors. *Stroke*, *40*(6), 2068–2072. https://doi.org/10.1161/STROKEAHA.108.540112

Anderson, C. S., Robinson, T., Lindley, R. I., Arima, H., Lavados, P. M., Lee, T.-H., Broderick, J. P., Chen, X., Chen, G., Sharma, V. K., Kim, J. S., Thang, N. H., Cao, Y., Parsons, M. W., Levi, C., Huang, Y., Olavarría, V. V., Demchuk, A. M., Bath, P. M., … Chalmers, J. (2016). Low-Dose versus Standard-Dose Intravenous Alteplase in Acute Ischemic Stroke. *New England Journal of Medicine*, *374*(24), 2313–2323. https://doi.org/10.1056/NEJMoa1515510

Anney, V. N. (2014). *Ensuring the Quality of the Findings of Qualitative Research: Looking at Trustworthiness Criteria*. 10.

Aoki, J., Kimura, K., Iguchi, Y., Shibazaki, K., Sakai, K., & Iwanaga, T. (2010). FLAIR can estimate the onset time in acute ischemic stroke patients. *Journal of the Neurological Sciences*, *293*(1–2), 39–44. https://doi.org/10.1016/j.jns.2010.03.011

Aroor, S., Singh, R., & Goldstein, L. B. (2017). BE-FAST (Balance, Eyes, Face, Arm, Speech, Time): Reducing the Proportion of Strokes Missed Using the FAST Mnemonic. *Stroke*, *48*(2), 479–481. https://doi.org/10.1161/STROKEAHA.116.015169

Bae, H.-J., Kim, D.-H., Yoo, N.-T., Choi, J. H., Huh, J.-T., Cha, J.-K., Kim, S. K., Choi, J. S., & Kim, J. W. (2010). Prehospital Notification from the Emergency Medical Service Reduces the Transfer and Intra-Hospital Processing Times for Acute Stroke Patients. *Journal of Clinical Neurology (Seoul, Korea)*, *6*(3), 138–142. https://doi.org/10.3988/jcn.2010.6.3.138

Baird, A. E. (2018). Paving the Way for Improved Treatment of Acute Stroke with Tenecteplase. *New England Journal of Medicine*, *378*(17), 1635–1636. https://doi.org/10.1056/NEJMe1801978

Barber, P. A., Demchuk, A. M., Zhang, J., & Buchan, A. M. (2000). Validity and reliability of a quantitative computed tomography score in predicting outcome of hyperacute stroke before thrombolytic therapy. *The Lancet*, *355*(9216), 1670–1674. https://doi.org/10.1016/S0140-6736(00)02237-6

Berge, E., Cohen, G., Roaldsen, M. B., Lundström, E., Isaksson, E., Rudberg, A.-S., Slot, K. B., Forbes, J., Smith, J., Drever, J., Wardlaw, J. M., Lindley, R. I., Sandercock, P. A. G., & Whiteley, W. N. (2016). Effects of alteplase on survival after ischaemic stroke (IST-3): 3 year follow-up of a randomised, controlled, open-label trial. *The Lancet Neurology*, *15*(10), 1028–1034. https://doi.org/10.1016/S1474-4422(16)30139-9

Berglund, A., Svensson, L., Sjöstrand, C., von Arbin, M., von Euler, M., Wahlgren, N., Engerström, L., Höjeberg, B., Käll, T.-B., Mjörnheim, S., & Engqvist, A. (2012). Higher Prehospital Priority Level of Stroke Improves Thrombolysis Frequency and Time to Stroke Unit: The Hyper Acute STroke Alarm (HASTA) Study. *Stroke*, *43*(10), 2666–2670. https://doi.org/10.1161/STROKEAHA.112.652644

Berkhemer, O. A., Fransen, P. S. S., Beumer, D., van den Berg, L. A., Lingsma, H. F., Yoo, A. J., Schonewille, W. J., Vos, J. A., Nederkoorn, P. J., Wermer, M. J. H., van Walderveen, M. A. A., Staals, J., Hofmeijer, J., van Oostayen, J. A., Lycklama à Nijeholt, G. J., Boiten, J., Brouwer, P. A., Emmer, B. J., de Bruijn, S. F., … Dippel, D. W. J. (2015). A Randomized Trial of Intraarterial Treatment for Acute Ischemic Stroke. *New England Journal of Medicine*, *372*(1), 11–20. https://doi.org/10.1056/NEJMoa1411587

Bettger, J. P., & Cadilhac, D. A. (2022). Stroke Care Costs and Cost-Effectiveness to Inform Health Policy. *Stroke*, *53*(6), 2078–2081. https://doi.org/10.1161/STROKEAHA.122.037451

Bhatia, R., Hill, M. D., Shobha, N., Menon, B., Bal, S., Kochar, P., Watson, T., Goyal, M., &

Demchuk, A. M. (2010). Low Rates of Acute Recanalization With Intravenous Recombinant Tissue Plasminogen Activator in Ischemic Stroke: Real-World Experience and a Call for Action. *Stroke*, *41*(10), 2254–2258. https://doi.org/10.1161/STROKEAHA.110.592535

Boulanger, J., Gubitz, G., Stotts, G., Smith, E., & Lindsay, M. (2018). CANADIAN STROKE BEST PRACTICE RECOMMENDATIONS ACUTE STROKE MANAGEMENT: PREHOSPITAL, EMERGENCY DEPARTMENT, AND ACUTE INPATIENT STROKE CARE Update 2018. *Heart & Stroke Foundation*, 1–135.

Boulanger, J., Lindsay, M., Gubitz, G., Smith, E., Stotts, G., Foley, N., Bhogal, S., Boyle, K., Braun, L., Goddard, T., Heran, M., Kanya-Forster, N., Lang, E., Lavoie, P., McClelland, M., O'Kelly, C., Pageau, P., Pettersen, J., Purvis, H., … Butcher, K. (2018). Canadian Stroke Best Practice Recommendations for Acute Stroke Management: Prehospital, Emergency Department, and Acute Inpatient Stroke Care, 6th Edition, Update 2018. *International Journal of Stroke*, *13*(9), 949–984. https://doi.org/10.1177/1747493018786616

Bracard, S., Ducrocq, X., Mas, J. L., Soudant, M., Oppenheim, C., Moulin, T., & Guillemin, F. (2016). Mechanical thrombectomy after intravenous alteplase versus alteplase alone after stroke (THRACE): A randomised controlled trial. *The Lancet Neurology*, *15*(11), 1138–1147. https://doi.org/10.1016/S1474-4422(16)30177-6

Braun, V., & Clarke, V. (2012). *Themantic analysis. In H. Cooper, P. M.Camic, D. L.. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), APA handbook of research methods inpsychology, Vol. 2. Research designs: Quantitative, qualitative, neuropsychology, and biology (pp. 57-71)*. American Psychological Association.

Bray, J. E., Johnson, R., Trobbiani, K., Mosley, I., Lalor, E., & Cadilhac, D. (2013). Australian Public's Awareness of Stroke Warning Signs Improves After National Multimedia Campaigns. *Stroke*, *44*(12), 3540–3543. https://doi.org/10.1161/STROKEAHA.113.002987

Broderick, J. P., Palesch, Y. Y., Demchuk, A. M., Yeatts, S. D., Pooja, K., Hill, M. D., Jauch, E. C., Jovin, T. G., Yan, B., Silver, F. L., Rüdiger, von K., Molina, C. A., Demaerschalk, B. M., Ronald, B., Clark, W. M., Zaidat, O. O., Malisch, T. W., Mayank, G., Schonewille, W. J., … Tomsick, T. A. (2013). Endovascular Therapy after Intravenous t-PA versus t-PA Alone for Stroke. *The New England Journal of Medicine*, *368*(10), 893–903. http://dx.doi.org.qe2a-proxy.mun.ca/10.1056/NEJMoa1214300

Bruno, A., Levine, S. R., Frankel, M. R., Brott, T. G., Lin, Y., Tilley, B. C., Lyden, P. D., Broderick, J. P., Kwiatkowski, T. G., & Fineberg, S. E. (2002). *CME Admission glucose level and clinical outcomes in the NINDS rt-PA Stroke Trial*. 51.

Burgos, A. M., & Saver, J. L. (2019). Evidence that Tenecteplase Is Noninferior to Alteplase for Acute Ischemic Stroke: Meta-Analysis of 5 Randomized Trials. *Stroke*, *50*(8), 2156–2162. https://doi.org/10.1161/STROKEAHA.119.025080

Busby, L., Owada, K., Dhungana, S., Zimmermann, S., Coppola, V., Ruban, R., Horn, C., Rochestie, D., Khaldi, A., Hormes, J. T., & Gupta, R. (2016). CODE FAST: A quality improvement initiative to reduce door-to-needle times. *Journal of NeuroInterventional Surgery*, *8*(7), 661–664. https://doi.org/10.1136/neurintsurg-2015-011806

Caceres, J. A., Adil, M. M., Jadhav, V., Chaudhry, S. A., Pawar, S., Rodriguez, G. J., Suri, M. F. K., & Qureshi, A. I. (2013). Diagnosis of Stroke by Emergency Medical Dispatchers and Its Impact on the Prehospital Care of Patients. *Journal of Stroke and Cerebrovascular*

Diseases, *22*(8), e610–e614. https://doi.org/10.1016/j.jstrokecerebrovasdis.2013.07.039

Campbell, B. C. V., Mitchell, P. J., Churilov, L., Yassi, N., Kleinig, T. J., Dowling, R. J., Yan, B., Bush, S. J., Dewey, H. M., Thijs, V., Scroop, R., Simpson, M., Brooks, M., Asadi, H., Wu, T. Y., Shah, D. G., Wijeratne, T., Ang, T., Miteff, F., … Davis, S. M. (2018). Tenecteplase versus Alteplase before Thrombectomy for Ischemic Stroke. *New England Journal of Medicine*, *378*(17), 1573–1582. https://doi.org/10.1056/NEJMoa1716405

Campbell, B. C. V., Mitchell, P. J., Kleinig, T. J., Dewey, H. M., Churilov, L., Yassi, N., Yan, B., Dowling, R. J., Parsons, M. W., Oxley, T. J., Wu, T. Y., Brooks, M., Simpson, M. A., Miteff, F., Levi, C. R., Krause, M., Harrington, T. J., Faulder, K. C., Steinfort, B. S., … Davis, S. M. (2015). Endovascular Therapy for Ischemic Stroke with Perfusion-Imaging Selection. *New England Journal of Medicine*, *372*(11), 1009–1018. https://doi.org/10.1056/NEJMoa1414792

Campbell, R. J. (2020). *Change Management in Health Care*. *39*(2), 50–65.

Canadian Institute for Health Information. (2018a). *DAD Special Project 440: Endovascular Therapy*.

Canadian Institute for Health Information. (2018b). *Project 340: Canadian Stroke Strategy Performance Improvement*. 18.

Canadian Institute for Health Information. (2018c). *Project 640: Canadian Stroke Strategy Performance Improvement II*. *8*, 7.

Canadian Stroke Best Practices Health Systems Quality Advisory Committee. (2022). *QUALITY OF STROKE CARE IN CANADA KEY QUALITY INDICATORS FOR ACUTE STROKE MANAGEMENT 7TH EDITION - Update 2022*. Heart and Stroke Foundation.

Canadian Stroke Best Practices Stroke Quality Advisory Committee. (2021). *QUALITY OF*

STROKE CARE IN CANADA KEY QUALITY INDICATORS AND STROKE CASE DEFINITIONS 7TH EDITION. Heart & Stroke Foundation.

Carter, N., Bryant-Lukosius, D., DiCenso, A., Blythe, J., & Neville, A. J. (2014). The Use of Triangulation in Qualitative Research. *Oncology Nursing Forum*, *41*(5), 545–547. https://doi.org/10.1188/14.ONF.545-547

Casaubon, L. K., Boulanger, J.-M., Blacquiere, D., Boucher, S., Brown, K., Goddard, T., Gordon, J., Horton, M., Lalonde, J., LaRivière, C., Lavoie, P., Leslie, P., McNeill, J., Menon, B. K., Moses, B., Penn, M., Perry, J., Snieder, E., Tymianski, D., … Lindsay, P. (2015). *Canadian Stroke Best Practice Recommendations*: Hyperacute Stroke Care Guidelines, Update 2015. *International Journal of Stroke*, *10*(6), 924–940. https://doi.org/10.1111/ijs.12551

Central Zone. (2022). Nova Scotia Health Authority. https://recruitment.nshealth.ca/place/central-zone

Chao, A.-C., Hsu, H.-Y., Chung, C.-P., Liu, C.-H., Chen, C.-H., Teng, M. M.-H., Peng, G.-S., Sheng, W.-Y., Hu, H. H., & the Taiwan Thrombolytic Therapy for Acute Ischemic Stroke (TTT-AIS) Study Group. (2010). Outcomes of Thrombolytic Therapy for Acute Ischemic Stroke in Chinese Patients: The Taiwan Thrombolytic Therapy for Acute Ischemic Stroke (TTT-AIS) Study. *Stroke*, *41*(5), 885–890. https://doi.org/10.1161/STROKEAHA.109.575605

Christou, I., Burgin, W. S., Alexandrov, A. V., & Grotta, J. C. (2001). Arterial status after intravenous TPA therapy for ischaemic storke. A need for further interventions. *International Angiology*, *20*(3), 208–213. http://www.proquest.com/docview/229909653/abstract/4DF41415FC1D4F73PQ/1

Ciccone, A., Valvassori, L., Nichelatti, M., Sgoifo, A., Ponzio, M., Sterzi, R., & Boccardi, E. (2013). Endovascular Treatment for Acute Ischemic Stroke. *New England Journal of Medicine*, *368*(10), 904–913. https://doi.org/10.1056/NEJMoa1213701

Clark, W. M., Wissman, S., Albers, G. W., Jhamandas, J. H., Madden, K. P., Hamilton, S., & for the ATLANTIS Study Investigators. (1999). Recombinant Tissue-Type Plasminogen Activator (Alteplase) for Ischemic Stroke 3 to 5 Hours After Symptom Onset: The ATLANTIS Study: A Randomized Controlled Trial. *JAMA*, *282*(21), 2019. https://doi.org/10.1001/jama.282.21.2019

Coutinho, J. M., Liebeskind, D. S., Slater, L.-A., Nogueira, R. G., Clark, W., Dávalos, A., Bonafé, A., Jahan, R., Fischer, U., Gralla, J., Saver, J. L., & Pereira, V. M. (2017). Combined Intravenous Thrombolysis and Thrombectomy vs Thrombectomy Alone for Acute Ischemic Stroke: A Pooled Analysis of the SWIFT and STAR Studies. *JAMA Neurology*, *74*(3), 268. https://doi.org/10.1001/jamaneurol.2016.5374

Crotty, M. (1998). *The foundation of social research: Meaning and perspective in the research process*. SAGE Publications, Inc.

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). The case study approach. *BMC Medical Research Methodology*, *11*, 100. https://doi.org/10.1186/1471-2288-11-100

Deb, P., Sharma, S., & Hassan, K. M. (2010). Pathophysiologic mechanisms of acute ischemic stroke: An overview with emphasis on therapeutic significance beyond thrombolysis. *Pathophysiology*, *17*(3), 197–218. https://doi.org/10.1016/j.pathophys.2009.12.001

Deguchi, I., Mizuno, S., Kohyama, S., Tanahashi, N., & Takao, M. (2018). Drip-and-Ship Thrombolytic Therapy for Acute Ischemic Stroke. *Journal of Stroke and*

Cerebrovascular Diseases, *27*(1), 61–67. https://doi.org/10.1016/j.jstrokecerebrovasdis.2017.07.033

Demchuk, A. M., Morgenstern, L. B., Krieger, D. W., Linda Chi, T., Hu, W., Wein, T. H., Hardy, R. J., Grotta, J. C., & Buchan, A. M. (1999). Serum Glucose Level and Diabetes Predict Tissue Plasminogen Activator–Related Intracerebral Hemorrhage in Acute Ischemic Stroke. *Stroke*, *30*(1), 34–39. https://doi.org/10.1161/01.STR.30.1.34

Dombrowski, S. U., White, M., Mackintosh, J. E., Gellert, P., Araujo-Soares, V., Thomson, R. G., Rodgers, H., Ford, G. A., & Sniehotta, F. F. (2015). The stroke "Act FAST" campaign: Remembered but not understood? *International Journal of Stroke: Official Journal of the International Stroke Society*, *10*(3), 324–330. https://doi.org/10.1111/ijs.12353

Dosing & Administration Guidelines for Activase® (alteplase). (2022). Activase. https://www.activase.com/ais/dosing-and-administration/dosing.html

Eastern Health. (2023). *Eastern Health – Eastern Health Newfoundland and Labrador, Regional Health Authority*. https://www.easternhealth.ca/

Eastern Health Regional Stroke Program and Evaluation Framework. (2014). Eastern Health.

Emberson, J., Lees, K. R., Lyden, P., Blackwell, L., Albers, G., Bluhmki, E., Brott, T., Cohen, G., Davis, S., Donnan, G., Grotta, J., Howard, G., Kaste, M., Koga, M., von Kummer, R., Lansberg, M., Lindley, R. I., Murray, G., Olivot, J. M., … Hacke, W. (2014). Effect of treatment delay, age, and stroke severity on the effects of intravenous thrombolysis with alteplase for acute ischaemic stroke: A meta-analysis of individual patient data from randomised trials. *The Lancet*, *384*(9958), 1929–1935. https://doi.org/10.1016/S0140-6736(14)60584-5

Endovascular treatment of stroke. (2022). CIRSE. https://www.cirse.org/patients/ir-procedures/endovascular-treatment-of-stroke/

Fargen, K. M., Jauch, E., Khatri, P., Baxter, B., Schirmer, C. M., Turk, A. S., & Mocco, J. (2015). Needed Dialog: Regionalization of Stroke Systems of Care Along the Trauma Model. *Stroke*, *46*(6), 1719–1726. https://doi.org/10.1161/STROKEAHA.114.008167

Feske, S. K. (2021). Ischemic Stroke. *The American Journal of Medicine*, *134*(12), 1457–1464. https://doi.org/10.1016/j.amjmed.2021.07.027

Fink, J. N., Kumar, S., Horkan, C., Linfante, I., Selim, M. H., Caplan, L. R., & Schlaug, G. (2002). The Stroke Patient Who Woke Up: Clinical and Radiological Features, Including Diffusion and Perfusion MRI. *Stroke*, *33*(4), 988–993. https://doi.org/10.1161/01.STR.0000014585.17714.67

Finlay, L. (2012). *Five lenses for the reflexive interviewer. Ch 22. In J. Gubrium, J. A.Holstein, A. B. Marvasti, & K.D. McKinney (Eds), The SAGE Handbook of Interview Research: The Complexity of the Craft (pp. 317-331)*. SAGE Publications, Inc.

Fischer, U., Kaesmacher, J., S Plattner, P., Bütikofer, L., Mordasini, P., Deppeler, S., Cognard, C., Pereira, V. M., Siddiqui, A. H., Froehler, M. T., Furlan, A. J., Chapot, R., Strbian, D., Wiesmann, M., Bressan, J., Lerch, S., Liebeskind, D. S., Saver, J. L., & Gralla, J. (2021). SWIFT DIRECT: Solitaire™ With the Intention For Thrombectomy Plus Intravenous t-PA Versus DIRECT Solitaire™ Stent-retriever Thrombectomy in Acute Anterior Circulation Stroke: Methodology of a randomized, controlled, multicentre study. *International Journal of Stroke*, 17474930211048768. https://doi.org/10.1177/17474930211048768

Fonarow, G. C., Saver, J. L., Smith, E. E., Broderick, J. P., Kleindorfer, D. O., Sacco, R. L., Pan, W., Olson, D. M., Hernandez, A. F., Peterson, E. D., & Schwamm, L. H. (2012). Relationship of National Institutes of Health Stroke Scale to 30-Day Mortality in Medicare Beneficiaries With Acute Ischemic Stroke. *Journal of the American Heart Association: Cardiovascular and Cerebrovascular Disease*, *1*(1), 42–50. https://doi.org/10.1161/JAHA.111.000034

Fugate, J. E., & Rabinstein, A. A. (2015). Absolute and Relative Contraindications to IV rt-PA for Acute Ischemic Stroke. *The Neurohospitalist*, *5*(3), 110–121. https://doi.org/10.1177/1941874415578532

Geeganage, C. M., Diener, H.-C., Algra, A., Chen, C., Topol, E. J., Dengler, R., Markus, H. S., Bath, M. W., Bath, P. M. W., & null, null. (2012). Dual or Mono Antiplatelet Therapy for Patients With Acute Ischemic Stroke or Transient Ischemic Attack. *Stroke*, *43*(4), 1058–1066. https://doi.org/10.1161/STROKEAHA.111.637686

Gerry Fraiberg (Director). (2015, September 11). *Code Stroke—QHC Belleville General Hospital*. https://www.youtube.com/watch?v=Un0HienMwnU

Gerry Fraiberg (Director). (2016, September 26). *Code Stroke—Race Car Pit Stop Model of Care at Belleville General Hospital*. https://www.youtube.com/watch?v=CrAY467g2E8

Government of Canada, S. C. (2017a, February 8). *Census Profile, 2016 Census—Calgary Zone [Health region, December 2017], Alberta and Alberta [Province]*. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=HR&Code1=4832&Geo2=PR&Code2=48&SearchText=Calgary%20Zone&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=4832&TABID=1&type=0

Government of Canada, S. C. (2017b, February 8). *Census Profile, 2016 Census—Eastern*

Regional Health Authority [Health region, December 2017], Newfoundland and Labrador and Newfoundland and Labrador [Province]. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=HR&Code1=1011&Geo2=PR&Code2=10&SearchText=Eastern%20Regional%20Health%20Authority&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=1011&TABID=1&type=0

Government of Canada, S. C. (2017c, February 8). *Census Profile, 2016 Census—South East, [Health region, December 2017], Ontario and Ontario [Province]*. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=HR&Code1=3510&Geo2=PR&Code2=35&SearchText=South%20East&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=3510&TABID=1&type=0

Government of Canada, S. C. (2017d, February 8). *Census Profile, 2016 Census—Zone 4—Central [Health region, December 2017], Nova Scotia and Nova Scotia [Province]*. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=HR&Code1=1204&Geo2=PR&Code2=12&SearchText=Zone%204%20-%20Central&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=1204&TABID=1&type=0

Government of Canada, S. C. (2022, January 24). *Leading causes of death, total population, by age group*. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310039401

Goyal, M., Almekhlafi, M. A., Fan, L., Menon, B. K., Demchuk, A. M., Yeatts, S. D., Hill, M.

D., Tomsick, T., Khatri, P., Zaidat, O. O., Jauch, E. C., Eesa, M., Jovin, T. G., & Broderick, J. P. (2014). Evaluation of Interval Times from Onset to Reperfusion in Patients Undergoing Endovascular Therapy in the IMS III Trial. *Circulation*, *130*(3), 265–272. https://doi.org/10.1161/CIRCULATIONAHA.113.007826

Goyal, M., Demchuk, A. M., Menon, B. K., Eesa, M., Rempel, J. L., Thornton, J., Roy, D., Jovin, T. G., Willinsky, R. A., Sapkota, B. L., Dowlatshahi, D., Frei, D. F., Kamal, N. R., Montanera, W. J., Poppe, A. Y., Ryckborst, K. J., Silver, F. L., Shuaib, A., Tampieri, D., … Hill, M. D. (2015). Randomized Assessment of Rapid Endovascular Treatment of Ischemic Stroke. *New England Journal of Medicine*, *372*(11), 1019–1030. https://doi.org/10.1056/NEJMoa1414905

Greene, J. C. (2007). *Mixed Methods in Social Inquiry*. Wiley.

Grix, J. (2004). *The Foundations of Research* (2nd ed.). Palgrave Macmillan.

Gould, L., Kelleher, E., Pt, S. P., & Kin, B. A. (2017). *Stroke Special Project 640 and 740*. 45.

Guba, E. G., & Lincoln, Y. A. S. (1994). *Competing Paradigms in Qualitative Research*. 13.

Hacke, W., Kaste, M., Bluhmki, E., Brozman, M., Dávalos, A., Guidetti, D., Larrue, V., Lees, K. R., Medeghri, Z., Machnig, T., Schneider, D., von Kummer, R., Wahlgren, N., & Toni, D. (2008). Thrombolysis with Alteplase 3 to 4.5 Hours after Acute Ischemic Stroke. *New England Journal of Medicine*, *359*(13), 1317–1329. https://doi.org/10.1056/NEJMoa0804656

Hacke, W., Kaste, M., Fieschi, C., Toni, D., Lesaffre, E., von Kummer, R., Boysen, G., Bluhmki, E., Höxter, G., Mahagne, M.-H., & Hennerici, M. (1995). Intravenous Thrombolysis With Recombinant Tissue Plasminogen Activator for Acute Hemispheric Stroke: The

European Cooperative Acute Stroke Study (ECASS). *JAMA*, *274*(13), 1017–1025. https://doi.org/10.1001/jama.1995.03530130023023

Hacke, W., Kaste, M., Fieschi, C., von Kummer, R., Davalos, A., Meier, D., Larrue, V., Bluhmki, E., Davis, S., Donnan, G., Schneider, D., Diez-Tejedor, E., & Trouillas, P. (1998). Randomised double-blind placebo-controlled trial of thrombolytic therapy with intravenous alteplase in acute ischaemic stroke (ECASS II). *The Lancet*, *352*(9136), 1245–1251. https://doi.org/10.1016/S0140-6736(98)08020-9

Haley, E. C., Thompson, J. L. P., Grotta, J. C., Lyden, P. D., Hemmen, T. G., Brown, D. L., Fanale, C., Libman, R., Kwiatkowski, T. G., Llinas, R. H., Levine, S. R., Johnston, K. C., Buchsbaum;, R., Levy, G., & Levin, B. (2010). Phase IIB/III Trial of Tenecteplase in Acute Ischemic Stroke: Results of a Prematurely Terminated Randomized Clinical Trial. *Stroke*, *41*(4), 707–711. https://doi.org/10.1161/STROKEAHA.109.572040

Hamilton, S., McLaren, S., & Mulhall, A. (2007). Assessing organisational readiness for change: Use of diagnostic analysis prior to the implementation of a multidisciplinary assessment for acute stroke care. *Implementation Science*, *2*(1), 21. https://doi.org/10.1186/1748-5908-2-21

Harris, D., Hall, C., Lobay, K., McRae, A., Monroe, T., Perry, J. J., Shearing, A., Wollam, G., Goddard, T., & Lang, E. (2015). Canadian Association of Emergency Physicians Position Statement on Acute Ischemic Stroke. *CJEM*, *17*(2), 217–226. https://doi.org/10.1017/cem.2015.26

Harris, D. R. (2018). A new era in stroke care. *Canadian Journal of Emergency Medicine*, *20*(5), 656–657. https://doi.org/10.1017/cem.2018.448

Health Accord NL. (2022). *Our Province. Our Health. Our Future. A 10-Year Transformation:*

The Report.

Health, N. (2020, April 2). Hypertensive Intracranial Haemorrhage. *Narayana Health Care*. https://www.narayanahealth.org/blog/hypertensive-intracranial-haemorrhage/

Heart & Stroke. (2019). *2019 Report on Heart, Stroke and Vascular Cognitive Impairment*. Heart & Stroke Foundation.

Heart & Stroke. (2022). *Signs of stroke*. Heart and Stroke Foundation of Canada. https://www.heartandstroke.ca/en/stroke/signs-of-stroke/

Heldner, M. R., Zubler, C., Mattle, H. P., Schroth, G., Weck, A., Mono, M.-L., Gralla, J., Jung, S., El-Koussy, M., Lüdi, R., Yan, X., Arnold, M., Ozdoba, C., Mordasini, P., & Fischer, U. (2013). National Institutes of Health Stroke Scale Score and Vessel Occlusion in 2152 Patients With Acute Ischemic Stroke. *Stroke*, *44*(4), 1153–1157. https://doi.org/10.1161/STROKEAHA.111.000604

Hemorrhagic Strokes (Bleeds). (2020). Www.Stroke.Org. https://www.stroke.org/en/about-stroke/types-of-stroke/hemorrhagic-strokes-bleeds

Heran, M., Shamy, M., Lindsay, P., Lund, R., Martin, C., Gubitz, G., Moutain, A., Smith, E. E. (2022). Canadian Stroke Best Practice Recommendations, Acute Stroke Management, 7th Edition, Update 2022. Heart and Stroke Foundation of Canada.

Higashida, R., Alberts, M. J., Alexander, D. N., Crocco, T. J., Demaerschalk, B. M., Derdeyn, C. P., Goldstein, L. B., Jauch, E. C., Mayer, S. A., Meltzer, N. M., Peterson, E. D., Rosenwasser, R. H., Saver, J. L., Schwamm, L., Summers, D., Wechsler, L., & Wood, J. P. (2013). Interactions Within Stroke Systems of Care: A Policy Statement From the American Heart Association/American Stroke Association. *Stroke*, *44*(10), 2961–2984. https://doi.org/10.1161/STR.0b013e3182a6d2b2

Hill, M. D., & Buchan, A. M. (2005). Thrombolysis for acute ischemic stroke: Results of the Canadian Alteplase for Stroke Effectiveness Study. *CMAJ*, *172*(10), 1307–1312. https://doi.org/10.1503/cmaj.1041561

Holland, E. (2023). *This Revolutionary Stroke Treatment Will Save Millions of Liver. Eventually.* The New York Times Magazine.

Holodinsky, J. K., Williamson, T. S., Kamal, N., Mayank, D., Hill, M. D., & Goyal, M. (2017). Drip and Ship Versus Direct to Comprehensive Stroke Center: Conditional Probability Modeling. *Stroke*, *48*(1), 233–238. https://doi.org/10.1161/STROKEAHA.116.014306

Hoving, J. W., van Voorst, H., Kappelhof, M., Tolhuisen, M., Treurniet, K. M., LeCouffe, N. E., Rinkel, L. A., Koopman, M. S., Cavalcante, F., Konduri, P. R., van den Wijngaard, I. R., Ghariq, E., Anton Meijer, F. J., Coutinho, J. M., Marquering, H. A., Roos, Y. B. W. E. M., Emmer, B. J., & Majoie, C. B. L. M. (2023). Infarct Evolution in Patients with Anterior Circulation Large-Vessel Occlusion Randomized to IV Alteplase and Endovascular Treatment versus Endovascular Treatment Alone. *AJNR: American Journal of Neuroradiology*, *44*(4), 434–440. https://doi.org/10.3174/ajnr.A7826

Huang, X., Cheripelli, B. K., Lloyd, S. M., Kalladka, D., Moreton, F. C., Siddiqui, A., Ford, I., & Muir, K. W. (2015). Alteplase versus tenecteplase for thrombolysis after ischaemic stroke (ATTEST): A phase 2, randomised, open-label, blinded endpoint study. *The Lancet Neurology*, *14*(4), 368–376. https://doi.org/10.1016/S1474-4422(15)70017-7

Huo Xiaochuan, Ma Gaoting, Tong Xu, Zhang Xuelei, Pan Yuesong, Nguyen Thanh N., Yuan Guangxiong, Han Hongxing, Chen Wenhuo, Wei Ming, Zhang Jiangang, Zhou Zhiming, Yao Xiaoxi, Wang Guoqing, Song Weigen, Cai Xueli, Nan Guangxian, Li Di, Wang A.

Yi-Chou, … Miao Zhongrong. (2023). Trial of Endovascular Therapy for Acute Ischemic Stroke with Large Infarct. *New England Journal of Medicine*, *388*(14), 1272–1283. https://doi.org/10.1056/NEJMoa2213379

Information (CIHI), C. I. for H. (2016, June 30). *Ambulance Use for Time-Sensitive Conditions: Stroke and Heart Attack* [Text]. https://secure.cihi.ca/estore/productFamily.htm?pf=PFC3216&lang=en

Intracerebral Hemorrhage | Mount Sinai—New York. (2023). Mount Sinai Health System. https://www.mountsinai.org/locations/cerebrovascular-center/conditions/intracerebral-hemorrhage

Jauch, E. C., Saver, J. L., Adams, H. P., Bruno, A., Connors, J. J. (Buddy), Demaerschalk, B. M., Khatri, P., McMullan, P. W., Qureshi, A. I., Rosenfield, K., Scott, P. A., Summers, D. R., Wang, D. Z., Wintermark, M., & Yonas, H. (2013). Guidelines for the Early Management of Patients With Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke*, *44*(3), 870–947. https://doi.org/10.1161/STR.0b013e318284056a

Jauch, E., French, David, & McGeorge, Todd. (2015, January 20). Timely Prehospital Management of Stroke Victims Crucial for Patient Outcome. *JEMS: EMS, Emergency Medical Services - Training, Paramedic, EMT News*. https://www.jems.com/patient-care/timely-prehospital-management-stroke-vic/

Jia, J., Band, R., Abboud, M. E., Pajerowski, W., Guo, M., David, G., Mechem, C. C., Messé, S. R., Carr, B. G., & Mullen, M. T. (2017). Accuracy of Emergency Medical Services Dispatcher and Crew Diagnosis of Stroke in Clinical Practice. *Frontiers in Neurology*, *8*. https://doi.org/10.3389/fneur.2017.00466

Jin, A. Y., Karen Pearson, McCallum, A., & Martin, C. (2017). *Final Pilot Evaluation Report—Endovascular Thrombectomy in Hyperacute Stroke Care: Improving outcomes for those with severe stroke across Southeastern Ontario*. https://www.strokenetworkseo.ca/

Johnston, K. C., Connors, A. F., Wagner, D. P., & Haley, E. C. (2004). Risk Adjustment Effect on Stroke Clinical Trials. *Stroke*, *35*(2), e43–e45. https://doi.org/10.1161/01.STR.0000109768.98392.4D

Josephson, S. A., Hills, N. K., & Johnston, S. C. (2006). NIH Stroke Scale reliability in ratings from a large sample of clinicians. *Cerebrovascular Diseases (Basel, Switzerland)*, *22*(5–6), 389–395. https://doi.org/10.1159/000094857

Jovin, T. G., Chamorro, A., Cobo, E., de Miquel, M. A., Molina, C. A., Rovira, A., San Román, L., Serena, J., Abilleira, S., Ribó, M., Millán, M., Urra, X., Cardona, P., López-Cancio, E., Tomasello, A., Castaño, C., Blasco, J., Aja, L., Dorado, L., … Dávalos, A. (2015). Thrombectomy within 8 Hours after Symptom Onset in Ischemic Stroke. *New England Journal of Medicine*, *372*(24), 2296–2306. https://doi.org/10.1056/NEJMoa1503780

Jurkowski, J. M., Maniccia, D. M., Spicer, D. A., & Dennison, B. A. (2010). Impact of a Multimedia Campaign to Increase Intention to Call 9-1-1 for Stroke Symptoms, Upstate New York, 2006-2007. *Preventing Chronic Disease*, *7*(2). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2831789/

Kamal, N., Benavente, O., Boyle, K., Buck, B., Butcher, K., Casaubon, L. K., Côté, R., Demchuk, A. M., Deschaintre, Y., Dowlatshahi, D., Gubitz, G. J., Hunter, G., Jeerakathil, T., Jin, A., Lang, E., Lanthier, S., Lindsay, P., Newcommon, N., Mandzia, J., … Hill, M. D. (2014). Good is not Good Enough: The Benchmark Stroke Door-to-Needle Time Should be 30 Minutes. *Canadian Journal of Neurological Sciences / Journal Canadien*

Des Sciences Neurologiques, *41*(6), 694–696. https://doi.org/10.1017/cjn.2014.41

Kaplan, H. C., Brady, P. W., Dritz, M. C., Hooper, D. K., Linam, W. M., Froehle, C. M., & Margolis, P. (2010). The Influence of Context on Quality Improvement Success in Health Care: A Systematic Review of the Literature. *The Milbank Quarterly*, *88*(4), 500–559. https://doi.org/10.1111/j.1468-0009.2010.00611.x

Katz, B. S., Adeoye, O., Sucharew, H., Broderick, J. P., McMullan, J., Khatri, P., Widener, M., Alwell, K. S., Moomaw, C. J., Kissela, B. M., Flaherty, M. L., Woo, D., Ferioli, S., Mackey, J., Martini, S., De Los Rios la Rosa, F., & Kleindorfer, D. O. (2017). Estimated Impact of Emergency Medical Service Triage of Stroke Patients on Comprehensive Stroke Centers: An Urban Population-Based Study. *Stroke*, *48*(8), 2164–2170. https://doi.org/10.1161/STROKEAHA.116.015971

Katz, B. S., McMullan, J. T., Sucharew, H., Adeoye, O., & Broderick, J. P. (2015). Design and Validation of a Prehospital Scale to Predict Stroke Severity: Cincinnati Prehospital Stroke Severity Scale. *Stroke*, *46*(6), 1508–1512. https://doi.org/10.1161/STROKEAHA.115.008804

Kaufmann, A. M., Firlik, A. D., Fukui, M. B., Wechsler, L. R., Jungries, C. A., & Yonas, H. (1999). Ischemic Core and Penumbra in Human Stroke. *Stroke*, *30*(1), 93–99. https://doi.org/10.1161/01.STR.30.1.93

Kawano, H., Hirano, T., Inoue, M., Fukuda-Doi, M., Iwasaki, K., Omae, K., Tanaka, K., Yamamoto, H., Koga, M., Sakai, N., Nagao, T., Sasaki, M., Hayakawa, N., & Toyoda, K. (2022). Tenecteplase versus alteplase for large vessel occlusion recanalization (T-FLAVOR): Trial protocol. *European Stroke Journal*, *7*(1), 71–75. https://doi.org/10.1177/23969873211070455

Keyt, B. A., Paoni, N. F., Refino, C. J., Berleau, L., Nguyen, H., Chow, A., Lai, J., Peña, L., Pater, C., & Ogez, J. (1994). A faster-acting and more potent form of tissue plasminogen activator. *Proceedings of the National Academy of Sciences of the United States of America*, *91*(9), 3670–3674. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC43643/

Kidwell, C. S., Reza, J., Gornbein, J., Alger, J. R., Val, N., Zahra, A., Feng, L., Meyer, B. C., Olson, S., Schwamm, L. H., Yoo, A. J., Marshall, R. S., Meyers, P. M., Yavagal, D. R., Max, W., Guzy, J., Sidney, S., & Saver, J. L. (2013). A Trial of Imaging Selection and Endovascular Treatment for Ischemic Stroke. *The New England Journal of Medicine*, *368*(10), 914–923. http://dx.doi.org.qe2a-proxy.mun.ca/10.1056/NEJMoa1212793

Kijpaisalratana, N., Chutinet, A., Akarathanawat, W., Vongvasinkul, P., & Suwanwela, N. C. (2020). Outcomes of thrombolytic therapy in acute ischemic stroke: Mothership, drip-and-ship, and ship-and-drip paradigms. *BMC Neurology*, *20*(1), 45. https://doi.org/10.1186/s12883-020-1631-9

Kim, B. J., Han, M.-K., Park, T. H., Park, S.-S., Lee, K. B., Lee, B.-C., Yu, K.-H., Oh, M. S., Cha, J. K., Kim, D.-H., Lee, J., Lee, S. J., Ko, Y., Park, J.-M., Kang, K., Cho, Y.-J., Hong, K.-S., Kim, J.-T., Choi, J. C., … Bae, H.-J. (2015). Low-Versus Standard-Dose Alteplase for Ischemic Strokes Within 4.5 Hours: A Comparative Effectiveness and Safety Study. *Stroke*, *46*(9), 2541–2548. https://doi.org/10.1161/STROKEAHA.115.010180

Kim, S. K., Lee, S. Y., Bae, H. J., Lee, Y. S., Kim, S. Y., Kang, M. J., & Cha, J. K. (2009). Pre-hospital notification reduced the door-to-needle time for iv t-PA in acute ischaemic stroke. *European Journal of Neurology*, *16*(12), 1331–1335. https://doi.org/10.1111/j.1468-1331.2009.02762.x

Kothari, R., Pancioli, A., Liu, T., Brott, T., & Broderick, J. (1999). Cincinnati Prehospital Stroke Scale: Reproducibility and Validity. *Annals of Emergency Medicine*, *33*(4), 373–378. https://doi.org/10.1016/S0196-0644(99)70299-4

Krueger, H., Lindsay, P., Cote, R., Kapral, M. K., Kaczorowski, J., & Hill, M. D. (2012). Cost Avoidance Associated With Optimal Stroke Care in Canada. *Stroke*, *43*(8), 2198–2206. https://doi.org/10.1161/STROKEAHA.111.646091

Kvistad, C. E., Novotny, V., Kurz, M. W., Rønning, O. M., Thommessen, B., Carlsson, M., Waje-Andreassen, U., Næss, H., Thomassen, L., & Logallo, N. (2019). Safety and Outcomes of Tenecteplase in Moderate and Severe Ischemic Stroke: Results From NOR-TEST. *Stroke*, *50*(5), 1279–1281. https://doi.org/10.1161/STROKEAHA.119.025041

Kwak, H. S., & Park, J. S. (2020). Mechanical Thrombectomy in Basilar Artery Occlusion: Clinical Outcomes Related to Posterior Circulation Collateral Score. *Stroke*, *51*(7), 2045–2050. https://doi.org/10.1161/STROKEAHA.120.029861

Kwiatkowski, T. G., Libman, R. B., Frankel, M., Tilley, B. C., Morgenstern, L. B., Lu, M., Broderick, J. P., Lewandowski, C. A., Marler, J. R., Levine, S. R., & Brott, T. (1999). Effects of tissue plasminogen activator for acute ischemic stroke at one year. *The New England Journal of Medicine*, *340*(23), 1781–1787. https://www.proquest.com/docview/223950102/abstract/E3744152167A495FPQ/1

Kwiatkowski, T., Libman, R., Tilley, B. C., Lewandowski, C., Grotta, J. C., Lyden, P., Levine, S. R., Brott, T., & the National Institute of Neurological Disorders and Stroke Recombinant Tissue Plasminogen Activator Stroke Study Group. (2005). The Impact of Imbalances in Baseline Stroke Severity on Outcome in the National Institute of Neurological Disorders and Stroke Recombinant Tissue Plasminogen Activator Stroke

Study. *Annals of Emergency Medicine*, *45*(4), 377–384. https://doi.org/10.1016/j.annemergmed.2004.06.021

LaBresh, K. A. (2006). Quality of Acute Stroke Care Improvement Framework for the Paul Coverdell National Acute Stroke Registry. *American Journal of Preventive Medicine*, *31*(6), S246–S250. https://doi.org/10.1016/j.amepre.2006.08.012

Langhorne, P., & Ramachandra, S. (2020). Organised inpatient (stroke unit) care for stroke: Network meta-analysis. *The Cochrane Database of Systematic Reviews*, *2020*(4), CD000197. https://doi.org/10.1002/14651858.CD000197.pub4

LeCouffe, N. E., Kappelhof, M., Treurniet, K. M., Rinkel, L. A., Bruggeman, A. E., Berkhemer, O. A., Wolff, L., van Voorst, H., Tolhuisen, M. L., Dippel, D. W. J., van der Lugt, A., van Es, A. C. G. M., Boiten, J., Lycklama à Nijeholt, G. J., Keizer, K., Gons, R. A. R., Yo, L. S. F., van Oostenbrugge, R. J., van Zwam, W. H., … Roos, Y. B. W. E. M. (2021). A Randomized Trial of Intravenous Alteplase before Endovascular Treatment for Stroke. *New England Journal of Medicine*, *385*(20), 1833–1844. https://doi.org/10.1056/NEJMoa2107727

Lees, K. R., & Bluhmki, E. (2010). *Time to treatment with intravenous alteplase and outcome in stroke: An updated pooled analysis of ECASS, ATLANTIS, NINDS, and EPITHET trials*. *375*, 9.

Lees, K. R., Emberson, J., Blackwell, L., Bluhmki, E., Davis, S. M., Donnan, G. A., Grotta, J. C., Kaste, M., von Kummer, R., Lansberg, M. G., Lindley, R. I., Lyden, P., Murray, G. D., Sandercock, P. A. G., Toni, D., Toyoda, K., Wardlaw, J. M., Whiteley, W. N., Baigent, C., … del Zoppo, G. J. (2016). Effects of Alteplase for Acute Stroke on the Distribution of Functional Outcomes: A Pooled Analysis of 9 Trials. *Stroke*, *47*(9), 2373–2379. https://doi.org/10.1161/STROKEAHA.116.013644

Lima, F. O., Furie, K. L., Silva, G. S., Lev, M. H., Camargo, É. C. S., Singhal, A. B., Harris, G. J., Halpern, E. F., Koroshetz, W. J., Smith, W. S., & Nogueira, R. G. (2014). Prognosis of Untreated Strokes Due to Anterior Circulation Proximal Intracranial Arterial Occlusions Detected by Use of Computed Tomography Angiography. *JAMA Neurology*, *71*(2), 151–157. https://doi.org/10.1001/jamaneurol.2013.5007

Lima, F. O., Silva, G. S., Furie, K. L., Frankel, M. R., Lev, M. H., Camargo, É. C. S., Haussen, D. C., Singhal, A. B., Koroshetz, W. J., Smith, W. S., & Nogueira, R. G. (2016). Field Assessment Stroke Triage for Emergency Destination: A Simple and Accurate Prehospital Scale to Detect Large Vessel Occlusion Strokes. *Stroke*, *47*(8), 1997–2002. https://doi.org/10.1161/STROKEAHA.116.013301

Lin, C.-H., Saver, J. L., Ovbiagele, B., Huang, W.-Y., & Lee, M. (2022). Endovascular thrombectomy without versus with intravenous thrombolysis in acute ischemic stroke: A non-inferiority meta-analysis of randomized clinical trials. *Journal of NeuroInterventional Surgery*, *14*(3), 227–232. https://doi.org/10.1136/neurintsurg-2021-017667

Logallo, N., Novotny, V., Assmus, J., Kvistad, C. E., Alteheld, L., Rønning, O. M., Thommessen, B., Amthor, K.-F., Ihle-Hansen, H., Kurz, M., Tobro, H., Kaur, K., Stankiewicz, M., Carlsson, M., Morsund, Å., Idicula, T., Aamodt, A. H., Lund, C., Næss, H., … Thomassen, L. (2017). Tenecteplase versus alteplase for management of acute ischaemic stroke (NOR-TEST): A phase 3, randomised, open-label, blinded endpoint trial. *The Lancet Neurology*, *16*(10), 781–788. https://doi.org/10.1016/S1474-4422(17)30253-3

Loh, E. D. W., Toh, K. Z. X., Kwok, G. Y. R., Teo, Y. H., Teo, Y. N., Goh, C., Syn, N. L., Ho, A. F.-W., Sia, C.-H., Sharma, V. K., Tan, B. Y., & Yeo, L. L. (2023). Endovascular therapy for acute ischemic stroke with distal medium vessel occlusion: A systematic review and meta-analysis. *Journal of NeuroInterventional Surgery*, *15*(e3), e452–e459. https://doi.org/10.1136/jnis-2022-019717

Lucas-Noll, J., Clua-Espuny, J. L., Lleixà-Fortuño, M., Gavaldà-Espelta, E., Queralt-Tomas, L., Panisello-Tafalla, A., & Carles-Lavila, M. (2023). The costs associated with stroke care continuum: A systematic review. *Health Economics Review*, *13*(1), 32. https://doi.org/10.1186/s13561-023-00439-6

Lyden, P., Ramen, R., Liu, L., Emr, M., Warren, M., & Marler, J. (2009). National Institutes of Health Stroke Scale Certification Is Reliable Across Multiple Venues. *American Heart Association*, *40*(7), 2507–2511. https://doi.org/10.1161/STROKEAHA.108.532069

Ma, H., Campbell, B. C. V., Parsons, M. W., Churilov, L., Levi, C. R., Hsu, C., Kleinig, T. J., Wijeratne, T., Curtze, S., Dewey, H. M., Miteff, F., Tsai, C.-H., Lee, J.-T., Phan, T. G., Mahant, N., Sun, M.-C., Krause, M., Sturm, J., Grimley, R., … Donnan, G. A. (2019). Thrombolysis Guided by Perfusion Imaging up to 9 Hours after Onset of Stroke. *New England Journal of Medicine*, *380*(19), 1795–1803. https://doi.org/10.1056/NEJMoa1813046

Mackey, J., Kleindorfer, D., Sucharew, H., Moomaw, C. J., Kissela, B. M., Alwell, K., Flaherty, M. L., Woo, D., Khatri, P., Adeoye, O., Ferioli, S., Khoury, J. C., Hornung, R., &

Broderick, J. P. (2011). Population-based study of wake-up strokes. *Neurology*, *76*(19), 1662–1667. https://doi.org/10.1212/WNL.0b013e318219fb30

Man, S., Xian, Y., Holmes, D. N., Matsouaka, R. A., Saver, J. L., Smith, E. E., Bhatt, D. L., Schwamm, L. H., & Fonarow, G. C. (2020). Association Between Thrombolytic Door-to-Needle Time and 1-Year Mortality and Readmission in Patients With Acute Ischemic Stroke. *JAMA*, *323*(21), 2170–2184. https://doi.org/10.1001/jama.2020.5697

Marler, J. R. (1995). Tissue plasminogen activator for acute ischemic stroke. *The New England Journal of Medicine*, *333*(24), 1581–1588. https://www.proquest.com/docview/223967923/abstract/B18A5F37EE574E19PQ/1

Marler, J. R., Tilley, B. C., Lu, M., Brott, T. G., Lyden, P. C., Grotta, J. C., Broderick, J. P., Levine, S. R., Frankel, M. P., Horowitz, S. H., Haley, E. C., Lewandowski, C. A., & Kwiatkowski, T. P. (2000). Early stroke treatment associated with better outcome. *Neurology*, *55*, 1649–1655.

Mattle, H. P., Arnold, M., Lindsberg, P. J., Schonewille, W. J., & Schroth, G. (2011). Basilar artery occlusion. *The Lancet Neurology*, *10*(11), 1002–1014. https://doi.org/10.1016/S1474-4422(11)70229-0

McMullan, J. T., Hinckley, W., Bentley, J., Davis, T., Fermann, G. J., Gunderman, M., Hart, K. W., Knight, W. A., Lindsell, C. J., Miller, C., Shackleford, A., & Gibler, W. B. (2012). Ground Emergency Medical Services Requests for Helicopter Transfer of ST-segment Elevation Myocardial Infarction Patients Decrease Medical Contact to Balloon Times in Rural and Suburban Settings. *Academic Emergency Medicine*, *19*(2), 153–160. https://doi.org/10.1111/j.1553-2712.2011.01273.x

McMullan, J. T., Hinckley, W., Bentley, J., Davis, T., Fermann, G. J., Gunderman, M., Hart, K.

W., Knight, W. A., Lindsell, C. J., Shackleford, A., & Gibler, W. B. (2011). Reperfusion Is Delayed Beyond Guideline Recommendations in Patients Requiring Interhospital Helicopter Transfer for Treatment of ST-segment Elevation Myocardial Infarction. *Annals of Emergency Medicine*, *57*(3), 213-220.e1. https://doi.org/10.1016/j.annemergmed.2010.08.031

Menon, B. K., Buck, B. H., Singh, N., Deschaintre, Y., Almekhlafi, M. A., Coutts, S. B., Thirunavukkarasu, S., Khosravani, H., Appireddy, R., Moreau, F., Gubitz, G., Tkach, A., Catanese, L., Dowlatshahi, D., Medvedev, G., Mandzia, J., Pikula, A., Shankar, J., Williams, H., … Aljundi, Z. E. (2022). Intravenous tenecteplase compared with alteplase for acute ischaemic stroke in Canada (AcT): A pragmatic, multicentre, open-label, registry-linked, randomised, controlled, non-inferiority trial. *The Lancet*, *400*(10347), 161–169. https://doi.org/10.1016/S0140-6736(22)01054-6

Menon, B. K., d'Esterre, C. D., Qazi, E. M., Almekhlafi, M., Hahn, L., Demchuk, A. M., & Goyal, M. (2015). Multiphase CT Angiography: A New Tool for the Imaging Triage of Patients with Acute Ischemic Stroke. *Radiology*, *275*(2), 510–520. https://doi.org/10.1148/radiol.15142256

Meretoja, A., Strbian, D., Mustanoja, S., Tatlisumak, T., Lindsberg, P. J., & Kaste, M. (2012). Reducing in-hospital delay to 20 minutes in stroke thrombolysis. *Neurology*, *79*(4), 306–313. https://doi.org/10.1212/WNL.0b013e31825d6011

Minhas, J. S., Chithiramohan, T., Wang, X., Barnes, S. C., Clough, R. H., Kadicheeni, M., Beishon, L. C., & Robinson, T. (2022). Oral antiplatelet therapy for acute ischaemic stroke. *Cochrane Database of Systematic Reviews*, *2022*(1). https://doi.org/10.1002/14651858.CD000029.pub4

Mitchell, P. J., Yan, B., Churilov, L., Dowling, R. J., Bush, S. J., Bivard, A., Huo, X. C., Wang, G., Zhang, S. Y., Ton, M. D., Cordato, D. J., Kleinig, T. J., Ma, H., Chandra, R. V., Brown, H., Campbell, B. C. V., Cheung, A. K., Steinfort, B., Scroop, R., … Hong, Y. (2022). Endovascular thrombectomy versus standard bridging thrombolytic with endovascular thrombectomy within 4·5 h of stroke onset: An open-label, blinded-endpoint, randomised non-inferiority trial. *The Lancet*, *400*(10346), 116–125. https://doi.org/10.1016/S0140-6736(22)00564-5

Mokin, M., Primiani, C. T., Siddiqui, A. H., & Turk, A. S. (2017). ASPECTS (Alberta Stroke Program Early CT Score) Measurement Using Hounsfield Unit Values When Selecting Patients for Stroke Thrombectomy. *Stroke*, *48*(6), 1574–1579. https://doi.org/10.1161/STROKEAHA.117.016745

Moseley, M. E., Kucharczyk, J., Mintorovitch, J., & Cohen, Y. (1990). Diffusion-Weighted MR Imaging of Acute Stroke: Correlation with T2- Weighted and Magnetic Susceptibility-Enhanced MR Imaging in Cats. *American Society of Neuroradiology*, *11*, 423–429.

Mulder, M. J. H. L., Jansen, I. G. H., Goldhoorn, R.-J. B., Venema, E., Chalos, V., Compagne, K. C. J., Roozenbeek, B., Lingsma, H. F., Schonewille, W. J., van den Wijngaard, I. R., Boiten, J., Albert Vos, J., Roos, Y. B. W. EM., van Oostenbrugge, R. J., van Zwam, W. H., Majoie, C. B. L. M., van der Lugt, A., Dippel, D. W. J., & null, null. (2018). Time to Endovascular Treatment and Outcome in Acute Ischemic Stroke. *Circulation*, *138*(3), 232–240. https://doi.org/10.1161/CIRCULATIONAHA.117.032600

Muruet, W., Rudd, A., Wolfe, C. D. A., & Douiri, A. (2018). Long-Term Survival After Intravenous Thrombolysis for Ischemic Stroke. *Stroke*, *49*(3), 607–613. https://doi.org/10.1161/STROKEAHA.117.019889

Nakagawara, J., Minematsu, K., Okada, Y., Tanahashi, N., Nagahiro, S., Mori, E., Shinohara, Y., Yamaguchi, T., & for J-MARS Investigators. (2010). Thrombolysis With 0.6 mg/kg Intravenous Alteplase for Acute Ischemic Stroke in Routine Clinical Practice: The Japan post-Marketing Alteplase Registration Study (J-MARS). *Stroke*, *41*(9), 1984–1989. https://doi.org/10.1161/STROKEAHA.110.589606

National Association EMS Physicians. (2018). *Stroke destination: An opportunity for innovation in system design*. EMS1. https://www.ems1.com/ems-products/medical-monitoring/articles/stroke-destination-an-opportunity-for-innovation-in-system-design-lUPOFp30cZs10XgQ/

Nogueira, R. G., Jadhav, A. P., Haussen, D. C., Bonafe, A., Budzik, R. F., Bhuva, P., Yavagal, D. R., Ribo, M., Cognard, C., Hanel, R. A., Sila, C. A., Hassan, A. E., Millan, M., Levy, E. I., Mitchell, P., Chen, M., English, J. D., Shah, Q. A., Silver, F. L., … Jovin, T. G. (2018). Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct. *New England Journal of Medicine*, *378*(1), 11–21. https://doi.org/10.1056/NEJMoa1706442

Northeastern Ontario Stroke Network (Director). (2022, October 6). *Provincial Stroke Rounds October 5, 2022*. https://www.youtube.com/watch?v=6k-Yy2-RhCE

NS Stroke Network. (2020). *Emergency Health Services*.

O'Connor, H., & Gibson, N. (2003). *A Step-by-Step Guide to Qualitative Data Analysis*. 29.

Ontario Health Regions – Ontario Health. (2022). https://www.ontariohealth.ca/about-us/our-programs/ontario-health-regions

Ontario Stroke Network. (2014). *New Stroke Data Field in DAD CIHI Special Project 740: AlphaFIM*.

Ospel, J. M., & Goyal, M. (2021). A review of endovascular treatment for medium vessel occlusion stroke. *Journal of NeuroInterventional Surgery*, *13*(7), 623–630. https://doi.org/10.1136/neurintsurg-2021-017321

Our Region | Stroke Network of Southeastern Ontario. (2022). https://www.strokenetworkseo.ca/about/our-region

Palm, F., Urbanek, C., Rose, S., Buggle, F., Bode, B., Hennerici, M. G., Schmieder, K., Inselmann, G., Reiter, R., Fleischer, R., Piplack, K.-O., Safer, A., Becher, H., & Grau, A. J. (2010). Stroke Incidence and Survival in Ludwigshafen am Rhein, Germany: The Ludwigshafen Stroke Study (LuSSt). *Stroke*, *41*(9), 1865–1870. https://doi.org/10.1161/STROKEAHA.110.592642

Parsons, M., Spratt, N., Bivard, A., Campbell, B., Kong, C., Ferdinand, M., O'Brien, B., Christopher, B., Patrick, M., Allen, C., Bateman, G., Donnan, G., Davis, S., & Levi, C. (2012). A Randomized Trial of Tenecteplase versus Alteplase for Acute Ischemic Stroke. *The New England Journal of Medicine*, *366*(12), 1099–1107. http://dx.doi.org.qe2a-proxy.mun.ca/10.1056/NEJMoa1109842

Parsons, M. W. (2009). *Imaging-guided tenecteplase treatment in an extended time window*. 7.

Pasarikovski, C. R., Khosravani, H., da Costa, L., Heyn, C., Priola, S. M., Ku, J. C., Black, S. E., Gladstone, D. J., & Yang, V. X. D. (2020). Outcomes of Endovascular Thrombectomy for Basilar Artery Occlusion. *Canadian Journal of Neurological Sciences / Journal Canadien Des Sciences Neurologiques*, *47*(4), 479–485. https://doi.org/10.1017/cjn.2020.51

Pellerin, B. (2019, December 20). *Achieving Distinction in Stroke Care*. Accreditation Canada. https://accreditation.ca/news/distinction-in-stroke-care/

Petkova, M., Rodrigo, S., Lamy, C., Oppenheim, G., Touzé, E., Mas, J.-L., Méder, J.-F., & Oppenheim, C. (2010). MR Imaging Helps Predict Time from Symptom Onset in Patients with Acute Stroke: Implications for Patients with Unknown Onset Time. *Radiology*, *257*(3), 782–792. https://doi.org/10.1148/radiol.10100461

Phan, K., Dmytriw, A. A., Maingard, J., Asadi, H., Griessenauer, C. J., Ng, W., Kewagamang, K., Mobbs, R. J., Moore, J. M., Ogilvy, C. S., & Thomas, A. J. (2017). Endovascular Thrombectomy Alone versus Combined with Intravenous Thrombolysis. *World Neurosurgery*, *108*, 850-858.e2. https://doi.org/10.1016/j.wneu.2017.08.040

Potla, N., & Ganti, L. (2022). Tenecteplase vs. alteplase for acute ischemic stroke: A systematic review. *International Journal of Emergency Medicine*, *15*(1), 1. https://doi.org/10.1186/s12245-021-00399-w

Powers, W. J., Rabinstein, A. A., Ackerson, T., Adeoye, O. M., Bambakidis, N. C., Becker, K., Biller, J., Brown, M., Demaerschalk, B. M., Hoh, B., Jauch, E. C., Kidwell, C. S., Leslie-Mazwi, T. M., Ovbiagele, B., Scott, P. A., Sheth, K. N., Southerland, A. M., Summers, D. V., & Tirschwell, D. L. (2018). 2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke*, *49*(3). https://doi.org/10.1161/STR.0000000000000158

Prabhakaran, S., Ruff, I., & Bernstein, R. A. (2015). Acute Stroke Intervention: A Systematic Review. *JAMA*, *313*(14), 1451. https://doi.org/10.1001/jama.2015.3058

Quality of Care NL. (2019a). *Practice Points Jan-Jun 2019: Volume 5*.

Quality of Care NL. (2019b). *Practice Points Jul-Dec 2019 Volume 6*. Choosing Wisely NL.

Quality of Care NL. (2020). *Practice Points Jan-Jun 2020 Volume 7*. Choosing Wisely NL.

Ribo, M., Molina, C. A., Delgado, P., Rubiera, M., Delgado-Mederos, R., Rovira, A., Munuera, J., & Alvarez-Sabin, J. (2007). Hyperglycemia during Ischemia Rapidly Accelerates Brain Damage in Stroke Patients Treated with tPA. *Journal of Cerebral Blood Flow & Metabolism*, *27*(9), 1616–1622. https://doi.org/10.1038/sj.jcbfm.9600460

Richards, K. (2003). *Qualitative Inquiry in TESOL*. Palgrave Macmillan.

Rimmele, D. L., & Thomalla, G. (2014). Wake-Up Stroke: Clinical Characteristics, Imaging Findings, and Treatment Option – an Update. *Frontiers in Neurology*, *5*, 35. https://doi.org/10.3389/fneur.2014.00035

Rodriguez-Calienes, A., Vivanco-Suarez, J., Dibas, M., Casanova, D., Galecio-Castillo, M., Farooqui, M., & Ortega-Gutierrez, S. (2023). Current challenges in the endovascular treatment of medium vessel occlusions. *Frontiers in Stroke*, *2*. https://doi.org/10.3389/fstro.2023.1242961

Rodrigues, F. B., Neves, J. B., Caldeira, D., Ferro, J. M., Ferreira, J. J., & Costa, J. (2016). Endovascular treatment versus medical care alone for ischaemic stroke: Systematic review and meta-analysis. *BMJ*, i1754. https://doi.org/10.1136/bmj.i1754

Rogers, Everett. M. (1995). *Diffussion of Innovations* (4th Edition). the Free Press.

Rpn, L. G., Kelleher, E., Pt, S. P., & Kin, B. A. (2017). *Stroke Special Project 640 and 740*. 45.

Rutledge, T. (2001). Thrombolytic therapy for acute ischemic stroke. *CJEM : Journal of the Canadian Association of Emergency Physicians*, *3*(1), 8. http://www.proquest.com/docview/195784472/citation/F948154599FA4C06PQ/1

Sacco, R. L., Kasner, S. E., Broderick, J. P., Caplan, L. R., Connors, J. J. (Buddy), Culebras, A., Elkind, M. S. V., George, M. G., Hamdan, A. D., Higashida, R. T., Hoh, B. L., Janis, L.

S., Kase, C. S., Kleindorfer, D. O., Lee, J.-M., Moseley, M. E., Peterson, E. D., Turan, T. N., Valderrama, A. L., & Vinters, H. V. (2013). An Updated Definition of Stroke for the 21st Century: A Statement for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke*, *44*(7), 2064–2089. https://doi.org/10.1161/STR.0b013e318296aeca

Sadeghi-Hokmabadi, E., Farhoudi, M., Taheraghdam, A., Rikhtegar, R., Ghafouri, R. R., Asadi, R., Far, E. M., Ghaemian, N., Mehrara, M., & Mirnour, R. (2018). Prehospital notification can effectively reduce in-hospital delay for thrombolysis in acute stroke. *Future Neurology*, *13*(1), 5–11. https://doi.org/10.2217/fnl-2017-0031

Sarraj, A., Pizzo, E., Lobotesis, K., Grotta, J. C., Hassan, A. E., Abraham, M. G., Blackburn, S., Day, A. L., Dannenbaum, M. J., Hicks, W., Vora, N. A., Budzik, R. F., Sharrief, A. Z., Martin-Schild, S., Sitton, C. W., Pujara, D. K., Lansberg, M. G., Gupta, R., Albers, G. W., & Kunz, W. G. (2021). Endovascular thrombectomy in patients with large core ischemic stroke: A cost-effectiveness analysis from the SELECT study. *Journal of Neuro*

Sarraj Amrou, Hassan Ameer E., Abraham Michael G., Ortega-Gutierrez Santiago, Kasner Scott E., Hussain M. Shazam, Chen Michael, Blackburn Spiros, Sitton Clark W., Churilov Leonid, Sundararajan Sophia, Hu Yin C., Herial Nabeel A., Jabbour Pascal, Gibson Daniel, Wallace Adam N., Arenillas Juan F., Tsai Jenny P., Budzik Ronald F., … Albers Gregory W. (2023). Trial of Endovascular Thrombectomy for Large Ischemic Strokes. *New England Journal of*

Medicine, *388*(14), 1259–1271. https://doi.org/10.1056/NEJMoa2214403

Saver, J. L. (2006). Time Is Brain—Quantified. *Stroke*, *37*(1), 263–266. https://doi.org/10.1161/01.STR.0000196957.55928.ab

Saver, J. L., Fonarow, G. C., Smith, E. E., Reeves, M. J., Grau-Sepulveda, M. V., Pan, W., Olson, D. M., Hernandez, A. F., Peterson, E. D., & Schwamm, L. H. (2013). *Time to Treatment With Intravenous Tissue Plasminogen Activator and Outcome From Acute Ischemic Stroke*. 9.

Saver, J. L., Goyal, M., Bonafe, A., Diener, H.-C., Levy, E. I., Pereira, V. M., Albers, G. W., Cognard, C., Cohen, D. J., Hacke, W., Jansen, O., Jovin, T. G., Mattle, H. P., Nogueira, R. G., Siddiqui, A. H., Yavagal, D. R., Baxter, B. W., Devlin, T. G., Lopes, D. K., … Jahan, R. (2015). Stent-Retriever Thrombectomy after Intravenous t-PA vs. T-PA Alone in Stroke. *New England Journal of Medicine*, *372*(24), 2285–2295. https://doi.org/10.1056/NEJMoa1415061

Saver, J. L., Goyal, M., van der Lugt, A., Menon, B. K., Majoie, C. B. L. M., Dippel, D. W., Campbell, B. C., Nogueira, R. G., Demchuk, A. M., Tomasello, A., Cardona, P., Devlin, T. G., Frei, D. F., du Mesnil de Rochemont, R., Berkhemer, O. A., Jovin, T. G., Siddiqui, A. H., van Zwam, W. H., Davis, S. M., … for the HERMES Collaborators. (2016). Time to Treatment With Endovascular Thrombectomy and Outcomes From Ischemic Stroke: A Meta-analysis. *JAMA*, *316*(12), 1279. https://doi.org/10.1001/jama.2016.13647

Saver, J. L., & Yafeh, B. (2007). Confirmation of tPA Treatment Effect by Baseline Severity-Adjusted End Point Reanalysis of the NINDS-tPA Stroke Trials. *Stroke*, *38*(2), 414–416. https://doi.org/10.1161/01.STR.0000254580.39297.3c

Schmitz, M. L., Simonsen, C. Z., Hundborg, H., Christensen, H., Ellemann, K., Geisler, K., Iversen, H., Madsen, C., Rasmussen, M.-J., Vestergaard, K., Andersen, G., & Johnsen, S. P. (2014). Acute Ischemic Stroke and Long-Term Outcome After Thrombolysis:

Nationwide Propensity Score–Matched Follow-Up Study. *Stroke*, *45*(10), 3070–3072. https://doi.org/10.1161/STROKEAHA.114.006570

Schröder, J., & Thomalla, G. (2017). A Critical Review of Alberta Stroke Program Early CT Score for Evaluation of Acute Stroke Imaging. *Frontiers in Neurology*, *7*. https://doi.org/10.3389/fneur.2016.00245

Schuberg, S., Song, S., Saver, J. L., Mack, W. J., Cen, S. Y., & Sanossian, N. (2013). Impact of Emergency Medical Services Stroke Routing Protocols on Primary Stroke Center Certification in California. *Stroke*, *44*(12), 3584–3586. https://doi.org/10.1161/STROKEAHA.113.000940

Seenan, P., Long, M., & Langhorne, P. (2007). Stroke Units in Their Natural Habitat. *Stroke*, *38*(6), 1886–1892. https://doi.org/10.1161/STROKEAHA.106.480871

Services, A. H. (2023a). *About AHS*. Alberta Health Services. https://www.albertahealthservices.ca/about/about.aspx

Services, A. H. (2023b). *AHS In My Zone*. Alberta Health Services. https://www.albertahealthservices.ca/zones/zones.aspx

Sharma, V. K., Ng, K. W. P., Venketasubramanian, N., Saqqur, M., Teoh, H. L., Kaul, S., Srivastava, P. M. V., Sergentanis, T., Suwanwela, N., Nguyen, T. H., Lawrence Wong, K. S., & Chan, B. P. L. (2011). Current status of intravenous thrombolysis for acute ischemic stroke in Asia. *International Journal of Stroke*, *6*(6), 523–530. https://doi.org/10.1111/j.1747-4949.2011.00671.x

Sheth, K. N., Smith, E. E., Grau-Sepulveda, M. V., Kleindorfer, D., Fonarow, G. C., & Schwamm, L. H. (2015). Drip and Ship Thrombolytic Therapy for Acute Ischemic

Stroke: Use, Temporal Trends, and Outcomes. *Stroke*, *46*(3), 732–739. https://doi.org/10.1161/STROKEAHA.114.007506

Soini, H., Kronqvist, E.-L., & Huber, G. L. (2011). *Epistemologies for qualitative research*. Center for Qualitative Psychology.

Southeastern Ontario Stroke Network (Ed.). (2022). *KHSC-KGH Roles and Responsibilities Chat: Stroke Activation and Administration of IV Thrombolysis Endovascular Thrombectomy (EVT), or IV Thrombolysis +EVT*.

Stiell, I. G., Clement, C. M., Campbell, K., Sharma, M., Socha, D., Sivilotti, M. L. A., Jin, A., Perry, J. J., Lumsden, J., Martin, C., Froats, M., Dionne, R., & Trickett, J. (2017). *Impact of Expanding the Prehospital Stroke Bypass Time Window in a Large Geographic Region*. https://doi.org/10.1161/STROKEAHA.116.014868

Stroke Network of Southeast Ontario. (2018). *ACT-FAST Triage Tool*.

Stroke Network of Southeast Ontario. (2021). *Stroke Network of Southeastern Ontario: HyperAcute Questions from the Office of the Auditoe General of Ontario*.

Stroke Network Southeastern Ontario. (2021). *Achieving Best Practice Target Times for HyperAcute Treatments—What we Learned*.

Stroke Unit Trialists' Collaboration. (2013). Organised inpatient (stroke unit) care for stroke. *The Cochrane Database of Systematic Reviews*, *2013*(9), CD000197. https://doi.org/10.1002/14651858.CD000197.pub3

Suzuki, K., Matsumaru, Y., Takeuchi, M., Morimoto, M., Kanazawa, R., Takayama, Y., Kamiya, Y., Shigeta, K., Okubo, S., Hayakawa, M., Ishii, N., Koguchi, Y., Takigawa, T., Inoue, M., Naito, H., Ota, T., Hirano, T., Kato, N., Ueda, T., … Kimura, K. (2021). Effect of Mechanical Thrombectomy Without vs With Intravenous Thrombolysis on Functional

Outcome Among Patients With Acute Ischemic Stroke. *JAMA*, *325*(3), 244–253. https://doi.org/10.1001/jama.2020.23522

Teleb, M. S., Ver Hage, A., Carter, J., Jayaraman, M. V., & McTaggart, R. A. (2017). Stroke vision, aphasia, neglect (VAN) assessment—a novel emergent large vessel occlusion screening tool: Pilot study and comparison with current clinical severity indices. *Journal of NeuroInterventional Surgery*, *9*(2), 122–126. https://doi.org/10.1136/neurintsurg-2015-012131

The ATLANTIS, ECASS, and NINDS rt-PA Study Group Investigators. (2004). Association of outcome with early stroke treatment: Pooled analysis of ATLANTIS, ECASS, and NINDS rt-PA stroke trials. *The Lancet*, *363*(9411), 768–774. https://doi.org/10.1016/S0140-6736(04)15692-4

The Canadian Stroke Strategy. (2010). *Education Workshop For Emergency Medical Services Care of Suspected Acute Stroke Patients*.

The Heart and Stroke Foundation 2015 Report. (2015). *ACCESS TO STROKE CARE:THE CRITICAL FIRST HOURS*. Heart & Stroke Foundation.

The IST-3 collaborative group. (2012). The benefits and harms of intravenous thrombolysis with recombinant tissue plasminogen activator within 6 h of acute ischaemic stroke (the third international stroke trial [IST-3]): A randomised controlled trial. *The Lancet*, *379*(9834), 2352–2363. https://doi.org/10.1016/S0140-6736(12)60768-5

The NINDS t-PA Stroke Study Group. (1997). Generalized Efficacy of t-PA for Acute Stroke: Subgroup Analysis of the NINDS t-PA Stroke Trial. *American Heart Association*, *28*(11), 211902125. https://oce-ovid-com.qe2a-proxy.mun.ca/article/00007670-199711000-00002/HTML

Thomalla, G., Cheng, B., Ebinger, M., Hao, Q., Tourdias, T., Wu, O., Kim, J. S., Breuer, L., Singer, O. C., Warach, S., Christensen, S., Treszl, A., Forkert, N. D., Galinovic, I., Rosenkranz, M., Engelhorn, T., Köhrmann, M., Endres, M., Kang, D.-W., … Gerloff, C. (2011). DWI-FLAIR mismatch for the identification of patients with acute ischaemic stroke within 4·5 h of symptom onset (PRE-FLAIR): A multicentre observational study. *The Lancet Neurology*, *10*(11), 978–986. https://doi.org/10.1016/S1474-4422(11)70192-2

Thomalla, G., Rossbach, P., Rosenkranz, M., Siemonsen, S., Krützelmann, A., Fiehler, J., & Gerloff, C. (2009). Negative fluid-attenuated inversion recovery imaging identifies acute ischemic stroke at 3 hours or less. *Annals of Neurology*, *65*(6), 724–732. https://doi.org/10.1002/ana.21651

Thomalla, G., Simonsen, C. Z., Boutitie, F., Andersen, G., Berthezene, Y., Cheng, B., Cheripelli, B., Cho, T.-H., Fazekas, F., Fiehler, J., Ford, I., Galinovic, I., Gellissen, S., Golsari, A., Gregori, J., Günther, M., Guibernau, J., Häusler, K. G., Hennerici, M., … Gerloff, C. (2018). MRI-Guided Thrombolysis for Stroke with Unknown Time of Onset. *New England Journal of Medicine*, *379*(7), 611–622. https://doi.org/10.1056/NEJMoa1804355

Thomas, D. R. (2006). A General Inductive Approach for Analyzing Qualitative Evaluation Data. *American Journal of Evaluation*, *27*(2), 237–246. https://doi.org/10.1177/1098214005283748

Thrombolytic therapy: MedlinePlus Medical Encyclopedia. (2021). https://medlineplus.gov/ency/article/007089.htm

Toyoda, K., Koga, M., Naganuma, M., Shiokawa, Y., Nakagawara, J., Furui, E., Kimura, K., Yamagami, H., Okada, Y., Hasegawa, Y., Kario, K., Okuda, S., Nishiyama, K., &

Minematsu, K. (2009). Routine Use of Intravenous Low-Dose Recombinant Tissue Plasminogen Activator in Japanese Patients: General Outcomes and Prognostic Factors From the SAMURAI Register. *Stroke*, *40*(11), 3591–3595. https://doi.org/10.1161/STROKEAHA.109.562991

Treurniet, K. M., LeCouffe, N. E., Kappelhof, M., Emmer, B. J., van Es, A. C. G. M., Boiten, J., Lycklama, G. J., Keizer, K., Yo, L. S. F., Lingsma, H. F., van Zwam, W. H., de Ridder, I., van Oostenbrugge, R. J., van der Lugt, A., Dippel, D. W. J., Coutinho, J. M., Roos, Y. B. W. E. M., & Majoie, C. B. L. M. (2021). MR CLEAN-NO IV: Intravenous treatment followed by endovascular treatment versus direct endovascular treatment for acute ischemic stroke caused by a proximal intracranial occlusion—study protocol for a randomized clinical trial. *Trials*, *22*, 141. https://doi.org/10.1186/s13063-021-05063-5

Turner, S., Ramsay, A., Perry, C., Boaden, R., McKevitt, C., Morris, S., Pursani, N., Rudd, A., Tyrrell, P., Wolfe, C., & Fulop, N. (2016). Lessons for major system change: Centralization of stroke services in two metropolitan areas of England. *Journal of Health Services Research & Policy*, *21*(3), 156–165. https://doi.org/10.1177/1355819615626189

Types of Stroke. (2020). Www.Stroke.Org. https://www.stroke.org/en/about-stroke/types-of-stroke

US EPA, O. (2016, November 16). *Lean Thinking and Methods—Kaizen* [Overviews and Factsheets]. https://www.epa.gov/sustainability/lean-thinking-and-methods-kaizen

Van de Werf, F. (1999). Single-bolus tenecteplase compared with front-loaded alteplase in acute myocardial infarction: The ASSENT-2 double-blind randomised trial. *The Lancet*, *354*(9180), 716–722. https://doi.org/10.1016/S0140-6736(99)07403-6

van Swieten, J. C., Koudstaal, P. J., Visser, M. C., Schouten, H. J. A., & van Gijn, J. (1988).

Interobserver agreement for the assessment of handicap in stroke patients. 19(5), 604–607.

Wahlgren, N., Ahmed, N., Dávalos, A., Ford, G. A., Grond, M., Hacke, W., Hennerici, M. G., Kaste, M., Kuelkens, S., Larrue, V., Lees, K. R., Roine, R. O., Soinne, L., Toni, D., & Vanhooren, G. (2007). *Thrombolysis with alteplase for acute ischaemic stroke in the Safe Implementation of Thrombolysis in Stroke- Monitoring Study (SITS-MOST): An observational study*. *369*, 8.

Wahlgren, N., Ahmed, N., Dávalos, A., Hacke, W., Millán, M., Muir, K., Roine, R. O., Toni, D., & Lees, K. R. (2008). Thrombolysis with alteplase 3–4·5 h after acute ischaemic stroke (SITS-ISTR): An observational study. *The Lancet*, *372*(9646), 1303–1309. https://doi.org/10.1016/S0140-6736(08)61339-2

Wahlgren, N., Ahmed, N., Eriksson, N., Aichner, F., Bluhmki, E., Dávalos, A., Erilä, T., Ford, G. A., Grond, M., Hacke, W., Hennerici, M. G., Kaste, M., Köhrmann, M., Larrue, V., Lees, K. R., Machnig, T., Roine, R. O., Toni, D., & Vanhooren, G. (2008). Multivariable Analysis of Outcome Predictors and Adjustment of Main Outcome Results to Baseline Data Profile in Randomized Controlled Trials: Safe Implementation of Thrombolysis in Stroke-MOnitoring STudy (SITS-MOST). *Stroke*, *39*(12), 3316–3322. https://doi.org/10.1161/STROKEAHA.107.510768

Wardlaw, J. M., Murray, V., Berge, E., & del Zoppo, G. J. (2014). Thrombolysis for acute ischaemic stroke. *Cochrane Database of Systematic Reviews*. https://doi.org/10.1002/14651858.CD000213.pub3

Wardlaw, J. M., Seymour, J., Cairns, J., Keir, S., Lewis, S., & Sandercock, P. (2004). Immediate

Computed Tomography Scanning of Acute Stroke Is Cost-Effective and Improves Quality of Life. *Stroke*, *35*(11), 2477–2483. https://doi.org/10.1161/01.STR.0000143453.78005.44

Wintermark, M., Sanelli, P., Albers, G. W., Bello, J., Derdeyn, C., Hetts, S. W., Johnson, M. H., Kidwell, C., Lev, M. H., Liebeskind, D. S., Rowley, H., Schaefer, P. W., Sunshine, J. L., Zaharchuk, G., & Meltzer, C. C. (2013). Imaging Recommendations for Acute Stroke and Transient Ischemic Attack Patients: A Joint Statement by the American Society of Neuroradiology, the American College of Radiology and the Society of NeuroInterventional Surgery. *AJNR. American Journal of Neuroradiology*, *34*(11), E117–E127. https://doi.org/10.3174/ajnr.A3690

Wolters, F. J., Paul, N. L. M., Li, L., & Rothwell, P. M. (2015). Sustained impact of UK FAST-test public education on response to stroke: A population-based time-series study. *International Journal of Stroke*, *10*(7), 1108–1114. https://doi.org/10.1111/ijs.12484

Wong, K. S. L., Wang, Y., Leng, X., Mao, C., Tang, J., Bath, P. M. W., Markus, H. S., Gorelick, P. B., Liu, L., Lin, W., & Wang, Y. (2013). Early Dual Versus Mono Antiplatelet Therapy for Acute Non-Cardioembolic Ischemic Stroke or Transient Ischemic Attack. *Circulation*, *128*(15), 1656–1666. https://doi.org/10.1161/CIRCULATIONAHA.113.003187

Yafasova, A., Fosbøl, E. L., Johnsen, S. P., Kruuse, C., Petersen, J. K., Alhakak, A., Vinding, N. E., Torp-Pedersen, C., Gislason, G. H., Køber, L., & Butt, J. H. (2021). Time to Thrombolysis and Long-Term Outcomes in Patients With Acute Ischemic Stroke: A Nationwide Study. *Stroke*, *52*(5), 1724–1732. https://doi.org/10.1161/STROKEAHA.120.032837

Yamaguchi, T., Mori, E., Minematsu, K., Nakagawara, J., Hashi, K., Saito, I., & Shinohara, Y. (2006). Alteplase at 0.6 mg/kg for Acute Ischemic Stroke Within 3 Hours of Onset: Japan Alteplase Clinical Trial (J-ACT). *Stroke*, *37*(7), 1810–1815. https://doi.org/10.1161/01.STR.0000227191.01792.e3

Yang, P., Zhang, Y., Zhang, L., Zhang, Y., Treurniet, K. M., Chen, W., Peng, Y., Han, H., Wang, J., Wang, S., Yin, C., Liu, S., Wang, P., Fang, Q., Shi, H., Yang, J., Wen, C., Li, C., Jiang, C., … Liu, J. (2020). Endovascular Thrombectomy with or without Intravenous Alteplase in Acute Stroke. *New England Journal of Medicine*, *382*(21), 1981–1993. https://doi.org/10.1056/NEJMoa2001123

Yin, R. K. (2014). *Case Study Research Design and Methods (5th ed.)*. SAGE Publications, Inc. Yoshimura, S., Sakai, N., Yamagami, H., Uchida, K., Beppu, M., Toyoda, K., Matsumaru, Y., Matsumoto, Y., Kimura, K., Takeuchi, M., Yazawa, Y., Kimura, N., Shigeta, K., Imamura, H., Suzuki, I., Enomoto, Y., Tokunaga, S., Morita, K., Sakakibara, F., … Morimoto, T. (2022). Endovascular Therapy for Acute Stroke with a Large Ischemic Region. *New England Journal of Medicine*, *386*(14), 1303–1313. https://doi.org/10.1056/NEJMoa2118191

Yvonne Feilzer, M. (2010). Doing Mixed Methods Research Pragmatically: Implications for the Rediscovery of Pragmatism as a Research Paradigm. *Journal of Mixed Methods Research*, *4*(1), 6–16. https://doi.org/10.1177/1558689809349691

Zhang, J., Yuan, C., Deng, X., Yuan, Q., Wang, M., Fu, P., Fang, J., Du, Z., & Hu, J. (2022). Efficacy and safety of endovascular treatment with or without intravenous alteplase in acute anterior circulation large vessel occlusion stroke: A meta-analysis of randomized controlled trials. *Neurological Sciences*. https://doi.org/10.1007/s10072-022-06017-8

Zhao, H., Pesavento, L., Coote, S., Rodrigues, E., Salvaris, P., Smith, K., Bernard, S., Stephenson, M., Churilov, L., Yassi, N., Davis, S. M., & Campbell, B. C. V. (2018). Ambulance Clinical Triage for Acute Stroke Treatment: Paramedic Triage Algorithm for Large Vessel Occlusion. *Stroke*, *49*(4), 945–951. https://doi.org/10.1161/STROKEAHA.117.019307

Zi, W., Qiu, Z., Li, F., Sang, H., Wu, D., Luo, W., Liu, S., Yuan, J., Song, J., Shi, Z., Huang, W., Zhang, M., Liu, W., Guo, Z., Qiu, T., Shi, Q., Zhou, P., Wang, L., Fu, X., … DEVT Trial Investigators. (2021). Effect of Endovascular Treatment Alone vs Intravenous Alteplase Plus Endovascular Treatment on Functional Independence in Patients With Acute Ischemic Stroke: The DEVT Randomized Clinical Trial. *JAMA*, *325*(3), 234. https://doi.org/10.1001/jama.2020.23523

Appendix I: Paramedic Code Stroke Assessment

Patient Name: ______________________
MCP Number: ______________________
PCR Number: ______________________

1. **Screen for an acute Stroke**

Cincinnati Prehospital Stroke Scale	
Unilateral arm **and / or** leg weakness or drift	
Slurred speech **or** inappropriate words **or** unable to speak	
Unilateral facial weakness or droop	

Establishing a clear and accurate Last Known Well Time is essential
Recognize and Mobilize - Scene time should be minimized, and interventions performed during transport, if possible
Pre-arrival notification/patient registration should occur

2. **If acute stroke screen is positive, evaluate for exclusion criteria:**

Exclusion Criteria			
GCS less than 10		Brain hemorrhage in the past 6 months	
Blood glucose less than 4 mmol/L despite treatment		History of brain tumor, arteriovenous malformation (AVM) or brain aneurysm	
Seizure since onset of symptoms		History of stroke or brain surgery within the last 3 months	
Terminally ill or palliative care patient		Anticoagulation with any of the following medications: Xarelto (Rivaroxaban), Eliquis (Apixban), Lixiana (Edoxaban) *Note: Warfarin or Pradaxa (Dabigatran) are not exclusions, all the above medications are not contraindications if missed last dose or late for current dose*	
Pregnancy			
Stroke symptoms completely resolved			

3. **If there are any exclusion criteria, do not call a Code Stroke but continue to transport to the nearest Stroke Center.**
4. **If acute stroke screen is positive and there are no exclusion criteria, screen for Large Vessel Occlusion (LVO) Stroke:**

RACE Stroke Scale (Rapid Arterial oCclusion Evaluation Scale)			
ASSESSMENT	**INSTRUCTIONS**	**RESPONSE**	**SCORE**
Facial Palsy	Ask patient to show their teeth	**Absent** - symmetrical movement **Mild** - slightly asymmetrical **Moderate to Severe** - completely asymmetrical	0 1 2
Arm Motor Function	Extend the arms of the patient 90 degrees if sitting or 45 degrees if supine	**Normal to Mild** - held more than 10 seconds **Moderate** - held less than 10 seconds **Severe** - cannot lift against gravity	0 1 2
Leg Motor Function	Extend the legs of the patient 30 degrees when supine	**Normal to Mild** - held more than 5 seconds **Moderate** - held less than 5 seconds **Severe** - cannot lift against gravity	0 1 2
Head And Gaze Deviation	Observe for eyes *and* head to be deviated to one side	**Absent** - can turn head *and* eyes to both sides **Present** - cannot turn head *and* eyes to one side	0 1
Aphasia If right hemiparesis	Ask the patient to: **"Close your eyes"** **"Make a fist"** (unparalyzed hand)	**Normal** - completes both tasks correctly **Moderate** - completes one task correctly **Severe** – cannot complete either task	0 1 2
Agnosia If left hemiparesis	Show them their paralyzed arm: ***"Whose arm is this?"*** (Correct response is "my arm/mine") ***"Can you move your arm?"*** (Correct	**Normal** - completes both correctly **Moderate** - completes one correctly **Severe** - completes neither task	0 1 2

	response is "no" if they can't move it or "yes" if they can move it)		

Total RACE Score (5 or more is a positive score)	

5. **Determine appropriate destination as per the destination flow sheet on the reverse page *(call Online Medical Control (OLMC) if there is any uncertainty about the appropriate destination)***

Appendix II: HREB Quantitative Ethics Approval Letter

Research Ethics Office
Suite 200, Eastern Trust Building
95 Bonaventure Avenue St.
John's, NL

NEWFOUNDLAND AND LABRADOR
HREB
HEALTH RESEARCH ETHICS BOARD

A1B 2X5

October 09, 2020
13 Regent Street
Dear Mr. Parfrey:

Researcher Portal File # 20210824
Reference # 2020.256

RE: Stroke outcomes and treatment in Newfoundland Hospitals

Your application was reviewed by a subcommittee under the direction of the HREB and the following decision was rendered:

X	Approval
	Approval Subject to changes
	Rejection

Ethics approval is granted for one year effective 09 Oct 2020. This ethics approval will be reported to the board at the next scheduled HREB meeting.

This is to confirm that the HREB reviewed and approved or acknowledged the following documents (as indicated):

- Variable List, acknowledged
- Proposal, approved

Please note the following:

- This ethics approval will lapse on 09 Oct 2021. It is your responsibility to ensure that the Ethics Renewal form is submitted prior to the renewal date.
- This is your ethics approval only. Organizational approval may also be required. It is your responsibility to seek the necessary organizational approvals.
- Modifications of the study are not permitted without prior approval from the HREB. Request for modification to the study must be outlined on the relevant Event Form available on the Researcher Portal website.
- Though this research has received HREB approval, you are responsible for the ethical conduct of this research.
- If you have any questions please contact info@hrea.ca or 709 777 6974.

The HREB operates according to the Tri-Council Policy Statement: Ethical Conduct for

Research Involving Humans (TCPS2), ICH Guidance E6: Good Clinical Practice Guidelines (GCP), the Health Research Ethics Authority Act (HREA Act) and applicable laws and regulations.

We wish you every success with your study.

Sincerely,

[redacted]

Health Research Ethics Board

You Have Received Ethics Approval, Now What?: HREB Reporting Requirements
Once a study has received ethics approval from the Health Research Ethics Board (HREB), there are still associated reporting requirements. In the conduct of approved research researchers are required to report to the HREB, in a timely manner, proposed changes from approved research that affect participants at any stage of the process. This includes, but is not limited to, changes to the consent form, changes to the tasks or interventions involved in the research, or changes to measures to protect privacy and confidentiality.

Any substantive change to the research should not be implemented prior to documented approval by the HREB, except when necessary to eliminate an immediate risk(s) to the participants. Below are examples of post approval documentation that must be submitted to the HREB:

Amendments
Any proposed change in the conduct of a study must be submitted to the HREB, and approved, before the change may be implemented. Such changes might include modification of recruitment procedures, inclusion or exclusion criteria, revised sample size, addition or deletion of study sites, changes to an intervention, consent forms, questionnaires or scripts, etc. If there are changes in project team members or changes to funding source(s)/sponsor(s), there are specific forms to complete to report this to the HREB.

Adverse Events
Serious and unanticipated adverse events that occur within Newfoundland and Labrador are required to be reported to the HREB. Such events may occur in both clinical trials and in other types of research, e.g. collapse during a rehabilitation program, emotional breakdown requiring follow up care during an interview, or breach of privacy during correspondence. Serious adverse events that are fatal or life-threatening are required to be reported to the HREB as soon as the research team is aware of the event.

Protocol Deviations
Deviations from an approved study protocol must be reported to the HREB. Changes that eliminate immediate hazards to participants do not require prior approval, but must be reported soon as reasonably possible.

Safety Reports
Safety reports providing information on all serious adverse events (SAEs) occurring in a clinical trial must be provided by the sponsor to the HREB, normally on a three or six monthly basis (i.e. in accordance with the specified reporting timelines that were outlined in the approved ethics application).

Investigator Brochure (IB) and Product Monograph (PM)
Throughout the course of a clinical trial, changes may be implemented to study documents. All revisions to approved study documents must be submitted to the HREB to ensure the record is up to date. If the revisions include new risk or safety information there may be a requirement to notify research participants.

Ethics Renewal/Study Closure

Ethics approval lasts for one year. Ethics renewal is required annually, on the anniversary of the date of the HREB notification of approval. Once data collection is no longer ongoing, a study closure form is required to be submitted to the HREB for the study to remain active or to be closed in good standing.

Appendix III: RPAC Quantitative Ethics Approval Letter

Department of Research
5th Floor Janeway Hostel
Health Sciences Centre
300 Prince Philip Drive
St. John's, NL A1B 3V6
Tel: (709) 752-4636
Fax: (709) 752-3591

Eastern Health

March 3, 2022

Mr. Patrick Parfrey
300 Prince Philip Drive
St. John's, NL
A1B 3V6

Dear Mr. Parfrey,

Your research proposal *HREB Reference #: 2020.256 "Stroke Outcomes and Treatment in Newfoundland Hospitals"* was reviewed by the Research Proposals Approval Committee (RPAC) of Eastern Health February 8th, 2022, and we are pleased to inform you that the proposal has been granted full approval.

The approval of this project is subject to the following conditions:

- The project is conducted as outlined in the HREB approved protocol;
- Adequate funding is secured to support the project;
- In the case of Health Records, efforts will be made to accommodate requests based upon available resources. If you require access to records that cannot be accommodated, then additional fees may be levied to cover the cost;
- A progress report being provided upon request.

If you have any questions or comments, please contact Krista Rideout, Manager of the Patient Research Centre at 777-7283 or by email at krista.rideout@easternhealth.ca.

Sincerely,

[redacted]

Appendix IV: HREB Qualitative Ethics Approval Letter

Research Ethics Office
Suite 200, Eastern Trust Building
95 Bonaventure Avenue St.
John's, NL

NEWFOUNDLAND AND LABRADOR
HREB
HEALTH RESEARCH ETHICS BOARD

A1B 2X5

December 17, 2019
13 Regent Street
Dear Mr. Parfrey:

Researcher Portal File # 20193099
Reference # 2019.076

RE: Newfoundalnd Stroke Care and the Barriers and Enablers affecting progress

Your application was reviewed by a subcommittee under the direction of the HREB and the following decision was rendered:

X	Approval
	Approval Subject to changes
	Rejection

Ethics approval is granted for one year effective December 16, 2019. This ethics approval will be reported to the board at the next scheduled HREB meeting.

This is to confirm that the HREB reviewed and approved or acknowledged the following documents (as indicated):

- Application, approved
- Research proposal, approved
- Email script, approved
- Consent form, approved
- EMS Questionnaire, approved
- Interview Script, approved

Please note the following:

- This ethics approval will lapse on December 16, 2020. It is your responsibility to ensure that the Ethics Renewal form is submitted prior to the renewal date.
- This is your ethics approval only. Organizational approval may also be required. It is your responsibility to seek the necessary organizational approvals.
- Modifications of the study are not permitted without prior approval from the HREB. Request for modification to the study must be outlined on the relevant Event Form available on the Researcher Portal website.
- Though this research has received HREB approval, you are responsible for the ethical conduct of this research.
- If you have any questions please contact info@hrea.ca or 709 777 6974.

The HREB operates according to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2), ICH Guidance E6: Good Clinical Practice Guidelines (GCP), the Health Research Ethics Authority Act (HREA Act) and applicable laws and regulations.

We wish you every success with your study.

Sincerely,

[redacted]

You Have Received Ethics Approval, Now What?: HREB Reporting Requirements
Once a study has received ethics approval from the Health Research Ethics Board (HREB), there are still associated reporting requirements. In the conduct of approved research researchers are required to report to the HREB, in a timely manner, proposed changes from approved research that affect participants at any stage of the process. This includes, but is not limited to, changes to the consent form, changes to the tasks or interventions involved in the research, or changes to measures to protect privacy and confidentiality.

Any substantive change to the research should not be implemented prior to documented approval by the HREB, except when necessary to eliminate an immediate risk(s) to the participants. Below are examples of post approval documentation that must be submitted to the HREB:

Amendments
Any proposed change in the conduct of a study must be submitted to the HREB, and approved, before the change may be implemented. Such changes might include modification of recruitment procedures, inclusion or exclusion criteria, revised sample size, addition or deletion of study sites, changes to an intervention, consent forms, questionnaires or scripts, etc. If there are changes in project team members or changes to funding source(s)/sponsor(s), there are specific forms to complete to report this to the HREB.

Adverse Events
Serious and unanticipated adverse events that occur within Newfoundland and Labrador are required to be reported to the HREB. Such events may occur in both clinical trials and in other types of research, e.g. collapse during a rehabilitation program, emotional breakdown requiring follow up care during an interview, or breach of privacy during correspondence. Serious adverse events that are fatal or life-threatening are required to be reported to the HREB as soon as the research team is aware of the event.

Protocol Deviations
Deviations from an approved study protocol must be reported to the HREB. Changes that eliminate immediate hazards to participants do not require prior approval, but must be reported soon as reasonably possible.

Safety Reports
Safety reports providing information on all serious adverse events (SAEs) occurring in a clinical trial must be provided by the sponsor to the HREB, normally on a three or six monthly basis (i.e. in accordance with the specified reporting timelines that were outlined in the approved ethics application).

Investigator Brochure (IB) and Product Monograph (PM)
Throughout the course of a clinical trial, changes may be implemented to study documents. All revisions to approved study documents must be submitted to the HREB to ensure the record is up to date. If the revisions include new risk or safety information there may be a requirement to notify research participants.

Ethics Renewal/Study Closure
Ethics approval lasts for one year. Ethics renewal is required annually, on the anniversary of the date of the HREB notification of approval. Once data collection is no longer ongoing, a study closure form is required to be submitted to the HREB for the study to remain active or to be closed in good standing.

Appendix V: RPAC Qualitative Ethics Approval Letter

Department of Research
5th Floor Janeway Hostel
Health Sciences Centre
300 Prince Philip Drive
St. John's, NL A1B 3V6
Tel: (709) 752-4636
Fax: (709) 752-3591

Eastern Health

January 25, 2023

Mr. Patrick Parfrey
13 Regent Street
St. John's, NL
A1A 5A4

Dear Mr. Parfrey,

Your research proposal *HREB Reference #: 2019.076 "Newfoundland Stroke Care and the Barriers and Enablers affecting progress"* was reviewed by the Research Proposals Approval Committee (RPAC) of Eastern Health December 13th, 2022, and we are pleased to inform you that the proposal has been granted full approval.

The approval of this project is subject to the following conditions:

- The project is conducted as outlined in the HREB approved protocol;
- Adequate funding is secured to support the project;
- In the case of Health Records, efforts will be made to accommodate requests based upon available resources. If you require access to records that cannot be accommodated, then additional fees may be levied to cover the cost;
- A progress report being provided upon request.

If you have any questions or comments, please contact Laura Genge, Manager of the Patient Research Centre at 777-7283 or by email at laura.genge@easternhealth.ca.

[redacted]

Appendix VI: Consent to Take Part in Research

TITLE: Newfoundland Stroke Care and the Barriers and Enablers Affecting Progress
RESEARCHER: Patrick Parfrey Phone Number: (709) 687-8870

SUPERVISOR(S): Dr. Brendan Barrett, Dr. Victor Maddalena, Dr. Marsha Eustace, Dr. Michelle Ploughman

You have been invited to take part in a research study. Taking part in this study is voluntary. You may choose to take part, or you may choose not to take part in this study. You also may change your mind at any time.

This consent form has important information to help you make your choice. Please ask the researcher to explain anything that you do not understand. It is important that you have as much information as you need and that all your questions are answered. Please take as much time as you need to think about your decision to participate or not and ask questions about anything that is not clear. The researcher will tell you about the study timelines for making your decision.

1. Why am I being asked to join this study?

This objective of this study is to discover why the health care system in Newfoundland is not providing its stroke patients the care recommended by Canadian Stroke Best Practices Recommendations. It is likely we can learn from other provinces in how to overcome barriers in stroke care. This study will interview stroke care professionals involved in the stroke care pathway as part of case studies. You have been identified as a stroke care professional who can provide great insight within the care of stroke patients.

2. How many people will take part in this study?

We have chosen to examine stroke care delivery in Calgary zone Alberta because it is the national leader in this area; Southeastern Ontario (Kingston) because it is a city reasonably close in size to urban St. John's, Mount Pearl and Conception Bay South; and Central Zone Nova Scotia because it has an Urban: Rural divide somewhat similar to Newfoundland. We expect to enroll 8-12 participants at each site

3. How long will I be in the study?

You will be expected to participate in an interview either in person at a location of your choosing or through a phone or computer. This interview will take up to 1 hour and 30 minutes

4. What will happen if I take part in this study?

- Interview: You will be expected to participate in an interview either in person at a location of your choosing or through a phone or computer. This interview will take up to 1 hour. You will be asked to provide information about areas in the stroke care pathway that your hospital/region provides. You can choose not to answer questions
- Audio recording used: You will be recorded during the interview. The recording will be transcribed after the interview and will be analyzed by the researcher. The transcription will be done by the researcher. Your name or any other identifying information will not be included during the recording, except your voice. The audio recording will be destroyed after it has been transcribed and checked for accuracy.
- The primary investigator will reach out through email to request documentary and archival evidence you would be willing to share. If willing to stay in touch, other questions may be asked about how your region manages their hyper acute stroke program
- A follow-up interview may be requested if there are gaps in the analysis

5. Are there risks to taking part in this study?

There should be minimal risks or inconveniences to taking in this study. Taking the time out of your day to participate in the interview will be an inconvenience. If there are any questions that you find uncomfortable, you can skip the question or take break from answering questions at any time.

There are potential risks to your loss of confidentiality. Even though your name will not be part of the audio recordings or the transcriptions, your voice will be identifiable, and your profession and location may be used in the results.

6. What are the possible benefits of participating in the study?

There may not be direct benefits to you taking part in the study, but we hope that the information learned from this study can be used in the future to benefit stroke patients.

7. If I decide to take part in this study, can I stop later?

It is your choice to take part in this study, participation is voluntary. You can change your mind at any time during interview. You have the option to withdraw from answering certain questions or stopping the interview altogether at any time during the interview process. The study team may ask why you are withdrawing for reporting purposes, but you do not need to give a reason to withdraw from the study if you do not want to. You will only conduct one interview, but once the data has been de-identified and/or aggregated, withdrawal may not be feasible.

8. What are my rights when participating in a research study?

You have the right to receive all information that could help you make a decision about participating in this study, in a timely manner. You also have the right to ask questions about this study at any time and to have them answered to your satisfaction.

Your rights to privacy are legally protected by federal and provincial laws that require safeguards to ensure that your privacy is respected.

Signing this form gives us your consent to be in this study. It tells us that you understand the information about the research study. When you sign this form, you do not give up any of your legal rights against the study researcher, nor does this form relieve the study researcher, of their legal and professional responsibilities.

You have the right to be informed of the results of this study once the entire study is complete. The major audience for the research results will be decision makers and health care delivery professionals responsible for stroke care. The translation of the new knowledge will be undertaken using KT (Knowledge Translation) processes including oral presentations, one –page information sheets in Practice Points (a Newfoundland publication aimed at improving the health care system), and collaboration with Process Improvement teams. In addition, a publication will be submitted to a Canadian health policy journal that will include both the quantitative and qualitative research from my thesis.

The paper arising from my work will be sent to the respondents across the country.

You will be given a copy of this signed and dated consent form prior to participating in this study

9. What about my privacy and confidentiality?

Protecting your privacy is an important part of this study. If you decide to participate in this study, the researcher will collect and use information from your interview. The researcher will only collect and use the information they need for this study, including:

- Information from study interviews and questionnaires

- Profession
- Location of hospital
- Available documentary evidence:
    - Protocols
    - Policy
    - Checklists
    - Run-through of group reviews

The personal information collected about you will have your directly identifiable information removed (i.e., name) and replaced with a code or with a "study number". There will be a master list linking the code numbers to names. The researcher is responsible for keeping it separate from the samples and personal health information.

Study information collected will be kept on a password protected computerthat only the researcher will be able to access. After the study closes, study information will be kept as long as required by law, which could be 7 years or more. The researcher (Patrick Parfrey) is the person responsible for keeping it secure.

When the results of this study are published, or presented at scientific meetings, your name and other personal information will not be used in the publication.

All information that identifies you will be kept confidential, and to the extent permitted by applicable laws, will not be disclosed or made publicly available, except as described in this consent document. Every effort to protect your privacy will be made. Even though the risk of identifying you from the study data is small, it can never be completely eliminated. If there is a breach of your privacy resulting from your participation in this study, you will be notified.

Communication via e-mail is not absolutely secure. We do not recommend that you communicate sensitive personal information via e-mail.

10. Who will see my personal information?
Representatives from the Health Research Ethics Board may come to look at the study records under the supervision of the researcher to check that the information collected for the study is correct and to make sure the study followed the required laws and guidelines.

We may continue to review your interview script that you have consented for the study to access for a period after your last study visit to check that the information, we collected is correct

<u>**Your access to records**</u>
You have the right to see the information that has been collected about you for this study. If you wish to do so, please contact the study researcher.

11. What about questions or problems?
If you have any questions about taking part in this study, you can meet with the principal investigator who oversees the study. That person is:

Patrick Parfrey - (709) 687-8870
[Or you can speak to my supervisor: Dr. Brendan Barrett – (709) 864-6660]

Or you can talk to someone who is not involved with the study at all but can advise you on your rights as a participant in a research study. This person can be reached through:

Ethics Office at 709-777-6974
Email at info@hrea.ca

Signature Page

My signature on this consent form means:

- I have had enough time to think about the information provided and ask for advice if needed.
- All my questions have been answered and I understand the information within this consent form.
- I understand that my participation in this study is voluntary.
- I understand that I am completely free at any time to refuse to participate or to withdraw from this study at any time, without having to give a reason.
- I understand that it is my choice to be in the study and there is no guarantee that this study will provide any benefits to me.
- I am aware of the risks of participating in this study.
- I do not give up any of my legal rights by signing this consent form.
- I understand that all the information collected will be kept confidential and that the results will only be used for the purposes described in this consent form.

____

Signature of participant　　　　　Printed name　　　　　Day Month Year

____

Signature of person conducting the consent discussion　　　　　Name printed　　　　　Day Month Year

____

To be signed by the investigator:

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant/substitute decision maker fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

____

Signature of Researcher　　　　　Name Printed　　　　　Day Month Year

Appendix VII: Consent Addendum

ADDENDUM TO
PARTICIPANT INFORMATION & CONSENT

Title of Study: Newfoundland Stroke Care Barriers and Enablers Affecting Progress

RESEARCHER: Patrick Parfrey Phone Number: (709) 687-8870

SUPERVISOR(S): Dr. Brendan Barrett, Dr. Victor Maddalena, Dr. Marsha Eustace, Dr. Michelle Ploughman

You signed a Consent Form describing the study and your rights as a participant. At that time, it was believed that a single interview would suffice to obtain the appropriate information and achieve data saturation. Upon revisions from my qualitative supervisor, additional questions investigating barriers, enablers, and keys to success for hyper acute stroke care should be applied. Also, an up-to-date interview will highlight how previous barriers were surpassed. After discussing the new information with the researcher, if you would like to continue the study, sign the Consent Form Addendum. Other information from the original consent that you signed at the beginning of the study still applies.

New Information: Since originally joining the study, the design has been changed to a Case Study. This design change has added the ability to request documentary and archival evidence participants are willing to share to support the interview data. Also, if the participant is willing to remain in touch, other questions may be asked about how your region manages their hyper acute stroke care program.

ADDENDUM TO CONSENT FORM

Title of Study: Newfoundland Stroke Care Barriers and Enablers Affecting Progress

Principle Investigator: Patrick Parfrey **Phone Number:** (709) 687-8870
Study Supervisor: Dr: Brendan Barrett **Phone Number:** (709) 684-6660

I have read all new information in the addendum concerning the study I am currently participating in.

I have been given the opportunity to discuss the information contained in this addendum. All of my questions have been answered to my satisfaction.

This signature on this Consent Form Addendum means that I agree to continue to take part in this study. I understand that I remain free to withdraw at any time

____

Signature of participant Printed name Day Month Year

____

Signature of person conducting the consent discussion Name printed Day Month Year

Appendix VIII: Stroke Management Interview Script

Different professionals will be more comfortable answering certain questions

Public Awareness

- Do you have a public awareness campaign for stroke care? If so, could you tell me about how it is structured and implemented?
- Do you feel your public awareness campaign has been successful in achieving its aims?
    - Prompt: What are some of the factors you feel make it successful or not successful
    - Who is involved in your stroke awareness campaign?
    - Has your stroke awareness campaign been formally evaluated?
- What would you like to see improved in your stroke awareness campaign?
- What challenges have you faced in implementing public awareness for stroke care? How did you manage to deal with these challenges?

Emergency Medical Services/Paramedics

These next few questions deal with personnel who are called to care for an acute stroke patient

- Could you describe your role when you arrive on scene to a stroke victim? Could you use an example of a recent case (without patient identifiers)?
- In the process you described, what do you feel works well and maybe doesn't work so well? Where do you see room for improvement?
    - Prompts:
        - Do you use any particular screening tool to assess the patient?
        - Are you instructed to by-pass non-stroke care facilities and go straight to the closest stroke care facility?
        - What type of patient information do you collect and pass to the next person in the chain of care? Would that be the Hospital?
        - Do you call to inform of an incoming stroke patient?
        - When does your role end?
- What barriers prevent (or factors that enable) you to get a patient to a stroke care facility as fast as possible?
- What solutions would you recommend?
- If you could redesign your current service/process, what would you change?

Pre-Hospital

- Could you describe what happens when an ambulance pre-notifies an incoming stroke patient. (Code Stroke)
    - Prompts:
        - Is the code stroke activated immediately?
        - Who activates the code stroke?
        - Who is notified? What are their roles in the process?
- In this process, what do you feel are the strengths? Do you feel there are any weaknesses?
- Are there (or were there) any barriers preventing this activation?
- How did you manage (or how would you propose) to deal with these barriers?

Emergency Department Phase

- Could you lead me through a stroke patients' pathway when they arrive in the Emergency department?
- What do you believe are the key steps?
- Based on your hospital, what are the strengths?
- What factors contribute to success?
    - Prompt: Administrative factors, champions strong leadership, team cohesion, funding, knowing your roles, practice/simulation, group meetings/review, outcome measurements?
- What challenges have you faced, when advancing stroke protocols and treatment? How have you been able to get deal with these challenges?

- What challenges are you facing at the moment, not COVID related? How would you deal with these challenges?
- What are the outcome measurements your hospital emphasizes?
    - tPA rates / Door to needle time
    - EVT rates / Door to puncture time
    - Functional dependence?

Endovascular Therapy

- Does your hospital provide EVT?
    - Yes: What are the challenges to implementing EVT? How did you deal with these challenges?
    - NO: What are the barriers preventing EVT in your community? How would you deal with these barriers?
- How important is EVT for stroke care?
- What is you protocol for an eligible patient.
- Who is involved?

Telestroke (for rural hospitals) or an on-call method

- Do you avail of telehealth technologies or process to manage stroke care?
- Do you believe telestroke or a consultation line is beneficial to rural hospitals? Why?
- What do you believe works or doesn't work?
- Do you see barriers is providing this resource for rural hospitals?

Non-Clinical Factors

- Do you believe that your program is providing any non-clinical factors that contribute to success?
    - Is there ongoing continuing education?
    - Is there an ongoing quality improvement process?
    - Are there stroke rounds? If so, who is included? How often?
    - Do you provide leadership development?
    - What is the relationship like between different units within the stroke team and the stroke team with other aspects of the hospital?

Final Discussion

- What are your thoughts on the way we currently manage acute stroke?
- What directions do you see your program taking in the future? Short and longer term?
- If you could improve one thing about your stroke care program, what would that be?
- Are there any unique cultural, geographical factors that influence the delivery of good stroke care in your community?

Appendix IX: Case Study Descriptive Themes and Associated Codes

Public Awareness

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Mainstay of the Heart and stroke campaign			
Heart and stroke FAST	Depends on H&S – FAST	Public awareness is the H&S mandate	Primary education by H&S – FAST
FAST on EMS trucks and throughout emerge	Work closely with H&S and support their campaigns	Work closely with H&S telling patient stories	CSP works closely with H&S
H&S commercials			Good uptake
Additional Campaigns			
Stroke Manager send messaging to their communications team to post	Increase visibility: social media, blogs, podcasts, TV ads	We don't do a year-round campaign. Periodic campaigns	Stroke month
June stroke month – social media	Intergenerational education		Reactive – Help when asked
Tapped out of resources	Learn from COVID		
Quality of Care NL campaign	Learn from other departments (Cardiac)		
High Risk Education			
Lack of education in some regions.	Face to face engagement	Care pathway with stroke consultation services	Treat High-Risk
Admitted with stroke or high risk receive education booklet		TIAs should get proper meds and endarterectomy	Great TIA Clinic
Barriers			
Awareness comes at a cost	FAST only captures anterior strokes	Canada has issues with awareness	Language barriers – new immigrants
Need to reach more patients			Delays is patients don't go to FMC

Emergency Medical Services

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Emergency Medical System			
EMS medical director sits on hyper acute stroke subcommittee	Paramedics are integral to initiating Acute Stroke protocols	5 municipally funded service providers – Maintain close contact	Integral aspect on their stroke team
RHA and Private Ambulance Services	Central training module	Common set of standards	Unified provincial pre-hospital system
All services receive medical direction from the provincial medical director			
Efficiency Processes			
Eastern Health	Nova Scotia	Southeastern Ontario	Calgary
Protocols require interprofessional input	Standardized Protocols	Clarity in roles and responsibilities	Uniform protocols across the province. Clear specific criteria

Centralized dispatch for St. John's, metro, and Carbonear – Pro QA system	Educated dispatchers – effective communication	Appropriate use of a dispatcher	Dispatchers with algorithms
Recognize that stroke is time sensitive - LSN	Leaning management clinical app with the up-to-date guidelines	Paramedic prompt card	Standardized stroke screening form – clinical rules to follow
Follow a paramedic prompt card – Cast a large net when screening	Specific algorithms to identify stroke symptoms and LSN	By-pass protocol to KGH or QHC – Use a GPS to indicate the closest	Training EMS to ask specific questions to gather collateral information
By-pass protocol	Bypass to the closest stroke centre	Pre-notification – earlier the better	Bypass protocol
Pre-notification ASAP	Pre-notify ASAP – Ability to provide the right information	Pre-identification: clear through ethics at QHC	Pre-notification with ETA
Pre-identification – Call on a secure line	Pre-identification – supplied in life and limb threatening emergencies	Paramedic blood glucose	Pre-registration. Electronic records, or register as Unknowns
	Vascular access – two 18 guage - direct to CT suite		Electronic response cards on their computer units
Rural region care			
Eastern Health	Nova Scotia	Southeastern Ontario	Calgary
EMRs have a different level of training that effect protocols	FAST VAN	Dealing with ACT FAST patients	RAAPID – A centralized access point to coordinate all movement and care
Get to a CT scanner and potential thrombolysis	Go to closest stroke centre for imaging and thrombolysis	Two centres with thrombolysis	RAAPID can bring in STARS
			Biggest thing is getting imaging
EVT additions			
Eastern Health	Nova Scotia	Southeastern Ontario	Calgary
6h treatment window from LSN	Never bypass a PSC for EVT – need a CT	LAMS – 4 or greater	LAMS stroke scale
LVO screening	Get to an EVT centre within 11h LSN	6h screening window from LSN	LAMS of 4 or 5 = automatic activation
Longer transfer distances	FAST-VAN screening tool		Activate if 6H LSN. Want to transition to 24H
Barriers			
Eastern Health	Nova Scotia	Southeastern Ontario	Calgary
Advocating centralized dispatch for the whole province	Posterior strokes are missed – 5 D's	Issues with IV starts	System Overload – rural regions
Opportunity to strengthen support across the province	Stroke onset for wake-up strokes	Privacy Issues	Degree of training between ambulance designations
Opportunity for a new approach – One centralized provincial ambulance system	Missed stroked due to bias	Differing competencies	No pre-identification through ambulance patch
Emergency Medical Responders		6h screening window from LSN	STARS effected by weather

Acute Stroke Protocol

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Activation			
Standardized process	ED physician contacts locating to activate	Nurse contacts the hospital operator	Streamlined by quality improvement
Patient Care facilitator activates	Nurse if physician is busy	Page to stroke team with ETA	Triage nurse will take the info and activate
Page fanned out to the stroke team	Checklist to activate	QHC = Paged overhead	Page fanned out to the stroke team – ETA and details
	Locating individually calls the stroke team	Second page when closer	Also allows to clear/hold a bed
Interprofessional Protocol			
Patient centered culture and focused on urgency	Importance of working together	Good policy and role relations = less dependent on physician	Streamlined their processes – Achievable DTNT targets
Interprofessional teamwork – working in tandem	Streamline protocols and pathways	Choreograph roles and transitions	Standardized across the province
Communication	Good relationships and communication	Keep protocols organized – clear and evidence based	Nurse practitioner organizes their service
Neurology are the clinical leaders and decision makers	Neurology are the decision makers – drive the standards	KGH is one of the most efficient sites in ON. < 30-min DTNT	Interprofessional stroke team led by stroke physicians
Emerge physicians are there if needed before CT	Emerge physicians pre-screen	QHC was first PSC with medium DTNT < 30 minute	Team culture understands the need for urgency
Efficiency Processes			
Efficient pathway	Every minute matters	Role clarity	Fast registration
Team is waiting for the patient – senior neurology resident	Checklists to gather information – meet upon arrival	First 4 minutes are choreographed	Joint car model = Dual assessment – quick assessment
Clear CT table	Parallel processes upon arrival - limit ED time	Remain on the paramedic stretcher	Remain on paramedic stretcher
Identify any contraindications before scan	Patients remains on the ambulance bed	Get to the scanner as quickly as possible – 30 seconds	Straight for imagine – do not wait for radiology
Straight to CT suite	Direct to CT – CT tech has clear a table	Emerge stretcher with scale (for dose) waiting	Stroke physicians read images and make treatment decisions
Always an available radiology resident	Get immediate radiology diagnosis	Nurse has thrombolysis ready	Stroke kit
Stroke Box	Request a 24/7 dedicated stroke nurse	Don't care about lab results – only for patients on warfarin	Give thrombolysis as soon as the scan is done
Thrombolysis in the CT suite	Stroke box	Deliver thrombolysis in the CT suite	Thrombolysis right outside CT suite
	Do not delay thrombolysis,		24/7 stroke nurse stroke nurse coverage
Primary Stroke Centres			
Different decision makers	Decision makers - various experience	QHC has great processes and outcomes.	Train their peripheral physicians for better screening

Radiology for PSCs	Use Telehealth	Standard operating procedures.	Send images to Calgary/on call stroke physician
On-call Neurology for consultation	Smaller centres need leadership	Establishing nursing roles	External electronic medical record
Patient accessed before activation		Radiology is immediately involved	Make a plan together with the PSCs
Transferred from EMS to ED bed		Pit Stop Model –	RAAPID system facilitates all consults
Thrombolysis is ready		Telestroke – less use if more experienced	Built a network – no reluctancy
Barriers			
Provincial standardized efficient pathway	Reluctancy to provide thrombolysis	Paramedics are better at screening than inpatient staff	Telestroke was not popular – trouble with video
Blood work	Walk in Strokes	Walk in strokes	Not functionally set up
Arriving outside the treatment window	Inpatient strokes	Inpatient strokes – plan a protocol	Vomiting or airway concerns
Walk in Strokes		Issues with IV starts	Collateral history
Inpatient strokes			Timelines remain tight for thrombolysis

Endovascular Therapy

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Additional Roles			
IR – Leaders – engaged in EVT	IR are the king or queen of EVT – create a standard approach	IR does image interpretation and the procedure.	IR - Decision makers and technicians.
Anesthesiologists -	Requires additional communication	IR tell Neurology to have low thresholds	Use Procedural sedation.
	Anesthesiologists – Chechlists and anesthesia asistants	Use Procedural sedation to a specific Ramsey score	Call anesthesiologist if needed
	Standardize provincial imaging process	Call anesthesiologist if needed	Additional imaging
		Additional imaging protocol	
Initial Roll-Out			
Eastern Health	Nova Scotia	Southeastern Ontario	Calgary
A lot of pre-EVT work	Involved in the Escape trial (2015)	10 case launch	Leaders of the Escape Trail (2015)
Began June 2022, 10 case trial	Use experts to plan	EVT Workgroup	
Going slower than expected	Include all stakeholders	Include all stakeholders	
Debriefed all cases		Faced a lot of criticism	
Included all programs		Now a top CSC	
Expansion			
Eastern Health	Nova Scotia	Southeastern Ontario	Calgary
	Relationships are critical	Treatment window = 24h from LSN	Treatment window = 6h LSN – varies
March 13th, 2023, Patient population extended to EH	Clarity on roles – back and forth trailing	Each group knows their roles	Trialing 24 h treatment window at FMC

Need additional IR?	Provincial transferring process	We have documented all	RAAPID communication/ transfer pathway
Need transfer and communication protocols	Treatment window = 12h LSN	CT Perfusion imaging with RAPID software	Mothership or Drip and Ship
Drip and Ship	Drip and Ship	ACT FAST protocol	STARS
Treatment window = remaining at 6h LSN		Telestroke for PSC decision making	Can lyse with a helicopter
		Drip and Ship	
Barriers			
Eastern Health	Nova Scotia	Southeastern Ontario	Calgary
Resources	Anesthesioly	Paramedic screening ends at 6h LSN	Extending treatment window
Provincial plan	Treatment window	Drip and Ship escort	Resources
Geography	Drip and Ship escort	resources	
Air ambulances	Resources		

Patient Monitoring

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Patient Monitoring			
Admitted to critical care for 24 h	Admit onto a stroke unit	Direct to the critical car unit	Direct to a stroke unit
Then admitted to the stroke unit - HSC	Repatriation agreement to original hospital	Repatriation agreement – back to local stroke unit	Hold a bed open on their unit
No repatriation agreement	Every major centre has a stroke unit	Provincial agreement	Monitor for 24h minimum
	Neurology contacts bed manager to admit the patient into a stroke unit	SEO had a lot of work to get three units throughout their region	Stroke Unit Equivalent Care (SUEC)
	Develop relationships with other sites	FAST TRACK for rehab	Stroke follow-up clinic – month and 90 days after
			Paired with TIA clinic
			Machine telehealth
Barriers			
Rural stoke units	Waiting for repatriation	Long rehab delays	Go to Emerge if no bed
Resources			Repatriation varies on system burden

Enablers

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Leaders			
Vice President with stroke in their primary portfolio	Strong leadership is critical – Especially smaller centres	Regional stroke team – collaborative approach	Acute stroke expert working group
Program manager	Stroke coordinator for system change	Clinical care leadership	Clinical leadership
Local champions on the frontline	Stroke champions	Continuous recognition	Stroke champions
Lead charge nurses	Nursing leadership	Senior leadership	Stroke coordinators
Reinforcement	Provide positive feedback		
Teamwork and Culture			
Teamwork	Team building	Interprofessional EVT Workgroup	Teamwork

Include all Stakeholders	Quality relationships	Well-coordinated team	Experience
QI culture	Inclusion	Culture understands Time is Brain	Include all Stakeholders
	Challenge the system	Race Car model	
		Communication and coordination	Motivated by continuous improvement
		Stroke expertise	
Review			
Debriefing	Stroke rounds	Interprofessional debriefs	Review
	Include all stakeholders	Problem solving collaborative approach	Stroke process improvement committee
	A lot of preparation	Well-designed implementation plan	
Education			
Protocols printed and posted	Extensive EMS training	Protocols and structures in place	Mapped out processes
Simulations	Teachable moments	Mapping protocols	Clinical trials
Neurology	Outreach	MOCK simulations	Collaboration
EVT Education	Local and external experts	Lean Kaizen Process	Continuous Medical Education
Want a provincial lens	Virtual learning sessions	Education workplan	Stroke trial nurses
	Practice/Simulations – establish first 5mins	Education roll-outs for process change	
	Clinical trials	Continuous process	

Barriers

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Resource Management			
Staff – Nursing and EMS	Demand on resources, funding, and staff	Staffing issues – Latent effect of COVID	Nursing staff
Best-efforts clause	Competing priorities	Finding education speakers	EMS staff
EVT – additional staff	Increased strain with EVT	Funding with last year's volume	Complaints about imaging overuse
Interventional Neuroradiologists	Administration only sees dollars associated	Growth in volumes and patient selection	ED blockages
Single Angiography Suite	Stroke Nurse	IR suite capacity	Saturation of Stroke Unit
Increased patient population	LifeFlight	Turnover	Increases in patient volume
Disparity Between Rural and Urban Stroke Care			
Geography	Geography	Smaller rural communities	Geography
Emergency Medical Services	Reluctance with thrombolytics	Emergency Medical Services	Emergency Medical Services
Resources	Transport time	Stroke Units	STARS
Stroke Units	Fewer resources	Physician resistance	
Activation	Training	Telestroke	
Hopes to add a more comprehensive stroke strategy	Stroke Units	Ground vs Air	
	Telestroke		

Process Barriers			
Laboratory testing	Lost Strategic command support	Engagement and teamwork	In hospital strokes
Differences in decision makers and staff	Teamwork/ communication issues	Communication and coordination	Nausea, vomiting, and airway control
Walk in and inpatient	Process disruptions	Flow and transition	EVT treatment window
Night shifts	Pre-identification	Ongoing trainng	
	Experience	Implementing EVT	
Data Collection and Analytics			
Resources - understaffed		Tedious work	Clear definition
Time consuming - manual		Long wait periods for reports	Appropriate denominators

Qualitive Improvement Initiatives

Eastern Health Newfoundland	***Central Zone Nova Scotia***	***Southeastern Ontario***	***Calgary Zone Alberta***
Quality Improvement			
Provincial Stroke Scorecard	HI has their own stroke registry to inform outcomes	Continuous QI approach	QuICR -> Tableau Dashboard
Wanting automated processes	Review monthly – Quarterly for PSCs	Robust report card system	Collection of quality data
HSC evaluate their code stroke data	Publish outcomes with benchmarks	Multiple reports	Reliably reporting
Clarenville audited their efficiency processes	Data feedback and reward systems	Strong QI initiatives – Never stop evolving	Sharing information
Practice Points	Electronic capture		Feedback mechanisms
Accountability?	Essential efficiency outcomes - DTNT		Data reflects the stroke system
	90-day home time		

Appendix X: Roles and Responsibilities to Activate the Acute Stroke Protocol

Health Care Provider	Responsibilities
Paramedic	- Pre-hospital pre-notification: Communicate with Regional Stroke Center ED. Upon scene departure, advise KGH that Stroke Protocol is en route and estimated time of arrival. - Additional updates to ED while en route to include establishment of IVs or if patient becomes unstable
ED Charge Nurse	- Call or delegate a KGH staff member to call Switchboard to alert Stroke Team: Stroke Protocol – XX minutes out
Switchboard	- Initiate Stroke Protocol call - Call KHSC-KGH staff listed in Table 5.53 - Ensure that all members on the Stroke Team are aware that patient is on the way to the ED, and estimated time of arrival

(Southeastern Ontario Stroke Network, 2022)

Appendix XI: Acute Stroke Protocol Team Day Hours Versus After Hours, Weekends, and Holidays

Day Hours	After Hours, Weekends, and Holidays
Staff Neurologist on Call and Neurology Fellow	Staff Neurologist on Call
Neuroradiologist	Neurology Fellow (if on Call)
PGY2 – Year 2 resident (or PGY1 if PGY 2 is post call	Radiology resident on call
ED Charge Nurse	ED Charge Nurse
ED Registration Clerk	ED Registration Clerk
Operation Manager	Operation Manager
Stroke Specialist Case Manager (page)	CT Technologist (on call)
CT Technologist	Admitting
Admitting	Core Lab
Core Lab	Stroke Specialist Case Manager (leave message)
Regional Director, Stroke Network of Southeastern Ontario (leave message)	Regional Director, Stroke Network of Southeastern Ontario (leave message)

(Southeastern Ontario Stroke Network, 2022)

Appendix XII: Southeast Ontario Paramedic Prompt Card for Acute Stroke Bypass Protocol

This prompt card provides a quick reference of the *Acute Stroke Protocol* contained in the *Basic Life Support Patient Care Standards* (BLS PCS). Please refer to the BLS PCS for the full protocol.

Indications under the Acute Stroke Protocol

Redirect or transport to the closest or most appropriate Designated Stroke Centre* will be considered for patients who meet **ALL** of the following:

1. Present with a new onset of at least one of the following symptoms suggestive of the onset of an acute stroke:
    a. Unilateral arm/leg weakness or drift.
    b. Slurred speech or inappropriate words or mute.
    c. Unilateral facial droop.
2. Can be transported to arrive at a Designated Stroke Centre within 6 hours of a clearly determined time of symptom onset or the time the patient was last seen in a usual state of health.
3. Perform a secondary screen for a Large Vessel Occlusion (LVO) stroke using the Los Angeles Motor Scale (LAMS) and inform the CACC/ACS to aid in the determination of the most appropriate destination.

*A Designated Stroke Center is a Regional Stroke Centre, District Stroke Centre or a Telestroke Centre regardless of EVT capability.

Contraindications under the Acute Stroke Protocol

ANY of the following exclude a patient from being transported under the Acute Stroke Protocol:

1. CTAS Level 1 and/or uncorrected airway, breathing or circulatory problem.
2. Symptoms of the stroke resolved prior to paramedic arrival or assessment**.
3. Blood sugar <3 mmol/L***.
4. Seizure at onset of symptoms or observed by paramedics.
5. Glasgow Coma Scale <10.
6. Terminally ill or palliative care patient.
7. Duration of out of hospital transport will exceed two hours.

**Patients whose symptoms improve significantly or resolve during transport will continue to be transported to a Designated Stroke Centre.

*** If symptoms persist after correction of blood glucose level, the patient is not contraindicated.

CACC/ACS will authorize the transport once notified of the patient's need for redirect or transport under the Acute Stroke Protocol.

Appendix XIII: Alberta Health Services Emergency Medical Service Stroke Screen

EMS must obtain critical patient information and complete this form on scene

<table>
<tr><td colspan="2">Patient last seen neurologically normal</td><td>Patient Name:</td><td>Event Number:</td></tr>
<tr><td>Date
(yyyy-Mon-dd)</td><td>Time
(hh:mm)</td><td>Patient last seen by (witness name)</td><td>Witness phone</td></tr>
<tr><td colspan="2">History provided by
o Patient
o Family Member
o Other (specify) _________________</td><td>History Provider name</td><td>History provider phone</td></tr>
</table>

Complete **Physical Examination Findings** and **LAMS scoring,** then continue with **screening process**

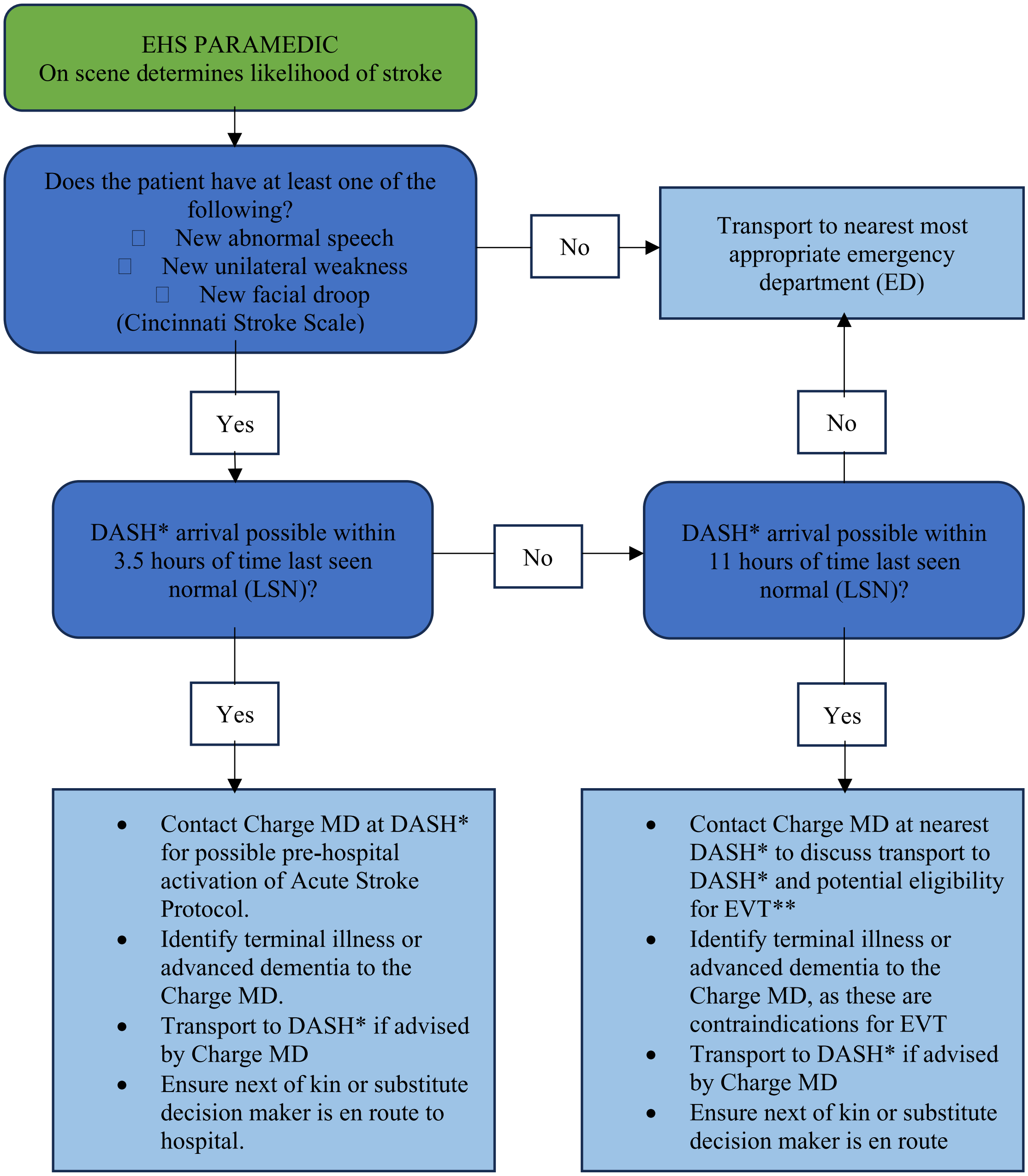
<table>
<tr><td colspan="2">Physical Examination Findings
Level of consciousness
o Alert
o Responds to verbal
o Responds to pain only
o Unresponsive

Speech
o Normal
o Slurred
o Incomprehensible or mute</td><td>Is blood glucose level greater than 3.0 mmol/L?
o No → Treat as per Adult Stroke MCP, then
________ continue screening process
o Yes → Continue screening process</td></tr>
<tr><td colspan="2">Leg Strength
o Normal
o Right-Drifts down
o Left-Drifts down
o Right-Falls rapidly
o Left-Falls rapidly</td><td>Is one or more red Physical Examination Findings checked?
o No → Transport to the closest medical facility

o Yes → Continue with screening process</td></tr>
<tr><td>Facial Smile
Smile, show teeth, raise eyebrows, and squeeze eyes shut
o Normal (0)
o Right-Droop (1)
o Left-Droop (1)</td><td>LAMS</td><td>Patient last seen normal less than 6 hours ago or awoke with stroke symptoms
o No → STOP screening process; Treat and
________ transport as per local stroke strategy
________ guidelines.
o Yes → EMS Stroke Screen is positive; Continue
________ with screening process</td></tr>
<tr><td>Arm Strength
Elevate with palm down and hold for 10 second count (45 degrees if laying down, 90 degrees id sitting)
o Normal (0)
o Right-Drifts down (1)
o Left-Drifts down (1)
o Right-Falls rapidly (2)
o Left-Falls rapidly (2)</td><td></td><td>Is the LAMS score 4 or greater?
o No → STOP provide early pre-notification and
________rapid transport to the most appropriate
________Primary or Comprehensive stroke Centre
o Yes → STOP Call OLMC number and state:
_______ “I have a STAT Stroke patient with a
_______ LAMS Score of 4 or 5”</td></tr>
<tr><td>Grip Strength
Have patient try to grasp examiners fingers
Normal (0)
Right-Weak grip (1)
Left-Weak grip (1)
Right-No grip (2)
Left-No grip (2)</td><td></td><td>Los Angeles Motor Scale (LAMS) Scoring
1. Score the affected side using the values provided
2. Score Facial Smile, Arm Strength, and Grip Strength
3. Calculate Score (0-5)</td></tr>
<tr><td>Total LAMS Score</td><td></td><td>A Score of 4 or greater is predictive of LVO</td></tr>
</table>

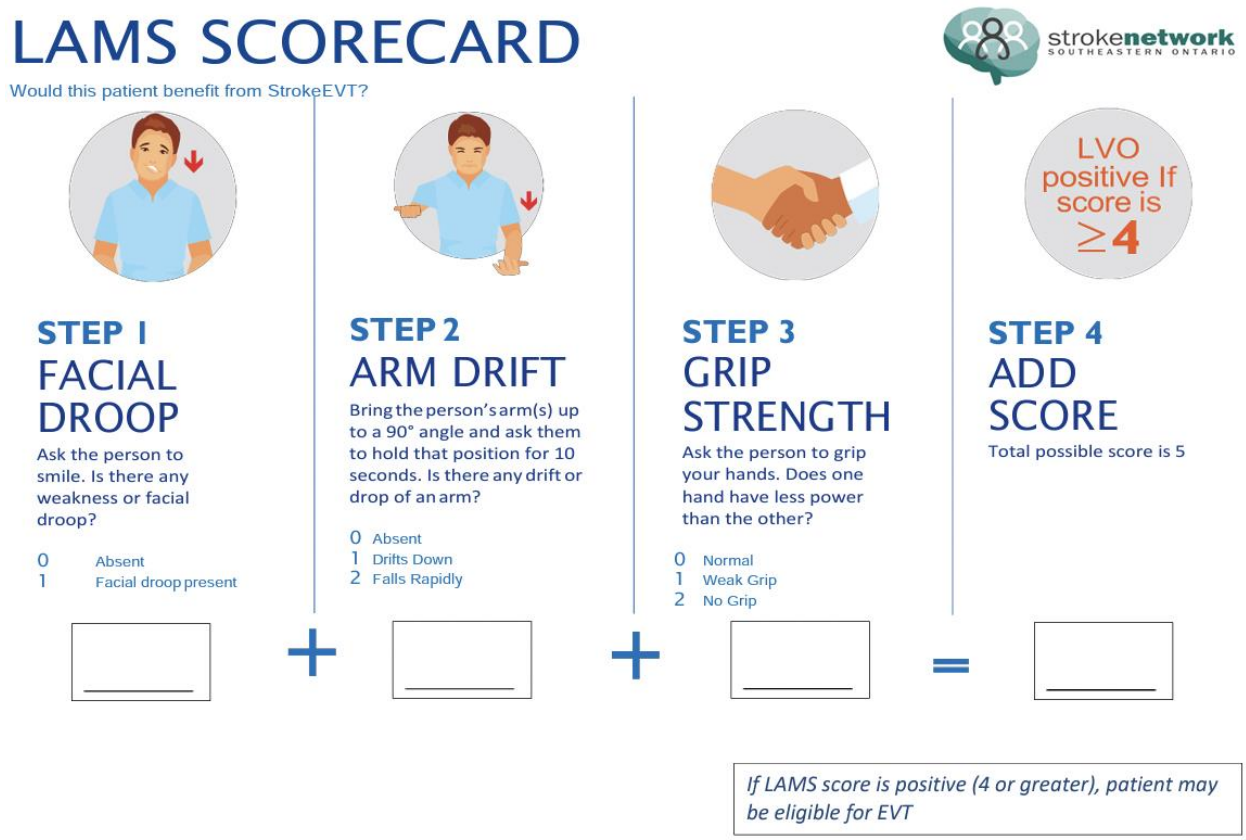
Practitioner Name (print)	Practitioner Signature	Date (yyyy-Mon-dd)

Appendix XIV: Ground Ambulance NS Acute Stroke Protocol



* Designated Acute Stroke Hospital (In Central Zone this is Halifax Infirmary)
**The nearest DASH centre SHOULD NOT be bypassed for direct transport to the Halifax Infirmary. Potential EVT candidates are always transported to the NEAREST DASH first.

Appendix XXII: Los Angeles Motor Scale



Key Messages for the LAMS assessment and EVT

There is NO change across SEO in terms of stroke bypass/re-direct. The process is the usual ASP process for paramedics. Patients who fit prompt card criteria will go to the closest stroke centre if six hours from LSN. Outside of six hours, they go to the local hospital Emergency Department (ED) who will assess and decide on transfer to KGH for EVT. EDs are using ACT FAST as their LVO screen/triage tool and can transfer directly to KGH on stroke protocol if ACT FAST positive in 6-24 hours form LSN.
Paramedics provide Central Ambulance Communications Centre (CACC) with actual LAMS score
Paramedics let local hospital ED know that they have a patient that is LVO positive when patching in about ASP. This gives ED a "heads up" to help the ED make faster decisions about ASP, including transfers

Appendix XVI: Health Science Centre Standard Operation Procedure for Code Stroke Activation and Administration of rt-PA Protocol, and/or Endovascular Thrombectomy

Function	Component	Responsible Person
Communication re: activation of Code Stroke	• **Pre-hospital pre-notification:**	Paramedic
	• Charge RN or Unit 1 RN will activate Code Stroke. Call xxxx – Alert Code • Make bed space for patient in Unit 1 • Stroke and time and fill out Code Stroke Sheet	ER Charge Nurse RN Unit 1
	• Initiate Code Stroke Protocol • Ensure that all members on the Stroke Team are aware that patient is on the way to the ED, and estimated time of arrival	Switchboard
Patient Registration	• Register patient when en route via Ambulance • Paramedicine will call ER Registration Clerk	Paramedicine ER Registration
Initial ED Evaluation Bloodwork/IV/LAB	• Go directly to CT via EMS stretcher • Take Code Stroke Kit and ensure all contents are in kit.Print and order blood labels prior to patient arrival • ED Registration Clerk to register patient • CT will notify ER when ready Upon patient arrival at UNIT 1 • Paramedic reports last seen normal, symptoms, medical conditions and medications if available, vital signs and glucometer readings, allergies, Cincinnati Screen and LVO Screen - Assessment by Neurology - CT requisition to be completed • Paramedics to leave patient on EMS Cardiac Monitor until can be connected to ER transport monitor • Finish triage either before or after CT • **Nurse to insert IVs and draw bloodwork** • Porter to bring bloodwork to lab immediately.	Paramedic Unit 1 RN ER Unit Clerk Paramedic Physician who assesses *Goal – during pilot phase Neurologist/Resident to meet patient in ER ER Nurse
CT Readiness	• Ensure the patient is "next on scan", and the CT scan is ready within 10 minutes of arrival to ED	CT Technologist
Medical assessment and clinical decision making	• Candidacy for rt-PA administration and/or EVT • Completion check lists • Completion of NIH Stroke Scale • If Code Stroke is cancelled notify appropriate personnel	Attending Neurologist/Resident
Patient Transport to CT Suite	• Follow patient to CT suite with ED stretcher, monitor, pump, Code Stroke kit • Ensure jewelry, dentures, and hearing aids are removed. • Remove all clothes, and dawn gown • GOAL -> neurologist/resident to go with patient to CT	ER Nurse
Consent processes	• Patient and family education is ongoing to prepare for consent	Attending Neurologist/Resident
Consent for CT +/- CTA	• Review the risks and benefits and answer any questions • Sign a consent and scanned into PACS • Patient's armband and identification checked as per policy • eGFR implied consent	CT Technologist
CT Results/Medical Management/Decision Making	• Neurologist views CT scan plus RAPID AI report +/- multiphase CTA with Radiologist • Inclusion/ Exclusion Criteria for rt-PA is used	Attending Neurologist Resident/Radiologist

	• Inclusion/Exclusion Criteria for EVT is used • ICU to be notified ASAP for beds- • Clinical Efficiency to be notified ASAP- patient is a priority – one directional flow- standard of care	IR Nursing and Neurology
Administration of IV rt-PA in CT Suite ***New Process***	• After CT If patient candidate for TPA they will receive the bolus while in scanner while preparing for CTA • **Ensure Consent process has been complete (see below)** • Write and follow order for IV rt-PA • Begin infusion with assistance of ED Nurse • Patient then to have CTA to determine EVT candidacy	****The order in which CTA and rt-PA depends on readiness****
Obtain consent for: IV rt-PA EVT	***NOTE: this process begins PRIOR to CT to prepare for timely decision post CT.*** • Patient or substitute decision-maker is provided appropriate and specific information regarding risks and benefits of the planned procedure, and sufficient time is given to patient/family to give informed consent • For IV rt-PA administration verbal consent is obtained from patient or substitute decision • Informed consent if patient/family unable to provide same • For EVT consent is obtained and documented	Attending Neurologist/Resident Interventional Radiologist (IR)
IV rt-PA or EVT +/- IV rt-PA if unable to consent	• Verbal consent over the telephone may be obtained from substitute decision-maker • Substitute decision-maker cannot be contacted, Neurologist and IR (if EVT) is responsible for making decision to treat patient based on clinical judgment • Rationale for treatment decision and reasons why consent could not be obtained must be documented	Attending Neurologist/Resident and Interventional Radiologist
	If IV rt-PA is administered without EVT	
Communication re rt-PA & Bed Planning	<u>**If the patient is a candidate for IV rt-PA:**</u> • Notify Intensivist and ICU Charge Nurse • If after hours notify Site Manager	Neurologist/ Resident Charge ER Nurse
Administration of IV rt-PA	**** Patient may have received rt-PA bolus and infusion started in CT suite**** • Transport patient back to ER and transfer to ER stretcher • If patient did not receive rt-PA bolus infusion in CT, now ED RN to prepare for IV rt-PA • Write order for IV rt-PA in chart • Start rt-PA infusion <u>***If not done in CT***</u>	ER Nurse Neurologist/Resident
Patient assessment and monitoring during and following rt-PA infusion	• Follow Doctor's Order Sheet • Neurological signs every 15 minutes during infusion • **Post Infusion**: Neurologic Signs every 30 minutes for first 6 hours then every hour until 24 hours • Follow Doctor's Order Sheet Alteplase (rt-PA) therapy	ER NURSE ER Nurse/ICU (pending patients' location)
Patient Transferred for ICU	• Communicate with ICU Charge Nurse • Transfer to ICU as soon as bed available for 24 hour monitoring – ICU follow Doctor's Order Sheet	ER Nurse
	If Patient a Candidate for EVT with or without rt-PA	
Clinical decision re EVT	• Decision to proceed with EVT after multiphase CTA is interpreted	Attending Neurologist/ Resident and Interventional Radiologist

EVT Candidate during Pilot Hours	**If the patient is a candidate for EVT +/-rt-PA:** o Notify Interventional Radiologist (Neurologist) o Notify MI (IR) Technologist and Charge Nurse o Notify **Out of OR** Anesthesiologist o Notify ICU Intensivist and ICU Charge Nurse o Notify Urinary Tech if Male Patient- do not delay care	Neurologist/Resident IR ED Nurse/Charge RN Neurologist ER Charge RN
IR suite triaging	• Clinical decision & plan regarding most appropriate triage care must be executed in consultation with all Attending Physicians responsible for care of all patients requiring emergent Medical Imagining procedures.	Daily Operations Team for IR Suite with Attending Neurologist and IR
Communication & Bed Location	• Notify family-inform family to wait in ICU Waiting Room • Notify that IVR suite is ready • Notify Charge RN ICU • CE or ICU to notify patient's bed location	ICU Nurse/CE
Prepare patient for EVT Procedure WITHOUT rt-PA	Prepare suite and return patient to ER to be prepped • Complete and follow Doctor's Order Sheet Endovascular Acute Ischemic Stroke Adult • Ensure patient is in hospital gown with no underwear • Prepare patient for procedure including: continuous SpO_2 & cardiac monitoring, end tidal C02 monitoring, EKG, CBC, Lytes, BUN, Creatine, Coags, TS • Insert urinary catheter (contact urinary tech if required) • Transport patient to IR suite when ready • Once in suite Bilateral prep both groins (10cmx10cm square, around femoral arterial pulse) • Pedal pulses marked and TED Stockings	ER Nurse *Partially Neurologist/ IR ER Nurse ER +/- MI Staff
Patient to receive EVT and rt-PA ***Follow above section on EVT Prep Simultaneously***	**If Medical Imaging Suite Available** – Patient to go directly to Suite from CT. • Patient should have received rt-PA bolus in CT suite while in scanner and infusion started* • **ER nurse to give detailed report to MI staff and Anesthesia regarding patient's status, rt-PA, interventions completed, bloodwork results, etc** • Consult ICU and completed admission order set ***FOLLOW ABOVE SECTION ON EVT PREP SIMULTANEOUSLY***	ER Nurse Neurologist/ Resident ER Nurse
Monitor patient during procedure	• Follow standard MI care processes including: o Continuous SpO_2 & Cardiac monitoring, BP monitoring, assess airway, comfort, and level of consciousness, sedation, and agitation • Monitor for angioedema and bleeding. • Keep patient NPO	Anesthesia
Femoral Sheath Removal	• Femoral Sheaths will typically be removed in almost all cases and angio-seals will be used • If sheath must stay in Neuro Interventional will remove sheath when appropriate • If angiography sheath fails (not common) consult Neuro IR	Interventional Radiologist ICU RN
Transfer patient to ICU	• Communicate with ICU Charge Nurse • Handover Report to ICU • Patient to be transferred to ICU for 24 hours monitoring. • Follow Doctor's Order Sheet Alteplase and EVT • ICU to bring transport monitor to IR for patient. • Transfer patient on transport monitor	MI Nurse/Anesthesia

Appendix XVII: Intravenous Thrombolysis in Acute Ischemic Stroke (Adult) Order Set

Name:
HCN:
Date of Birth:

Allergies:
☐ No Known

Date and Time of Stroke Onset:____DD/MONTH/YYYY____HH/MM

Review inclusion and exclusion criteria below. If patient is **Yes** to all inclusion criteria and **No** to all absolute ____ exclusion criteria,Intravenous Thrombolysis (Alteplase **OR** Tenecteplase) may be given.
If patient is yes to relative exclusion criteria OR treating physician is uncertain if to administer thrombolysis, ____ consult neurology.

Inclusion Criteria: Check yes or no for each item.
☐Yes ☐No – Patient is diagnosed with an acute ischemia stroke
☐Yes ☐No – Potentially disabling neurological deficit, usually defined as NIHSS greater than 4
☐Yes ☐No – Age 18 years and older
☐Yes ☐No – Life expectancy of 3 months or more
☐Yes ☐No – Time of last known well less than 4.5 hours before thrombolysis administration

Exclusion Criteria: Check yes or no for each item in each section
Absolute Exclusion Criteria
☐Yes ☐No – Any hemorrhage on brain imaging
☐Yes ☐No – Bleeding diathesis
☐Yes ☐No – Systolic blood pressure greater than or equal to 180 mmHg or diastolic blood pressure greater ____________ than or equal to 105 mmHg and **NOT** responding to antihypertensive treatment
☐Yes ☐No – Pre-treatment Computed Technology (CT) scan of the brain showing either: 1) Hemorrhage ____________ 2) Edema 3) Mass Effect (shift)
Relative Exclusion Criteria (requiring clinical judgement based upon the specific situation)
Historical:
☐Yes ☐No – History of intracranial Hemorrhage
☐Yes ☐No – Stroke or serious head or spinal trauma within the preceding 3 months
☐Yes ☐No – Major surgery within the proceeding 14 days
☐Yes ☐No – Arterial puncture at non-compressible site within the previous 7 days
Clinical:
☐Yes ☐No – Symptoms suggestive of subarachnoid hemorrhage
☐Yes ☐No – Stroke symptoms due to another acute neurological condition such as seizure with post-ictal ____________ Todd's Paralysis or focal neurological signs due to severe hypoglycemia or hyperglycemia
☐Yes ☐No – Patient currently prescribed and taking a direct non-vitamin K oral anticoagulant (DOAC) ____________ (Dabigatran can be an exception as consideration can be made to give ldarucizumab (Praxbind) ____________ before intravenous thrombolysis)
CT or MRI Findings:
☐Yes ☐No – CT showing early signs of extensive infarction (greater than 1/3 of MCA territory, or Alberta ____________ Stroke Program Early CT Score (ASPECTS) score less than 6)
Laboratory:
☐Yes ☐No – blood glucose less than 2.7 mmol/L or greater than 22 mmol/L, point of care testing
☐Yes ☐No – Unfractionated heparin in the preceding 48 hours and elevated PTT
☐Yes ☐No – INR greater than 1.7
☐Yes ☐No – Platelets less than 100 x 10^9/L

Pre-Treatment Management
- CT Head of the brian

☐ CT Angio of Head/Neck where possible
- Obtain weight ________ Kg
- Establish 2 large bore Intravenous (IV) lines
- Complete vital signs Heart Rate, Respiratory Rate, Blood Pressure, SpO2) and neurological signs
- EKG (Do not delay administration of intravenous thrombolysis for this investigation)

Lab Investigations

The decision to wait for blood work results when administrating IV thrombolysis will be based on the treating ___ physician's assessment. Standard of care is to proceed without waiting for bloodwork results unless there are ___ medical reasons abnormalities are expected. Example: patient is taking warfarin

- CBC ● PTT ● INR ● Type and Screen ● Creatine
- Urea. ● Electrolytes. ● Glucose ● Urine Pregnancy test (if female, childbearing age)

Other Investigations:

____

Administration of Intravenous Thrombolysis

- Standard of care is to proceed with Intravenous Thrombolysis without waiting for bloodwork results, unless there are medical reasons abnormalities are expected.

Do not administer both, choose one.

☐ **Alteplase** ☐Yes ☐No

a. Total Dose of Alteplase: _____________ mg [0.9mg/Kg (max 90 mg) by IV infusion over 60 minutes with 10 % total dose administered as bolus at start of infusion]
b. Bolus Dose of Alteplase (10%): ____________ mg over one minute
    i. DATE and TIME OF BOLUS DOSE: _DD/MONTH/YYYY___HH/MM___
c. Infusion Dose of Alteplase (90%): ___________ mg over one hour

OR

☐ **Tenecteplase** ☐Yes ☐No

d. Total Dose of Tenecteplase: __________ mg [0.25 mg/Kg up to maximum of 25 mg, given as single bolus over 10-20 second. Select dose from table below.
    i. DATE and TIME OF DOSE; _DD/MONTH/YYYY___HH/MM___

Patient Weight (Kg)	Tenecteplase Dose (mg)	Volume of Tenecteplase (5mg/mL)
Less than 60	15	3
60 to 69	17.5	3.5
70 to 79	20	4
80 to 89	22.5	4.5
90 and greater	25	5

- If there is neurological deterioration, severe headache, acute hypertension or new nausea and vomiting, notify physician immediately and stop infusion if patient receiving alteplase.
- Monitor neurological signs, vital signs, and for orolingual angioedema every 15 minutes during thrombolysis infusion

Consult Intensive Care Unit (ICU) for 24 hour monitoring post Intravenous Thrombolysis therapy

Post Treatment Thrombolysis

- IV Therapy: ____________________
- Neurological Signs:
    - Every 30 minutes for first 6 hours post treatment administration
    - Every hour until 24 hours post treatment administration
    - Notify physician if neurologic deterioration, new nausea or vomiting
- Vital Sign (Temperature, Heart Rate, Respiratory Rate, Blood Pressure, SpO2 ___):
    - Every 15 minutes for the first 2 hours
    - Every 30 minutes for the next 6 hours
    - Every hour until 24 hours post treatment administration
    - Notify physician if systolic blood pressure is greater than 180 mmHg or if diastolic blood pressure is greater than 105 mmHg
- Oxygen Therapy: Titrate oxygen to keep saturation: SpO2 greater than 92% or SpO2 ________ to _________% if patient requires greater than or equal to 5L/min of oxygen, notify physician
- Monitor for orolingual angioedema every 30 minutes X 2 hours, if present notify physician immediately
- No nasogastric tube or urinary catheter for 24 hours. Unless urinary catheter required for Endovascular Thrombectomy or urinary retention

• No ASA or other antiplatelet or anticoagulant medications for 24 hours post infusion and only after assessment of repeat CT scan of the brain Repeat CT scan of brain 24 hours post thrombolysis (ICU physician/resident to arrange)
Prescriber's Name: _____________ Signature: _____________ Date: DD/MONTH/YYYY Time: HH/MM
Nurse's Name: _______________ Signature: _______________ Date: DD/MONTH/YYYY Time: HH/MM

Appendix XVIII: Roles and Responsibilities at KHSC-KGH from Patient Registration to Thrombolysis

Function	Responsibility	Role
Registration	- Register patient as soon as patient arrives in ED	Registration Clerk
Initial ED evaluation including medical screening by ED physician or Neurologist	- Ambulance Triage in ED - If patient walks into ED, Perform rapid triage - Ask ED Registration Clerk to register patient if not already done - Notify CT of patient's arrival in ED: ED Physician or Neurologist ensures that KGH staff member has notified CT of patient's arrival - Upon patient arrival at central desk near section A: Paramedic reports LSN, symptoms, medical conditions, and medications if available, vital signs and glucometer readings; - Immediate medical screen to ascertain a potential stroke patient	Triage Nurse ED Charge Nurse ED Unit Clerk Paramedic Neurologist or ED Physician
Stroke Call cancellation if needed	- If stroke activation is to be cancelled, notify, or delegate a KGH staff member to call Switchboard who repeats calls to those listed in Appendix XXIII and notes "Stroke Protocol cancelled"	ED Charge Nurse Switchboard
CT Readiness	- Ensure that patient is "next on scan", and that CT scan is ready for stroke patient within 10 minutes of arrival to ED	CT Technologist
Repatriation planning	- If attending physician suspects that patient may not be an IV thrombolysis or EVT candidate, and will qualify for repatriation back to a bypassed community hospital ED. Dispatch will be immediately contacted to request that the EMS crew be held up to regulated timeframe.	Attending Neurologist or ED Physician
Medical assessment and clinical decision making	- Initial assessment re: candidacy for IV thrombolysis with TNK or rt-PA administration and/or EVT - Completion of NIH Stroke Scale (including in the Stroke Assessment form found in the Stroke Protocol package	Neurologist Neurology House staff supervised by Neurology
Preparation of patient before CT scan	- Print blood labels - 2peripheral IVs – (1 IV with 18 Gauge needle in Rt. ACF is preferred – if unable, use 20 Gauge, must be above hand) - Bloodwork sent to lab using Acute Stroke Protocol package yellow labeled blood tubes. Attending Physician directs Nurse to draw bloodwork before or after CT. Waiting for bloodwork results in not mandatory to make decision for IV thrombolysis +/- EVT	ED Nurse
POC INR	- When possible, obtain INR using Point-of-Care (POC) device. Quality assurance check to be done at 24 hours	Attending Neurologist
Lab Blood Work	- Lab processes bloodwork STAT and informs ED of results ASAP	Lab
Patient Transport to CT Suite	- Patient to remain in EMS stretcher until CT - Follow patient to CT suite with ED stretcher, monitor, pump, transport kit, and TNK or rt-PA from Omnicell - Transport patient to CT suite - Prior to CT scan, switch paramedic monitor to ED monitor in CT suite. Check leads are moved away from center chest area - Ensure jewelry, dentures, and hearing aids are removed	ED Nurese Stroke Team ED Nurse

	- Care for patient in CT suite -Before Paramedics leaves KGH, report is given to ED Nurse	Paramedic
Consent Processes	- Patient and family education is ongoing to prepare for consent	Neurology
Consent for CT+/- CTA	- Verbal consent is obtained for IV contrast if CTA is to be used and is documented in chart. If verbal consent cannot be obtained, emergency consent procedures are followed and documented	CT Technologist
Medical Management & Decision Making	- Neurologist views CT scan +/- multiphase CTA with Neuroradiology - Inclusion/Exclusion Criteria for TNK/rt-PA is used - Neurologist will use ESCAPE trial criteria and KGH Stroke EVT Checklist to determine candidacy for EVT - If patient is candidate for administration of IV thrombolysis and/or EVT, then patient will be transferred to Neurology Service - Medical management and clinical decision-making surrounding initial and any additional radiological imaging performed (i.e., CT Perfusion, MRI, MRA, Angiography). Interpretation of imaging. Decisions regarding indications for pursuing additional diagnostic imaging. This is done keeping "time is brain" in mind - Accountability regarding clinical interpretations of diagnostic imaging and decision regarding treatment choice re: administration of IV TNK or rt-PA, and/or EVT	Neurologist and Interventional Radiologist (EVT)
Communication re IV thrombolysis & Bed Planning	<u>If patient is a candidate for IV thrombolysis with Tenecteplase (TNK) or Alteplase (rt-PA):</u> • Notify D4ICU Charge Nurse	Attending Neurologist ED Charge Nurse
Obtain consent for IV thrombolysis	NOTE: begins PRIOR to CT to prepare for timely decision post CT • Patient or substitute decision-maker is provided appropriate and specific information regarding risks and benefits of the planned procedure, and sufficient time is given to patient/family to give informed consent • For IV TNK or rt-PA administration, verbal consent is obtained from patient or substitute decision-maker	Attending Neurologist
Administration of IV thrombolysis in CT Suite	- Direct ED RN to prepare for IV TNK or rt-PA - Write order for IV thrombolysis in chart/Entry Point - MD or ED/Critical Care RN administer IV TNK; or MD administers bolus dose of rt-PA while RN prepares infusion pump and begins rt-PA infusion (TNK does not require infusion)	Neurologist Neurologist House staff supervised by Neurologist
Patient Assessment & monitoring during and following TNK bolus or rt-PA infusion	- Follow Acute Ischemic Stroke CCP re IV thrombolysis +/- EVT - IV rt-PA infusion start in CT Suite (only for rt-PA NOT TNK) - Transport patient back to ED after CT scan - CNS scale & VS q 15 min for 2 hours then q 1 hour for 22 hours, follow CCP - Assess patient's airway, comfort, and level of consciousness, sedation, and agitation - Continuous SpO2 & cardiac monitoring - Monitor for angioedema & bleeding - Keep patient NPO - Change patient into hospital gown - ECG post initiation of IV thrombolysis	ED Nurse
Patient transfer to D4ICU	- Acute Ischemic Stroke Thrombolysis/EVT QBP Order Set is completed in Entry Point - Communicate with D4IU Charge Nurse re: bed planning; stroke patients' readiness for transfer - Monitor in accordance with Acute Ischemic Stroke CCP while awaiting transfer to Unit	Attending Neurologist ED Charge Nurse

(Southeastern Ontario Stroke Network, 2022)

Appendix XIX: KGH Stroke/TIS Consult History and Physical Assessment

Demographics

Location: ☐ Emergency Department ☐ Inpatient Unit | **Type:** ☐ Code Stroke ☐ Consult

Age: **Sex:** ☐ Male ☐ Female | **Arrival:** ☐ EMS ☐ Walk-in ☐ Inpatient ☐Transfer from other hospital

Baseline modified Rankin Score: please circle below

0 – No symptoms. 1 – No significant disability.
2 – Slight disability. 3 – Moderate disability.
4 – Moderate severe disability 5 – Severe disability

Living situation:
☐ Home. ☐ Retirement Home
☐ Nursing Home. ☐Rehab
☐ Other

Past Medical History

☐ Diabetes ☐ Hypertension ☐ Dyslipidemia
☐ Migraine ☐ Epilepsy ☐ Dementia
☐ TIA ____________________________(yyyy/mm/dd)
☐ Ischemic stroke
___________________(yyyy/mm/dd)
☐ Hemorrhagic stroke _______________
(yyyy/mm/dd)
☐ Arterial fibrillation/Arterial flutter
☐ Coronary artery disease ☐ CABG ☐ Cardiac stent
☐ Mechanical valve ☐Congestive heart failure
☐ Pacemaker/Defibrillator/Loop

☐ Sleep Apnea
☐CRAP ☐COPD
☐ Dialysis
☐ Renal disease
☐ Peripheral arterial disease
☐Depression ☐ Anxiety
Other: _______________
____

☐ Antiplatelets:_______
____
☐ Anticoagulant:______
____
☐ Other: ____________
____

Smoking: ☐ Nonsmoker ☐ Ex-Smoker, quit _______ ☐ Current smoker: **PK/yr**:____
Alcohol: ☐ Low risk (Male < 3/d or 15/wk ; Female < 2/d or <10/wk) ☐ Moderate to high risk
Substance use: ☐ Marijuana ☐ Others:

Adverse Reactions/ Allergies:_________
____

History & Physical Examination

Symptom onset/Last known well: (yyyy/mm/dd) (hhmm): | **NIHSS Score:**

HR (bpm): **BP** (mmHG): **Gluscose** (mmol/L):
RR (rpm): **SpO2:** **Temp** (ºC):

Neurological examination:

Systemic Examination:

Imaging/Lab:

☐ CT Head
– ASPECTS score: ____/10

☐ CTP
☐ Normal ☐ Abnormal
Core: _______ Penumbra: _______

☐ MRI:

☐ CTA
☐No occlusion seen ☐ LVO
☐ ICA ☐ M1 ☐M2 ☐ACA
☐Vertebral ☐ Basilar ☐ PCA
☐ Carotid Stenosis:☐ <50% ☐Right ☐Left
☐ >50% ☐Right ☐Left
☐ High risk plaque: ☐ Right ☐Left
☐ Arch disease
☐ Intrecranial Atherosclerosis

Creat:	Hb:
eGFR:	WBC:
Na:	Platelets:
K:	PT:
	INR:

ECG:

Resident Impression:

Print Name:	Designation	Signature:	Date: yyyy/mm/dd	Time: hh/mm

Staff Impression:

☐ Ischemic Stroke ☐ Transient Ischemic Attack ☐ Hemorrhagic Stroke Location: ☐ Lobar
☐ Deep Etiology: ☐ HTM ☐ CAA ☐ Anti-coagulation ☐ Other
☐ Stroke Mimic: ☐ Miraine ☐ Seizuare ☐ Hypoglycemia ☐ Peripheral vertigo ☐ Others:

Plan:
☐ Thrombolysis Bolus given at (hhmm) _______________ by _____________________________________
☐ Endovascular Thrombectomy (Staff to complete EVT worksheet)
☐ Medical Treatement:

Note:

Disposition: ☐ Admit ☐ Discharge ☐ Repatriate ☐ Consult other Service ☐ Will follow (inpatient consult)
Investigation: ☐ Echo ☐ Holter ☐ MRI ☐ Other:

Print Name:	Designation	Signature:	Date: yyyy/mm/dd	Time: hh/mm

Appendix XX: SEO Inclusion and Exclusion Criteria for TNK or rt-PA

Inclusion Criteria	Exclusion Criteria
1. Patient suspected of having ischemic stroke 2. Deficit should be of a severity that would lead to significant compromise in patient's quality of life 3. Deficit should be relatively stable during period of observation 4. Clear and credible time of stroke onset can be established, and patient can receive IV thrombolysis within 4.5 hours. Time of onset is time patient was last seen well 5. Pregnancy in **NOT** a contraindication 6. Age <18 years is **NOT** a contraindication. **If a child presents with stroke symptoms, Neurology-Stroke Service + Paediatric Intensive Care Service to jointly decide on next steps (e.g., consider contacting The Hospital for Sick Children in Toronto)**	1. Major surgery during previous 2 weeks 2. Major cerebral infarct or head/spinal injury in past 3 months 3. A known source of recent bleeding 4. Puncture of non-compressible artery or biopsy site within 7 days, including lumbar puncture 5. Blood pressure remains at systolic > 185 and/or diastolic > 110 despite treatment 6. Serious co-morbidity (e.g., advanced cancer, renal failure, hepatic failure) that would increase bleeding risk or limit effectiveness of treatment 7. Coma during current event 8. INR > 1.7; Increased PTT Platelet Count < 100,000; or Direct Oral Anticoagulants taken within 24 hours Caution if Warfarin taken within 48 hours 9. Blood glucose < 2.7 or > 22.2 mmol/L 10. Rapidly resolving neurologic signs

Appendix XXI: FMC Thrombolysis (Tenecteplase and Alteplase) Inclusion and Exclusion Protocol

Physician to Complete

Inclusion Criteria (Inclusion requires both criteria to be present)

o Diagnosis of ischemic stroke causing disabling neurologic deficit in a patient who is 18 years of age or older

- For adolescents, decision to administer Tenecteplase should be based on clinical judgement, present symptoms, and patient age; and, if possible, consultation with a pediatric stroke specialist.

o Time from last know well (onset of stroke symptoms) less than 4.5 hours before administration

Absolute Exclusion Criteria (Any criteria present qualifies as exclusion to Tenecteplase protocol)

o Any active hemorrhage or any condition that could increase the risk of major hemorrhage after _______ __ thrombolysis administration.

o Any hemorrhage on brain imaging

Relative Exclusion Criteria (Requiring clinical judgement based upon specific situation. Consult Stroke Specialist at Comprehensive Stroke Centre for the presence of any of the relative exclusion criteria listed)

Historical

o History of intracranial hemorrhage.

o Stroke or serious head or spinal trauma in the preceding three months.

o Major surgery, such as cardiac, thoracic, abdominal, or orthopedic in the preceding 14 days. Risk varies _ __ according to the procedure.

o Arterial puncture at a non-compressible site in the previous seven days.

Clinical

- **Diagnosis is not ischemic stroke**
  o Symptoms suggestive of subarachnoid hemorrhage
  o Stroke symptoms due to another non-ischemic acute neurological condition such as seizure with _ __ postictal Todd's paralysis or focal neurological signs due to severe hypo- or hyperglycemia
- **Co-morbid conditions that indicate a higher risk**
  o Hypertension refractory to aggressive hyperacute antihypertensive treatment such that target __ __ blood pressure less than 180/105 cannot be achieved or maintained. Blood pressure should be _ __ treated rapidly and aggressively to this target. Treatment may be concurrent with administration __ of intravenous thrombolysis
  o Patient anticoagulated eg. currently prescribed and taking a direct non-vitamin K oral anticoagulant __ (DOAC) or elevated International Normalized Ratio (INR) greater than 1.7 or elevated aPTT (not due __ to lupus anticoagulant)

CT or MRI Findings or Laboratory Findings

o CT or MRI showing early signs of extensive infraction

o Blood glucose concentration below 2.7 mmol/L or above 22.2 mmol/L

o Platelet count below 100,000 per cubic millimetre

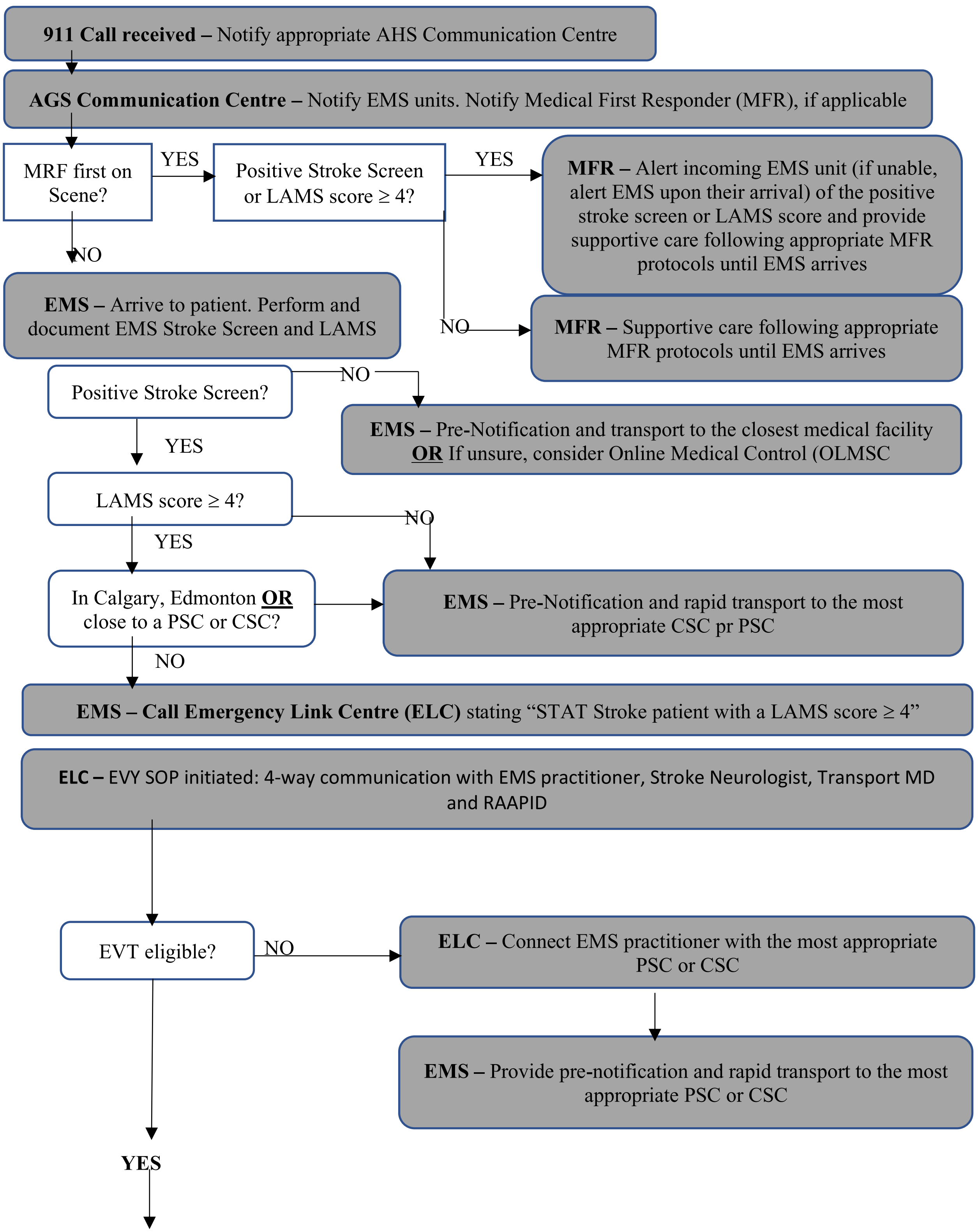
Appendix XXII: FMC Tenecteplase (TNK) Order and Administration

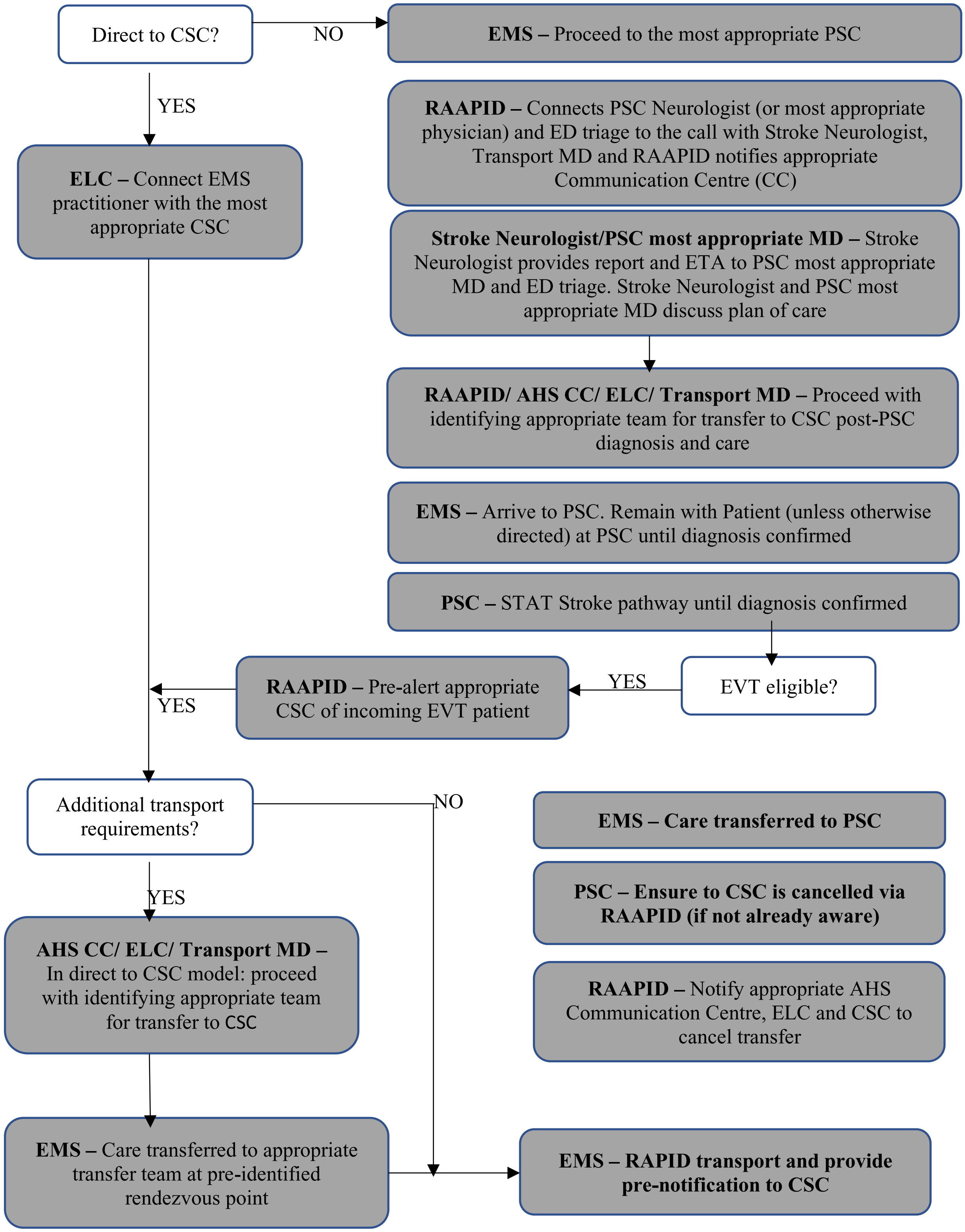
Tenecteplase Administration
Patient Weight ______________ Kg o Actual o Estimated **Imaging** o CT Scan Head Result: Non-hemorrhage **Dose** - Patient will receive a single bolus dose of TNK 0.25mg/Kg (maximum dose 25 mg) over 5 seconds. - Flush IV with normal saline prior to and following administration to ensure full delivery of drug dosage. **Mixing/Administration of Tenecteplase** - Draw up all diluent from the vial and slowly inject into powder. Avoid aggressive agitation of solution. Gently swirl – DO NOT SHAKE. Precipitation may occur if TNK is administered in an IV line containing dextrose. - Draw up amount in millilitres (ml). The dose will be between 3-5ml ** NOT to exceed 5 ml. - Perform an independent double check with a member of the stroke team. Dosing for Ischemic Stroke is **NOT THE SAME** as for Myocardial In fraction. Failure to give the ischemic stroke dose could result in intracranial hemorrhage and be fatal - Run 0.9% NaCl to keep vein open. - Ensure CBC, electrolyte panel, PT(INR), random glucose, and pregnancy test (if applicable) were done, and results are available. - Notify physician if blood pressure is higher than 185/110 mmHg. - **No anticoagulant or antithrombotic** agents for 24 hours after TNK Intravenous TNK (0.25mg/Kg, max 25 mg) - 50mg lyophilized drug per vial diluted with 10ml sterile water = 5mg/ml

Physician Tenecteplase Orders		
Bolus Dose (mg):	Date: (yyyy-Mon-dd)	Time: (hh:mm)
Physician Name:	Signature:	

Tenecteplase Administration		
Bolus Dose (mg):	Date: (yyyy-Mon-dd)	Time: (hh:mm)
Health Providers Name:	Signature:	
Health Providers Name:	Signature:	

Appendix XXIII: AHS EVT Communication Strategy




Direct to CSC?
NO
EMS – Proceed to the most appropriate PSC
YES
ELC – Connect EMS practitioner with the most appropriate CSC
RAAPID – Connects PSC Neurologist (or most appropriate physician) and ED triage to the call with Stroke Neurologist, Transport MD and RAAPID notifies appropriate Communication Centre (CC)
Stroke Neurologist/PSC most appropriate MD – Stroke Neurologist provides report and ETA to PSC most appropriate MD and ED triage. Stroke Neurologist and PSC most appropriate MD discuss plan of care
RAAPID/ AHS CC/ ELC/ Transport MD – Proceed with identifying appropriate team for transfer to CSC post-PSC diagnosis and care
EMS – Arrive to PSC. Remain with Patient (unless otherwise directed) at PSC until diagnosis confirmed
PSC – STAT Stroke pathway until diagnosis confirmed
EVT eligible?
YES
RAAPID – Pre-alert appropriate CSC of incoming EVT patient
YES
Additional transport requirements?
NO
EMS – Care transferred to PSC
PSC – Ensure to CSC is cancelled via RAAPID (if not already aware)
RAAPID – Notify appropriate AHS Communication Centre, ELC and CSC to cancel transfer
YES
AHS CC/ ELC/ Transport MD – In direct to CSC model: proceed with identifying appropriate team for transfer to CSC
EMS – Care transferred to appropriate transfer team at pre-identified rendezvous point
EMS – RAPID transport and provide pre-notification to CSC

Appendix XXIV: NS Pre-EVT Anesthesia checklist:

COVID-19 Swab Completed: Yes / No

ALLERGIES: Yes / No Details:____
MEDICATIONS: Diabetes Meds: Yes / No Details: ________________________________
Antihypertensives: Yes / No Details: ________________________________

Anti-Thrombotics: Yes / No Details: ________________________________

TPA: Yes / No Infusion Ongoing: Yes / No Time started: _____ h_____ (24hr)
TNK: Yes / No
PAST MEDICAL HISTORY:
Cardiac History: Yes / No Details: ____
Respiratory History: COPD: Yes / No OSA: Yes / No Difficult Intubation: Yes / No / Unknown

LAST MEAL: When was the last time the patient had something to eat? _____h_____ (24hr)

ENVIRONMENTAL: LOC: Aphasic: Yes / No
Hemiparetic: Yes / No Cooperative: Yes / No

IV Access: Yes / NoDetails:____
Supplemental O_2: Yes / NoDetails:____
Estimated Weight (kg): ___________. Morbidly Obese: Yes / No
Other Relevant Details (use other side of page if necessary):

Completed by: ______________________________. ________________________________.
(Printed name) (Signature)

Status:__________________________. Contact information: ________________________.

Date: ______/______/______ Time: _____h_____ (24h)

Appendix XXV: HSC Endovascular Thrombectomy (EVT) in Acute Ischemic Stroke (Adult) Order Set

Name: ______________________________
HCN: _______________________________
Date of Birth: ________________________

ALLERGIES: ☐ **NO KNOWN**

Date and Time of Stroke Onset: ~~DD/MONTH/YYYY~~___
Review inclusion and exclusion criteria below.

Inclusion Criteria

*All inclusion criteria must be met

☐Yes ☐No – Less than 6 hours of symptom onset?

☐Yes ☐No – Ischemic Stroke with Large Vessel Occlusion (LVO) with Internal Carotid Artery T Occlusion or ____________M1 segment?

☐Yes ☐No – Potentially disabling neurological deficit

☐Yes ☐No – Age greater than or equal to 18 years old?

☐Yes ☐No – 08:00-16:00 Monday to Friday?

Absolute Exclusion Criteria
☐Yes ☐No – Acute cerebral infarct with Alberta Stroke Program Early Computed Technology Score (ASPECTS) ____________ less than or equal to 5 of infarct on Computed Technology (CT)
☐Yes ☐No – Platelet Count Less than 50 x 10^9/L

Relative Exclusion Criteria
*Consider eligible on an individual basis based on benefit/risks
☐Yes ☐No – National Institute Health Stroke Scale (NIHSS) less than 5
☐Yes ☐No – CT evidence of central nervous system lesions with high potential for hemorrhage
☐Yes ☐No – Neuroimaging **NOT** completed within the last 60 minutes
☐Yes ☐No – Blood glucose less than 2.7 mmol/L or greater than 22.2 mmol/L
☐Yes ☐No – Recent stroke in territory of affected occluded vessel
☐Yes ☐No – Life expectancy less than 90 days or several medical co-morbidity or baseline severe disability

Pre-Treatment Management
If patient also candidate for alteplase (rt-PA) please refer to Doctor's Order Sheet Alteplase (rt-PA) Therapy in Acute Ischemic Stroke Adult (CH-1010)

Diagnostics

- CT Head Scan of the brain and CT Angio of head/neck

Interventions

- Obtain ECG
- Establish 2 large bore peripheral IV lines (if not done)
- Remove clothes and don gown prior to transfer to Interventional Radiology Suite

Vitals

- Temp, Heart Rate, Respiratory Rate, Blood Pressure, SPO_2 and Neurologic Signs every 15 minutes pre treatment
- If patient received intravenous alteplase follow vital and neurologic sign as per Doctor's Order Sheet Alteplase (rt-PA) therapy in Acute Ischemic (Adult)
  - Maintain blood pressure: __________ and below: _________ if not in this range notify physician
  - If patient has received rt-PA, maintain blood pressure below 180/105mmHg, if greater, notify physician

Urinary Catheter

- Urinary Catheter to straight drainage PRE EVT

Lab Investigations

- CBC, PTT, INR, Type and Screen, Creatinine, Urea, Glucose, Electrolytes, urine pregnancy test (if female of childbearing age)

Consults

- Consult Critical Care for 24-hour monitoring post EVT.

Post EVT Intervention

- IV Therapy: ______________________________
- Nothing by Mouth (NPO)
- Elevate Head of Bed: _________________
- Bed rest, maintain leg straight and immobilize 4 hours after sheath removal
- Is sheath present: ☐ Yes ☐ No (If sheath present, refer to policy Client Specific Care in the Post-Anesthesia Care Unit: Endovascular Treatment (Neurocoiling) 260-PACU-200)

Check Puncture Site:

- Every 15 minutes for an hour, then
- Every 30 minutes for an hour, then
- Every 60 minutes for 2 hours, then
- Every 4 hours for 24 hours

Check Neurological Signs:

- Every 30 minutes for the first 6 hours post procedure
- Every hour until 24 hours post procedure
- Call physician if neurologic deterioration, new nausea or vomiting

Check Vital Signs (Temperature, Heart Rate, Respiratory Rate, Blood Pressure, SPO_2):

- Every 15 minutes for the first 2 hours
- Every 30 minutes for the next 6 hours
- Every hour until 24 hours post procedure
- If systolic blood pressure is greater than 180mmHg or diastolic is greater than 100mmHg notify physician
- Blood Pressure Range: ____________________________; if outside of this range, notify physician

Repeat CT scan of brain 24 hours post EVT Procedure (ICU physician/resident to arrange)

Prescriber's Name: ______________________ Signature: _______________________
Date: DD/MONTH/YYYY__________________Time: __HH/MM__

Nurse's Name: _________________________ Signature: _______________________
Date: DD/MONTH/YYYY__________________Time: __HH/MM__

Appendix XXVI: Additional Roles and Responsibility at KHSC-KGH for Endovascular Therapy

Function	Responsibility	Role
Communication re: EVT & Bed Planning	If the patient is a candidate for EVT +/- IV thrombolysis: • Notify Interventional Radiologist • Notify IR Technologist and IR Charge Nurse (After hours: Call back EVT team via Switchboard see Table 2) • Notify D4ICU or K2ICU (+ Intensivist) • If after hours and patient returning to ED, Notify ED Charge Nurse • Notify Operations Manager – Administrative Coordinator to locate or confirm critical care bed in D4ICU or K2ICU & help with nurse staffing	Neurologist Interventional Radiologist (IR) Neurologist ED Nurse D4ICU Charge Nurse/ IR Charge Nurse
IR suite triaging	- In cases of more than one patient requiring emergent IR procedures in IR suite, clinical decision & plan regarding most appropriate triage care must be executed in consultation with all Attending Physicians responsible for care of all patients requiring emergent IR procedures. Triage follows the principle that EVT/ IA rt-PA in appropriate stroke patients is an Emergency	Daily Operations Team for IR Suite with Attending Neurologist
EVT +/- IV thrombolysis consent	For EVT +/- thrombolysis administration written consent is obtained from patient or substitute decision-maker using appropriate Radiology Consent Form • Part A: Explained to patient and consent obtained by Neurologist • Part B: Explained to patient and consent obtained by Interventional Radiologist	Attending Neurologist and IR
Clinical decision	- Decision to proceed with EVT after multiphase CTA is interpreted	Neurologist and IR
Communication & Bed Location	- Notify family – Inform family to wait in IVR Waiting Room - Notify CT Suite or ED that IVR suite is ready - D4ICU or K2ICU Charge Nurse informs IVR of Bed location - Contact Ops Manager if delay in locating bed	IR Charge Nurse or Technologist if after hours D4ICU or K2ICU Charge Nurse
Patient to receive IV thrombolysis	- See above See Appendix XXVI for IV thrombolysis - Prepare IVR suite while patient is receiving IV thrombolysis in CT or ED	IR Nurse IR Nurse and IR Technologist
Prepare patient for EVT +/- IA rt-PA procedure	- Ensure patient is in hospital gown with no underwear - If potential candidate for EVT, insert foley catheter (if patient is to receive TNK or rt-PA, insert foley catheter prior to TNK or rt-PA) - Ensure 2 working IVs - Transport patient to IVR when IVR suite is ready - Prepare patient for procedure including: Place patient on continuous SpO2 & cardiac monitoring; Shave prep both groins-only if absolutely necessary - Administration conscious procedural sedation & follow Procedural Sedation Policy & IVR Procedure Order Set	ED Nurse +/- IR Nurse IR Nurse
Monitor patient during procedure	- Follow standard IVR care processes including: Continuous SpO2 & Cardiac monitoring; BP Monitoring; Assess patient's airway comfort, and level of consciousness, sedation, and agitation - Monitor for angioedema and bleeding - Keep patient NPO	IR and IR Nurse
Medical management of	As a general principle, patients undergoing procedures are under the immediate care of the procedural physician although that physician may seek consultative support from referring and other physicians	IR with consultation as required with the

patient in IVR suite	• IR technologists and IR Nurses assist with procedure • Attending Neurologist is available in IVR suite to assist as needed • Decision making regarding modifying/aborting planned EVT procedure	Attending Neurologist
Medical Management of Sedation	- Ordering sedation and analgesia as required per IVR Procedure Order Set (Adult) - When no Anesthesiologist is present, medical management of the patient who develops complications in IVR suite, including consultation of other medical services (i.e. Anesthesiology) is initiated by Intervention Radiologist in consultation with the Neurologist - If there is concern about patient's airway or Level of Conscious (LOC) in the IVR suite, a code 99 for Anesthesiology is to be called - If patient arrives intubated, decision is made to contact Anesthesiology as needed - If Anesthesiology is present, patient monitoring, sedation and analgesia will be responsibility of the Anesthesiologist	Neurologist with IR ICU Intensivist Anesthesiologist
Femoral Sheath Removal	- Check ACT & remove sheath per IVR Femoral Arterial Sheath Removal Nursing Policy & Procedure & Arterial Sheath Removal Order Set - Apply bandages to puncture site - If Angio-Seal is not applied post procedure and femoral sheath remains in situ – complete Arterial Sheath Removal Order Set - IR Nurse removes the femoral sheath wherever the patient is located per Arterial Sheath Removal Order Set	IR Nurse IR IR Nurse
For Cases Where EVT is Aborted	In the case that EVT is aborted, the Ops Manager is contacted to locate appropriate bed	Attending Neurologist
Transfer patient to Davies 4 ICU or K2 ICU	- Notify D4ICU Charge Nurse or K2ICU Charge Nurse when procedure is completed - Contact Ops Manager is delay in locating bed - Handover report in IVR to K2ICU Nurse/ ICU Intensivist if patient going to K2ICU bed - IR Nurse returns ED portable monitor to ED - Transfer patient with Stroke Team to D4ICU or K2ICU - Neurologist gives hand over report once patient has been transferred to D4ICU or K2ICU	IR Charge Nurse or IR Nurse if after hours Attending Neurologist

Appendix XXVII explains issues of consent

(Southeastern Ontario Stroke Network, 2022)

Appendix XXVII: SEO Inclusion and Exclusion Criteria for EVT

Inclusion	Exclusion
1. Presenting < 6 hours from stroke onset - Highly selected patients presenting between 6-24 hours based on clinical & imaging criteria 2. NIH Stroke Scale (NIHSS) greater than 5 3. Pre-stroke functioning independently in activities of daily living in their community 4. Age 18 yrs or greater (if < 18 yrs see additional info)	1. Complete resolution of neurological signs (TIA) 2. Serious co-morbidity with limited lifespan (e.g., advanced cancer, advanced dementia) 3. Recent intracranial bleed 4. Severe contrast allergy or absolute contraindication to Iodinated Contrast 5. Difficult femoral, radial, or brachial artery access 6. Fibromuscular Dysplasia (relative contraindication)

Appendix XXVIII: RAPID Software Benefits

Quantifies brain regions of reduced cerebral blood flow, volume, and transit time in real time. Regions are colour coded and automatically measured and sent securely to computer and handheld devices. RAPID imaging software generates an objective quantifiable measure of tissue mismatch on CT perfusion and helps to select patients rapidly for EVT using an evidence-based approach. Cases are selected with small to no infarct core volume and large ischemic but metabolically active penumbra.
We are also seeing added patient complexity and comorbidities, so it has been helpful to have RAPID software. IRs and stroke neurologists have indicated that the use of RAPID in combination with clinical presentation has greatly improved confidence with case selection. The use of Rapid in concert with the clinical history and exam provides a more accurate clinical picture. It is also important to know the patient's baseline function to weigh the benefits and risks
RAPID is now being used for mostly all ASP activations presenting within 24 hours. Use of RAPID is well embedded into the normal workflow
RAPID at QHC-Belleville site (District Stroke Centre and Telestroke Site) facilitates decision making and communication between QHC-Belleville and KHSC-KGH about EVT transfers. The use of RAPID is also assisting with improved rates of treatment for those transferred from QHC (now above 58%). • The EVT checklist in the CT suite and pocket-sized version used by physicians were each updated to include the RAPID decision-making criteria. • Once a week for six months during Stroke Rounds after installation of RAPID at KHSC, the cases were reviewed, and learnings shared regarding RAPID and case selection. Joint meetings were also held between KHSC and QHC to share the RAPID learnings and to trouble shoot any potential issues.

The KHSC RAPID CT Perfusion contract will end in two years. At that time it will be helpful to be able to take advantage of a provincial procurement process to ensure rates are kept as low as possible both at the KHSC and QHC

Appendix XXIX: NS Thrombolytic Infusion Transfer Guidelines

This guideline is for interfaculty transfers of patients with thrombolytic infusions initiated by the sending facility who require emergency transfer to another facility for further management, including EVT therapy.

Alteplase (tPA) for CVA is dosed as an IV bolus followed by a 60-minute continuous infusion. Due to anticipated timelines, the bolus should be completed, and continuous infusion started prior to paramedics assuming care of the patient.

Patients treated with Tenecteplase (TNK) will receive a bolus at the sending facility and no continuous infusion will be required.

Procedure:

1. Initiate ALS assessment and monitoring
2. Confirm alteplase infusion start and stop times and infusion rate
3. Continue alteplase infusion as started at the sending facility and stop at designated time
4. Minimize venipuncture, IM and subcutaneous injections, expect to hold 10-30 min of pressure
5. Vitals q15 minutes, manual blood pressures only
6. Keep patient NPO
7. Call OLMC to discuss further management if SBP greater than 180 mmHg or DBP greater than 105 mmHg
8. Do not insert a nasogastric tube or Foley catheter
9. Do not administer ASA or other antiplatelet/anticoagulation medication
10. If angioedema/anaphylaxis develops, stop Alteplase infusion, treat as per **Allergy and Anaphylaxis (pg xx)** and contact OLMC
11. If acute neurologic deterioration suggesting an intracerebral hemorrhage (new severe headache, vomiting, seizure or acute decrease of consciousness), stop Alteplase infusion and contact OLMC.

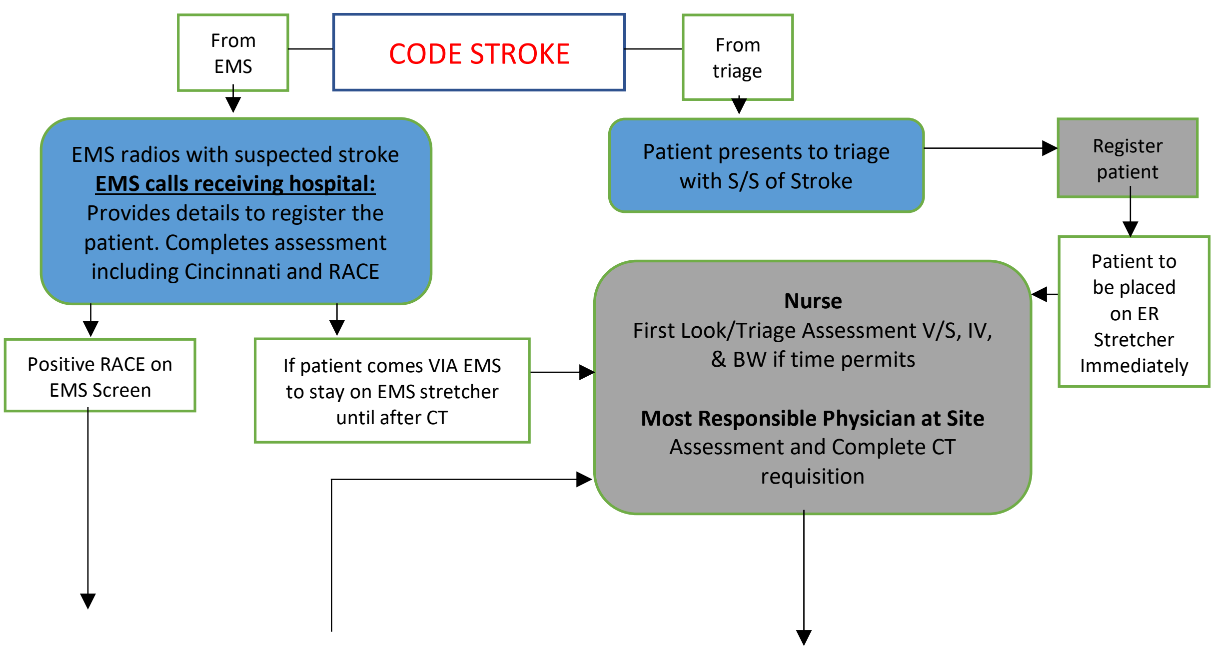
Contact OLMC to discuss further management if alteplase infusion is stopped for any reason

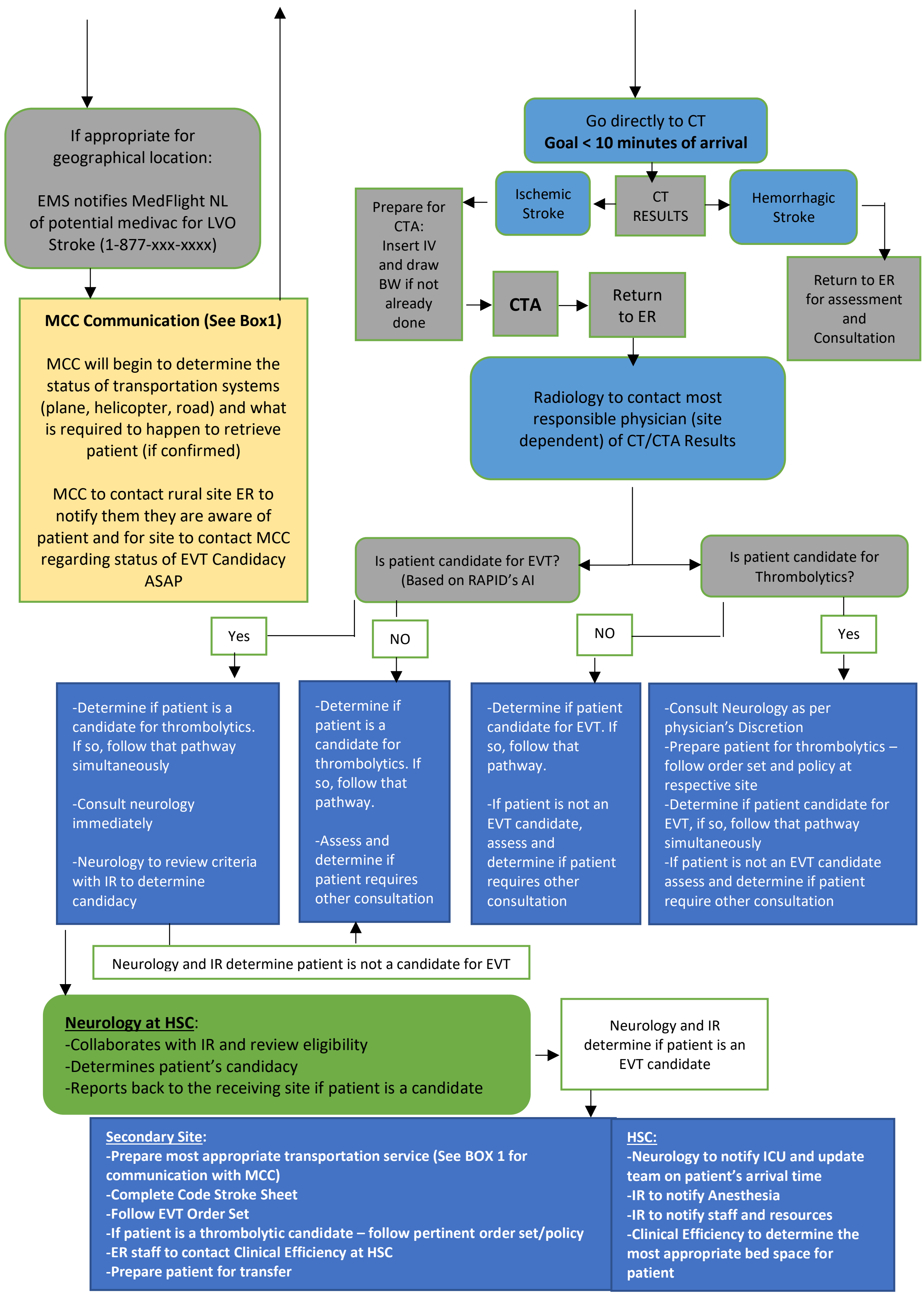
Appendix XXX: EVT Transfer from Rural site to HSC for EVT

Steps foe EVT Rural Communication to MCC/Neurology

1) Rural EMS to notify MCC of potential EVT Candidate
   a. MCC will begin to detrermine what current status of transportation systems (plane, helicopter, road) and what is required to happen to retrieve patient (if confirmed)
   b. MCC to contact rural site ER to notify them they are aware of patient and for site to contact MCC regarding status of patient ASAP
2) Patient has CT/CTA at site-most responsible physician at the RURAL site receives report from Radiology
   a. If patient is NOT a EVT candidate based on scan results – rural physician to contact MCC to update them
   b. If patient is CONFIRMED candidate based on scan result proceed to step 3
3) Rural-Most Responsible Physician to consult Neurology to review patient and CT results
4) Neurology to consult/collaborate with Neuro Interventional Radiology regarding candidacy for EVT
5) Neurology to contact Rural Physician regarding Candidacy for EVT.
   a. If patient is NOT a confirmed EVT Candidate, the rural physician to contact MCC to update
   b. If patient is COMFIRMED EVT Candidate, the rural physician to call MCC to update and arrange transportation
6) Once MCC is notified of confirmed EVT patient they will connect with Neurology on call to review timelines and transportation. ***The On Calll MCC Physician can be contacted and involved in conversation, if required***
   a. The discussion may determine patient is not a candidate, if this happens, Neurology to reconnect with rural physician and discuss next steps for patient care

Appendix XXXI: Code Stroke – Secondary Site EVT Process Map.





If appropriate for geographical location:
EMS notifies MedFlight NL of potential medivac for LVO Stroke (1-877-xxx-xxxx)
MCC Communication (See Box1)
MCC will begin to determine the status of transportation systems (plane, helicopter, road) and what is required to happen to retrieve patient (if confirmed)
MCC to contact rural site ER to notify them they are aware of patient and for site to contact MCC regarding status of EVT Candidacy ASAP
Go directly to CT
Goal < 10 minutes of arrival
Ischemic Stroke
CT RESULTS
Hemorrhagic Stroke
Prepare for CTA: Insert IV and draw BW if not already done
CTA
Return to ER
Return to ER for assessment and Consultation
Radiology to contact most responsible physician (site dependent) of CT/CTA Results
Is patient candidate for EVT? (Based on RAPID's AI
Is patient candidate for Thrombolytics?
Yes
NO
NO
Yes
-Determine if patient is a candidate for thrombolytics. If so, follow that pathway simultaneously
-Consult neurology immediately
-Neurology to review criteria with IR to determine candidacy
-Determine if patient is a candidate for thrombolytics. If so, follow that pathway.
-Assess and determine if patient requires other consultation
-Determine if patient candidate for EVT. If so, follow that pathway.
-If patient is not an EVT candidate, assess and determine if patient requires other consultation
-Consult Neurology as per physician's Discretion
-Prepare patient for thrombolytics – follow order set and policy at respective site
-Determine if patient candidate for EVT, if so, follow that pathway simultaneously
-If patient is not an EVT candidate assess and determine if patient require other consultation
Neurology and IR determine patient is not a candidate for EVT
Neurology at HSC:
-Collaborates with IR and review eligibility
-Determines patient's candidacy
-Reports back to the receiving site if patient is a candidate
Neurology and IR determine if patient is an EVT candidate
Secondary Site:
-Prepare most appropriate transportation service (See BOX 1 for communication with MCC)
-Complete Code Stroke Sheet
-Follow EVT Order Set
-If patient is a thrombolytic candidate – follow pertinent order set/policy
-ER staff to contact Clinical Efficiency at HSC
-Prepare patient for transfer
HSC:
-Neurology to notify ICU and update team on patient's arrival time
-IR to notify Anesthesia
-IR to notify staff and resources
-Clinical Efficiency to determine the most appropriate bed space for patient

BOX 1: Steps for EVT Rural Communication to MCC/Neurology

1)Rural EMS to notify MCC of potential EVT Candidate

a. MCC will begin to determine what current status of transportation systems (plane, helicopter, road) and what is required to happen to retrieve patient (if confirmed)
b. MCC to contact rural site ER to notify them they are aware of patient and for site to contact MCC regarding status of patient ASAP.

2) Patient has CT/CTA at site- most responsible physician at that RURAL site receives report from Radiology

a. If patient is NOT a EVT candidate based on scan results – rural physician to contact MCC to update them.
b. If patient is a CONFIRMED candidate based on scan results proceed to step 3.

3) Rural- Most Responsible Physician to consult Neurology to review patient and CT results

4) Neurology to consult/collaborate with Neuro Interventional Radiology regarding candidacy for EVT

5) Neurology to contact Rural Physician regarding Candidacy for EVT.

a. If patient is NOT a confirmed EVT Candidate, the rural physician to call MCC to update.
b. If patient is a CONFIRMED EVT Candidate, the rural physician to call MCC to update and arrange transportation.

6) Once MCC is notified of confirmed EVT patient they will connect with Neurology on call to review timelines and transportation. *The On Call OLMC (Flight) Physician can be contacted and involved in conversation, if required*

a. This discussion may determine patient is not a candidate, if this happens Neurology to reconnect with rural physician and discuss next steps for patients care.

BOX 2: Important Numbers:

- When paging on-call neurology please advise Health Sciences Switchboard the page number for a Code Stroke at you SITE.
  - **Clinical Efficiency HSC**: 777-xxxx
  - **HSC ER**: 777-xxxx
  - **HSC Switchboard:** 777-xxxx
  - **Med Flight NL** 1-877-xxx-xxxx
  - **Med Flight NL Fax:** 777-xxxx
  - **Burin ER:** 891-xxxx/891-xxxx
  - **Carbonear ER:** 945-xxxx
  - **Clarenville ER:** 466-xxxx

BOX 3: Referring Site Hospital Responsibilities:

-Access to CT/CTA RAPIDS AI

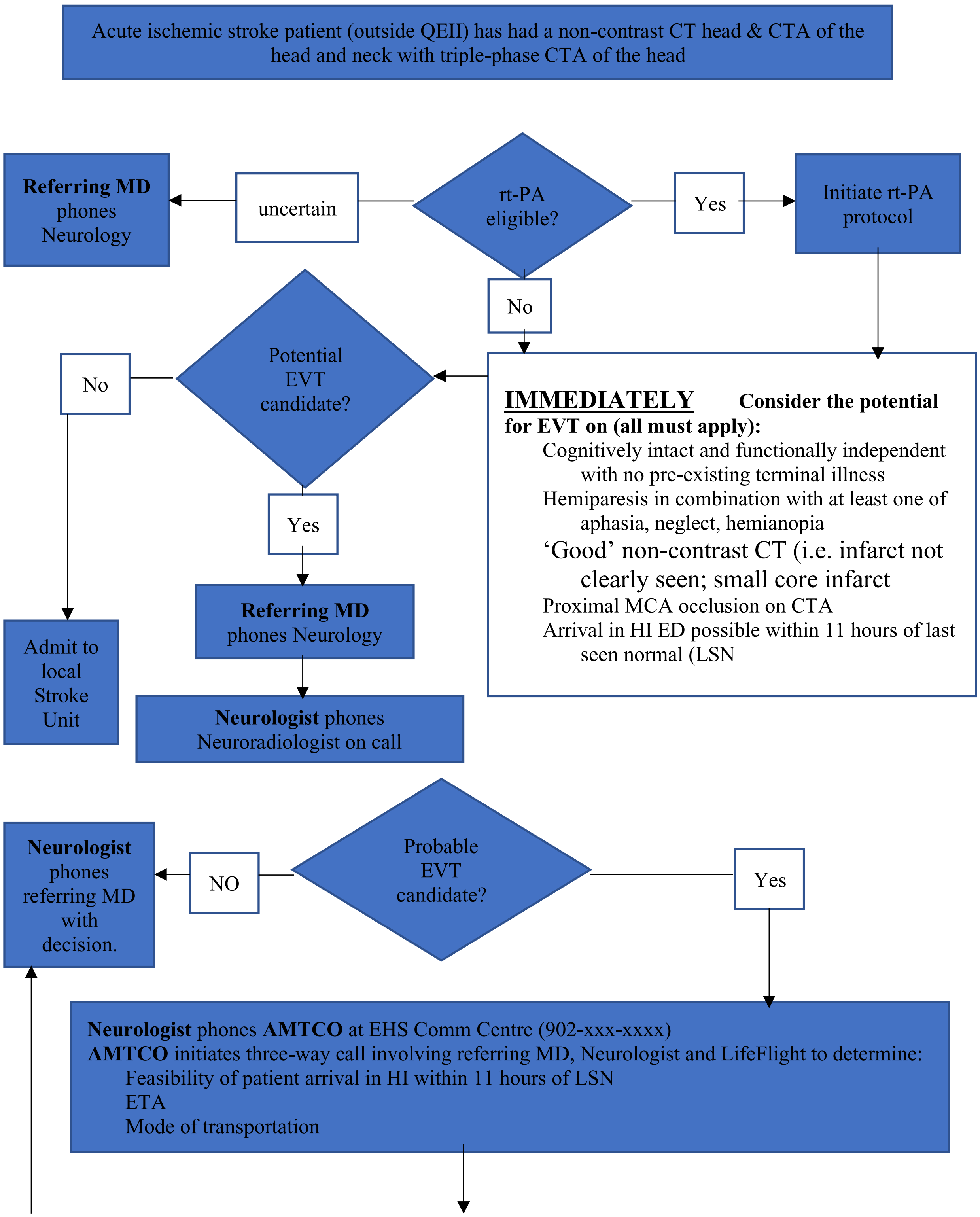
-Code Stroke Process Built

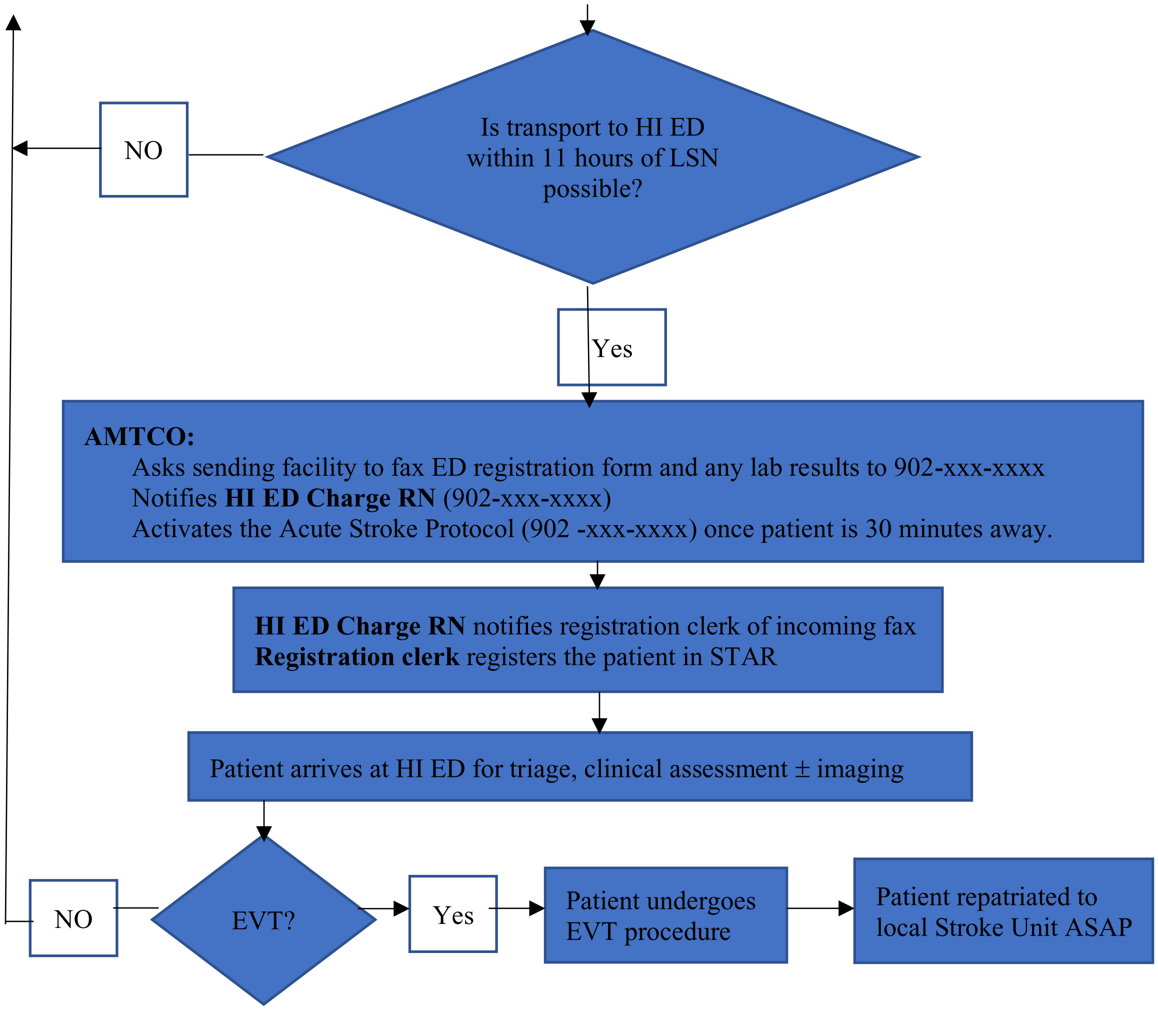
-Arrange transportation (Ground vs. Flight based on your geographical location)

-If patient has received thrombolytics (and is infusing) and/or the patient is unstable, it is the expectation of the referring hospital to arrange appropriate health care provider accompaniment with the stroke patient (ground transfer)

-If patient status changes after acceptance at HSC, but patient has not left, then updates should be provided to Neurologist on call before proceeding with transfer – this includes medical status and/or changes in consciousness, deterioration.

Appendix XXXII: Provincial Protocol for Endovascular Thrombectomy (EVT)




Is transport to HI ED within 11 hours of LSN possible?
NO
Yes
AMTCO:
Asks sending facility to fax ED registration form and any lab results to 902-xxx-xxxx
Notifies **HI ED Charge RN** (902-xxx-xxxx)
Activates the Acute Stroke Protocol (902 -xxx-xxxx) once patient is 30 minutes away.
HI ED Charge RN notifies registration clerk of incoming fax
Registration clerk registers the patient in STAR
Patient arrives at HI ED for triage, clinical assessment ± imaging
EVT?
NO
Yes
Patient undergoes EVT procedure
Patient repatriated to local Stroke Unit ASAP

Appendix XXXIII: ACT FAST Triage Tool

Triage Tools for Acute Strooke < 24 hours

FAST Stroke Screen:

One or more symptom from Face, Arm, Speech **AND**

If < 6 hours, Call Switchboard to Activate Acute Stroke Protocol
If 6-24 hours, Complete ACT FAST

ACT FAST Stroke Screen:

"ARM" (one-sided arm weakness)
Position both arms at 45 degress from horizontal with elbows straight
Positive Test: One are falls completely within 10 second

For patients that are uncooperative or cannot follow commands
Positive Test: Witness minimal or no movements in one arm & movement in other arm

If **RIGHT ARM** is weak

"CHAT" (Svere Language Deficit)
Positive Test: Mute, speaking incomprehensible, or unable to follow simple commands

If **LEFT ARM** is weak

"TAP" (gaze & shoulder tap)
Stand on patients weak side
Positive Test: Consistent eye gaze away from weak side
Otherwise: Tap shoulder & call name
Positive Test: Does not quickly turn head & eyes to you

Call Switchboard to Activate Acute Stroke Protocol

If Acute Strok Protocol is Activated: Contact Charge Nurse & ED Phycisian

Charge Nurse will delegate nurse to take over & locate holding spot

Physician will assess EVT eligibility
1. Deficits are not pre-existing (mild deficits that are now worse are acceptable as true defects)
2. Onset of symptoms or Last Seen Normal less than 24 hours
3. Living at home independently with only minor assistance – must be independent with hygiene, personal care tasks, walking (walking aids are acceptable)
4. Patient does NOTE have stroke mimics: seizure preceding symptoms, Hypoglycemia = glucose less than 2.8 mmol/L, Active malignancy with brain legion

If patient is uncooperative or cannot follow commands and clearly shows minimal to no movements in one arm and normal or spontaneous movements in the other arm, if both arms are similarly weak, or testing is clearly affected by shoulder problems or pain, notify ED physician
Try to use clues to guess time LSN (did someone talk to or call patient?)
For suspected Wake-Up symptoms, did patient get up overnight? Were they normal when first getting up?
Negative eligibility if time of onset is greater than twenty-four hours
If there is uncertainty as to LSN or whether a patient meets the ACT-FAST criteria, the ED physician can contact the on-call neurologist for stroke consultation

(Stroke Network of Southeast Ontario, 2018)

Appendix XXXIV: Emergency Transfer Guide for Thrombolytic Therapy and/or Endovascular Therapy to Kingston General Hospital

<table>
<tr>
<td>Inclusion Criteria
☐ Patient is suspected of having ischemic stroke.
☐ Clear and credible time of symptom onset can be established, and patient can reach KGH:
- Within 6.0 hours from LSN, or.
- Within 6-24 hours LSN if ACT FAST screen is positive
☐ Time is Brain – The sooner patient arrives at KGH, the greater potential for better outcomes. KGH stroke team requires 1 hour from KGH ED door to treatment
☐ Pregnancy is NOT a contraindication
☐ Age < 18 years is NOT a contraindication</td>
<td>Exclusion Criteria
☐ Unknown onset of symptoms or patient LSN > 24 hours
☐ Complete resolution of neurological signs (TIA)
☐ Serious co-morbidity with limited lifespan (e.g., advanced cancer, advanced dementia)
☐ If uncertain about whether patient meets Acute Stroke Protocol, contact Neurologist on call for stroke at KGH</td>
</tr>
<tr>
<td colspan="2">Th following steps are recommended if patient meets eligibility criteria and is stable to transfer:

Step 1: Arrange for ambulance transfer by calling dispatch. Inform the dispatcher that patient fits “Acute Stroke Protocol”

Step 2: Call KGH emergency department. Ask to speak to the charge nurse and inform them you have a patient that meets the “Acute Stroke Protocol”. KGH will activate their Stroke Team
Phone: (613) xxx-xxxx extension xxxx

Step 3: Complete the following if time permits (never delay transfer to complete):
A. Preferred:
• 1 IV (no glucose solutions unless required)
• 1 saline lock started with an 18-gauge needle in the right antecubital fossa unless contraindicated
B. Optional (If time still permits):
• CBC, electrolytes, urea, creatinine, troponin, INR, PTT, glucose, pregnancy test (βHCG) if indicated
• ECG

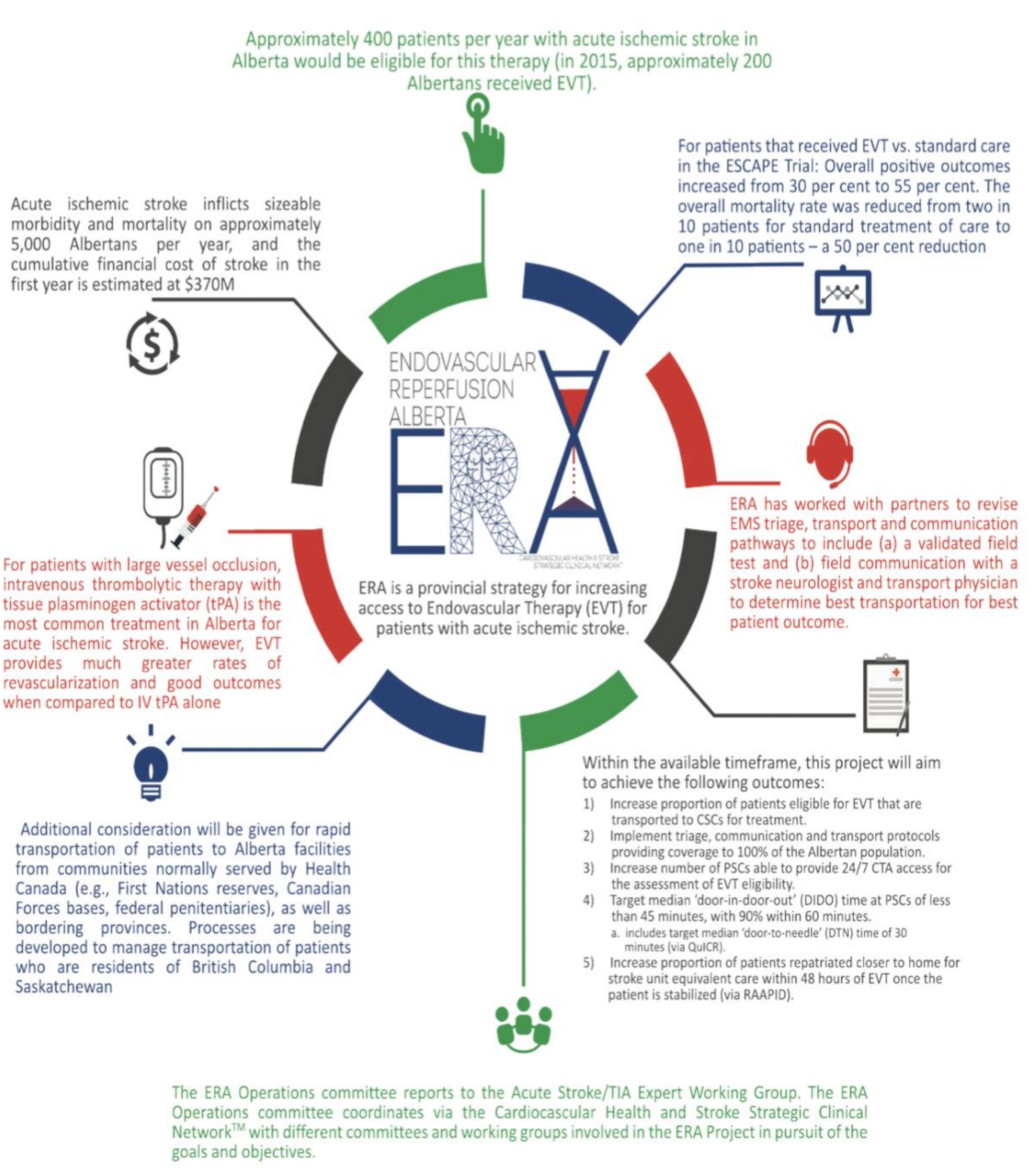
Step 4: Fax blood work and all relevant patient information to KGH emergency department. Include Blood Pressure elevations od systolic > 185 and/or diastolic > 110 so the stroke team can be prepared to treat BP upon arrival
Fax: (613) xxx-xxxx</td>
</tr>
</table>

Appendix XXXV: Code Stroke Record

1) Was a Code stroke activated: ☐ **Yes** ☐ **No** **Date**: DD/MONTH/YYYY **Time**: HH:MM
2) Time of EMS Arrival on scene: **Date**: DD/MONTH/YYYY **Time**: HH:MM
3) Time of Arrival to receiving site: **Date**: DD/MONTH/YYYY **Time**: HH:MM
4) Date and Time Patient **Last Seen Normal: Date**: DD/MONTH/YYYY **Time**: HH:MM
5) Cincinnati Score: ☐ **Positive** ☐ **Negative**
6) Large Vessel Occlusion Screen (RACE): ________________________
7) National Institute Health Stroke Scale: __________________________
8) Was a CT performed? ☐ **Yes** ☐ **No** **Date:** DD/MONTH/YYYY **Time:** HH:MM **Result:** Intracranial hemorrhage present? ☐ **Yes** ☐ **No**
   ____
   ____
9) Most Responsible Diagnosis: ____

Alteplase (t-PA)		**Endovascular Thrombectomy (EVT)**	
Was t-PA administered? ☐ **Yes** ☐ **No**	**Date:** DD/MONTH/YYYY **Time:** HH:MM	Time of arrival to EVT site: **Date:** DD/MONTH/YYYY **Time:** HH:MM	
If no tPA administered, provide reason:	☐ Contraindicated ☐ No Stroke ☐ Outside of Window ☐ Refused by Patient/Family ☐ TIA	Was EVT completed? ☐ **Yes** ☐ **No**	Groin puncture time: **Date:** DD/MONTH/YYYY **Time:** HH:MM
If contraindicated please provide reason:	☐ Bleeding diathesis ☐ Any source of active hemorrhage ☐ Systolic blood pressure greater than or equal to 185mmHg or diastolic blood pressure greater than or equal to 110mmHg and NOT responding to antihypertensive treatment ☐ Pre-treatment CT scan of the brain showing either: 1) Hemorrhage 2) Edema 3) Mass Effect (shift) ☐ Other: ________________________	If no EVT completed, provide reason:	☐ Contraindicated ☐ No Stroke ☐ Outside of Window ☐ Refused by Patient/Family ☐ TIA ☐ No LVO
Was this an ischemic stroke? ☐ **Yes** ☐ **No**	Will the patient be transferred for EVT? ☐ **Yes** ☐ **No** If no, provide reason? _____________ ________________________________	If contraindicated, please provide reason:	☐ ASPECTS Score **less than or equal to** 5 ☐ Platelet count **less than** 50 x 10^9/L ☐ Other: ______________

Appendix XXXVI: Presents ERAs Reasoning to Increase Access to EVT with Their Five Objectives



(Alberta Health Services, 2016)