NEONATAL FLIGHT SAFETY: NORTHERN CARE OUTREACH

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Abstract

Background and Purpose: Neonatal aeromedical transport is inherently dangerous, (Bouchut, Lancker, Chritin, & Gueugniaud, 2011; Schierholz, 2010), but for Nunavut, Canada, serviced by Keewatin Air, this is the only option to accessing specialized care (McKenzie, 2015). The purpose of this practicum is to support Keewatin Air with a Neonatal Transport Improvement Project (NTIP) to help their staff safely transport neonates. *Methods:* A needs assessment with Keewatin Air was conducted to determine: 1) neonatal knowledge gaps; 2) relevant primary needs; and 3) resources for continuing education. This writer then consulted with neonatal experts to identify evidence-based recommendations for neonatal transport team training, and how to maintain neonatal safety on transport. *Results:* Keewatin Air staff identified three primary needs: risk mitigation; improving access to Neonatal Resuscitation Program (NRP); and financial support, and consultation with neonatal experts revealed simulation is the ideal training format. NTIP is presented in two parts: Program Support Presentation, and Simulation Educational Toolkit. The former is a PowerPoint presentation that offers solutions to the identified program needs, and the latter includes the foundations of simulation, educator preparatory material, advice for facilitating effective simulation, and a collection of neonatal simulation scenarios. The simulation toolkit also includes an objective evaluation plan to assess the efficacy of this education. *Conclusion:* Keewatin Air will now have a toolkit to integrate into their curriculum to improve their medical staff's neonatal competencies and ultimately neonatal safety during aeromedical transport.
Key Words: transport, aeromedical, neonatal transport, aeromedical simulation

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PRACTICUM OVERVIEW

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- NTIPS Part I: Program Support Presentation
- NTIPS Part II: Neonatal Simulation Scenarios

List of Abbreviations

- Aeromedical transport team (AMT)
- Neonatal Transport Improvement Project (NTIP)
- Winnipeg Children's Hospital (WCH)
- Neonatal intensive care unit (NICU)
- Keewatin Air's medical education team (MET)
- Neonatal Resuscitation Program (NRP)
- Evidence- based best practice (EBP)

Introduction

Aeromedical transport of the vulnerable neonatal population is inundated with tremendous risks (Bouchut et al., 2011; Schierholz, 2010), but for remote areas such as Northern Canada, this remains the only viable option for accessing specialized care (McKenzie, 2015). Aeromedical transport of neonates from Nunavut, Canada is contracted out to Keewatin Air. As this team is tasked with aeromedical transport of all patient ages, fewer opportunities for maintaining neonatal competencies exist. This is concerning as according to the Canadian Pediatric Society, there is a significantly higher incidence rate of adverse events such as the need for cardiopulmonary resuscitation, or improper management of the neonate's airway when a non-specialized team performs neonatal transport (Whyte & Jefferies, 2015). The purpose of this practicum therefore was build an education resource stemming from existing literature and expert consultations to meet the identified learning needs of Keewatin Air. A Neonatal Transport Improvement Project was established to help ensure Keewatin Air is equipped with the neonatal competencies and resources to safely provide neonatal aeromedical transport.

With an aim to ensure safe neonatal medical transport is delivered to all patients regardless of their location of origin, this practicum is titled Neonatal Flight Safety: Northern Care Outreach. In today's healthcare climate, the matter of improving service delivery and healthcare access to culturally diverse groups has become compulsory (CNA, 2010). Many Nunavut patients are Inuit, a culture that is unfortunately medically underserved (Greenwood, de Leeuw, & Lindsay, 2018). The idea behind this practicum project was that by providing neonatal specific education and training to Keewatin Air's medical staff, overall patient outcomes for Nunavut neonates could be improved.

Recognizing the importance of understanding an organization's culture, values, and resources when developing a resource that is effective and delivered in a manner that Keewatin Air's medical staff would be receptive to, this Neonatal Transport Improvement Project (NTIP) began with a needs assessment of Keewatin Air. This involved speaking with organizational leadership and front-line staff to determine what Keewatin Air identifies as the three primary needs for improving the neonatal transport program. These were: greater awareness of neonatal perils during aeromedical transport and respective risk mitigation solutions; improved access to Neonatal Resuscitation Program (NRP) for the medical staff certification; and financial support. As well, front-line staff voiced interest in receiving education beyond the scope of NRP to encompass a wider variety of neonatal diagnoses and clinical scenarios.

From here, a literature review was conducted to help explore evidence-based best practice recommendations (EBP) for neonatal aeromedical transport, and determine the ideal training format for aeromedical transport teams (AMTs). This review illustrates an overwhelming preference in the aeromedical literature for simulation training as the educational gold standard, which helped inform the design of the educational toolkit component of NTIP. The review also highlights evidence-based transport-specific risks to neonates, but sheds light on the insufficient evidence for respective risk mitigation strategies. Therefore, this writer consulted with neonatal experts (i.e. established neonatal

AMTs, neonatologists, and NICU nurses) to help identify possible risk mitigation solutions.

This report details the activities undertaken during my practicum, beginning with an outline of the practicum objectives followed by the literature review and consultation report. Following these sections is an overview of the Neonatal Transport Improvement Project including Part I: Program Support Presentation and Part II: Simulation Educational Toolkit. The report concludes with an implementation/ evaluation plan, a discussion of possible recommendations for further research, and an overview of the advanced practice nursing competencies that were applied throughout this practicum.

One of this writer's priorities in deciding on a practicum project was to help reduce health inequities in Northern Canada, particularly for neonates, a population that requires highly specialized care (Campbell & Dadiz, 2016). Establishing a Neonatal Transport Improvement Project does so by improving access to competent, safe neonatal care for Nunavut neonates transported by Keewatin Air. This practicum also provided an opportunity to employ a number of advanced practice nursing competencies, and identify potential areas for further research at a doctoral level in the future.

Practicum Objectives

The overall goal of this practicum was to develop a program support initiative to address the need of improved neonatal aeromedical competencies for Keewatin Air. The objectives for this practicum were:

- To develop a program support resource based on conducting relevant needs assessment, literature review, and expert consultation

- To review existing literature to identify evidence-based neonatal risks on aeromedical transport, risk mitigation strategies, and the gold standard for AMT training
- To disseminate the findings of the literature review and consultation report into a formal resource
- To devise implementation strategies and objective evaluation plans to help effectively facilitate the resource
- To collaborate with neonatal experts to build the educational content of the resource

Following a needs assessment, the resource was divided into two parts: NTIPS Part I- Program Support Presentation, and NTIPS Part II- Simulation Educational Toolkit. The objectives for these parts are presented below.

NTIPS Part I: Program Support Presentation

- In consultation with neonatal experts, present risk mitigation strategies to address evidence-based risks identified in the literature review
- To present solutions for improving access to NRP in Keewatin Air's remote bases
- To provide funding opportunities for consideration and detail how each grant could support the organization's needs

NTIPS Part II: Simulation Educational Toolkit

- Explain the rationale for simulation training as choice of this toolkit's instructional delivery format

- Provide educator preparatory material to help Keewatin Air's MET understand how to facilitate simulation, and to give background information on a variety of neonatal diagnoses
- Present tips for effective facilitation and focus points to guide the educator's delivery of simulation
- In collaboration with neonatal experts for simulation content, provide a collection of simulation scenarios with structured learning objectives
- Provide formal evaluation plan to assess the effectiveness of this toolkit

Overview of Methods

As this writer sought to reduce existing health inequities for neonates located in northern communities of Canada, Keewatin Air, an aeromedical organization tasked with transporting Nunavut neonates, was chosen as a beneficiary of this practicum's output. The practicum project was designed as a program support resource to help Keewatin Air delivery access to specialized, competent care for neonates of Northern Canada during aeromedical transports.

To obtain evidence-based recommendations for improving aeromedical neonatal transport, a literature review was conducted. The resulting evidence, or lack thereof in some parts, found in this review helped to frame the interview questions used when consulting neonatal experts and established neonatal transport programs. As well, an organizational needs assessment was conducted by consulting with Keewatin Air's medical staff to identify needs of the neonatal transport program. These methods helped to ensure the resulting program support resource was evidence-based, and was designed in a way that would address Keewatin Air's primary needs.

Data Acquisition

Summary of Literature Review

Methods

The two key questions this literature review sought to address were 1) What evidence based best practice recommendations exist for the care of neonatal patients with special consideration to flight transports? 2) What education format is considered gold standard for training aeromedical teams? The studies and information presented in this literature review stemmed from CINAHL and PubMed searches for English quantitative studies since 2000. Exclusion criteria included: studies before 2000, studies that are of broad transport focus and do not explicitly address neonatal and/or pediatric considerations, and qualitative studies.

The following key words were used in the searches: neonatal flight transport, neonatal best practice, northern healthcare, neonatal medevac, premature neonate, aeromedical education, transport team training, and neonatal flight nursing. Boolean operators and various MeSH terms were used. After reading the abstract of each study, if deemed applicable to the key question in this review, the complete study was analyzed. This review shed light on the deficiency in transport specific evidence based practice recommendations for neonates (Cornette, 2004). The focus of the review therefore had to be broadened to include evidence-based safety risks for neonates on transport. Refer to Appendix A, pages 32-71 for full literature review.

Synthesis of Literature Review

Key transport-specific safety risks for neonates included excessive sound and vibration, and the effects altitude, acceleration, and deceleration have on physiologic stability (Bouchut, et al., 2011; Grosek, 2014; Ohning, 2015; Ratnavel, 2009; Schierholz, 2010; Skeotch, Jackson, Wilson, & Booth, 2005). Despite ample evidence to describe *what* the risks are for neonates during aeromedical transport, there was scant evidence available to describe *how* to mitigate such risks.

One exception was improved monitoring using near-infrared spectroscopy (NIRS) to help transport teams detect altitude related physiologic deterioration sooner than traditional methods of monitoring. Stroud, Gupta, and Prodhan (2012) explained that NIRS monitoring provides the benefit of earlier decreased oxygenation detection as their study revealed no change in pulse oximetry (SpO2) values despite significant reduction in cerebral oxygenation levels with NIRS (baseline and 5000 altitude: NIRS= 69.2%, 66.3%, $p<0.001$; SpO2= 98.7%, 98.9% $p= 0.61$). For this reason, NIRS was provided as a recommendation for risk mitigation of altitude stressors in this practicum's NTIP Part I-Program Support Presentation.

Of the identified stressors, noise and vibration were predominantly reflected in neonatal transport literature (Bailey et al., 2018; Campbell, Lightstone, Smith, Kirpalani, & Perlman 1984; Karlson et al., 2011; Gajendragadkar et al., 2000; Sittig, Nesbitt, Krageschmidt, Sobczak, & Johnson, 2011), but little evidence was found for ways to manage these stressors. This was concerning as sound and vibration can lead to intraventricular hemorrhage or bradycardia-desaturation events due to poor stress tolerance in neonates (Gajendragadkar et al., 2000; Skeoch et al., 2005). This is why these two stressors were selected as focus points in consultation discussions with NICU nurses and neonatologists to discover methods of abating loud sound and vibration.

As well, the literature review highlighted the importance of pre-transport stabilization to ensure optimal outcomes for neonates being transported (Messner, 2011; Ohning, 2015; Schierholz, 2010). Numerous guidelines were identified to help teams organize their approach for stabilizing a neonate prior to departure. Among these guidelines was S.T.A.B.L.E (Mears & Chalmers, 2009; Taylor & Price-Douglas, 2008), which cues teams to assess: S- sugar and safety; T- temperature; A- airway; B- blood pressure; L- lab results; E- emotional support. Aeromedical literature's emphasis on pre-transport stabilization and this useful mnemonic helped to guide the development of focus points of the educational toolkit.

The literature review also demonstrated that high-fidelity simulation training is the leading format for educational delivery on transport teams (Atwood, Peeples, & Donovan, 2011; Bender & Kenally, 2016; Martin, Bekiaris, & Hansen, 2017; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011; Campbell & Dadiz, 2016. Researchers explained how such training is especially pertinent to neonatal transport given the low-volume, high-acuity nature of this population (Grisham et al., 2016). Transport clinicians experienced higher levels of satisfaction in simulation training and reported greater confidence in practical skill performance and assessment abilities (LeFlore & Anderson, 2008).

The findings from this literature review helped steer the beginning of the consultation process and determine what pertinent questions would help expand on the neonatal risk mitigation component and affirm the literature's claim of simulation being optimal training format for neonatal transport teams.

Consultations

This practicum's consultation had a three part purpose: 1) to garner insight to Keewatin Air's neonatal program needs; 2) to obtain best practice recommendations from neonatologists and NICU nurses for neonatal risk mitigation, and 3) to discover the optimal format of neonatal transport team training by speaking with established neonatal transport programs. Refer to Appendix B, pages 73-98 for consultation report.

Methods

As the organizations and neonatal experts who were included in this practicum's consultation were located across Canada and the United States, discussions were held primarily over the telephone and through email correspondence. Although it was the intention to perform the needs assessment with Keewatin Air's staff at one of their medical bases, transportation to this location was not feasible.

Recruitment. The consultation with established neonatal transport teams was focused primarily on those in the Canadian context as this project was linked to a Canadian transport program. The recruitment process at times had a snowballing effect, as teams would occasionally reference what they had learned from other transport programs, and consultation would be then be extended to said teams. A few neonatal transport teams from the United States were also consulted as many of these teams align their curriculum with standards set forth by accrediting organizations such as Air and Surface Transport Nurses Association, and Commission on Accreditation of Medical Transport (ASTNA, 2014; CAMTS, 2018).

The recruitment process was more purposeful when speaking with neonatologists and NICU nurses, as consults were mostly selected from tertiary care hospitals that Keewatin Air transports neonates to. A handful of NICUs were contacted in the USA after speaking with their respective neonatal transport team.

Data Management. All data obtained from consultations were entered into Microsoft Word. From here, in order to keep the data organized and to permit easier thematic and/or content analysis, tagging with text attributes were used. For instance, if looking to see if vibration on neonatal transport is a recurring issue from the interviews that would warrant more analysis, the steps were as follows: 1) Type *Ctrl F* (find) and input "vibration" 2) Click on the *More* button 3) Click on the *Format* button and select *Font* 4) Select all of the attributes you'd like to apply to "vibration" such as bold or a new font color 5) select *OK.* An index was then built at the beginning of the document to reference that themes align with certain text attributes. This enabled easy separation of the data sections that contained each attribute to enable further analysis.

Keewatin Air

To understand how best to support Keewatin Air's neonatal transport, an organizational needs assessment was necessary to appreciate the learning gaps and what the organization felt their primary program needs were with respect to neonatal transport. Additionally, this writer sought to garner an appreciation for Keewatin Air's existing resources for education delivery, and what their continuing education curriculum looked like in order to design a program support initiative that would be feasible to implement, and delivered in a manner Keewatin Air's staff would be receptive to.

Keewatin Air's leadership identified risk mitigation, improved funding, and expanded access to Neonatal Resuscitation Program certification for the northern bases as primary organizational needs. Speaking with a few front-line staff members however revealed a greater need for skill development that transcends what is covered in NRP. As such, a wide range of neonatal diagnoses and competencies were built into NTIPS Part II: Simulation Educational Toolkit to help meet these front-line staff learning needs.

Although this author could not perform an environmental scan of the remote bases to ascertain availability of resources (i.e. TeleHealth equipment, simulation mannequins, etc.) for continuing education, this data was gathered by speaking with Keewatin Air's staff.

Neonatal Expertise and Established Transport Teams

The consultation included an expert panel of neonatologists and NICU nurses to obtain evidence based best practice protocols that exist in the nurseries for risk mitigation (i.e. ways to reduce neonatal stress from vibration and sound) and to gauge whether such can be used on transport. Some interventions that were deemed translatable into a transport setting were the use of foam padding in the isolette to reduce vibration, and neonatal earmuffs to dampen loud noises. Such solutions identified in discussion with neonatal experts helped to inform risk mitigation section of NTIPS Part I: Program Support Presentation.

The consultation with well-established neonatal transport programs helped this author gather information on how they operate, what their curriculum entails, and the training format they utilize to ensure elite levels of skill proficiency, and neonatal competencies are upheld on their team. Simulation training was overwhelmingly reported as the gold standard for aeromedical education. As such, the educational toolkit was designed in this manner.

Resource Summary

Neonatal Transport Improvement Project

The literature review coupled with consultation with Keewatin Air, neonatologists, NICU nurses, and established neonatal transport programs helped guide the development of this practicum's project, Neonatal Transport Improvement Program (NTIP). This was divided into two parts: Part I- Program Support Presentation and Part II- Simulation Educational Toolkit (Refer to Appendix D pages 114-209 for NTIP Parts I + II). Although the original intent of this practicum was to develop an educational toolkit, numerous program needs were identified in the consultation with Keewatin Air. To address these concerns and ensure continued success of Keewatin Air's neonatal transport program, a program support presentation was built into the final project to go with the educational toolkit.

NTIP Part I: Program Support Presentation

A presentation was put together to address Keewatin Air's identified needs for their neonatal transport program: risk mitigation, improved access to NRP certification, and financial support (Refer to Appendix D, pages 118-130 for overview of NTIP Part I).

Risk Mitigation. Solutions for risk mitigation stemmed from consultation with neonatologists and NICU nurses to minimize vibration and noise stressors for neonates being transported. Heavy cloth covering the isolette exterior, dense foam padding underneath the isolette mattress, and neonatal earmuffs are presented as possible interventions Keewatin Air could employ to reduce the impact of noise and vibration on neonates. As neonates are sensitive to altitude related physiologic changes such as oxygen desaturation, the use of NIRS monitoring device is offered as a way for Keewatin Air's medical staff to have earlier detection of neonatal deterioration during flight and request altitude modifications such as lowered cabin pressure.

Improving NRP Access. In this program support presentation, ways of improving access to NRP certification for Keewatin Air's medical staff are proposed. One suggestion is to increase the number of certified NRP instructors in their staff so that front-line staff can receive their certification at Keewatin Air's medical bases rather than traveling to tertiary care facilities where the course is typically offered. Additionally, the option of expanding an existing TeleHealth program in Winnipeg, MB is explored as a way to provide the NRP certification remotely with instructors from Winnipeg teaching the course through TeleHealth. Lastly, a number of grants are presented as potential ways to fund the NRP expansion in Keewatin Air's northern locations.

Funding Opportunities. The three grants that are presented include: Canadian Paediatric Society: NRP Emerging Investigator, Nunavut Department of Family Services- Training and Employment Initiative, and Northern Health- IMAGINE (CPS, 2019; NDFS, 2019; Northern Health, 2019). The presentation details reasons why Keewatin Air would be competitive for each grant, how they can apply as a stand-alone organization or in collaboration with graduate students, and funding priorities of each grant.

The NTIP Part I- Program Support Presentation addresses Keewatin Air's identified primary organizational needs for their neonatal transport program. The presentation offers a number of solutions for consideration to help ensure optimal functioning of this northern neonatal transport program and thereby contribute to reducing existing health inequities of neonates in northern, underserved areas of Canada.

NTIP Part II: Educational Simulation Toolkit

Aeromedical transport of neonates demands advanced skill proficiency, strong patient assessment abilities, and excellent team dynamics for crisis management. To maintain such elite levels of neonatal competencies requires strong continuing education curriculum (Cross & Wilson, 2009). The purpose of NTIPS Part II: Simulation Educational Toolkit (Refer to Appendix D, pages 131-209 for overview of NTIP Part II) is to provide Keewatin Air with an educational toolkit that will largely consist of high fidelity simulation scenarios, which are considered the gold standard in education for aeromedical transport teams (Campbell & Dadiz, 2016; Martin et al., 2017; McGaghie et al., 2011).

Educator Preparation. To ensure Keewatin Air's MET (medical education team) has the necessary preparation to successfully facilitate the educational toolkit, suggestions for reading material are provided. This material includes: an overview of simulation's foundation and the rationale for its use as an educational format; advice for effectively facilitating simulation including how to provide debriefing and feedback; and extensive background information on a variety of neonatal diagnoses and transport-specific considerations. This was done to ensure Keewatin Air's MET had the tools and expertise necessary to successfully integrate the simulation educational toolkit into their continuing education curriculum.

As well, focus points are provided to help Keewatin Air's MET appreciate which elements of the learning exercise should be encouraged in each scenario, such as pre-transport stabilization using S.T.A.B.L.E (Taylor & Price-Douglas, 2008), effective communication and strong team dynamics. The importance of providing constructive feedback in simulation's debriefing is also emphasized.

Implementation and Evaluation. Other than the overarching recommendations for how best to facilitate this toolkit, how it is woven into the continuing education curriculum is at the discretion of Keewatin Air's MET. However the NTIP Part II includes an extensive section on evaluation. Learning outcomes are presented in a SMART (specific, measureable, achievable, realistic, time-phased) format (CDC, 2009) and a formal evaluation plan is built into the simulation's toolkit. In the evaluation forms, a number of categories are assessed (i.e. overall confidence in skill execution, team dynamics and communication, understanding of neonatal competencies for transport, etc.) using a Likert scale format. Keewatin Air's MET is provided with instructions for how to deliver the evaluations, and how to utilize the SMART objectives to assess whether learning outcomes are met.

Categories of Simulation Scenarios. Through consultation with Keewatin Air's medical staff members, learning needs that extended beyond the scope of NRP were identified. This is not surprising as NRP is applicable to a very specific and brief time frame directly following delivery, and the transport of a neonate may occur days or weeks after birth in some cases. The staff expressed interest in learning how to stabilize and properly manage various neonatal diagnoses that may warrant transport to tertiary care facilities. Therefore, an assortment of simulation scenarios was compiled to provide Keewatin Air's medical staff with a well-rounded education to adequately prepare them for safely and competently transporting this vulnerable population. Some of the categories include: shock; congenital cardiac defects; thermoregulation; prematurity; trauma; and altered mental status. For each category, the simulation facilitator for Keewatin Air's MET is encouraged to provide participants with the scenario background.

Next Steps

Resource Implementation

Keewatin Air's MET will begin implementing this program support resource late this spring. How the resource is integrated into Keewatin Air's medical education curriculum will be at the discretion of the MET. For instance, it may be more beneficial to only deliver portions of it periodically during existing continuing education days already built into the medical staff's schedules, rather than delivering the resource all at once. As well, when implementing NTIP Part II: Simulation Educational Toolkit, which medical staff members participate in certain scenarios may depend on the typical team composition (i.e. Keewatin Air might use physician, nurse, respiratory therapist during congenital cardiac defect transports whereas hyperbilirubinemia transports may require nurse only). Therefore, other than the overarching recommendations for how best to deliver the resource (i.e. debriefing for feedback post-simulation) Keewatin Air's MET will determine how best to implement this resource.

Resource Evaluation

A formal evaluation was developed and provided to Keewatin Air with one section to be distributed pre- and post education, and the remaining sections to be distributed to participants following the completion of education (Refer to Appendix D pages 205-207). To help Keewatin Air's MET self-evaluate instructor effectiveness, gauge success of the overall educational program, and determine whether participants met the learning outcomes of each simulation scenario, objectives are presented in SMART format (CDC, 2009).

Although outside of the scope of this practicum's timeline, this writer will be gathering data from these evaluations to modify or add to the education as needed. For instance if the medical staff express interest in learning more about a certain concept, additional simulation scenarios can be developed accordingly. Or, using the SMART evaluation questions (Refer to Appendix D page 208), this writer might be able to identify areas for reinforcing educator preparation. For instance, in determining whether Keewatin Air's MET understood how to deliver effective debriefing this writer can the

SMART objective “Effective debriefing will be provided as evidenced by not more than 50% of participants scoring less than 2 on Section C question #s 3, 4, & 5 after the simulation training.” If this objective is not met, it will cue this writer to reconsider and improve the debriefing component of the educator preparatory material.

Having objective criteria for the appraisal of this program support resource will help to evaluate it at micro (individual simulation scenarios) and macro (overall resource effectiveness) levels (CDC, 2009). This data can be used to help continuously improve Keewatin Air’s neonatal transport program through stronger education.

Aeromedical Simulation Integrative Review

This practicum’s literature review illustrated how simulation is touted as the gold standard education for aeromedical transport teams, and the overwhelming majority of transport program respondents in this practicum’s consultation citing simulation as the preferred method of training. This writer recognized however a paucity of empirical data to support simulation’s efficacy in the aeromedical setting and whether knowledge is retained or translated into practice following simulation. Additionally, as an experienced aeromedical transport nurse, this writer brings an awareness of the tremendous financial costs associated with aeromedical simulation. For these reasons, an integrative review was conducted to determine what evidence exists to support aeromedical simulation as an effective, cost-efficient form of training and whether knowledge is retained and applied (Refer to Appendix E, pages 213-236 for integrative review journal article).

Only five studies met the inclusion criteria for this review (Beeman & Orduna, 2018; Berger, Kuszajewski, Borghese, & Muckler, 2018; Dotson, Gustafson, Tager, &

Peterson, 2018; LeFlore & Anderson, 2008; Wright et al., 2006) and did not reveal any statistically significant evidence to support aeromedical simulation's efficacy. This is not to say simulation training should not be used among aeromedical teams, but rather that further research is warranted to improve its efficacy. This writer has finalized the integrative literature review and will be submitting it to Air Medical Journal this spring for publication.

Advanced Nursing Competencies

This practicum required this author to develop and employ three advanced nursing competencies in the research, clinical, and leadership categories, listed below respectively.

- *Research utilization:* Identify and implement research-based innovations for improving patient care (CNA, 2008 p. 24)
- *Clinical:* Plan, initiate, coordinate, and conduct educational programs based on needs (CNA, 2008 p. 23)
- *Leadership*: Evaluating programs in the organization and the community and developing innovative approaches to complex issues (CNA, 2008 p. 25)

The research competency "Identify and implement research-based innovations for improving patient care" (CNA, 2008 p. 24) was demonstrated in this practicum by conducting a literature review and consulting with neonatal experts to identify exists for research-based innovations that can be used to improve the care and overall safety of the neonatal patient on aeromedical transports. The literature review highlighted research-based safety risks, which informed the interview questions with neonatal experts to identify respective risk mitigation innovations that are employed in NICUs to improve patient care. This process enabled this author to provide Keewatin Air with advice for implementing research-based risk-mitigation recommendations to improve neonatal care and overall safety on aeromedical transport.

The advanced clinical nursing competency demonstrated in this practicum is "plan, initiate, coordinate, and conduct educational programs based on needs" (CNA, 2008 p. 23). During the beginning phases of the practicum, conversations with Keewatin Staff helped identify educational needs to inform the development of the program support resource, NTIP. The literature review and neonatal expert consultations were then essential to planning the education's content and delivery format. The educational toolkit component of NTIP was formally developed in the latter half of this practicum, and this author is helping Keewatin Air coordinate with the TeleHealth program at Winnipeg Children's Hospital to implement the program. The implementation phase extends beyond the scope of this practicum but instructions for how Keewatin Air's MET can facilitate the education were clearly outlined in the toolkit.

For the advanced nursing leadership competency, "evaluating programs in the organization and the community and developing innovative approaches to complex issues (CNA, 2008 p. 25), this author sought to address the complex issue of improving access to neonatal care in remote communities of Northern Canada through safe, competent aeromedical neonatal transport. Keewatin Air was identified as an aeromedical program that provides such aeromedical transport service delivery and an evaluation was conducted to identify neonatal knowledge gaps and ways to improve competent, safe care. A program support resource was developed (NTIPS Part I and II) to help bridge identified knowledge gaps and provide curriculum that aligns with recommendations from transport organizations such as CAMTS (2018). As well, innovative approaches to remedy the barriers to accessing resources in the remote northern communities are presented in NTIPS Part I. These entail using the existing TeleHealth program in WCH's NICU to give Keewatin Air staff access to expert resources and guidance, having NRP certification delivered remotely through TeleHealth, and various funding opportunities Keewatin Air could engage to help address the complex issue of neonatal health inequity in Northern Canada.

This practicum provided an opportunity to demonstrate the aforementioned advanced nursing competencies because it involved evaluating an organization through a formal needs assessment to garner an awareness of the complex issue of improving access to safe neonatal care in remote areas; identifying evidence-based practice recommendations to improve patient safety; and designing and coordinating an educational resource for an organization. The success of this practicum project required advanced nursing competencies that span across clinical, research and leadership realms.

Conclusion

Neonatal aeromedical transport is a risky endeavor (Schierholz, 2010) but remains the only option available for neonates from Northern Canada to access specialized care (McKenzie, 2015). To safely and competently transport this vulnerable population requires certification in NRP, an appreciation for neonatal risk mitigation, and a strong continuing education curriculum to maintain advanced competencies. This practicum's

Neonatal Transport Improvement Project provides Keewatin Air with resources to support its neonatal transport service delivery to the remote communities of Northern Canada. Keewatin Air will now have a toolkit to integrate into their clinical curriculum to improve their medical staff's neonatal competencies and ultimately neonatal safety during aeromedical transport.

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Appendix A

Literature Review
Improving Aeromedical Neonatal Transport

The number of communities in northern Canada that are inaccessible by ground transport (StatsCan, 2015) and lack specialized neonatal care (CANN, 2014) warrants the need for neonatal medevac flight transports. Optimization of neonatal clinical outcomes on flight transports requires the identification of key safety issues for neonates that are unique to air transport, and evidence-based practice recommendations to address these concerns. This literature review examines studies that identify evidence to support various interventions transport clinicians can use to maximize neonatal patient safety on flights and improve clinical outcomes. As well, the review underlines simulation as an effective training method that has been found to adequately preparing transport teams for safe clinical practice. The overall conclusion drawn from this literature review is that there is evidence to support pre-transport stabilization, the use of specialized neonatal teams for transport, and high fidelity simulation for transport clinician training.

Background

Despite ample evidence for aeromedical services (AMS) improving response times and clinical outcomes for adult conditions such as myocardial infarctions or cerebrovascular accidents, scant data exist demonstrating improved neonatal outcomes with AMS (Killion & Stein, 2009, p.207). In addition to inherent risks with flying when faced with urgency (Zigmond, 2008), numerous safety concerns exist for neonates such as intolerance to extreme temperatures, noise, and atmospheric pressure changes (Schierholz, 2010), and the cerebral bleeding risk associated with rapid acceleration or deceleration (Bouchut, Lancker, Chritin, & Gueugniaud, 2011). However, the remoteness of Canada's northern communities, in particular those of Nunavut, often necessitates AMS for neonatal transport as many communities lack road-access or are located too many hours away from tertiary care centers to make ground transport feasible (McKenzie, 2015). In Alvarado-Socarras, Idrovo, and Bermon's (2016) study on Columbia, another country with geographical characteristics that hinder ground access to communities and equality in healthcare services, AMS was the only feasible method of reducing mortality rates for remote critically ill neonates to at least levels comparable to more stable neonates transported by ground.

Researchers argue that neonatal AMS risks strengthen the case for making every effort to transport the neonate in utero to reduce neonatal vulnerability to such aforementioned risks (Barker, Costello, & Clark, 2013; Lang, Brun, Kaaresen, & Klingenberg, 2007; Hohlagschwandtner et al., 2001; Truffert, Goujard, Dehan, Vodovar, & Breart, 1998). However, while in-utero transport is considered gold standard for transporting high risk neonates, it comes with many barriers including maternal refusal of transport, the team having to be trained in both maternal and neonatal critical care (Meyer, 2013, p.210) and the risk of delivering the vulnerable neonate during flight in an environment without adequate resources or support (Lang et al., 2007). Given the longer flight durations required to access the northern communities in Canada, the latter risk can be seen as a possible impediment to in-utero transport.

In today's healthcare climate, the matter of improving service delivery and healthcare access to culturally diverse groups has become compulsory (CNA, 2010;

CIHR, 2017; Health Canada, 2013). Many Nunavut patients are Inuit, a culture that is medically underserved (Greenwood, de Leeuw, & Lindsay, 2018). Waldram and Herring (2006) illustrated the effects this health disparity has on Inuit children by revealing an infant mortality rate three times higher among the Inuit population than the national average in Canada. According to a report by the international aid organization Save the Children, Canada has the second highest first-day infant mortality rate among countries of similar status in the industrialized world (CBC, 2013). This further demonstrates the need for improved AMS safety, particularly as it relates to the transport of neonates from northern Canada.

Making recommendations for Canadian AMS quality improvement for neonatal transports however is complicated by a deficiency in transport specific evidence based practice recommendations (Cornette, 2004), and the lack of governing bodies or accreditation organizations for neonatal transport teams in Canada. Where the United States mandates either Certified Transport Registered Nurse or Certified Flight Registered Nurse certifications through the Air and Surface Transport Nurses Association (ASTNA, 2014), no such organization exists for Canada. According to Whyte and Jeffries (2015), the lack of standardized education, equipment, and protocols among neonatal transport teams in Canada is a significant barrier to patient safety. Additionally, although the Canadian Association of Paediatric Health Centres recently put forth recommendations for a minimum set of standards for neonatal and pediatric transports (CAPHC 2012), no quality indicators exist for evaluating neonatal transport team performance (Cross & Wilson, 2009). Given the paucity of regulations in Canada, the purpose of this review is to reveal which neonatal safety issues on AMS are most frequently cited in the literature, and to provide possible recommendations to remedy such issues.

Literature Review

The key question this literature review will address is: What evidence based best practice recommendations exist for the care of neonatal patients with special consideration to flight transports? The studies and information presented in this literature review stemmed from CINAHL and PubMed searches for English quantitative studies since 2000. Exclusion criteria included: studies before 2000, studies that are of broad transport focus and do not explicitly address neonatal and/or pediatric considerations, and qualitative studies. The following key words were used in the searches: neonatal flight transport, neonatal best practice, northern healthcare, neonatal medevac, premature neonate, and neonatal flight nursing. Boolean operators and various MeSH terms were used. After reading the abstract of each study, if deemed applicable to the key question in this review, the complete study was analyzed.

Many of the studies with stronger designs were dated (Campbell, Lightstone, Smith, Kirpalani, & Perman, 1984; Truffert et al., 1998; Chance, Matthews, Gash, Williams, & Cunningham, 1978), or had authors admitting to reporting bias (Chance et al., 1978). As such, it was necessary to interpret the aforementioned studies with caution and to broaden the search to include relevant retrospective chart reviews. This was helpful as the data gleaned from these reviews substantiated the identified safety issues.

The purpose of this literature review is to identify evidence based practice recommendations for the transport of critically ill neonates. Additionally, the literature review will illustrate the top five safety issues to focus on for neonatal flight transports. The Public Health Agency of Canada's (2014) Critical Appraisal Tool for Analytic Studies and Critical Appraisal Tool for Descriptive Studies are used to evaluate the studies in this review. In seeking to determine how evidence based practice recommendations can be used to improve neonatal patient safety on medevac flights, the studies are discussed as they relate to the development of an educational resource for an existing neonatal transport service, Keewatin Air. A table presenting the studies can be found in the Appendix with the heading: studies examining neonatal aeromedical transport, where additional details on each study can be found.

Critically Appraised Studies

Using the PHAC (2014) Critical Appraisal Tool for Analytic Studies, two cohort studies were assessed (Karlsson et al., 2011; Towers, Bonebrake, Padilla, Guadalupe, & Rumney, 2000), one prospective pilot study (Valente, Sherif, Azen, Pham, & Lowe, 2016), one controlled before and after study (Stroud, Gupta, & Prodham, 2012), one uncontrolled before and after study (Lee et al., 2001), one randomized study (Gajendragadkar, Boyd, Potter, Mellen, Hahn, & Shenai, 2000), and one correlational study (Bouchut et al., 2011). Refer to the Appendix for tables that provide critical appraisal details of these respective studies.

Pre-Transport Stabilization. References to neonatal specific safety risks associated with flight transports are well documented in existing literature (Bouchut et al., 2011; Grosek, 2014; Ohning, 2015; Ratnavel, 2009; Schierholz, 2010). An article by a leading AMS neonatal team in the United States, AirLife Denver, describes the effects of altitude changes on gas volume expansion (Schierholz, 2010), which if not properly managed can make stable pneumothoraxes or bowel obstructions expand into life threatening pneumothoraxes or intestinal perforations respectively (Grosek, 2014; Schierholz, 2010). In addition to altitude related complications, Skeotch, Jackson, Wilson, and Booth (2005) note that acceleration and deceleration, thermoregulation, sound and vibration, and respiratory management are primary safety concerns in neonatal transports.

To mitigate such risks requires skillful assessment of the neonate prior to departure, and pre-transport stabilization (Messner, 2011; Ohning, 2015) with preventative measures such as chest tube insertion, gastric decompression, and intubation (Schierholz, 2010). Additionally, transport teams must understand aviation physiology to know when to request lower barometric cabin pressure to alleviate hypoxia for instance (Woodward & Vernon, 2002).

Numerous tools have been developed for evaluating neonatal stability on transport but are not validated, such as the Neonatal Status Score (NSS) (Saldanha, Somes, Conklin, & Kopelman, 1986), and the Alberta Neonatal Transport Stabilization Score (ANTSS) (Shorten & Fox, 1993). Other instruments such as the Score for Neonatal Acute Physiology Version II (SNAP-II) (Richardson, Corcoran, Escobar, & Lee, 2001) or the Clinical Risk Index for Babies (CRIB) (Cockburn et al., 1993), though well-tested for reliability and validity are more conducive towards a neonatal intensive care unit (NICU) as the tools require data collection over an extended period of time.

Recognizing both the importance of pre-transport stabilization, and the lack of a psychometrically sound assessment tool for transport stability, Lee et al. (2001) sought to develop and validate an instrument that could be used for judging physiological stability pre-transport. Lee et al. (2001) created the Transport Risk Index of Physiologic Stability (TRIPS) which uses four empirically weighted items (temperature, response to noxious stimuli, respiratory status, and blood pressure) to score low to high risk (0-10 respectively) for predicting seven day mortality, total NICU mortality (until discharge), and severe (>grade 3) intraventricular hemorrhage (IVH) (Lee et al., 2001). While the instrument's predictive ability for total NICU mortality and severe IVH was significantly greater than ANTSS ($p < 0.05$), researchers admitted to data collection inconsistencies resulting in potential bias (Lee et al., 2001). In discussing their univariate analysis, Lee et al. (2001) explained that they omitted physiologic variables that they felt were not associated with mortality but failed to identify which variables or how they came to this conclusion.

Of additional concern, Lee et al. (2001) admitted to poor retention rates in their study (data available for only 71% of participants) but argued that this was due to inadvertent missed opportunities for data collection prior to interventions and not due to the TRIPS tool having poor usability. For determining the weight certain physiologic variables would have on the prediction of outcome, Lee et al. (2001) appropriately calculated β-coefficients using logistic regression. Researchers also used receiver operating characteristic (ROC) scores to demonstrate adequate criterion validity for

TRIPS to predict seven-day mortality (ROC 0.72-0.83), with 0.5 indicating non-discriminative and 1.0 being perfect discrimination (Lee et al., 2001).

Despite showing adequate criterion validity, good fit between instrument and the data measured, and strong predictive performance, Lee et al. (2001) confessed that additional validation would be beneficial. Further psychometric testing of TRIPS could include a common exploratory factor analysis to assess internal consistency, a test-retest method to examine the stability and reliability of the tool, and expert review for content validity. Despite the need for further testing, it would behoove neonatal transport teams to utilize the TRIPS tool as a way to gauge a neonate's physiological stability or the need for any additional prophylactic stabilization interventions prior to transport.

Sound and Vibration Stress. Neonatal transport-specific stressors must be identified and described prior to exploring possible interventions to mitigate the damaging effects on neonates. Bouchut et al.'s (2011) correlational study provides the top five physical stressors on the neonate: acceleration, vibration, noise, pitch, and rate of turn. In an effort to control for confounding variables, researchers used standardized patient positioning and equipment on transport (i.e. no shock suppression device or earmuffs were used in any of the transports), and continued recording results until data saturation was met (Bouchut et al., 2011). Furthermore, Bouchut et al. (2011) made efforts to improve the applicability of their findings by involving more than one form of transport (ground ambulance and helicopter) in their assessment. However, this study was limited by its descriptive nature and lack of statistical analysis of data. When providing comparisons between dynamic stressors on kinetics between helicopters and ambulances, Bouchut et al.

(2011) only offered differences in measures of central tendency and failed to demonstrate if said differences were statistically significant.

Of the aforementioned stressors, noise and vibration are predominantly reflected in neonatal transport literature (Bailey et al., 2018; Campbell et al., 1984; Karlson et al., 2011; Gajendragadkar et al., 2000; Sittig, Nesbitt, Krageschmidt, Sobczak, & Johnson, 2011). According to Bailey et al.'s (2018) cohort study, the levels of noise and vibration which neonates are exposed to during helicopter (80.4-86.4 dBA; 1.68-5.09 m/s^2 respectively) and ground transport (70.3-71.6 dBA; 1.82-3.96 m/s^2) exceed acceptable adult standards. Similarly, Sittig et al.'s (2011) study revealed close to 80dB incubator noise levels on AMS, which far exceeds proposed noise limit recommendations of 45dB in neonatal intensive care units.

To examine the degree to which sound and vibration affect neonates on transport, Karlsson et al. (2011) conducted a cohort study that measured neonatal stress by changes in heart rate. Using tachycardia as a stress indicator, they found that neonates were more affected by sound than vibration ($p= 0.05$), and using low heart rate variability (HRV) as an indicator for poorer physiologic status ($p<0.001$), they found that neither sound nor vibration effected HRV ($p<0.01$). The study's sample size, albeit small ($n=16$) was sufficient as statistically significant ($p=0.05$) differences were found in neonatal stress levels indicated by tachycardia, where higher heart rates were observed among neonates without hearing protection compared to those wearing earmuffs ($p<0.01$).

Although Karlson et al. (2011) clearly defined how neonatal stress was measured in their study, and used appropriate statistical testing for their data (ANOVA; simple and multiple logistic regression analysis) the study was not without limitations. For example, the study had poor generalizability, and confounding factors were acknowledged but not controlled for as baseline demographics (e.g. diagnosis, use of supplemental oxygen) were provided but differences between groups were not made available for comparison. Of additional concern, Karlsson et al. (2011) failed to demonstrate if neonate assignment to groups with or without earmuffs was randomized. This could have skewed the results if a higher number of neonates who would physiologically be more sensitive to sound (i.e. lower gestational age or weight) were in the group without earmuffs. The therapeutic effects of earmuffs on noise reduction in this study lays potential groundwork for an evidence-based practice recommendation that transport clinicians could use to reduce neonatal harm related to noise on transport, but further research is necessary to supplement and corroborate these findings due to the aforementioned limitations of Karlsson et al.'s (2011) study.

Using the PHAC (2014) appraisal tool, the studies by Bouchut et al. (2011) and Karlsson et al. (2011) were judged to be of low and medium quality respectively. This made it difficult to fully appreciate the association between physical stressors such as sound and vibration negatively impacting the neonate.

Gajendragadkar et al. (2000) conducted a randomized study of different transport mattresses to attempt vibration risk mitigation for neonates. Vertical acceleration measurements were taken from two locations, the forehead of a mannequin and the incubator base, to calculate root mean square (RMS) values (Gajendragadkar, 2000). The ratio of RMS values at the two locations was indicative of either vibration attenuation or accentuation (RMS <1.0; RMS >1.0 respectively). The findings revealed that the use of a gel mattress, by itself or combined with a foam mattress, reduced accentuation of vibration (regression coefficient +/- SE= 1.08 +/- 0.15, $P<0.001$) better than the foam mattress (regression coefficient +/- SE= 0.42 +/- 0.16, $p=0.017$), and none of the mattresses effectively attenuated vibration felt during transport (RMS>1.0 for all mattress types). Further, researchers tested mannequins with lower weight on each of the mattresses and found the gel mattress was less effective in vibration attenuation, suggesting potential for increased harm to very low birth weight (VLBW) neonates (Gajendragadkar et al., 2000). This is similar to findings by Prehn et al. (2014) where transport mattresses that reduced vibration for neonates weighing at least 2000 grams were markedly ineffective when used with VLBW neonates. This is concerning given the increased susceptibility VLBW neonates have to IVH from stressors such as vibration (Blackburn, 2009).

Despite Gajendragadkar et al.'s (2000) efforts of forming an evidence-based practice recommendation to mitigate the vibratory stress on neonates during transport, they admitted further research is needed to identify interventions more effective than the studied mattress types at absorbing said harmful vibration. Although there was adequate control of information bias with drivers on each ambulance run blinded to the mattress type being tested, the study was weakened by missing data (regression coefficient and statistical significance was not provided for gel mattress test or when lower weight mannequin was used). Additionally, a possible confounding factor, speed of vehicular travel, was not acknowledged or controlled for in this study. Gajendragakdar et al. (2000) illustrates the need for additional work on developing risk mitigation strategies for transport vibration, however to this author’s knowledge no further evidence-based practice recommendations have been published since.

Altitude, Acceleration, and Deceleration. During neonatal transport, the effects of rapid acceleration and deceleration on cerebral perfusion and increased risk for intraventricular hemorrhage (IVH) are well known (Fenton, Leslie, & Skeoch, 2004; Skeoch, Jackson, Wilson, & Booth, 2005; Valente et al., 2016). In a cohort study by Towers et al. (2000), incidence rates of IVH were compared between neonates transported from level 1 hospitals to a tertiary medical center (n=44) and neonates born at said tertiary center (n=285) given they met inclusion criteria (birth weight 500-1200g and gestation age of at least 24 weeks). A statistically significant higher incidence rate of IVH was found among transported neonates vs. inborn neonates (23% vs. 9%; $p<0.02$, 95% confidence interval 0.15, 0.87). Towers et al. (2000) identified possible confounders, (i.e. higher gestational age and weight as these are associated with reduced risk of IVH) but as such traits were more prevalent among the transported neonates, multivariate analysis was not necessary.

Despite the statistically significant findings, such results should be interpreted cautiously due to inadequate control of information bias as assessors were employees of the tertiary center, which funded the study, and Towers et al. (2000) were unable to demonstrate how such potential bias was controlled. For these reasons, this study was judged to be of medium quality using the PHAC (2014) appraisal tool.

In Valente et al.’s (2016) prospective pilot study, researchers measured peak acceleration force on neonatal transports and assessed the degree to which cerebral oxygenation was affected. Researchers also considered variations in patient positioning given the risk of increased intracranial pressure with a head-to-back patient orientation (Woodward & Vernon, 2002) and the decreased cerebral oxygenation with a head-to-front orientation during takeoff and vice versa with landing for each position respectively (Hurd & Jernigan, 2003). Using a cerebral oximeter to monitor regional saturation of oxygen (rSO_2) and an accelerometer to measure z-axis (aligned with the neonate's spine) peak acceleration (ZAPA), Valente et al. (2016) found decreased rSO_2 during takeoff with a head-to front position (20% of neonates) or landing with a head-to-back position (44% of neonates), but such findings were not statistically significant ($p=0.11$, $p=0.13$ respectively). Between ground, fixed wing, and helicopter transports there was minimal variation in ZAPA magnitude in takeoff and landing (illustrated by overlapping confidence intervals 0.01-0.43).

Valente et al. (2016) admitted to a number of limitations to their study and thus stressed that their findings should be interpreted with caution. Such limitations include: insufficient power with small sample size (n=24); inadequate control of selection bias with convenience sampling; limited battery life on the cerebral oximeter hindering monitoring duration; inadequate control of confounding variable (i.e. lateral and vertical forces impacting cerebral oxygenation); and tools used that were not tested for validity or reliability (i.e. cerebral oximeter not tested for medical transport settings). Additionally, despite not finding statistically significant evidence to support their hypothesis that such drops in rSO_2 would occur, Valente et al. (2016) cautioned that the rate of acceleration and deceleration in their study were smaller than those reported in other studies where jets were used for transport (Kobayashi, Kikukawa, & Onozawa, 2002; McKinley, Tripp, Bolia, & Roark, 2005), which may have skewed their findings. Given the vast of distance between northern Canadian communities and tertiary care centers, jets are frequently used for neonatal transports to cover expansive distances faster without requiring fuel stops (CBC, 2014; Helijet, 2018; Keewatin Air, 2015; Manitoba Health, 2017). The notion that greater drops in rSO_2 occur when traveling on jets is therefore highly relevant to the Canadian context.

Regarding the effects of altitude on cerebral oxygenation, Stroud, Gupta, and Prodham's (2012) controlled before-and-after study (CBA) revealed statistically significant differences between baseline (control group) cerebral oxygen levels using near-infrared spectroscopy (NIRS) and cerebral oxygen when transported at an altitude greater than 5000 feet above ground level (exposure group) (NIRS 69.2% SD 8.9% versus NIRS 66.3%, SD 9.8%, $p<0.001$ respectively). Stroud et al. (2012) used Dalton's Law ($P_t = P_1 + P_2 + ... + P_n$) to explain how drops in barometric pressures and partial pressures of oxygen at higher altitudes impair oxygen movement along the alveolar-capillary pressure gradient thereby reducing the amount of oxygen delivery to vital tissues and organs (p. 329). Stroud et al.'s (2012) findings suggest that NIRS monitoring provides the benefit of earlier decreased oxygenation detection as their study revealed no change in pulse oximetry (SpO2) values despite significant reduction in cerebral oxygenation levels (baseline and 5000 altitude: NIRS= 69.2%, 66.3%, $p<0.001$; SpO2= 98.7%, 98.9% $p= 0.61$). Researchers therefore stressed the importance of using NIRS monitoring during neonatal-pediatric transports to enable early detection and intervention for altitude related oxygenation impairment in this vulnerable population (Stroud et al., 2012).

Despite the use of appropriate statistical tests for the level of data (Student *t* test, Fischer exact test for continuous and categorical data respectively), and correct interpretation of the statistically significant findings at $p<0.05$, Stroud et al.'s (2012) study was not without limitations. Weaknesses to their CBA include: inadequate control of selection bias with convenience sampling; inadequate control for confounding variables with no standardization to medical interventions used; and no data on baseline demographic differences (i.e. wide age range of 1 month- 16 years old) made available to assess whether these factors played a role on the patient's response to altitude. For these reasons, using the PHAC (2014) appraisal tool for analytic studies, Stroud et al.'s (2012) CBA was judged to be of medium quality.

Recommendations to Improve Neonatal Transport Safety

Although numerous studies on neonatal transport exist, most are plagued by bias, dated publication, or medium quality. As Cornette (2004) and Quinn, Pierce, and Adler (2015) noted, there has been a noticeable gap in evidence-based literature for neonatal transport medicine, which leads to possible safety issues when teams rely on assumptions to inform best practice. Indeed, this literature review revealed sparse quality evidence to support best practice interventions for neonatal transport risk mitigation. One possible reason for this is the plethora of confounding factors that exist on neonatal transport including gestational age, reason for transport, interventions provided, and mode of mobilization, which Bouchet et al. (2011) argued makes the pathophysiologic effect of transport on neonatal health outcomes difficult to study. Therefore, further research is warranted with multiple logistic regression analysis used to control for confounding variables, or study designs with a control such as comparing stress levels (e.g. indicated by tachycardia) between neonates within a specified weight range transported via ground verses air ambulance.

The critically appraised studies in this review illustrated key safety risks neonates face during AMS transport. However, publications specific to evidence based practice recommendations for transport are scant and minimal quality indicators exist specific to transport (Cross & Wilson, 2009). As such the following recommendations for improving neonatal safety on AMS transport should be taken with the understanding that further research is warranted to explore if such interventions would correlate with improved neonatal outcomes.

Team Structure

Regarding the team composition for neonatal flight transports, there is a lack of uniformity, which is cited as leading to potential inconsistencies in safety and quality (Ratnavel, 2009). One AMS team rooted in a world-renowned pediatric medical center, St. Louis Children's Hospital, achieves impressive clinical outcomes and low safety incident rates in more than 1800 critical care neonatal and pediatric AMS transports annually (Atwood, Peeples, & Donovan, 2011). To achieve optimal neonatal care on transport, this team recommends the following a nurse (RN)- respiratory therapist (RT) or paramedic team composition with mandatory experience of at least five years of pediatric critical care, and the following certifications: Pediatric Advanced Life Support; Neonatal

Resuscitation Program; Certified Neonatal and Pediatric Transport Nurse; and Trauma Nursing Core Course (Atwood et al., 2011). Similarly in Canada, two of the main children's hospitals that receive neonatal transports from northern communities, Winnipeg Children's Hospital (WCH) and Children's Hospital of Eastern Ontario (CHEO), utilize the same team structure (RN/RT), and have the same qualification requirements. These two facilities also mandate up to 12 months of neonatal transport orientation with Objective Structured Clinical Examinations (OSCEs) and other formal evaluations (CHEO, 2013; WRHA, 2014). Although this level of resource availability, education time, and staffing may be impractical in some clinical areas, it is a standard with demonstrated success.

Woodward et al. (2002) provided an overview of the second national pediatric and neonatal inter-facility transport medicine leadership conference in the United States, which included a section highlighting the role of the medical director. According to Woodward et al.'s (2002) consensus of this conference, a best practice recommendation is to ensure the medical control for a neonatal-pediatric transport team has extensive acute care experience or subspecialty training in the specific population being transported. The conference's proceedings however did not provide concrete evidence as to which particular team structure (i.e. RN-RN, RN-RT, physician- RN, etc.,) leads to the most favorable clinical outcomes but rather stressed that the level of training and experience have greater impacts on safe patient care during transport (Woodward et al., 2002).

In agreement with the recommendations by Woodward et al. (2002) a review of current evidence shows that even if team composition varies, a key determinant of safe clinical outcomes in neonatal transport is the use of a neonatal specific team that is adequately trained versus a general all-encompassing medical transport team (Chance et al., 1978; Colyer, Sorenson, Wiggins, & Struwe, 2018; Fenton et al., 2004; Fenton & Leslie, 2009; Hamrin, Berner, Eksborg, Radell, & Flaring, 2016; Kumar, Kumar, Shaik, Ghanta, & Venkatalakshmi, 2010; Messner, 2011; Skeoch et al., 2005). As stated in Woodward et al.'s (2002) summary of the pediatric and neonatal inter-facility transport medicine leadership conference, of particular importance to patient safety with regards to team structure is the level of population specific training. For instance, recommendations from the conference included encouraging transport teams typically accustomed to older pediatric patients and/or adults to refrain from transporting neonates unless extensive training has been done to ensure a population-specific competency has been met (Woodward et al., 2002).

Indeed, a prospective cohort study by Orr et al. (2009) illustrated how use of a specialized pediatric transport team correlated with improved survival rates (death occurrence for patients transported by pediatric team (9%) compared with non-specialized team (23%) $p<0.001$) and fewer unplanned events (i.e. loss of vascular access, cardiopulmonary arrest, airway events). Considering the preceding evidence, recommendations for improving clinical outcomes during neonatal transport with respect to team structure are as follows: recruit team members who have a strong pediatric-neonatal clinical background; mandate that the transport team's medical director has extensive experience as an acute care provider for the neonatal-pediatric population; provide extensive ongoing pediatric-neonatal education; and operate exclusively as a pediatric-neonatal transport team to maximize exposure to and familiarity of population specific clinical considerations.

Style of Training

Given the need for transport clinicians to demonstrate advanced competencies and skills in settings with limited resources or support, high quality training is warranted. As instruction via didactic delivery provides insufficient assessment of a clinician's ability to manage a scenario, simulation training is warranted (Martin, Bekiaris, & Hansen, 2017; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011; Campbell & Dadiz, 2016) with OSCEs integrated throughout the curriculum (Fenton & Leslie, 2009). Grisham et al. (2016) explained how such training is especially pertinent to neonatal transport given the low-volume, high-acuity nature of this population. High satisfaction levels were reported with transport simulation training in LeFlore and Anderson's (2008) study with participants citing greater confidence in skill execution and improved communication and teamwork.

Considering the need for transport team members to be able to operate in sub-optimal environments with immense levels of stress and responsibility, strong teamwork and communication are imperative to improving clinical outcomes on neonatal transport as deficiencies in communication and teamwork were cited as the root cause in 70% of adverse events in Weaver, Dy, and Rosen's (2013) integrative review. In addition to strengthening team dynamics and communication, Bender and Kennally (2016) lauded the opportunities available for improving skill proficiency, ensuring transport equipment functions properly, and providing opportunities to identify potential safety issues when training is done through simulation. Indeed, according to Atwood et al. (2011) continuing education for neonatal transport teams is most successful when delivered via high fidelity simulation and cadaver labs for more realistic practice of advanced skills and assessments.

In Canada, both CHEO and WRHA require intensive simulation training as part of their onboarding process for new team members, and utilize simulations for their continuing education and competency evaluations (CHEO, 2013; WRHA, 2014). Certainly a recommendation can be made for the use of high-fidelity simulation as the ideal type of training for neonatal transport clinicians so that neonatal safety risks can be mitigated and optimal clinical outcomes achieved.

Conclusion

Ensuring safe outcomes during AMS transports of critically ill neonates requires a thorough understanding and awareness of the risks unique to transport particularly with respects to this vulnerable population. This literature review highlights the use of high-fidelity simulation training as the best-practice training tool for transport teams, and provides critical appraisals of studies on evidence-based risks that exist for neonates on transport. However, this review also gives insight to the gaps that exist for best practice interventions to be used during neonatal transport to optimize safe outcomes (Cornette, 2004; Cross & Wilson, 2009). As such, further research is warranted to explore interventions that can be employed to reduce the identified transport risks for neonates.

Recommendations made in this paper stem from studies that looked at ways to improve clinical training efficiency, and protocols from highly reputable neonatal transport teams in Canada and the United States (Atwood et al., 2011; CHEO, 2013; WRHA, 2014). Additional work is needed on standardizing protocols, equipment, and training to ensure high quality transports are available to all neonates regardless of their location of origin in Canada. This will help to reduce existing health inequities and be a potential step for improving Canada's infant mortality rate.

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Appendix

Table 1: Studies Examining Neonatal Transport Risks

Author	Participants/Setting/ Methods/Outcome Measures	Results	Comments
Karlsson, et al. (2011) Design: Cohort	**Participants & Setting:** - 16 infants transported by a Swedish neonatal team; 10 of these infants wore earmuffs during transport (group A), 6 did not (group B) - Means: age at time of transport, gestational age at birth, weight (17 days, 33wks, 2507g respectively); duration of transport (2h30min) - Demographics also provided for percentage of infants with certain diagnoses **Methods:** - Infant exposure to sound measured in dBA, vibration measured in m/s^2 (measured during flight and pre/post on ambulance to and from airport and hospitals) - Health status of infant measured pre- and post- transfer via Transport Risk Index of Physiologic Stability (TRIPS) tool - Heart rate (HR) and HR variability (HRV) examined using electrocardiogram - ANOVA and multiple linear regression analysis used	**Results:** - Sound and vibration during neonatal transports exceed recommended limits for adults - Mean vibration and sound levels = $0.19 m/s^2$ 73 dBA respectively - Neonates exhibited greater stress with higher sounds (high HR, $p = 0.05$), than with vibration; vibration in this study seemingly correlated with soothing effect (lower resting HR $p < 0.05$) - Lower HRV associated with neonatal stress and poorer physiologic status ($p<0.001$), but neither sound or vibration effected HRV ($p<0.01$)	**Overall Rating:** *Quality of Study: Medium* *Strength of Study Design: Moderate* - Heterogenous sample - Small sample size but significant differences found - Participants all from single facility (poor generalizability - Inadequate control of selection bias (random selection not used; no baseline demographic data provided between two groups) - Appropriate statistical analysis and interpretation of results - Unclear how infants were chosen for each group - TRIPS tool well-tested for reliability/validity - Moderate control for confounding variables with regression analysis - Strong feasibility of implementation or repeatability of the study

Table 1 Continued: Studies Examining Neonatal Transport Risks

Author	Participants/Setting/ Methods/Outcome Measures	Results	Comments
Towers et al. (2000) Design: Cohort	**Participants & Setting:** - All newborns admitted to large tertiary neonatal intensive care unit in California from June 1992- December 1995 were evaluated (infants arriving via transport within 24hrs of via transport from 11 level 1 facilities to the tertiary NICU [*group A:* n=44]; infants born at same tertiary center [*group B*: n=285] - Inclusion criteria: live born infants weighing between 500-1200g and at least 24 weeks gest age (n=329 for those who met study criteria) **Methods:** - Incidence rate of grade III & IV intraventricular hemorrhage (IVH) compared between groups A+B - Baseline demographic data gathered for both groups (i.e. gestational age, weight, apgars, etc.) - Data analyzed using Student *t* test, Mann-Whitney U test, Chi Squared, and Fischer exact test	**Results:** - Statistical significance defined as $p<0.05$ - No significant difference in baseline demographics between groups - 11% of all newborns in study experienced grade III or IV IVH - Group A had statistically significant higher incidence of IVH than Group B (23% vs. 9%; $p<0.02$, 95% confidence interval 0.15, 0.87) - Although not statistically significant, Group B had lower gestational age which further emphasizes the finding (as lower gest age= correlated with higher risk of IVH) - Multivariate analysis not warranted as factors that would have decreased the risk of IVH (i.e. higher gest age, heavier birth wt female gender, etc.) were found in Group A (which had the higher incidence rate)	**Overall Rating:** *Strength of Study Design: Moderate* *Quality of Study: Medium* - Appropriate statistical tests used for data and interpreted correctly - Confidence interval and statistical significance level identified - Similar baseline demographics between groups demonstrated - Participants from a variety of locations and efforts made to capture target population (very low birth weight VLBW infants in tertiary NICU and surrounding level 1 nurseries) - Does not show how bias reduced with respect to data collection (assessors were from tertiary center and funding received from tertiary center) - Authors admit an area of potential bias was not capturing all VLBW infants transferred but efforts made to analyze all transports q 1-3months and no infant that met the study criteria was transferred to a separate tertiary care facility

Table 1 Continued: Studies Examining Neonatal Transport Risks

Author	Participants/Setting/ Methods/Outcome Measures	Results	Comments
Stroud et al. (2012) Design: Controlled Before and After	**Participants & Setting:** - Convenience sample of 17 neonatal-pediatric patients transported via AMS to Arkansas Children's Hospital (ages 1mo 17 yrs) - Setting was in aeromedical helicopters used for neonatal-pediatric transports - Study timeframe between Jan 2010- Jan 2011 - Total sample (n=17); room air (n=2); supplemental oxygen (n=12); mechanical vent (n=3). **Methods:** - Patients received continuous near infrared spectroscopy (NIRS) for cerebral oxygenation, telemetry, (&end-tidal CO2 for vented patients) monitoring during transport - Comparisons made in NIRS from baseline to cruising altitude: control group (altitude <5000 feet) vs. exposure group (altitude >5000 ft). - Data provided for patients on RA, supplemental oxygen, and mech vent - S*t* test (continuous data) and Fisher exact test (categorical data) used for statistical analysis **Outcome Measures:** - NIRS known as a validated and reliable tool for cerebral oxygenation measurement	**Results:** - Statistical significance indicated by two-sided p<0.05 - Collectively (including all cruising altitudes) no statistically significant difference between baseline (B) and altitude (A) NIRS (B= 65.9%, SD 9.5% vs. A= 65.0%, 9.9%, p=0.06) - Significant difference between baseline and altitude >5000 (B=69.2%, SD 8.9%, vs. A= 66.3%, SD 9.8%, p<0.001). - Mech Vent also significant (B=78.1%, SD 5.9%, vs. A= 75%, SD 3.5%, p=0.01). - Interestingly, although patients were having decreased NIRS, the pulse oximetry was not yet registering decreased levels (collective: B=98%, SD 2.3% vs. A= 98.4%, SD 1.7%, p=0.33; >5000 B= 98.7%, SD 1.4%, vs. A= 98.9%, SD 1.3%, p=0.61; mech vent: B=99.5%, SD 1.0%, vs. A= 98.8%, SD 1.6%, p=0.46)	**Overall Rating:** *Strength of Study Design: Moderate* *Quality of Study: Medium* - Inadequate control of selection bias with convenience sampling - Inadequate control for confounding variables with no standardization to medical interventions used - No data on baseline demographic differences (i.e. wide age range of 1 month- 16 years old) made available to assess whether these factors played a role on the patient's response to altitude - No confidence intervals provided - Missing data (no comparisons available for group of patients on RA) - Use of appropriate statistical tests for level of data and correct interpretation of statistical significance - Small sample size but sufficient power - Poor generalizability due to heterogeneous sample, small sample size, and sample from single AMS transport organization

Table 1 Continued: Studies Examining Neonatal Transport Risks

Author	Participants/Setting/ Methods/Outcome Measures	Results	Comments
Lee et al. (2001) Design: Uncontrolled Before-and After	**Participants & Setting:** - From 1996-1997, pre-and-post transport data was obtained from 1723 infants at 8 neonatal intensive care units in the USA **Methods:** - Prediction model for neonatal mortality developed using logistic regression- this was then used to design the TRIPS instrument for assessing transport physiologic stability - 4 empirically weighted items (temp, blood pressure, response to noxious stimuli, & respiratory status) used to score low-high risk (0-10) for impacting clinical outcomes - Calculated β-coefficients using logistic regression to score weight of prediction each item has on: 7 day mortality, total NICU mortality, and severe >3 intraventricular hemorrhage - Receiver operating characteristic (ROC) used to find criterion validity - Hosmer & Lemeshow goodness of fit statistics used where $p<0.05$= significant differences between observed/expected values and $p>0.05$= no significant difference or "good fit" **Outcome Measures:** - Logistic regression and univariate analysis used appropriately	**Results:** - Adequate criterion validity: ROC 0.76 (total NICU mortality) and 0.83 (7-day NICU mortality) with scores 0.5 being non-discriminative and 1.0 as perfect discrimination - Predictive ability for total NICU mortality ($p<0.05$) and IVH ($p<0.05$) significantly stronger than ANTSS, and ANTSS and GA respectively - Goodness of fit: increase/decrease in TRIPS scores mirrored the increase/decrease in mortality, no scores with $p<0.05$	**Overall Rating:** *Strength of Study Design: Weak* *Quality of Study: Medium* - Missing data (researchers note that univariate analysis was used and they omitted variables they didn't feel would impact outcomes but did not say which these were or how they came to conclusion) - Further psychometric testing is warranted (i.e. common exploratory factor analysis to assess internal consistency, a test-retest method to examine the stability and reliability of the tool, and expert review for content validity - Poor retention rates (data available for only 71% of participants) - Researchers admitted to inadvertent loss of some data

Table 1 Continued: Studies Examining Neonatal Transport Risks

Author	Participants/Setting/ Methods/Outcome Measures	Results	Comments
Bouchut et al. (2011) Design: Descriptive Study- Correlational	**Participants & Setting:** - Assessment of physical parameters related to ground/air transport in a French neonatal transport service - Dynamic stressors on body kinetics were measured (including sound, vibration, rate of turn, acceleration and pitch) and recorded during neonatal transports in ground ambulances vs. helicopters over the course of 10 hours and 2 hours respectively - No assessments made on the impact of aforementioned effects on the neonate during this study **Methods:** - Non-invasive measurement attached to incubator: triaxal accelerometer, high temporal resolution inclinometer, microphone placed 10cm from neonate's ear, global positioning system - All instruments wired to digital data acquisition system for long-term recording of raw data for analysis **Outcome Measures:** - Unclear if measurement tools for each indicator (i.e. sound, acceleration) were valid or reliable - Compared their results to known standards such as International Standard ISO 2631 for vibration	**Results:** - Results expressed as mean with standard dev. expressed as percentages with +/- - Helicopter = higher but more stable dynamic levels of exposure than ambulance (sound: 86 +/- 1 vs. 67 +/-3; vibration 0.9 m/s^2 +12%/-10% vs. 0.35 m/s^2 +40%/-28%; acceleration 0. 7 m/s^2 +26%/-20% vs. 0.45 m/s^2 +100%/-50%) - Ambulance found to have more sudden/impulsive effects with braking, and jarring shocks or noise than helicopter (1 impulsive event per 2 minutes vs. 1 per 11 minutes respectively)	**Overall Rating:** *Strength of Study Design: Weak* *Quality of Study: Low* - Moderate control for confounding variables with standardization of neonatal positioning during transport & equipment used (i.e. no shock suppressors or earmuffs used in any case) - Strong feasibility of implementation or repeatability of the study - No confidence interval or p-values provided, just mean values from recordings - Measurement tools not shown to be well-tested for validity or reliability but results compared to known - international standards - Researchers provide suggestions to mitigate effects of stressors but admit that further research is warranted - Data collection methods were objective, no obvious missing data - Assessors (Biomedical Engineers) trained in data collection

Table 1 Continued: Studies Examining Neonatal Transport Risks

Author	Participants/Setting/ Methods/Outcome Measures	Results	Comments
Gajendragadkar et al. (2016) Design: Randomized Block Study	**Participants & Setting:** - 2000 gram and 300 gram mannequins used to represent neonates of like weights on transport - Setting was ambulance traveling on fixed routes (city and highway) with mannequin being transported on four mattress combinations (none, foam, gel, & gel on foam) **Methods:** - Vibration levels assessed by measuring vertical accelerations at two locations (forehead & incubator base) to calculate root mean square (RMS) - Ratios of the RMS values of the two locations represented attenuation and accentuation of vibration ($R<1.0$; $R>1.0$ respectively). **Outcome Measures:** - Unclear if RMS is standardized measure for this type of analysis	**Results:** - Statistical significance $p<0.05$; regression coefficients presented +/- SE - All observed ratios were $R>1.0$ for every mattress type with the highest ratios observed when gel mattress not used - Absence of gel mattress: (regression coefficient +/- SE= 1.08 6 0.15; $p< 0.001$) foam mattress alone: (regression coefficient +/- SE= 0.42 6 0.16; $p <0.017$) - No statistically significant difference between gel mattress and gel on foam mattress ($p>0.05$) - Gel mattress (standalone or with foam mattress) shifted natural frequency of incubator away from frequency of ambulance thereby not further amplifying the vibration but still not reducing it. - Higher vibrations when 300 gram mannequin used	**Overall Rating:** *Strength of Study Design: Moderate* *Quality of Study: Low* - Missing data (no p values for gel mattress, lower weight mannequin, or no mattress) - Confounding variables such as ambulance speed during vibration measurement not acknowledged or controlled for - Adequate control of information bias as ambulance drivers blinded to which mattress being tested - Unclear if RMS is standardized measure for this type of analysis - Poor generalizability to different transport settings (e.g. fixed wing aircraft, helicopter) - Clear definitions provided for each mattress being tested and the methods used for this analysis

Table 1 Continued: Studies Examining Neonatal Transport Risks

Author	Participants/Setting/ Methods/Outcome Measures	Results	Comments
Valente et al. (2016) Design: Prospective Pilot Study	**Participants & Setting:** - Convenience sample of neonatal-pediatric patients (n=24) transported by specialty neo-peds transport team to large urban tertiary care childrens hospital via ground (n=13), helicopter (n=6) or fixed wing aircraft (n=5) - Males (n=10) and females (n=14) with age ranges 0-11 years (mean =11 months, SD 2.59 years) - Diagnoses included cardiac (n=12); pulmonary (n=7); neurologic (n=3); gastroenterological (n=2); and chromosomal disorder (n=1) - Study timeframe Feb 2011- Jan 2012 **Methods:** - Patients received continuous cerebral oxygenation monitoring using INVOS-5100C to measure regional saturation of oxygen (rSO_2) - Comparisons made between ground, helicopter, and fixed wing aircraft rSO_2 levels on neonatal-pediatric transport - Peak acceleration monitored using accelerometer GP1 SENSR to measure z-axis accelerations (aligned with patient's spine) **Outcome Measures:** - INVOS-5100C not tested for reliability or designed for use on medevac transport	**Results:** - Mean z-axis peak accelerations for takeoff and landing were similar between ground, heli, and fixed wing as demonstrated by overlapping 95% CI intervals (0-0.43) - Decreased rSO_2 not significantly associated with patient positioning (head to rear or head to front) during takeoff or landing ($p=0.11$; $p=0.13$ respectively) - No significant association between z-axis peak acceleration and decreased rSO_2 during takeoff and landing ($p=0.97$; $p=0.15$ respectively)	**Overall Rating:** *Strength of Study Design: Moderate* *Quality of Study: Low* - Insufficient power with small sample size (n=24) - Inadequate control of selection bias with convenience sampling and small sample - Researchers admitted to slower acceleration/deceleration rates with the transport vehicles used in their study compared to numerous other studies - Limited battery life on the cerebral oximeter hindering monitoring duration - Inadequate control of confounding variable (i.e. lateral and vertical forces impacting cerebral oxygenation) - Tools used that were not tested for validity or reliability (i.e. cerebral oximeter not tested for medical transport settings) - Poor generalizability of results due to heterogeneous sample, insufficient sample size, and all participants from single transport organization - Researchers reported missing data during takeoff (n=2) and landing (n=1) due to technical issues with equipment

Appendix B

Consultation Report: Transport Team Training For

Neonatal Medevac Flight Safety

Improving access to healthcare for culturally diverse groups or medically underserved areas has become compulsory (CNA, 2010; CIHR, 2017; Health Canada, 2013). In Canada, the Inuit population located primarily in Nunavut easily falls under this umbrella (Greenwood, de Leeuw, & Lindsay, 2018) as they rely heavily on aeromedical transports (AMS) for life-saving interventions due to the remoteness of their northern communities. Neonates are especially vulnerable in such circumstances, and are transported by Keewatin Air to receive care at neonatal intensive care units (NICU) in tertiary medical centers in the south. As much of Keewatin Air's medical staff come from an adult medicine background with limited experience with the care of neonates, population-specific education is warranted to improve access to neonatal care in northern communities. The purpose of this consultation report is threefold: to reveal key transport safety issues from the perspective of neonatologists and NICU nurses; to identify best practice transport education used among established neonatal transport programs that could help mitigate identified risks; and to garner Keewatin Air's perspective on which barriers exist to accessing educational resources, and what type of education would be most appropriate for their northern setting. This consultation report will inform the development of a neonatal expert-based educational resource toolkit for Keewatin Air.

Background

According to the Canadian Pediatric Society, significantly higher incidence rates of adverse effects such as the need for cardiopulmonary resuscitation, or improper management of the neonate's airway occur when a non-specialized team performs neonatal transport (Whyte & Jefferies, 2015). Indeed, a study by Orr et al. (2009) illustrated how the use of a specialized transport team correlated with improved survival rates (death occurrence for patients transported by specialized team (9%) compared with non-specialized team (23%) $p<0.001$). In an ideal healthcare environment, a specialized team would be available for all neonatal transports, but due to resource limitations this is not feasible for Nunavut. It therefore was imperative to at least provide Keewatin Air an educational resource to help improve neonatal competencies and thereby expand access to neonatal care in northern Nunavut communities.

Consultation Participants

Recruitment

In deciding which established neonatal transport teams to include in this consultation report, it was important to include Canadian teams given the direct impact this project will have in the Canadian context. However, as transport programs in the United States often align their educational programs with requirements put forth by national accreditation organizations such as Air and Surface Transport Nurses Association, and Commission on Accreditation of Medical Transport (ASTNA, 2014; CAMTS, 2018) it was helpful to consult with these teams as well (refer to Appendix A for list of teams consulted and rationale). This provided a well-rounded assessment of transport education best practice to help guide the development of Keewatin Air's educational resource toolkit. When talking with transport teams, the recruitment process at times had a snowballing effect, as teams would occasionally reference what they had learned from other transport programs, and consultation would be then be extended to said teams.

Purposeful sampling was used to determine which neonatologists and NICU nurses to interview. Participants were chosen from receiving facilities of Keewatin Air's neonatal transports, Health Sciences Center Children's Hospital, Stollery Children's Hospital, and SickKids Children's Hospital in Winnipeg, MB and Edmonton, AB, respectively. Additionally, NICU nurses were consulted from hospitals where the transport teams consulted in this project were based.

For consultation with Keewatin Air's medical staff, this author initially spoke with Keewatin Air's Aeromedical Educator, Irene Pare, and Director of Medical Operations, Janet Busse. Following this, efforts were made to arrange a trip to a northern Keewatin Air medical base to permit a face-to-face interaction with Keewatin Air's medical staff (i.e. nurses, respiratory therapists, physicians, etc.). Being in the environment of the northern communities would help extrapolate important contextual factors during the consultations. However, due to financial and scheduling barriers, such trip was not feasible. This author therefore relied on discussions with Keewatin Air's medical staff to garner the necessary information to plan a successful resource.

Initial contact with all participants, including established neonatal transport teams, neonatologists, NICU nurses, was made either in-person or over the phone. At this time, participants were briefed on the project overview, objectives, and implications. All questions regarding the project's goals were answered, and the "practicum proposal" document was provided if additional information was requested. Verbal or written consent was also received as appropriate prior to engaging with the consultants.

Methods

Data Management

To ensure data security, all electronic communication was conducted using a secure hospital connection. After each data input session, the "Consultation Report" file was stored on a secure USB device and a backup hardware drive. To prevent theft of devices containing sensitive information, the computer, USB, and backup drive were kept in a locked office when not in use.

Data Collection and Analysis

Interview questions were peer-reviewed by fellow neonatal transport nurses and an academic supervisor to assess the clarity of each question, and to ensure the wording of questions would not influence any answers. Interviews were conducted using a semi-structured approach with open-ended questions to initiate discussion (refer to Appendix B for question samples). Additional probing questions were used as warranted to encourage elaboration, or to seek clarification from the respondents (King & Horrocks, 2010). Contextual features or non-verbal communication (i.e. sigh, frown) were also considered when deciding whether to ask additional questions or alter the interview's sequence.

In order to keep the data organized and to permit easier thematic analysis, tagging with text attributes was used. For instance, to determine which safety concerns (i.e.

vibration) were most frequently referenced in the interviews with neonatologists and NICU nurses, tagging was done as follows: 1) *Ctrl F* (find), input “vibration,” 2) click on *More* button, 3) click on *Format* → *Font*, 4) select attributes such as a new font color to apply to “vibration.” This attribute tagging helped highlight key sections for improved accessibility to and organization of data. In descriptive coding, the various attribute tags were reviewed to define codes for safety issues (i.e. vibration, noise, intraventricular hemorrhage (IVH), pneumothorax, etc.) referenced more than three times. From here interpretive coding was done to cluster related codes for thematic analysis. From the interviews with neonatologists and NICU nurses for example, codes “vibration,” and “noise” were clustered into external factors and “intraventricular hemorrhage” and “pneumothorax” were clustered into physiological factors.

Similar coding was used when assessing the structured education and training that exists in well-established neonatal transport teams. This author asked team coordinators which method of instruction their organization primarily used for transport education, and the rationale behind this. Minimal thematic analysis was necessary however as it became apparent very early on that high fidelity simulation was considered best practice for transport education, as evidenced by 100% of all teams consulted lauding this format as “gold standard.” To identify priority syllabi content, this author spoke with teams who had curriculum based on a national transport organization, such as ASTNA or CAMTS. The educational content for teams who aligned their curriculum with accreditation standards was then organized into categories to help construct the future educational resource for Keewatin Air.

Ethical Conduct

Confidentiality

Prior to conducting interviews, consultants were given a brief project overview and a form to sign indicating consent to participate. Unless the consultant was a key stakeholder in the project (i.e. Irene Pare), all other consultants remained anonymous and every effort was made to remove potential identifying factors. This project did not require review by the Health Research Ethics Review Board; refer to the completed ethics checklist in Appendix C for explanation.

Permissions

In this consultation, individuals verbally gave permission to having their responses shared on the condition of anonymity. Aside from the participant's organization, no other identifying factors would be included in the report. In the case of direct quotes being used in the report, written permission was obtained from the respondent. When consulting established neonatal transport teams to explore their transport education curriculum, this author obtained written consent to use established high fidelity simulation scenarios with the respective organization's permission.

Consultation Results

Mitigating Transport Associated Risks

Consultation with Keewatin Air Medical Staff. In speaking with Keewatin Air's Aeromedical Educator and Director of Medical Operations, Irene Pare and Janet Busse respectively, one of the major barriers to continuing education is distance. The remoteness of Keewatin's medical bases inhibits access to courses relevant to neonatal transport medicine such as Neonatal Resuscitation Program (NRP) certifications. Keewatin Air medical team members expressed learning valuable material from such courses but are not easily able to travel to urban centers where most courses are held. Janet and Irene have therefore sought to improve Keewatin Air's access to NRP by looking at ways to increase the number of certified NRP instructors in the northern communities.

In addition to having greater access to NRP education, two of Keewatin's front-line medical staff members stressed the need for additional training on pre-transport interventions that can be performed to ensure best outcomes on flight. A nurse who had recently worked with Keewatin Air expressed feeling that most of the medical staff was comfortable with the execution of practical skills, but would benefit from learning *when* to implement these. She spoke to the need for additional training on neonatal assessments to better recognize what is normal, and what will likely lead to neonate deterioration. This transcends what is covered in the NRP certification, which focuses mainly on the resuscitation of the neonate in the fresh newborn stage immediately following delivery. Another nurse expressed how aside from changing size of instruments (i.e. endotracheal tubes, needle gauges for intravascular devices), little is done differently between an adult transport and a neonatal transport. She spoke to how this could be improved by learning ways the team can reduce the harshness of the transport environment for the delicate neonates. During this part of the interview, additional probing questions were asked to assess whether sound or vibration were well controlled for on Keewatin Air, which according to this nurse are not.

The interviews with Keewatin nurses also revealed the importance of strong communication skills among team members. The two nurses spoke to how this is especially pertinent for crisis management when the team is faced with difficult scenarios in a hostile transport environment with limited resources. One of Keewatin's nurses voiced how most of the existing educational opportunities are centered around practical skills such as intubation or vascular access, or on pharmacological comprehension for emergency medications. She explained that although these are useful learning moments, more work needs to be done on practicing scenarios together to improve team dynamics and the overall approach used for crisis management.

Consultation with Neonatologists and NICU Nurses. If neonates require emergency aeromedical transport to a tertiary NICU center, they are already in a precarious situation given their critical condition. Flight-specific stressors such as noise, vibration, and effects of altitude compound the neonate's fragility and risk for deterioration (Bouchut, Lancker, Chritin, & Gueugniaud, 2011). However, the consensus from consultation with neonatologists and NICU nurses at receiving tertiary care facilities is that such risks can be mitigated with proper pre-transport stabilization. According to one neonatologist from Western Canada, the neonate should be delivered in similar or improved condition to when the transport team arrived at the referring facility. This requires the team to work proactively rather than reactively in handling potential problems on flight such as pneumothoraxes or bowel perforations.

Keewatin staff identified excessive sound and vibration as two factors that can impact neonatal safety on flights, which has also been well supported throughout existing literature (Bouchut et al., 2011; Karlson et al., 2011). Sound and vibration can lead to IVH or bradycardia-desaturation events due to poor stress tolerance (Gajendragadkar, Boyd, Potter, Mellen, Hahn, Shenai, 2000; Skeoch, Jackson, Wilson, and Booth, 2005).

To explore techniques used in NICUs to reduce the effects of sound and vibration on neonates, this author consulted with NICU nurses from Boston Children's Hospital and Winnipeg Children's Hospital. Nurses from the latter hospital reported covering isolettes with thick cloth to help insulate the interior from excessive noise or at least dull the intensity of exterior sound. They explained how the cloth is custom made with flaps that can lift for easy visualization of the neonate. The NICU nurses described how the thick layer of fabric helps absorb some of the noise and decreases the number of sound waves that pass through the plexiglass isolette. Regarding innovative solutions for reducing vibration, the NICU nurses from Boston Children's Hospital explained how they've moved towards using a type of thick high-density foam underneath the standard neonatal mattresses used in most conventional isolettes. These nurses explained how the firm foam sheet helps to dampen the vibration shocks thereby limiting the neonate's exposure to jolts or jarring impact when the isolette is knocked into, or when being transported to different areas of the hospital for instance.

Neonatologists from Dartmouth Hitchcock Medical Center (DHMC), a rural trauma center in northeastern United States, also weighed in on the effects loud sounds can have on micro-premature neonates weighing less than 1000 grams. In DHMC's nursery, sound is tightly controlled with walls built with acoustic softening properties, and sound-producing events like interdisciplinary report held in an enclosed area to prevent excessive noise reaching the fragile neonates. According to DHMC nurses, the fragility of premature neonates stems from underdeveloped neurologic capacity to regulate and coordinate basic life functions such as respirations. The neonatologists at DHMC explained that since neonates at such a delicate stage of life have to concentrate to regulate their bodies, sudden “startles” from sound or vibration is a sensory overload that exhausts their ability to regulate functions like respirations, resulting in apneic episodes for example.

Complete control of sound and vibration with acoustic dampening walls or holding group discussions in separate areas as done with DHMC are simply unrealistic in a transport setting. However, the use of cloth and foam could more easily be translated into the transport setting given the relative feasibility and cost-effectiveness of such interventions. The reported success of reducing vibration and sound with the aforementioned interventions in NICU settings strengthens the case for incorporating these recommendations in the educational resource toolkit for Keewatin Air.

Transport Education

Consultation with Established Neonatal Transport Teams. To identify the most effective form of education delivery for improving neonatal transport, numerous teams across Canada and the United States were consulted. The overwhelming response from all teams included in this consultation was that high-fidelity simulation training was the most effective because it could replicate the stress and urgency of critical scenarios.

According to nurse educators from two of the busiest neonatal transport teams in Canada and the United States, SickKids and St. Louis Children's Hospital respectively, simulation training is the ideal format for effectively testing team members' abilities to manage a crisis in real-time. These educators explained why didactic lectures simply could not provide the same level of comprehensive evaluation of the team's physiologic assessment and the resulting prioritization of practical skill execution. As well, five coordinators from various neonatal transport teams in Canada explained that although it is imperative for transport clinicians to have exemplary understanding of matters like neonatal congenital conditions and pharmacological interventions, without strong interdisciplinary communication and the ability to work together, the team would undoubtedly fail at crisis response when required. This is why simulation education days are incorporated into this team's work schedule once every two months. One coordinator explained how this style of training permits an assessment of team dynamics, and to foster interdisciplinary collaboration the nurses and respiratory therapists take turns debriefing on what went well and what could be better.

This author also consulted with the neonatal transport team from Boston Children's Hospital, the top-ranked pediatric hospital in the United States for the fifth consecutive year. One of the senior transport nurses on this team explained how they work together to build transport simulation scenarios based on real-life transport experiences. This way, the team has an opportunity to debrief, learn from difficulties, and develop solutions to identified challenges. He said in addition to these team-developed scenarios, they also utilize more formal simulations that are based on recommendations from regulating bodies such as the Commission on Accreditation of Medical Transport Systems (CAMTS). As well, Boston Children's Neonatal Transport Team has the luxury of using the operating theater for practicing skills such as managing neonatal airways. While this is not something easily accessible to most transport teams, use of a high-fidelity simulation mannequin could provide similar benefits for improving skill proficiency.

Curriculum Focus Points by CAMTS. Boston Children's Hospital and St. Louis Children's Hospital are two of the many neonatal transport teams in the United States that work diligently to align their simulation curriculum with CAMTS standards for accreditation. Although CAMTS is used almost exclusively in the United States, for the purpose of this practicum it will inform the curriculum development as Canada lacks standardized education and protocols for transport (Whyte & Jeffries, 2015).

Competency requirements cited by CAMTS include but are not limited to: advanced airway management; triage; recognition and support of congenital defects in neonates such as cardiac anomalies or gastroschesis; altitude related physiologic stressors; pharmacology; and central vascular access initiation. CAMTS also encourages more abstract curriculum components that are equally as important to the practical skills, albeit slightly more difficult to measure. For instance, neonatal teams are encouraged to routinely integrate stress recognition and interdisciplinary communication to their scenarios.

In speaking with a representative from CAMTS, educational activities as adjuncts to clinical experiences must have documentation to show how learning objectives are met. Per CAMTS, although simulation is considered gold standard for meeting transport specific learning objectives, there are options available for teams that lack access to advanced technology (personal communication, CAMTS representative, December 2, 2018). For instance, if a facility does not have high-fidelity simulation mannequins, the simulation training can take place with medical personnel doing role-play according to the lesson's objectives. This provides helpful alternatives in facilities without access to formal simulation labs, although it would be challenging to have realistic role-play for the neonatal population.

Transport Assessment Tools

Consultation with Established Neonatal Transport Teams. Pre-transport stabilization is crucial to achieving safe clinical outcomes for neonates on flight transports (Messner, 2011; Ohning, 2015; Schierholz, 2010). Numerous assessment tools such as the Transport Risk Index of Physiologic Stability (TRIPS) (Lee et al., 2001), and the Alberta Neonatal Transport Stabilization Score (ANTSS) (Shorten & Fox, 1993) exist to help transport teams evaluate the neonate's clinical condition and to guide the decision making process for whether additional stabilization interventions are warranted to improve patient safety. Through consultation with established neonatal transport teams in the United States and Canada, it was found that the standardized assessment tools allow for a more structured approach to managing the care of a transported neonate.

Per consult with SickKids in Toronto, ON, the transport team calculates a TRIPS score in three increments: 1) during the initial call, 2) on arrival to referral facility and team's assessment of the patient, and 3) as part of the hand-over procedure when the team delivers the neonate to the SickKids NICU. According to SickKids transport staff, calculating the TRIPS score at different phases of the transport helps to guide the triage process, determine which pre-transport stabilization interventions are needed, and evaluate the overall transport process at the end of the trip. London Health Sciences Center (LHSC)'s neonatal transport team also praised the TRIPS tool and explained it has been built into LHSC's electronic database to allow for automatic generation of the score based on data input.

In talking with various neonatal transport programs in the United States, it was revealed that California has a fairly innovative approach for quality improvement. This state has a mandatory data collection form that includes a modified TRIPS score section for all neonatal transports within California. According to Valley Children's Hospital in Madera, CA, the state then uses this data to evaluate the safety of neonatal transports and develop new protocols to address identified concerns. Certainly, the benefits of having a standardized evaluation tool such as TRIPS will be important to consider when developing Keewatin Air's educational resource.

Implications

Given the benefits of standardized evaluation tools, either the TRIPS score or one similar will be included in the educational resource toolkit for Keewatin Air. Use of such tool will help provide Keewatin Air's medical staff members with an accurate assessment of clinical severity, to determine which interventions are needed for pre-transport stabilization, and when perhaps to call for advice from neonatologists. For instance significantly elevated TRIPS scores indicate higher mortality risks and could help cue transport staff to seek recommendations prior to leaving. This could help provide care specialized to the neonate's unique clinical needs.

To address Keewatin Air's self-identified need, this practicum's educational resource toolkit will include innovative suggestions for how to expand the NRP instructor role in the northern communities. However, the plethora of valuable educational recommendations from the other consultants in this report must also be considered. Sound understanding of NRP is imperative to good outcomes in the newborn period, but the applicability of such to all transported neonates is limited in scope due to additional resuscitation and stabilization skills required, outside of the delivery room, when on flight. The resource therefore will include a larger section on how to effectively implement simulation exercises based on established curriculums that will help to mitigate safety risks.

A preliminary plan that is currently in discussion is to utilize the existing TeleHealth program at Winnipeg's Health Science's Center Neonatal Intensive Care Unit as a certification platform. Through this interface, training can be provided so that prospective candidates can receive the required onboarding for the instructor certification. The next step in becoming an NRP instructor is to "team teach" at least one NRP course under supervision of an NRP Instructor Trainer (Canadian Pediatric Society, 2018). Given the abundance of NRP Instructor Trainers located in Winnipeg, this sign-off will be easy to facilitate using TeleHealth. The use of an existing resource (TeleHealth) to help expand the number of certified NRP Instructors in northern communities is a cost-efficient way at improving access to continuing education for Keewatin Air's medical staff.

Conclusion

The vast remoteness of northern communities in Canada, particularly those in Nunavut necessitates having strong neonatal transport programs to ensure equal access to good health outcomes for all neonates. Keewatin Air is the primary provider of transport services to this area, and has identified a need for improved neonatal education. To help develop an educational resource toolkit to meet this need, consultation was undertaken to narrow down content focus. Content of the toolkit will include brief sections on pre-transport stabilization and risk mitigation as it relates to sound and vibration, as well as recommendations for improving access to NRP in the northern bases. The primary focus however for the educational toolkit will be a simulation based curriculum to help improve skill proficiency and patient assessments on neonatal transport. The valuable insights obtained in this consultation report will be a strong foundation from which to build the neonatal educational toolkit.

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Appendix A

Transport Team Consultations and Rationale

Transport Team	**Location**	**Rationale**
SickKids Neonatal Transport	Toronto, ON- Canada	One of the major pediatric centers of excellence in Canada where some of the more complex neonatal/pediatric cases are sent; busiest neonatal transport team in Canada
Manitoba Child Health Transport	Winnipeg, MB- Canada	Rooted in Health Sciences Center Children's Hospital (one of the main receiving facilities for Keewatin Air's neonatal transports); has made efforts to align education with CAPHC recommendations
London Health Sciences Center Neonatal Transport	London, ON: Canada	Recognized as one of the transport programs in Canada that utilizes TRIPS
Boston Children's Critical Care Transport	Boston, MA: USA	Named #1 children's hospital in the USA for the 5th consecutive year; their transport team participates in educational outreach program; transport education curriculum based on CAMTS standards
St. Louis Children's Hospital Neonatal Transport	St. Louis, MO: USA	One of the busiest neonatal transport programs with impressive safety ratings; transport education program based on CAMTS standards
Valley Children's Hospital Neonatal Transport	Madera, CA: USA	California was cited as using TRIPS for neonatal transport quality improvement

Appendix B

Consultation: Neonatologists and NICU Nurses

Sample Interview Items with Responses

- What complications have you seen that you feel might stem from aeromedical transport?
  - *Pneumothoraxes, intraventricular hemorrhage, drops in hemoglobin as most teams don't carry blood products with them so if transfusions are needed they're without access*
  - *The babies decompensating if the main treatment needed is surgery... particularly if they're coming from far away –* issues *such as gastroschesis become worse without surgery because there are limited actions transport teams can do to really make a big difference in these cases*
  - *Excessive sound and vibration can lead to things like IVH in the babies who are significantly small or premature*
- In the nursery how do you manage levels of sound or vibration to protect the neonate?
  - *Sounds in the nursery are probably more easily managed as less external factors come into play (i.e. sound of helicopter blades, ambulance siren) but one intervention we use is the covering of each isolette with a thick cloth to help insulate the interior from excessive noise or at least dull the intensity somewhat*
- When receiving neonates from aeromedical transports what are some common

issues seen upon arrival?

  - *Hypoglycemia either overlooked on transport due to distractions or emergent scenarios, or due to the neonate being overwhelmed by transport stress and using up all available energy stores*
  - *Intraventricular hemorrhage from either too much vibration, excessive noise, or the effects of landing/takeoff*
  - *Temperature instability- perhaps from inadequate insulation during frigid winter temperatures, or due to disease processes*
  - *Stable pneumothoraxes worsening on flight and requiring urgent intervention upon team's arrival for decompression*

- In addition to neonatal resuscitation program or pediatric advanced life support certifications, what additional training do you feel neonatal transport staff require to safely perform care as an RN-RT team?
  - *Critical airway management is key as most babies require intubation for transport even if the primary problem isn't respiratory in nature*
  - *Strong vascular access skills- if the team loses vascular access en route and are unable to initiate a new IV that's when a sick baby really decompensates*
  - *Excellent assessment skills- especially if the baby is coming down from up north where there are limited diagnostic tools available like CTs, X-Rays, Laboratory, etc. – the team has to be strong at*

performing focused assessments and coming up with accurate differential diagnoses to prioritize management and to avoid missing things like potential for pneumothorax on flight

Consultation: Keewatin Air Medical Staff

Sample Interview Items with Responses

- From your perspective, what are the barriers to accessible educational resources in northern communities?
    - *Many of our medical staff members have expressed the need for continuing education opportunities but are unable to travel to urban centers where most courses are held- the remoteness of many of our medical bases hinders the ease of access to education*
- What types of education do you think would be most beneficial to improving neonatal care on flight transports?
    - *Having more medical staff members certified through the Neonatal Resuscitation Program would help make them more comfortable when resuscitating newborns, or even just helping give a better understanding of what's considered "normal" for neonates to improve their assessment skills*
- What are some of your key concerns when transporting neonates via flight?
    - *Our team often knows how to perform the skill (intubation, vascular access, etc.) but it would be helpful to have better assessment skills to know when certain things are needed*

- *Sometimes with the tiny ones I feel like because their bodies are so fragile, they are more prone to damage from the turbulence and vibration in the plane and ambulance settings, or the loud noises during takeoff or sirens. We wear ear-plugs it is so loud.*

Appendix C

	Question	Yes	No
1.	Is the project funded by, or being submitted to, a research funding agency for a research grant or award that requires research ethics review		No ☐
2.	Are there any local policies, which require this project to undergo review by a Research Ethics Board?		No ☐
	IF YES to either of the above, the project should be submitted to a Research Ethics Board. **IF NO** to both questions, continue to complete the checklist.		
3.	Is the primary purpose of the project to contribute to the growing body of knowledge regarding health and/or health systems that are generally accessible through academic literature?		No
4.	Is the project designed to answer a specific research question or to test an explicit hypothesis?		No ☐
5.	Does the project involve a comparison of multiple sites, control sites, and/or control groups?		No
6.	Is the project design and methodology adequate to support generalizations that go beyond the particular population the sample is being drawn from?		No ☐
7.	Does the project impose any additional burdens on participants beyond what would be expected through a typically expected course of care or role expectations?	Yes	☐
LINE A: SUBTOTAL Questions 3 through 7 = (Count the # of Yes responses)		**1**	
8.	Are many of the participants in the project also likely to be among those who might potentially benefit from the result of the project as it proceeds?	Yes ☐	
9.	Is the project intended to define a best practice within your organization or practice?		No
10.	Would the project still be done at your site, even if there were no opportunity to publish the results or if the results might not be applicable anywhere else?	Yes ☐	
11.	Does the statement of purpose of the project refer explicitly to the features of a particular program, Organization, or region, rather than using more general terminology such as rural vs. urban populations?	Yes ☐	
12.	Is the current project part of a continuous process of gathering or monitoring data within an organization?		**No**
LINE B: SUBTOTAL Questions 8 through 12 = (Count the # of Yes responses)		**3**	
	SUMMARY See Interpretation Below		

Item #7- For the neonatologists at tertiary care centers, this project will add the burden of increased education time as they will actively engage in the high fidelity simulation evaluations.

Interpretation:

- If the sum of Line A is greater than Line B, the most probable purpose is **research**. The project should be submitted to an REB.
- If the sum of Line B is greater than Line A, the most probable purpose is **quality/evaluation**. Proceed with locally relevant process for ethics review (may not necessarily involve an REB).
- If the sums are equal, seek a second opinion to further explore whether the project should be classified as Research or as Quality and Evaluation.

These guidelines are used at Memorial University of Newfoundland and were adapted from ALBERTA RESEARCH ETHICS COMMUNITY CONSENSUS INITIATIVE (ARECCI). Further information can be found at: http://www.hrea.ca/Ethics-Review-Required.aspx.

Appendix C

Interim Report: Neonatal Flight Safety- Northern Care Outreach

Project Overview

Purpose

Keewatin Air is an aeromedical flight service tasked with performing all neonatal flight transports for Nunavut. Emergency flight transports have inherent risks but these are compounded by the vulnerability of the neonatal population. This strengthens the need for strong educational programs to ensure the medical staff can competently manage the care of these complex patients in the hostile transport environment. The purpose of this practicum therefore is to build an education resource stemming from existing literature and expert consultations to meet the identified learning needs of Keewatin Air.

Progress

Literature Review. The key question the literature was supposed to address was: what evidence based best practice recommendations exist for the care of neonatal patients with special consideration to flight transports? However, this was complicated by a deficiency in transport specific evidence based practice recommendations for neonates (Cornette, 2004). As the literature review was to be the foundation from which the remaining parts of the practicum would stem, modifications had to be made. Once the scant evidence-based best practice literature was revealed, the focus was instead redirected towards identifying evidence-based safety risks for neonates on transport, and exploring which educational format best prepared transport teams to care for neonates.

Key transport-specific safety risks for neonates included excessive sound and vibration, and the effects altitude, acceleration, and deceleration have on physiologic stability. These helped frame the interview questions in the consultation report to identify how neonatologists, neonatal intensive care unit (NICU) nurses, and established transport teams mitigate said risks.

The literature review also provided overwhelming evidence for high-fidelity simulation training as the leading format for educational delivery on transport teams. Existing literature demonstrated how simulation training was superior to didactic lessons for establishing key skills pertinent to transport, namely strong team dynamics and crisis management. In numerous studies, transport clinicians reported higher levels of satisfaction in simulation training with participants citing greater confidence in practical skill performance and assessment abilities. As well, this portion of the literature review highlighted a number of existing transport teams in Canada who use this format of instruction. This helped steer the beginning of the consultation process and determine which teams could provide useful feedback regarding simulation training.

Consultation Report. The consultation report had a three-pronged approach to garner insights from Keewatin Air, established neonatal transport teams, and neonatologists and NICU nurses.

The purpose of consulting with Keewatin Air was to establish an understanding of their perspective on organizational needs for education, and how they envision implementing curriculum changes. This author received extensive feedback from Keewatin Air’s leadership but struggled to secure more than a handful of interviews with front-line staff. The biggest push from Keewatin Air's executive team was to expand access to Neonatal Resuscitation Program certification for the northern bases. Speaking with a few front-line staff members however revealed a greater need for skill development that transcends what is covered in NRP. In the educational resource, recommendations for expanding NRP access will be included for Keewatin Air's consideration, but the emphasis will be placed on a more all-encompassing curriculum for the care of neonates on transport.

Consultation with neonatologists and NICU nurses stemmed from the evidence-based transport specific risks to neonates identified in the literature review. The goal was to explore ways certain safety risks were mitigated in the nursery setting and assess the degree to which these interventions could be translated into a transport setting. Neonatologists from leading institutions in the United States and Canada spoke to the attenuating effects certain foam mattresses have on vibration. Seemingly these are not especially costly, and can easily be adapted to fit different isolette models. This therefore could be considered as a risk reduction strategy for Keewatin Air's neonatal program, given the proper education on rationale and safe use of the product.

Secondly, NICU nurses spoke about ways they work to curb excessive sound in the nursery. Some approaches such as holding morning rounds in an enclosed soundproof area would simply not be feasible on flight transports. However, other innovative solutions were more simplistic and equally effective such as the heavy cloth overlay on the isolette's exterior and the acoustic paneling on the interior. These would be important interventions to consider as according to Sittig et al. (2011) neonates are exposed to 80dB noise levels on aeromedical transport, which far exceeds safe noise limit recommendations of 45dB in neonatal intensive care units.

Lastly, existing well-established neonatal transport teams were consulted to explore different formats used for education delivery. Not surprisingly, the consultation results aligned closely with existing literature lauding high-fidelity simulation as the gold standard for transport education. Transport team coordinators explained that simulation is superior to didactic instruction because it allows for real-life urgency to patient assessments, and timely skill execution. Front-line transport nurses who partake in regular simulation training exercises noted improvements in team communication and overall dynamic. This piece was especially important given how deficiencies in communications were cited as the root cause in 70% of adverse events on transport in Weaver, Dy, and Rosen's (2013) integrative review.

Moving Forward

Preparation. In preparation for Practicum 6661, this author has begun reaching out to established neonatal transport teams in the United States and Canada who provide regular simulation training. The practicum objectives have been provided and requests to review and borrow certain simulation scenarios have been made. Certain teams in the United States have built their simulation scenarios based on recommended standards from accrediting bodies such as Air and Surface Transport Nurses Association, and Commission on Accreditation of Medical Transport (CAMTS) (ASTNA, 2014; CAMTS, 2018). These will be useful in developing a structured simulation experience for Keewatin Air.

Secondly, a site visit to one of Keewatin Air's medical bases was originally planned for November 2018 but scheduling conflicts with Keewatin Air arose. It will be imperative to ensure this takes place eventually if possible as it will allow for more staff discussions to obtain diverse perspectives on educational needs, and it will give an opportunity to see where the education will be held. These are two factors that will influence the simulation content and how it is delivered.

Resource Outline. The developed resource toolkit, Neonatal Transport Improvement Project (NTIP) will have two parts: Program Support Presentation, and Simulation Educational Toolkit. The NTIP Part I will provide Keewatin Air with a presentation on risk mitigation strategies, ways to improve NRP access, and potential funding opportunities, and the NTIP Part II will provide Keewatin Air with simulation education to be integrated into their curriculum.

In efforts to satisfy Keewatin Air's self-reported need for greater access to NRP and funding resources, NTIP Part I will provide recommendations for how the organization might achieve this. Applying for funding through northern grants, or more specifically the Canadian Paediatric Society's NRP Research Grant. As well, the expansion of WCH's TeleHealth program will be considered as an alternative approach to providing access to the instructor certification course. If NRP instructors in Winnipeg can provide the course via TeleHealth to northern bases, this will help expand the number of NRP Certified Instructors. This approach is attractive because of its sustainability- the equipment for TeleHealth already exists and there is a plethora of NRP Certified Instructors in Winnipeg. To increase the number of instructors in northern bases will only take a handful of instructor courses delivered via TeleHealth to certify a number of instructors at northern bases. From here, these northern instructors can provide the NRP courses as needed. NTIP Part I will also include a brief PowerPoint presentation on evidence-based safety concerns unique to neonates on transport, and what exists for recommendations to mitigate these risks. The interventions such as foam mattresses and acoustic paneling on isolettes will stem from the consultation report and existing literature. The implementation of these will extend beyond the scope of this practicum however, and will involve substantial costs for configuring their entire fleet with such modifications. Nevertheless given the associated opportunity for safety improvements, these interventions will be presented to Keewatin Air merely for consideration as they find fit.

For NTIP Part II, this author is currently collaborating with established transport teams in the United States and Canada to identify scenarios that could be useful for Keewatin Air. Some scenarios, for instance ones pertaining to extracorporeal membrane oxygenation, may not be applicable as this is an advanced level of care Keewatin Air is not tasked with. It will therefore be important to review scenario goals and educational objectives to see if they align with Keewatin Air's responsibility. Then, with permission granted and citations provided to reflect where each scenario originates, a binder of different simulation topics will be organized for the NTIP Part II.

In order to ensure feasible implementation of and staff receptiveness to the simulation scenarios, a site visit to one of the northern medical bases will be conducted. During the site visit, this author will assess what part of the facility is available for education, and will observe day-to-day operations to understand how transports are coordinated in the northern communities. This will ensure there are no disconnects in the educational delivery and the reality of the northern bases.

To help provide expert feedback on Keewatin Air's performance in simulation scenarios, this author is working to configure Winnipeg Children's Hospital (WCH)'s existing TeleHealth system to permit neonatologists viewing access to Keewatin Air's medical bases during simulations. At this point, both Keewatin Air and WCH neonatologists are enthusiastically supportive of this idea, what remains are figuring out the logistics.

Timeline. Refer to Appendix for Practicum 6661's timeline.

Reflection

Learning Experience

In reflecting on what went well during the first half of this practicum, adaptability comes to mind. Although adaptability was required due to various difficulties along the way, learning to adapt and work through the process was a valuable lesson. Learning to be flexible with an evolving process began while working on the literature review when the key focus had to be reworked after realizing there were no evidence-based best practice recommendations for neonatal flight transports. Instead, evidence-based safety risks were analyzed in the review as well as which forms of educational delivery were most effective in transport settings. From here plans were made to discuss risk mitigation and simulation training in the consultation process.

Another area that required adaptability was when navigating difficulties with Keewatin Air due to sparse return communication from the organization's staff, and scheduling conflicts. These often created delays in a previously planned timeline for the practicum, and required a careful approach to maintain professionalism and come up with alternative solutions. One thing that could have been done differently is a more thorough assessment of the external organization prior to the commencement of the practicum. Although Keewatin Air was eager to participate in the practicum, with project expectations and objectives clearly described, no formal meetings were arranged ahead of time. If teleconferences or meetings had been scheduled, these would have been an opportunity to assess the organization's reliability and communication style.

Additionally, when planning consultations with established neonatal teams the intention had been to speak with a neonatal team in Oslo. The rational for this being Norway and Canada sharing similar geographical remoteness adding a unique challenge for transport teams tasked with serving the neonates in such isolated areas. However, after two months of fruitless efforts to make contact with Oslo's team, the plan was discarded for the sake of adhering to this project's timeline. This hurdle, albeit a frustrating setback, was another part of this practicum that fostered the development of adaptability.

Another lesson from this practicum so far has been to work within one's means. Originally the ideas for this educational initiative far surpassed the scope of this practicum. In working with Dr. Noseworthy the objectives were narrowed down fairly early on in the planning stages of the practicum, which made it more feasible. This will be important to remember in future projects so that smaller scale work is performed at a high bar rather than extensive work finished with subpar quality.

Accountability

From the beginning phases of planning what the practicum project will entail, to navigating difficult areas where progress was hindered, it has been imperative to maintain open communication with the project supervisor, Dr. Ann Noseworthy. Frequent discussions concerning the project helped this author adhere to timelines, and ensure expectations were being met. When faced with challenging barriers to the project, namely Keewatin Air's lack of timely responses and poor schedule availability, it was essential to maintain professionalism with the external organization. As well, to maintain accountability to the agreed upon project expectations, such issues were promptly relayed to the project supervisor so that a delay in external communications did not snowball into other delays. It was important to give regular updates to Dr. Noseworthy to inform her of the current progress, and plans for remedying the aforementioned impediments to the original project's plan.

Advanced Nursing Competencies

This practicum helped foster the development of three advanced nursing competencies in the research, clinical, and leadership categories. The research competency "Identify and implement research-based innovations for improving patient care" (CNA, 2008 p. 24) was demonstrated in this practicum by conducting a literature review to reveal which research-based innovations existed for improving the care and overall safety of the neonatal patient on flight transports. The literature review highlighted evidence-based safety risks, which informed the interview questions with NICU nurses and neonatologists to explore ways such risks are mitigated in NICUs. By researching ways to reduce identified evidence-based risks this author has been able to start developing a resource toolkit for Keewatin Air to help improve neonatal patient care.

The advanced clinical nursing competency demonstrated in this practicum is “plan, initiate, coordinate, and conduct educational programs based on needs” (CNA, 2008 p. 23). During Practicum 6660 the planning and initiation phases of this competency have been executed, with the coordination of the educational program to be carried out in Practicum 6661. During this semester, conversations with Keewatin Staff have been important for initiating the educational program’s foundation, and the literature review and consultations were essential to planning the education’s content and delivery format. In the latter half of this year, the educational toolkit will be developed and this author will be coordinating with Keewatin Air and the TeleHealth program at Winnipeg Children’s Hospital to implement the program. The implementation will likely extend beyond the scope of the practicum but will be introduced during this time.

For the advanced nursing leadership competency, “evaluating programs in the organization and the community and developing innovative approaches to complex issues (CNA, 2008 p. 25), this author evaluated Nunavut’s neonatal transport program, Keewatin Air to identify competency areas for improvement and ways to provide greater access to quality neonatal transport care in northern communities. To address this complex need, an educational resource is being developed to help bridge identified knowledge gaps and provide curriculum that aligns with recommendations from transport organizations such as CAMTS. As well, an innovative approach is being explored to remedy the barriers to accessing resources in the remote northern communities. This will entail using the existing TeleHealth program in Winnipeg Children's Hospital's NICU to give Keewatin Air staff access to expert resources and guidance.

Conclusion

To safely perform neonatal flight transports requires advanced skill proficiency, excellent team dynamics for crisis management, and strong patient assessment abilities. This practicum's purpose is to provide Keewatin Air with an educational resource to help their team improve access to safe neonatal acre in the northern communities. The literature review and consultations completed thus far have revealed key content areas for the educational resource, which include enhancing access to NRP, risk mitigation strategies, and simulation scenarios for skill and communication development. Moving forward the next steps in the educational resource development will be: performing a site visit to one of Keewatin Air's medical bases; collaborating with existing neonatal transport teams to gather simulation scenarios built off of CAMTS curriculum recommendations; organizing a list of evidence-based safety risks and NICU recommendations for mitigation; and detailing innovative solutions Keewatin Air can consider to expand access to NRP. By providing Keewatin Air with a research-informed educational toolkit, their medical team will be more prepared to safely care for neonates on flight transports.

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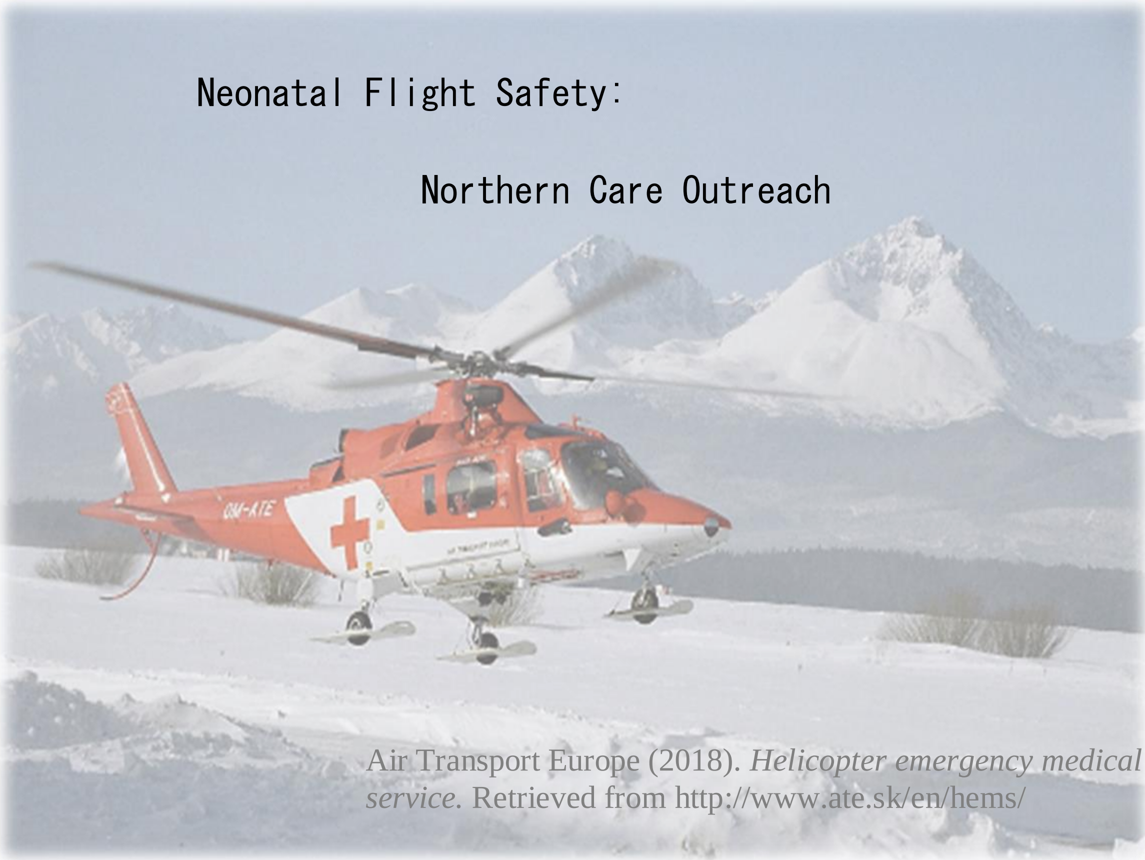
Appendix

Component	Step	Submit by	Feedback due by
Site Visit	Site Visit	10/Jan/2019	
	Implications to Original Plan	15/Jan/2019	20/Jan/2019
NRP and Risk Mitigation Components (Part1)	Outline (Parts 1+2)	07/Jan/2019	10/Jan/2019
	First	12/Jan/2019	17/Jan/2019
	Second	30/Jan/2019	04/Feb/2019
	Third	04/Feb/2019	09/Feb/2019
Simulation Scenario Compilation (Part2)	First	30/Jan/2019	07/Feb/2019
	Second	09/Feb/2019	14/Feb/2019
	Final	27/Feb/2019	03/Mar/2019
Dissemination Material	First	07/Mar/2019	14/Mar/2019
	Second	15/Mar/2019	19/Mar/2019
Presentation	Week of	25/Mar/2019	
Practicum report	First	03/Mar/2019	10/Mar/2019
	Second	18/Mar/2019	25/Mar/2019
	Final	10/April/2019	15/April/2019

Appendix D



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Executive Summary

To safely provide aeromedical transport for critical ill neonates, the transport program needs to be equipped with the appropriate knowledge, funding, and resources. This Neonatal Transport Improvement Project (NTIP) will serve Keewatin Air, an aeromedical organization tasked with providing neonatal transport services to all of Nunavut, Canada. The NTIP is presented in two parts: Program Support Presentation and Simulation Educational Toolkit. The former includes risk mitigation strategies, ways to improve access to neonatal resuscitation program, and possible funding opportunities to support Keewatin Air. Part II of NTIP will provide Keewatin Air's medical education team (MET) with a toolkit on how to deliver simulation training and a collection of neonatal simulation scenarios to help their staff improve their neonatal competencies and ultimately patient safety.

- ***Risk Mitigation***
    - Neonatal specific transport risks primarily include vibration, and noise stressors, and altitude related complications due to gas expansion
    - Recommendations that stem from consultation with established neonatal transport teams, neonatologists, and neonatal intensive care units
- ***Improving Neonatal Resuscitation Program Access***
    - Options for improving access to NRP include the use of existing TeleHealth program at Winnipeg Children's Hospital to offer the certification remotely
- ***Grant Funding Opportunities***
    - Keewatin Air would benefit from and be competitive for three grants. These include the Canadian Paediatric Society: NRP Emerging Investigator, Nunavut Department of Family Services- Training and Employment Initiative, and Northern Health- IMAGINE (CPS, 2019; NDFS, 2019; Northern Health, 2019).
    - Overview of each grant, application procedures, why Keewatin Air would benefit from this funding, and considerations for increasing their chance of success when applying (i.e. collaborating with Laurentian University, the

only doctoral program in Canada with a PhD exclusively in Rural and Northern Health).

- ***Simulation Educational Toolkit***
    - Rationale for simulation training as the instructional delivery format
    - Implementation and evaluation- how the simulation training is integrated into Keewatin Air's medical education curriculum will be at the discretion of the MET, but a recommendation to complement and benefit the education is use of TeleHealth via Winnipeg Children's Hospital (WCH) for added expertise. The evaluation form will be in three sections-
        - Section A- to be distributed pre-and post-simulation training to gauge whether the education was effective
        - Section B- to be distributed post-simulation training to provide participants with a narrative forum to speak to what worked for them and what could be done differently to improve the simulation training
        - Section C- to be distributed post-simulation to evaluate the simulation training as an education format
    - Educator preparation-
        - Includes suggested readings that explain the foundations of simulation training and focus points such as communication, pre-transport stabilization and debriefing
        - Reading material also gives content background on neonatal competencies to improve educator effectiveness at presenting the neonatal simulation scenarios and answering student questions in greater depth
    - Learning outcomes- objectives presented in SMART (specific, measurable, achievable, realistic, and time-phased) format (CDC, 2009) to evaluate participant success with each simulation scenario, the overall toolkit, and self-evaluation of instructor effectiveness
    - Tips for effective simulation- focus points provided (i.e. communication, pre-transport stabilization) and evidence-based advice for debriefing effectively
- ***Program Support Presentation*** *(Refer to Appendix A for PowerPoint slides)*
- ***Neonatal Simulation Scenarios*** *(Refer to Appendix B for scenarios)*
- ***Pre-transport stabilization guidelines*** *(Refer to Appendix C for S.T.A.B.L.E guidelines)*
- ***Simulation Educational Toolkit Evaluation Forms*** *(Refer to Appendix D for evaluation)*
- ***SMART Objectives*** *(Refer to Appendix E for SMART objectives for evaluating program and Keewatin Air's MET effectiveness as instructors)*

Neonatal Flight Safety: Northern Care Outreach

Keewatin Air Neonatal Transport Improvement Project: Part I

Program Support Presentation

Neonatal Flight Safety: Northern Care Outreach

Aeromedical transport of neonates comes with a plethora of risks (Bouchut, Lancker, Chritin, & Gueugniaud, 2011; Schierholz, 2010), and requires certification in neonatal resuscitation program (NRP) along with a strong continuing education curriculum to maintain competencies (Cross & Wilson, 2009). The purpose of the Program Support Presentation is to respond to three program needs identified in consultation with Keewatin Air. First, to improve clinical outcomes and neonatal safety during transport, risk mitigation strategies are presented. Second, since Keewatin Air's medical directors indicated a need for improved access to Neonatal Resuscitation Program (NRP) certification for their staff, this NTIP also contains a brief section addressing possible solutions for bridging the gap between urban facilities where most NRP courses are held, and the remote medical bases of Keewatin Air. Lastly, select grant opportunities are highlighted to provide possible funding options for Keewatin Air to consider (Refer to Appendix A for Program Support Presentation slides).

Risk Mitigation

Transport Risks

The transport environment can be quite hostile with exposure to extreme temperatures, turbulence, limited resources, and unpredictable scenarios (Campbell & Dadiz, 2016). The fragility of neonates makes this population tremendously vulnerable to transport risks (Schierholz, 2010), which necessitates the need for transport teams to take all possible risk mitigation measures to ensure neonatal flight safety.

Although risks abound with neonatal aeromedical transports, part 1 of the program improvement document will address three of the top five physical stressors (Bouchut et al., 2011): noise, vibration, and altitude.

Vibration and Noise. Noise and vibration levels that neonates are exposed to during helicopter (80.4-86.4 dBA; 1.68-5.09 m/s^2 respectively) and ground transport (70.3-71.6 dBA; 1.82-3.96 m/s^2) exceed acceptable *adult* standards (Bailey et al., 2018). Similarly, Sittig, Nesbitt, Krageschmidt, Sobczak, and Johnson's (2011) study reveals close to 80dB incubator noise levels on aeromedical transports, which far exceeds proposed noise limit recommendations of 45dB in neonatal intensive care units (NICU). Consultations with neonatologists at a rural trauma center in New Hampshire, USA, Dartmouth Hitchcock Medical Center (DHMC) and Winnipeg Children's Hospital (WCH) in Winnipeg, MB, Canada, found that since neonates are in such a delicate stage of life and have to concentrate to regulate their bodies, sudden "startles" from sound or vibration is a sensory overload that exhausts their ability to regulate functions like respirations, resulting in apneic episodes for example. According to DHMC neonatologists, the fragility of premature neonates stems from underdeveloped neurologic capacity to regulate and coordinate basic life functions such as respirations leaving this population extremely vulnerable to sound and vibration stressors.

One solution Keewatin Air could consider to reduce the neonate's exposure to intense sounds on transport is the use of earmuffs. In Karlsson et al.'s (2011) study, statistically significant (p=0.05) differences were found in neonatal stress levels (indicated by tachycardia), where higher heart rates were observed among neonates without hearing protection compared to those wearing earmuffs ($p<0.01$). Additionally, consultation with various neonatal transport teams and NICUs show earmuffs as a cost efficient and simple intervention to reduce sound stress on neonates.

Another feasible intervention for noise reduction stems from consultation with NICU nurses from WCH and Boston Children's Hospital who report covering isolettes with thick cloth helps insulate the interior from excessive noise or at least dull the intensity of exterior sound. They explained how the cloth is custom made with flaps that can lift for easy visualization of the neonate. The NICU nurses described how the thick layer of fabric helps absorb some of the noise and decreases the number of sound waves that pass through the plexiglass isolette. Incorporating heavy cloth coverings to the transport isolette exteriors is an attainable risk mitigation strategy Keewatin Air can employ for noise related neonatal stress.

With vibration, researchers found that the use of a gel mattress by itself or with a foam pad reduced accentuation of vibration (Gajendragadkar, Boyd, Potter, Mellen, Hahn, & Shenai, 2000). This helps to reduce vibration stress and prevents complications such as intraventricular hemorrhages or bradycardia-desaturation events while transporting the neonate (Gajendragadkar et al., 2000). However, Gajendragadkar et al. (2000) and Prehn et al. (2014) cautioned that the use of a gel mattress is ineffective for reducing vibration stress when used with very low birth weight babies due to not having enough weight on the mattress. Although further research is needed for vibration risk reduction in VLBW neonates, gel and/or foam can be used by Keewatin Air to help mitigate vibration for all other neonates transported.

Altitude Related Stressors. Altitude and barometric pressure changes during flights can adversely impact critically ill neonates during transport due to decreased tissue oxygenation or clinical deterioration due to gas expansion in body cavities (Bigham & Paxton, 2018; Schierholz, 2010). According to Essebag, Halabi, Churchill-Smith, and Lutchmedial (2003), the volume of trapped gas will expand by 35% when flying from sea level to 8000 feet in altitude. This gas expansion can result in complications such as pneumothoraxes or intracranial hemorrhages (Joshi & Sharma, 2010), which require transport specific consideration to optimize patient safety. With this in mind, Keewatin Air should consider pre-transport stabilization measures, such as chest tube insertion for even stable pneumothoraxes, in recognition of the gas expansion risk en route (Schierholz, 2010). In the same vein, as water does not share the same expansion properties of gas (Cooper, 2011) Keewatin Air should instill water rather than air in the cuffs of their ventilated neonates. This will help avoid tracheal tissue ischemia from cuff expansion during takeoff or loss of tidal volume with cuff collapse on landing (Joshi & Sharma, 2011).

Regarding tissue oxygenation issues, Stroud, Gupta, and Prodham's (2012) study reveals statistically significant differences between baseline (control group) cerebral oxygen levels using near-infrared spectroscopy (NIRS) and cerebral oxygen levels when transported at an altitude greater than 5000 feet above ground level (exposure group) (NIRS 69.2% SD 8.9% versus NIRS 66.3%, SD 9.8%, $p<0.001$ respectively). Dalton's Law ($P_t = P_1 + P_2 + ... + P_n$) explains why with drops in barometric pressures and partial pressures of oxygen at higher altitudes, oxygen movement along the alveolar-capillary pressure gradient is impaired. This is important to consider on neonatal transport as a compromised alveolar-capillary pressure gradient reduces the amount of oxygen delivery to vital tissues and organs (Stroud et al., 2012).

Stroud et al.'s (2012) study reveals no change in pulse oximetry (SpO2) values despite significant reduction in cerebral oxygenation levels (baseline and 5000 altitude: NIRS= 69.2%, 66.3%, $p<0.001$; SpO2= 98.7%, 98.9% $p= 0.61$), suggesting that NIRS monitoring provides the benefit of earlier decreased oxygenation detection. If financially feasible, Keewatin Air could utilize NIRS monitoring during transports to enable early detection and intervention with supplemental oxygen for altitude related oxygenation impairment in the vulnerable neonatal population (Stroud et al., 2012).

Additionally, it is imperative for aeromedical teams to understand aviation physiology and know when to request their pilots to fly at a lower barometric cabin pressure (Woodward & Vernon, 2002). The Canadian Aerospace Medicine and Aeromedical Transportation Association (CAMATA) offers an extensive aeromedical course, which covers altitude physiology, and can be done at a location of the sponsoring organization's choice (CAMATA, 2019). Should Keewatin Air decide to pursue refresher training on altitude related considerations for neonatal transport, this course may be a suitable option.

Improving NRP Access

Telehealth Expansion. There is an existing Telehealth program at WCH, one of the primary receiving facilities of Keewatin Air's neonatal transports. This Telehealth program has an established network of pre-set connections configured with remote sites, including most of Keewatin Air's bases (J. Buse, personal communication, January 8, 2019). The current use of the program is for neonatologists to provide expert guidance on the care of neonates until they can be transferred to the tertiary care facility as needed. The proposition is for this Telehealth program's use to expand to include provision of NRP courses to medical staff in remote locations. Presently, medical staff in remote areas must travel long distances to urban centers such as Winnipeg to receive continuing education, which can be quite costly. For instance, a round trip flight from Rankin Inlet, Nunavut, home of one of Keewatin Air's medical bases, to Winnipeg, MB is upwards of $2177 per person (First Air, 2019). By using WCH's Telehealth program to offer the NRP course by video helps to bridge the vast distance and offers a more cost-efficient model for northern continuing education.

Should Keewatin Air and WCH pursue the option of Telehealth expansion, two items for consideration that may create setbacks are intermittent connection and instructor availability. Regarding the former, if Telehealth is to be used for educational purposes, the priority must still go to triaging emergency calls from referring medical facilities. Such urgent situations arise sporadically and cannot be scheduled around to avoid NRP interruption. Though this would not be an absolute barrier to provide the course through a Telehealth format, the availability of the device may be unpredictable. As well, course instructors would have to be contracted out and be willing to teach NRP in this distance-education format.

Grant Funding Opportunities

Three grant opportunities were identified as possible funding opportunities to expand on NRP course availability in the northern remote communities. These grants include: Canadian Paediatric Society (CPS) - NRP Emerging Investigator, Nunavut Department of Family Services (NDFS) - Training and Employment Initiative, and Northern Health- IMAGINE (CPS, 2019; NDFS, 2019; Northern Health, 2019).

The Canadian Paediatric Society lists resuscitation education formats as one of the grant's research priorities (CPS, 2019). Should Keewatin Air choose to pursue this option, the delivery of NRP instruction through Telehealth could be pitched as an innovative education format to help create sustainable and accessible NRP programs in Northern Canada. As this grant is tailored to new researchers, it would behoove Keewatin to reach out to Canadian universities to identify PhD students who would be interested in pursuing research in this area. This would increase Keewatin's competitiveness for the CPS Emerging Investigator Grant. Laurentian University would be a good option as this is the only doctoral program in Canada with a PhD exclusively in Rural and Northern Health (Laurentian University, 2019). Students in this program are passionate about rural and northern health research and may be interested in applying for this grant to focus on improving neonatal health outcomes.

With the Nunavut Department of Family Services- Training and Employment Initiative, preference is given to initiatives that will provide training for essential skills related to line of employment, and will help with employment readiness and preparation. This grant could also be used to provide CAMATA training to Keewatin Air's medical staff. Keewatin Air would be competitive for this funding opportunity if they can provide the number of Nunavut residents employed by Keewatin Air's medical team who would benefit from this grant.

The final grant, Northern Health's IMAGINE, gives preference to projects that help to reduce health inequities. As Keewatin is tasked with all neonatal transports from Nunavut, an area largely populated by Inuit, a culture that is medically underserved (Greenwood, de Leeuw, & Lindsay, 2018), this is particularly relevant. Waldram and Herring (2006) illustrate the effects this health disparity has on Inuit children by revealing an infant mortality rate three times higher among the Inuit population than the national average in Canada. Keewatin Air's efforts at reducing the health inequity of Inuit neonates may increase their competitiveness for this grant should they choose to pursue such funding. Although this grant does not explicitly list tools or equipment in approved budgetary items, if Keewatin Air can demonstrate the benefits of NIRS for improving safety and thereby reducing health inequities for Inuit neonates, it may be possible for IMAGINE funding to go towards this monitoring system.

Conclusion

For an aeromedical organization to safely provide care, it must first have a sound understanding of inherent risks and the respective mitigation measures. As well, a successful aeromedical team requires adequate financial and educational resources. Following a needs assessment with Keewatin Air, a portion of this document was committed to identifying risk mitigation methods for neonatal transport, ways to improve access to NRP certification for Keewatin Air's medical staff, and potential funding sources to support continuing education efforts of Keewatin Air. With the recommendations for program support provided in this presentation, Keewatin Air can optimize patient safety, particularly when delivering access to care for neonates in northern communities.

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Neonatal Flight Safety: Northern Care Outreach

Keewatin Air Neonatal Transport Improvement Project: Part II

Simulation Educational Toolkit

Neonatal Flight Safety: Northern Care Outreach

Aeromedical transport is inherently dangerous, particularly for the vulnerable neonatal population (Bouchut, Lancker, Chritin, & Gueugniaud, 2011; Schierholz, 2010), but for remote areas, such as Northern Canada, this remains the only feasible option to access specialized services in tertiary care centers (McKenzie, 2015). To safely perform neonatal flight transports, advanced skill proficiency, strong patient assessment abilities, and excellent team dynamics for crisis management are required. The purpose of NTIPS Part II is to provide Keewatin Air with an educational toolkit that will largely consist of high fidelity simulation scenarios, which are considered the gold standard in education for aeromedical transport teams (Campbell & Dadiz, 2016; Martin, Bekiaris, & Hansen, 2017; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011).

Simulation Overview

Rationale for Use

There is an old proverb that says: "Tell me and I will forget, show me and I may remember, involve me and I will understand." This is the backbone of simulation training and is why many aeromedical teams consider simulation unparalleled for achieving transport educational objectives. According to Datta, Upadhyay, and Jaideep (2012) simulation training is a replication of real-world scenarios to provide education that is immersive in a risk-free environment. Lavine and Rabrich (2018) emphasize that simulation also helps foster teamwork in managing life-threatening situations to improve communication, skill proficiency, and assessment skills without risking patient harm during practice.

Simulation is particularly useful for high-risk, low-frequency scenarios such as neonatal transports (Campbell & Dadiz, 2016), and is recommended for maintaining required aeromedical competencies by The Commission on Accreditation of Medical Transport Systems, an organization which sets national patient safety standards for transport in the United States (CAMTS, 2018). Alfes, Steiner, and Rutherford-Hemming's (2016) exploratory study polled over 300 members of the Association of Air Medical Services, Air and Surface Transport Nurses Association, and the Association of Critical Care Transport. This study further validates that simulation is a preferred educational format for aeromedical transport teams. In order to provide Keewatin Air with an educational toolkit rooted in evidence-based best practice, simulation was chosen as the format of instructional delivery.

In addition to the educational benefits from simulation training, this style of training has also been touted as best practice for interdisciplinary team building (Austin et al., 2017; Germano, Brown, Hermosura, Bradshaw, Deutsch, & Hoy, 2018; Stuart & Flanagan, 2010). As Keewatin Air operates with a nurse-paramedic or nurse-respiratory therapist model, simulation was chosen as the instructional delivery format to help improve communication, task-sharing, and interpersonal relationships as a dynamic aeromedical team.

Implementation

After providing reading materials to give Keewatin Air's medical education team (MET) content background and instruction on how best to facilitate simulation training (i.e. with advice on when and how to provide constructive feedback, encouraging the use of provided focus points such as closed loop communication, etc.), the collection of simulation scenarios has been provided to Keewatin Air's MET. From here, the simulation (Refer to Appendix B: Neonatal Simulation Scenarios) can now be integrated into the medical staff's continuing education curriculum at each of the northern bases. Other than recommendations for overarching focus points to be used throughout the scenarios, it will be at the discretion of Keewatin Air's MET for how to implement the simulations. For instance, the number of participants and the medical roles involved in each scenario may depend on organizational protocols (i.e. the team configuration Keewatin Air uses for congenital cardiac defect transports may be physician, nurse, respiratory therapist whereas hyperbilirubinemia transports may require nurse only). For this reason, the educational toolkit should serve as a vehicle for Keewatin Air's MET to steer in the direction most appropriate to their organization's needs and dynamics.

The option of using WCH's Telehealth to have neonatologists and neonatal intensive care unit nurses observe Keewatin Air's simulation performances and provide feedback or recommendations has been discussed. As with the use of this program for NRP instruction, it will depend on the availability of the channel and will only be possible when it is not in use for triaging calls. However, when available it will provide Keewatin Air with an excellent opportunity to receive meaningful feedback on their simulations from experts in neonatal care.

Evaluation

Six months after initial implementation of the simulation training, this writer will provide written surveys to Keewatin Air's medical staff (refer to Appendix D: Evaluation

Report) to gauge what worked well with the simulation scenarios and what could be improved. As well, if the medical staff felt a certain concept could be elaborated on, or reinforced further through different angles, additional simulation scenarios on that topic can be developed. For instance, if after running through the simulation scenario on cardiogenic shock due to congenital heart disease (Refer to Appendix B, pages 177-179), participants wished for further education on specific congenital heart diseases, simulation scenarios on Tetralogy of Fallot, Left Hypoplastic Heart Syndrome, Pulmonary Atresia, etc., could be provided to meet this learning need.

The evaluation is divided into three sections (Refer to Appendix D). Keewatin Air's MET should distribute "Section A" pre-and post-simulation training to gauge whether the education was effective. The remaining two sections should be distributed after completion of the simulation program to help provide additional feedback or suggestions for improvement. After completion of the program, Keewatin Air's MET should ask participants to provide brief narratives to the open-ended questions in "Section B" to help identify what worked for the students or what could be done differently to improve the training. The final piece, "Section C," should also be distributed only after completion of the program and is meant to evaluate simulation as an educational format and allowing feedback on particular simulation components such as debriefing. The evaluation portion, albeit outside of this practicum's timeframe, will be imperative to ensuring continued success of the educational toolkit optimizing learner satisfaction.

Simulation Educational Toolkit

Educator Preparation

Prior to implementing this educational toolkit, Keewatin Air's MET is encouraged to review the foundations of simulation training. The following books and journal articles provide a comprehensive overview of this educational format and include recommendations for effective instructional delivery, rationale for simulation's use in healthcare, and common pitfalls to avoid when facilitating simulation scenarios

- *Healthcare Simulation Education: Evidence, Theory and Practice* (Nestel, Kelly, Jolly, & Watson (2017) and *Pocket Book for Simulation Debriefing in Healthcare* (Oriot, & Alinier, 2017)
    - Includes theoretical underpinnings of simulation training
    - Addresses the component of realism in simulation
    - Explains how to support the learner before, during, and after each simulation exercise
    - Gives the history of simulation's use in healthcare education and highlights its strengths as a training format
    - Provides strategies for managing adverse events during simulation
    - Details the art of effective debriefing and how to deliver feedback in a constructive, non-intimidating manner to maintain a safe learning environment
- *High- Fidelity Simulation Training for Transport Team Training and Competency Evaluation* (Cross & Wilson, 2009), *Foundations in Neonatal*

and Pediatric Respiratory Care - Chapter 33: *Transport of the Neonate and Child* (Bigham, & Paxton, 2018), and *Simulation in Neonatal Transport Medicine* (Campbell & Dadiz, 2016)

- Provides rationales for using simulation to train neonatal transport teams
- Identifies potential crises on neonatal transport and respective risk-mitigation that can be taught through simulation training (i.e. insertion of chest tube to prevent worsening of pneumothorax when flying at higher altitudes during transport)
- Highlights the history of simulation training among neonatal transport teams and reference national and international guidelines and standards that support simulation as gold standard for neonatal transport team education
- Provides percentages of neonatal issues (i.e. 20% of neonates require intubation for safe transport) to help educators decide which skills to prioritize during training
- Gives tips for facilitating neonatal simulation (i.e. the educator programming the infant's low heart rate to improve once effective bag-mask ventilation is performed)

Keewatin Air's MET will also benefit from the following reading material on neonatal specific transport competencies and diagnoses seen frequently in the neonatal population. This will prepare the educators to present each neonatal simulation scenario effectively. This will also ensure a more thorough understanding of the material and enable Keewatin Air's MET speak in greater depth to the neonatal concepts addressed in this toolkit.

- *ASTNA Patient Transport: Principles and Practice*- Chapter 32: *Care and Transport of the Neonate* (Tijerina, 2010), *Comprehensive Neonatal Nursing Care* (Kenner, 2013), and *Neonatal Emergencies: A Practical Guide for Resuscitation, Transport, and Critical Care of Newborn Infants* (Hansmann, 2009)
    - Provides neonatal specific considerations for transport including extended scope of practice skills such as umbilical venous catheter insertion
    - Covers a variety of neonatal pathologies (i.e. congenital cardiac defects) and their respective considerations for pre-transport stabilization
    - Details how to perform thorough physical assessments of neonates and highlights specific items to look for (i.e. number of vessels in umbilical cord – two arteries, one vein)
    - Explains prioritization of care and helps explain how transport teams can approach clinical scenarios to form differential diagnoses

As communication, pre-transport stabilization are two of the focus areas of this educational toolkit, Keewatin Air's MET should also review the following literature to garner a deeper understanding of the rationale behind certain communication formats and recommendations for teaching how to stabilize a neonate in an organized fashion.

- *Evaluation of Situation, Background, Assessment, Recommendation Tool During Neonatal and Pediatric Interfacility Transport* (Wilson, Kochar, Whyte-Lewis, Whyte, & Lee, 2017) and *Medical Emergency Teams: Implementation and Outcome Measurement*- Chapter 21: *Teaching Organized Crisis Team Functioning Using Human Simulators* (Fiedor, Hunt, & DeVita, 2007)
    - Presents formats (SBAR and closed-loop) that are rooted in evidence-based best practice for effective communication - this is important for Keewatin Air's MET to be familiar with as improved communication is a focus area of this toolkit
    - Explains how closed-loop communication can reduce chaos during crisis and ensure the right task is performed by the right person
    - Lists accrediting organizations and patient safety commissions that recommend the use of SBAR for reduction of error and patient harm
    - Illustrates SBAR's use in neonatal transport
- *The S.T.A.B.L.E. program: Post-Resuscitation/Pre-Transport Stabilization Care of Sick Infants* (Taylor & Price-Douglas, 2008)
    - Explains how this mnemonic (S: sugar and safety, T: temperature, A: airway, B: blood pressure, E: emotional support) helps to

prioritize pre-transport stabilization interventions when caring for neonates- this is important for Keewatin Air's MET to review because pre-transport stabilization is one of the focus areas of this toolkit

Learning Outcomes

The learning outcomes for each of the simulation scenarios as well as the overall toolkit are presented as SMART objectives. Having specific objectives for this educational resource will provide Keewatin Air's MET with a structured format for monitoring how well the simulation training is helping staff improve their neonatal competencies. According to the Center for Disease Control and Prevention (CDC, 2009), SMART is an acronym used to describe objectives that are: *specific* (who, what, etc.), *measurable* (how much change is expected), *achievable* (attainable within certain timeframes, budgets, etc.), *realistic* (accurately addresses the scope of the problem or purpose), and *time-phased* (when the objective will be accomplished).

Keewatin Air's MET should review the SMART objectives before each simulation scenario to understand what participants should accomplish or learn during that exercise. To help gauge how well the participants performed, Keewatin Air's MET can refer to the SMART objectives and clearly differentiate between objectives met vs. further education warranted. For example, one of the SMART objectives in the cardiogenic shock scenario (Refer to Appendix B pages 177-179) reads "by the end of this scenario participants will have improved awareness of cardiac symptoms as evidenced by verbalizing at least three assessments (liver palpation, murmur auscultation, femoral pulse palpation, 4-limb BP, pre- and post-ductal saturation checks, etc. will be acceptable answers).” This objective provides a certain number of correct answers the participants should be able to verbalize by the end of the scenario if the simulation was sufficient at improving their awareness of cardiac symptoms.

SMART objectives will also be used to help evaluate the overall success of the educational resource. A pre- and post- survey will be administered to Keewatin Air’s medical staff before and after their participation in the simulation training to help gauge whether the education was effective. A number of categories will be assessed (i.e. overall confidence in skill execution, team dynamics and communication, understanding of neonatal competencies for transport, etc.) using a Likert scale format. An example of a SMART objective that will help Keewatin Air’s MET appraise this educational program is “By the end of the simulation training, the overall mean score for the skill proficiency, stabilization, and prioritization of care (Section A: question #s 6, 8, & 10) will increase on pre- and post scores by at least 50%.” The SMART goals for the educational resource evaluation will help Keewatin Air’s MET determine whether the intended learning targets were met (Refer to Appendices D and E for Simulation Evaluation and SMART Objectives respectively).

According to Conzemius and O’Neill (2009) SMART goals can also be used to help instructors evaluate how well they are delivering the educational content, and what areas they can improve on. A number of SMART objectives have been provided for Keewatin Air’s MET to assess how well they performed as instructors (Refer to Appendix E: SMART Objectives for Educator Effectiveness). For example, in determinging whether the debriefing helped improve participants' learning experience Keewatin Air's MET can look at the SMART objective: "Effective debriefing will be provided as evidenced by not more than 50% of participants scoring less than 2 on Section C question #s 3, 4, & 5 after the simulation training." Using these SMART objectives as part of educators' self-evaluation will help Keewatin Air's MET understand what is working for the students and what could be changed to improve their instructional delivery (Conzemius & O'Neill, 2009).

Using objective criteria to evaluate an educational program can help determine the degree of knowledge acquisition at micro (individual simulation scenarios) and macro (overall educational program) levels, as well as the effectiveness of instructional delivery or program design (CDC, 2009).

Tips for Effective Simulation

Focus Points. Considering the need for aeromedical teams to be able to operate in sub-optimal environments with immense levels of stress and responsibility, strong teamwork and communication are imperative to improve clinical outcomes on neonatal transport. This is significant as deficiencies in communication and teamwork were cited as the root cause in 70% of adverse events in Weaver, Dy, and Rosen's (2014) integrative review. One of the key focus points for Keewatin Air's simulation training therefore should be on interdisciplinary communication. Learners will be taught to utilize closed-loop communication (i.e. rather than "can someone get me Epinephrine?" encourage "Thomas, will you please draw up 0.1ml/kg of Epinephrine," with Thomas replying, “Yes, I have drawn up 0.1ml/kg of Epinephrine.”) to avoid misinterpretation or tasks not being executed.

Learners should be encouraged to utilize an organized approach to their communication during transition of care phases. One method that has been demonstrated as effective during handoffs in healthcare is the situation, background, assessment, and recommendation (SBAR) technique (Lavine & Rabrich, 2018). The simulation facilitator for Keewatin Air can assess how well team members utilize this approach when reporting to medical control and discussing their plan of care for each simulation scenario.

Another focus point is maintaining a realistic environment to ensure knowledge translation to real-life transport scenarios is feasible. Bender and Kennally (2016) lauded the opportunities available during simulation to ensure transport equipment functions properly and to identify potential safety issues. Current literature shows that transport logistics and equipment malfunctioning account for a large percentage of adverse events on transport (Moss, Embleton, & Fenton, 2005; van den Berg, Olsson, Scensson, & Håkansson, 2014) As Keewatin Air implements the simulation scenarios, it will be imperative that they use their actual transport equipment to optimize team familiarity with the equipment and improve trouble-shooting abilities for use as needed. As well, depending on plane availability, it will behoove Keewatin Air to practice loading the isolette into the aircraft at the end of each simulation scenario once the team has stabilized the neonate, as loading and unloading are inherently high-risk components of transport (Bennett, Moran, & Collins, 2012).

As pre-transport stabilization is touted throughout the literature as being essential to reduce transport related morbidity and mortality (Cornette, 2004; Gente et al., 2015; Mears & Chalmers, 2005; Powell-Tippit, 2005; Teasdale & Hamilton, 2008), this should be an overarching focus point during the simulation training. The rationale for pre-transport stabilization is the ease of managing issues proactively in a facility rather than urgently as they arise in the hostile transport environment en route. Keewatin Air simulation facilitators should therefore challenge the team to think proactively as they respond to each given scenario and verbalize which interventions would be helpful for risk-mitigation. For example, in the supraventricular tachycardia (SVT) scenario (refer to Appendix A, pages 189-192), if adenosine only has a brief effect and the team is concerned about the neonate becoming hemodynamically unstable with SVT again en route, they should consider cardioverting in a facility prior to departure.

Keewatin Air's MET can consider utilizing published guidelines such as S.T.A.B.L.E (Taylor & Price-Douglas, 2008) to help structure how they provide feedback on the team's pre-transport stabilization approach at the end of each simulation scenario (Refer to Appendix C for explanation of S.T.A.B.L.E guidelines). These guidelines cue teams into some of the priorities in neonatal stabilization (i.e. S- sugars and safety; t-temperature; a- airway; b- blood pressure; l- lab results; e- emotional support). Pre-transport stabilization should be performed or at least discussed during each simulation scenario to foster a proactive rather than reactive mindset.

Debriefing. According to a systematic review by Issenberg, McGaghie, Petrusa, Gordon, and Scalese (2005), feedback is vital for simulation's effective learning because it facilitates knowledge retention. For simulation to be effective, students should feel comfortable to learn from their mistakes (Eppich et al., 2013). As such, Keewatin Air is encouraged to have debriefing that is supportive to avoid instilling fear or anxiety among participants, which could hinder their future performances.

An example of how to provide supportive debriefing is bookending the constructive criticism with strengths (Bonnel, 2016; Saleeby, 2002) or positive recognition. For example, in the altered mental status simulation (refer to Appendix A, pages 200-203) if hypoglycemia was appropriately recognized but the learner miscalculated how much dextrose was needed for correction, the facilitator could present the feedback as follows: “You were quick to recognize hypoglycemia as a possible cause for the baby’s altered mental status. The calculation for the weight based correction using a D10W infusion was incorrect, which could have resulted in overcorrecting the low sugar. As a team however, you worked to set a reminder to recheck sugar in 30 minutes, which was great.” Delivering feedback in an unintimidating manner would create a comfortable discussion where the student would be feel open to reflect on their practice and identify direction for change (Cederbaum & Klusaritz, 2009).

Feedback can be delivered through post-simulation debriefing or concurrently while the simulation is in progress (Eppich, Hunt, Duval-Arnould, Siddall, & Cheng, 2015). For instance, in the cardiogenic shock simulation (refer to Appendix B, pages 177-179), an unacceptable action of treating the low blood pressure would be initiating an intravascular fluid bolus. The facilitator could provide within-event feedback by saying “The patient appears to be deteriorating with the fluid bolus. Why do you think this might be happening? What could you do instead to treat the blood pressure in this situation?" These probing questions will prompt the learner to recognize the heart's intolerance to extra fluid in the cardiogenic shock state, and consider alternative measures such as vasopressor medication as needed.

Keewatin Air is also encouraged to use videotaping where possible to provide participants the opportunity to view their performance on film for an unbiased presentation of what occurred during the simulation (Fanning & Gaba, 2007). This self-reflection will allow for participants to evaluate their own performance and identify strengths or areas for improvement. Ensuring feedback is woven throughout the simulation curriculum will enhance learner mastery of concepts and optimize knowledge translation into practice (Fanning & Gaba, 2007; Rudolph, Simon, Raemer, & Eppich, 2008).

Conclusion

Aeromedical transport requires an elite level of skill proficiency, adaptability, and teamwork in crisis management. To safely and competently perform aeromedical transports, particularly with the vulnerable neonatal population, requires a sound understanding of risk mitigation and NRP pearls, as well as strong continuing education for the aeromedical transport team. This practicum serves Keewatin Air's aeromedical team by addressing neonatal specific transport risks, offering solutions to improve NRP access in northern locations, and providing an educational toolkit rooted in simulation scenarios to optimize the team's ability to safely care for neonates on transport. Integrating neonatal simulation training to Keewatin Air's aeromedical curriculum will improve access to neonatal care in remote communities and optimize neonatal patient outcomes on transport.

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Appendix A

Program Support Presentation

Appendix B

The material in Appendix B has been reprinted for educational purposes with permission from the Winnipeg Child Health Transport Team. Material is not to be distributed outside of this student practicum project.

I hereby give permission for Mollie Ryan to use the established educational content [see attached] from *Health Sciences Center- Children's Hospital (HSC Children's)* in her scholarly papers "Practicum Report," and "Educational Toolkit." I understand that these papers will be submitted to Memorial University of Newfoundland in partial fulfillment of her Master of Nursing degree requirements. Per this agreement, I understand that Mollie will credit *HSC Children's* with appropriate citation when incorporating the reprinted simulation scenario content into her project's educational toolkit. I grant my permission for the use of the direct quotation as indicated by my signature below.

Signature	Printed Name	Date
[signature]	Ainslie Penner	March 4/19

ATTACH EDUCATIONAL CONTENT TO EACH SIGNED FORM

Neonatal Simulation Scenarios
Traumatic Brain Injury: Infant

SMART Learning Outcomes

- Participants will demonstrate improved communication as evidenced by using SBAR format at least once by the end of this scenario.
- Following this scenario, participants will be able to verbally identify signs of acute herniation and describe appropriate actions to take.

Objectives:

1. To perform initial assessment and identify need for immediate interventions.
2. To identify initial presentation of a non-accidental trauma.
3. To identify and manage acute herniation.
4. To function with other team members to stabilize the patient for transport.

Environment: Health Center, standard resuscitation room.

Personnel: Referring center RN

Case Introduction: A 4 month old, 7kg infant is brought in by the local EMS. He was found unresponsive in his crib by his mother. The infant had last been seen 4 hours earlier when he was put down to nap. Mom indicates that he was fine this morning and became progressively irritable in the afternoon. Emesis was noted in the crib, he is afebrile.

On arrival: VS: HR 162, BP 75/39, T 37.2, Sats 91% on room air, RR 18, irregular.

GCS: 8/15 (E 2, V 3, M 3), fontanelle is full and tense, head is boggy.

Peripheral and central pulses are palpable. Cap refill 2 cent, 2 perph. No outward signs of bleeding. Liver border is not felt.

No increased work of breathing. No Xray available. On auscultation, chest is clear with good air entry.

Critical Assessments:

1. Airway
2. Breathing
3. Circulation
4. Disability/Exposure

Critical Interventions:

1. Determine need for intubation to secure airway secondary to low GCS.
2. Ineffective breathing pattern, requires respiratory support.
3. Establish 2 PIV or IO access.
4. Neuro assessment and C-spine immobilization, recognize the potential for TBI

   OG insertion, NOT NG to decompress the stomach

Traumatic Brain Injury Continued

Contact Medical Control

Situation: Hi Dr. X this is Nurse Y, I am in Z Nursing Station with a 4 month old infant with decreased LOC and irregular respirations. VS: HR 162, BP 75/39, T 37.2, Sats 91% on room air, RR 18.

Background: Previously healthy baby. Well in the morning, becoming increasingly irritable in the afternoon, laid down for a nap check on 4 hours later found unresponsive, emesis in crib.

Assessment: GCS is 8/15, he responds to painful stimuli, fontanelle is full and tense. Chest sounds clear but respirations are irregular. He has no fever, rash or indication of infection. He has bruising behind his ears.

Recommendation: Based on our assessment we are concerned about a TBI. We would like to intubate for airway protection and CO2 control. We will intubate with a 3.5 uncuffed ETT with a 3.0 cuffed ETT as a backup. We don't feel that an RSI is required as the baby is not responsive. If we are unable to intubate we will try to BMV or LMA. We have established 2 PIVs that are infusing well. Are you okay with this plan? If so, I will contact you once we have secured the airway.

<u>Considerations for Transport</u>

- HOB at 30 degrees
- Immobilize c-spine while being careful not to restrict venous drainage
- Maintain tight glucose control 4-7
- ETCO2 goals 35-40
- Avoid fever
- If there are indicators of cerebral edema, (bradycardia, wide pulse pressure, high systolic pressure), treat with 3% NS boluses, minimize noxious stimuli (sedate as needed), and ETCO2 30-35

Neonatal Simulation Scenarios
Non-Accidental Trauma

SMART Learning Outcomes

- By the end of this scenario, participants will feel prepared to manage non-accidental trauma as evidenced by verbalizing improved confidence.
- In this scenario, participants will demonstrate proper assessment of a potential trauma patient as evidenced by checking the patient's pupils and backside (i.e. looking for bruising behind ears).
- Participants will perform proper pre-transport stabilization as evidenced by electively intubating the baby prior to finishing the scenario.

Topic: Coma (Infant) – Non-accidental injury

Author: Jonathan Duff **Date Updated: November 27, 2012**

Target Audience:

Medical Specialty:	Peds	ER	PICU	
Level of Training:		Senior	Fellow	Staff
Medical Students:				
Nursing:		Staff		Transport/CNS
Allied Health:				

Learning Objectives:

1. To deal with initial presentation of non-accidental injury
2. To work through the basic differential of infantile coma.
3. Treatment of the acutely herniating infant
4. To function with other team members to treat the patient in the referral center.

Monitors:

3-lead EKG	x
Pulse Oximeter	x
Resp Rate	x
NIBP	x
Arterial Line	
CVP	
$EtCO_2$	
PAP	
Temperature	

Mannequin: Baby

Environment: Referring hospital, standard resus room

Personnel: Referral center nurse – helpful with assigned tasks but no pediatric experience

Case Intro:

6 month old baby brought in by EMS, found in crib unresponsive by mother this evening. Baby had been put down two hours previously, not checked on since. Seemed fine this morning though more irritable in the last few hours, really not settling well. Vomited x1 after feed before bed. Tactile fever at home. Otherwise previously well, no PMx. No meds, no allergies.

Notes for facilitator

- On arrival of the team, baby is comatose – will respond with flexion of extremities with stimulation and brief moan
- No eye opening
- Fontanelle is bulging.
- Initial vitals – HR 160s, BP 75/40, Sats are low 90s. RR is 20 and becoming uneven. Rest of the exam is unremarkable.
- 2 bruises on the back (not noticeable unless mannequin's back examined.

Case Progression

- RR will continue to decrease and child will start to desaturate due to decreasing GCS.
- RSI required.
- L pupil will become dilated with bradycardia (HR to 80s) and BP up to 90-100 systolic with intubation (coning). [pupil will need to be done by confederate]
- Mannitol should be given with good response

Expected/Critical Actions

- Initial cardiopulmonary assessment –
- Decision to perform RSI
- Discussion of differential – infectious vs. NAT – Abx given
- Discussion of RSI and differential with intensivist

Unacceptable Actions:

- Failure to contact medical control before treatment initiated
- No pupil check after intubation performed
- Back not examined
- Coning not treated with appropriate therapy after discussion with intensivist
- No antibiotics given
- Patient not intubated

For Bedside Nurse (Infant NAI)

You are the bedside nurse looking after this 6 month old boy – name is Bill. Brought in by EMS after being found by his mother in his crib unresponsive. She says she just checked on him 2 hours prior and he was fine.

If team asks: Vomited x 1, mother admits that he was more irritable this evening. Otherwise well, no medications, no allergies, immunizations up to date, no relevant past medical history.

You note that baby was more alert on arrival and was irritable and is settling more now. Baby will progress with worsening respiratory drive, Cushing's response and L pupil dilation. As child starts to desaturate, you will need to get in and dilate his L pupil.

Notes for mother

You had left baby with your boyfriend and gone to run some errands, return to find baby unresponsive in the crib. You won't reveal this history unless asked by the team "who looks after baby". You are very worried about your child.

Neonatal Simulation Scenarios
Occult Trauma

SMART Learning Outcomes

- Participants will demonstrate appropriate pre-transport stabilization measures for trauma patients as evidenced by discussing and/or performing cervical spine stabiliation prior to completion of scenario.

- Following this scenario, participants will have an improved ability of managing neonatal trauma cases as evidenced by performing both primary and secondary trauma surveys and verbally identifying priorities of care.

- Participants will recognize and respond to potential airway compromise as evidenced by electively intubating prior to sending patient for CT scan or departing referring facility.

Occult Trauma (Non-accidental Trauma)

Adam Cheng, MD, FRCPC, FAAP
Mark Adler, MD

Learning Objectives

- Describe the "red flags" in a history that raise concern for non-accidental trauma (and recognize t these might or might not be present in all cases).
- Describe the signs and symptoms of an infant with nonoccult multisystem trauma.
- Demonstrate the management of multisystem trauma.
  - Conduct a trauma evaluation (primary and secondary survey).
  - Consider stabilizing the cervical spine.
  - Control airway due to depressed level of consciousness, using appropriate medication.
  - Recognize and treat signs of elevated intracranial pressure.
  - Consider and evaluate for clinical significant injuries other than head injuries.

Simulator: Infant Simulator
IMPORTANT REMINDER: If required, change the lens of the simulator to simulate dilated pupil on the LEFT.

Occult Trauma Continued

Scenario Stage	Patient Condition	Intervention
STAGE 1	**History:** • Six-month-old child found by parent in crib, unarousable after nap • Babysitter put him down a few hours ago, thought he was fine • Child was completely well when parent left this morning • Triage nurse has rushed patient back to resuscitation room because he is barely responsive at triage • You arrive to assess the patient **Weight:** • 7 kg **Condition:** • Infant is pink and well perfused but comatose **Physical Examination Findings:** • Temperature 37.2°C (99°F), HR 104/min, RR 12/min, oxygen saturation 97% in room air, BP 89/66 mm Hg • CNS: unresponsive, if painful stimulation is given (nailbed pressure or sternal rub, demonstrate EXTENSOR posturing: "The child did this [demonstrate] when you did that?")	**Take a History:** • No allergies • No medications • No ill contacts • No idea at all what has happened • No history of trauma or fall • No other children in home • Babysitter has been with them approximately 1 month **Airway:** • Listen for breath sounds, present but slow • Apply oxygen via nonrebreather mask at 15 L/min **Breathing:** • Apply monitors, including oxygen saturation and BP • Auscultate chest and observe respiratory rate **Circulation:** • Assess pulse, HR, capillary refill, BP • Ask nurse to obtain IV access, ideally two larger IV catheters

Occult Trauma Continued

Scenario Stage	Patient Condition	Intervention
STAGE 1	**History:** • Six-month-old child found by parent in crib, unarousable after nap • Babysitter put him down a few hours ago, thought he was fine • Child was completely well when parent left this morning • Triage nurse has rushed patient back to resuscitation room because he is barely responsive at triage • You arrive to assess the patient **Weight:** • 7 kg **Condition:** • Infant is pink and well perfused but comatose **Physical Examination Findings:** • Temperature 37.2°C (99°F), HR 104/min, RR 12/min, oxygen saturation 97% in room air, BP 89/66 mm Hg • CNS: unresponsive, if painful stimulation is given (nailbed pressure or sternal rub, demonstrate EXTENSOR posturing: "The child did this [demonstrate] when you did that?")	**Take a History:** • No allergies • No medications • No ill contacts • No idea at all what has happened • No history of trauma or fall • No other children in home • Babysitter has been with them approximately 1 month **Airway:** • Listen for breath sounds, present but slow • Apply oxygen via nonrebreather mask at 15 L/min **Breathing:** • Apply monitors, including oxygen saturation and BP • Auscultate chest and observe respiratory rate **Circulation:** • Assess pulse, HR, capillary refill, BP • Ask nurse to obtain IV access, ideally two larger IV catheters

Occult Trauma Continued

Patient Condition	Intervention
	Circulation: • Reassess HR, pulse, capillary refill, BP **Disability:** • Avoid excessive hyperventilation for elevated ICP (see note below) • Consider IV mannitol (or other similar agents) **Medical Management:** • Review ordered laboratory test results
Condition: • Stable (see note)	**REASSESS THE PATIENT:** **Disposition:** • Arrange for transport for CT scan with appropriate staff (someone who could reintubate if airway is lost) • Notify surgeon of abdominal findings • Notify parents • Plan social work consult and report of suspected child abuse

Notes

1. This is an important topic for which some specific management steps vary among institutions. This case content reflects the Advanced Pediatric Life Support recommended management. The case can be tailored to your institutional practice, as it pertains to rapid sequence drug choices, endotracheal tube type (cuffed or not), use of mannitol or other osmotic agents, or short-term mild hyperventilation.
2. This case can incorporate intraosseous needle insertion if the simulator permits this procedure—have the nurse confederate report he or she cannot obtain access.
3. This case is written to be only mildly suggestive of non-accidental trauma to prevent immediate identification of the problem to the exclusion of all other causes. It is our experience that pediatric health care workers are sensitized to the more obvious "red flags" (eg, mom's boyfriend at home alone with child). Similarly, a bulging fontanelle (which might be present in a patient) is often so obvious on some simulators as to be a distractor and should be used at the instructor's discretion after evaluating this functionality on the simulator device to be used.
4. The role of sonography for trauma is not yet broadly established in pediatrics at this time and is not discussed here.

Common Pitfalls

- Participants do not recognize the severity of the medical condition, with an extended history obtained before resuscitation.
- Focus on the intracranial process to the exclusion of other injuries. This patient has a grade 5 liver laceration that is currently not causing hemodynamic issues. If the patient were to go to the operating room (OR) with this injury not identified, the personnel present in the OR (neurosurgeon) would not be the personnel best prepared to deal with intra-abdominal bleeding.
- The team considers sending the patient for computed tomography (CT) without airway control. The confederate nurse states, "This patient seems too ill to go to CT like this."
- Team does not know the correct intubation medications. In this case, treatment can be stopped before intubation, and this material can be reviewed as discussed in the text.
- The team intubates the patient without any medications. Allow the case to proceed and discuss afterward the likely impact on intracranial pressure of this approach.

Neonatal Simulation Scenarios
Trauma Arrest

SMART Learning Outcomes

- Upon assessing patient, participants will promptly recognize (palpate for pulses despite monitor showing HR in 170s) and respond to arrest using correct BLS algorithum.

- By the end of this scenario particpants will be able to verbally identify transport specific considerations for trauma patients such as chest tube insertion or using altitude restrictions on flights when transporting patients with pneumothoraces.

- Participants will correctly recognize no air entry on left side and respond with immediate needle decompression prior to finishing the scenario.

Case History

9 month old boy involved in MVC 2 hours ago outside Grande Prairie. Child is being transported to Grand Prairie by EMS – team is to meet them in Grande Prairie ED. Team arrives just after patient arrives. Informed that surgeon is coming in to assess patient.

Notes to Facilitator:

- Child has multiple injuries including epidural hematoma, pulmonary contusions, L sided tension pneumothorax, fractured L tib-fib and splenic laceration
- If no arrest
  - On arrival – HR 170, RR 70, Saturations 82% on NRM at 15 lpm, BP 61/45. Pulses present but weak. Pupils equal and reactive
- If arrest:
  - On arrival of team, patient is tachycardic in 170s, apneic (on NRM at 15lpm), no saturations on monitor and no BP measurable. No peripheral/central pulses
  - Team needs to start adequate BLS – CPR and PPV
- Further history from medics – patient was awake, GCS 12/15 on scene – progressively more somnolent. Had a good pulse and BP on departure, BP falling over the last 30 minutes
- No AE on the L side

<u>Considerations for Transport</u>

- BP management- prepare vasopressors to use en route if infant further deteriorates

- Altitude restriction- be mindful of how barometric pressures could worsen pneumothorax

Case Progression:

- Child needs emergent needle decompression on the L side
- With needle decompression – BP will improve to mid 60s
- Further BP improvement with fluid bolus

Expected/Critical Actions C-spine

- L-sided decompression
- Good BLS +/- intubation
- 20 cc/kg NS bolus for hypotension after ROSC
- Arrangements for chest tube placement
- CXR post decompression

Unacceptable Actions:

- Failure to contact medical control prior to initiating treatment
- Inadequate BLS
- No assessment of vital signs post-ROSC

Neonatal Simulation Scenarios
Iron Overdose

SMART Learning Outcome

- Participants will demonstrate proper blood pressure management as evidenced by rapid bolus of weight based IV fluids and the perparation of pressors prior to the third IV fluid bolus.
- Before starting interventions, participants will obtain a detailed history (i.e. asking if any access to medications at home) to help ensure the correct differential diagnosis is made.
- Following this scenario, participants will be able to verbally identify signs of iron overdose and describe appropriate actions to take.

Iron Overdose

Adam Cheng, MD, FRCPC, FAAP
Mark Adler, MD

Learning Objectives

- Describe the signs and symptoms of an infant with an iron overdo
- Demonstrate the management of acute iron intoxication.

Simulator: Infant Simulator

Scenario Stage	Patient Condition	Intervention
STAGE 1	**History:** • Twelve-month-old boy found at home sleepy • No preceding illness • Chaotic home setting with four other children and a single mother, shares home with another family **Weight:** • 10 kg **Condition:** • Ill appearance and tachypnea, sleepy **Physical Examination Findings:** • Temperature 36.6°C (97.9°F), HR 158/min, RR 42/min, oxygen saturation 97% in room air, BP 68/42 mm Hg • CNS: asleep, wakes briefly with stimulation • CVS: pulses present centrally, absent peripherally • Respiratory: clear • Abdomen: no hepatosplenomegaly • Extremities/skin: capillary refill approximately 3 s	**Take a History:** • No ill contacts • No medications • Patient has vomited at home and had loose stools • If asked, sibling is receiving iron supplementation for anemia • Mom has large bottle of iron liquid medication at home **Airway:** • Listen for breath sounds, present • Apply oxygen via nonrebreather mask at 15 L/min **Breathing:** • Apply monitors, including oxygen saturation and blood pressure • Auscultate chest and observe respiratory rate **Circulation:** • Assess pulse, HR, capillary refill, BP • Ask nurse to place IV catheter • Ask for normal saline or lactated Ringer solution bolus of 20 mL/kg to be given quickly (push) **Medical Management:** • Order laboratory tests (CBC, electrolytes, coagulation studies, blood cultures, venous blood gas, bedside glucose)

Iron Overdose Continued

Scenario Stage	Patient Condition	Intervention
STAGE 2	**Condition:** • HR remains elevated and BP is now 68/52 mm Hg • Blood glucose level is slightly elevated if bedside glucose was measured • Venous gas: pH 7.06, Pco_2 28 mm Hg, Po_2 39 mm Hg, base excess −20 mmol/L • Patient vomits again • Iron overdose exceeds 60 mg/kg body weight (provided if team asks dose) **Physical Examination Findings:** • HR 163/min, RR 36/min, oxygen saturation 98% in 100% oxygen (if placed), BP 63/52 mm Hg • CNS: barely responds to any stimuli • Respiratory: clear • CVS: clamped down and cool extremities • Abdomen: no hepatosplenomegaly	**REASSESSMENT OF THE PATIENT:** **Airway/Breathing:** • Reassess airway patency, RR, and saturations **Circulation:** • Reassess HR, pulse, capillary refill, BP after bolus • Order second bolus, also push • Order vasopressor (dopamine) to bedside ("That will take about 10–15 minutes to get from the pharmacy") in anticipation of need later **Medical Management:** • If team fails to suspect overdose, can prompt with statement "Someone has called to inform the mom that a bottle of sibling medication labeled ferrous sulfate is open and empty on the floor." • Orders additional tests - Venous gas to assess pH - Iron, salicylate, and acetaminophen (paracetamol) levels - Abdominal radiograph for pill fragments (given history of liquid ingestion) • Consult poison control for recommendations
STAGE 3	**Condition:** • "He doesn't seem much better." • Remains tachycardic after second bolus • Poison control recommends treatment with IV deferoxamine **Physical Examination Findings:** • Unchanged from stage 2 except that HR is now 150/min and BP is 66/52 mm Hg • Abdomen: no hepatosplenomegaly	**REASSESSMENT OF THE PATIENT:** **Circulation:** • Reassess HR, pulse, capillary refill, BP **Medical Management:** • Order third bolus of IV saline push • Begin administration of dopamine as it arrives, titrates to improve BP (this happens when dopamine is running at 10 mcg/kg/min) • Consult intensive care service for admission • Order deferoxamine as recommended
STAGE 4	**Condition:** • Patient improves with vasopressor support **Physical Examination Findings:** • HR 148/min, BP 78/62 mm Hg, saturation 98% on nonrebreather mask • Extremities feel warmer • Child is somewhat more alert	**REASSESS THE PATIENT:** **Disposition:** • Arrange for ICU admission or transport to tertiary care facility (depending on presenting facility resources)

Notes

1. Time course of case precludes availability of full electrolyte panel, which would reveal an anion gap acidosis. This could be reported if a rapid electrolyte test is available.
2. Deferoxamine therapy is not without risks (hypotension), and poison control consultation is recommended even if the team were to come up with this treatment on its own.

Common Pitfalls

- Intravenous (IV) fluid for volume expansion is not delivered in a rapid and/or controlled manner.
  - IV "wide open" fluid administration can lead to very rapid infusion of a whole liter of fluid OR can result in underresuscitation if there is significant resistance to flow (small IV gauge). Infants and small children should always receive resuscitation fluids using either a pump or push to allow for observation and control of fluid delivery. Pressure bags can increase the likelihood of excessive fluid overload.
  - Pushing fluid is accomplished by attaching a three-way stopcock in line with the IV catheter and pulling fluid directly from the bag (step 1) and then switching the stopcock and pushing the fluid into the patient.
- Failing to consider ingestion as a cause of a septic shock–like picture. Metabolic derangements, both inborn errors and those due to ingestions, can mimic sepsis. The sudden onset and absence of fever are clues, as is the history of lead toxic effects (suggesting pica) and the chaotic home setting.
- Waiting until the third bolus is started or finished to order pressors. Participants should recognize and anticipate that infant and pediatric pressor drips must be prepared individually for a patient's weight and are not stock items because these items are for adults. Depending on the institution, there might be a significant delay in preparation and delivery of pressor drips.

Neonatal Simulation Scenarios
Stridor due to Foreign Body

SMART Learning Outcomes

- During the initial assessment, participants will be able to correctly identify stridor as evidenced by verbalizing this assessment to one another and discussing possible causes.

- During the portion of this simulation when infant acutely deteriorates (desats to 30%, loss of consciousness, drop in HR, etc.), participants will demonstrate strong team dynamics as evidenced by using closed loop communication on how to manage the situation, and not speaking over one another.

Stridor Due to Foreign Body

Adam Cheng, MD, FRCPC, FAAP
Mark Adler, MD

Learning Objectives

- Describe the possible causes of stridor in an infant.
- Demonstrate the management of upper airway obstruction due to a foreign body.

Simulator: Infant Simulator

NOTE: Simulator should be placed in a sitting position at the beginning of case and a small object placed in the hypopharynx as the foreign body (eg, toy, pen cap, rolled-up piece of medical tape).

Stridor due to Foreign Body Continued

Scenario Stage	Patient Condition	Intervention
STAGE 1	**History:** • Twelve-month-old with sudden onset of stridor and respiratory distress • Parents rushed him to the ED for evaluation • You are called to see the patient **Weight:** • 10 kg **Condition:** • Alert and anxious, sitting upright in bed **Physical Examination Findings:** • Temperature 37.2°C (99°F), HR 153/min, RR 40/min, oxygen saturation 88% in room air, BP 85/68 mm Hg • CNS: alert • CVS: pulses present • Respiratory: clear • Extremities/skin: capillary refill <2 s	**Take a History:** • No ill contacts • Has been well • No medications • No allergies • Was playing unsupervised in playroom and mom heard coughing and then noticed the trouble breathing when she entered room **Airway:** • Listen for breath sounds, stridor easily noted, child is sitting and does not wish to be moved from sitting position • Ask for bag-mask, suction, laryngoscope, ETT, and Magill forceps to bedside **Breathing:** • Apply monitors, including oxygen saturation and blood pressure • Auscultate chest and observe respiratory rate • If health care worker attempts to place mask or inspect mouth, state "child becomes more anxious and pushes you away—do you want me to hold the child?" **Circulation:** • Assess pulse, HR, capillary refill, BP **Medical Management:** • Request ENT or anesthesia consultation • Minimize stimuli: no painful procedures

Stridor due to Foreign Body Continued

Scenario Stage	Patient Condition	Intervention
STAGE 2	**Condition:** • Airway obstruction (complete) • Occurs at 4 min regardless of actions OR if the health care workers look in mouth with tongue blade, force oxygen mask on to child, or place IV catheter **Physical Examination Findings:** • Immediately: respiratory effort without stridor; rapidly lapses until unconsciousness • RR: initially 40/min but then decreases to 0/min in 30 s • HR: increases to 170/min in first minute then decreases to 65/min in next 90 s • BP: 70/58 mm Hg • Saturation: decreases from 88% to 30% in 30 s	**REASSESSMENT OF THE PATIENT:** **Airway (ENT/anesthesia consultant not present yet):** • Lay child flat • Attempt to bag-mask patient with neck properly positioned and using two-person technique • When this fails to work, perform direct laryngoscopy and remove small foreign body **Circulation:** • Monitor decreasing vital signs, prepare to start compressions if HR decreases below 60/min
STAGE 3	**Recovery:** • Patient is now easily bagged **Physical Examination Findings:** • HR and saturation return to normal • RR remains zero as bagging continues	**REASSESSMENT OF THE PATIENT:** **Airway:** • Continue to bag patient • Place nasogastric tube to avoid stomach distension • May choose to intubate (can stop case before this is complete for time constraints) • Chest radiograph to assess for other possible foreign bodies (if radio-opaque) **Disposition:** ervation

Notes

1. It is easier to decrease and leave the respiratory rate at zero to both observe the quality of bagging and to avoid the participants being confused by the simulator's breathing effort.
2. This case can be changed to have foreign body below the vocal cords and having the participants intubate and push the foreign body into the right mainstem bronchus. The point of having the removable foreign body is to reinforce the Magill forceps as a useful tool.
3. For simulators that support obstructing air entry into the lungs, simulators should be turned on when obstruction occurs to stop chest movement. This can be a tangible visual cue that improves the case realism.

Common Pitfalls

- Beginning to treat for croup rather than aspiration.
- Trigger obstruction by stimulating child. This child should be taken to the operating room by an ear, nose, and throat surgeon and/or anesthesia personnel where a controlled evaluation and removal can be performed. Ideally, the child is placed in a parent's lap awaiting this event.
- Once complete obstruction occurs, failing to attempt airway evaluation and removal of obstruction or attempting intubation. The child now has an emergent condition that cannot await airway expertise.

Neonatal Simulation Scenarios
Status Epilepticus

SMART Learning Outcomes

- By the end of this scenario, participants will be able to verbally identify considerations for the care of status epilepticus neonates, (i.e. hypoglycemia management, airway protection).
- In this scenario, participants will identify and properly respond to airway compromise as evidenced by using bag mask ventilation until for apneas and electively intubating prior to transport.
- Participants will demonstrate strong interdisciplinary communication skills as evidenced by contacting medical control and describing scenario using SBAR format.

Topic: Status Epilepticus (infant)

Author: Allan de Caen **Date Updated:** November 27, 2012

Target Audience: Tpt nurse and RTs

Medical Specialty: PICU
Level of Training:
Medical Students:
Nursing: Staff Transport/CNS
Allied Health:

Learning Objectives:

1. To identify signs of status epilepticus and start emergency management
2. To function with other team members to treat the patient in the referral center.
3. To allow the team to perform some therapies prior to call to physician – giving ativan, glucose for hypoglycemia
4.

Monitors:

3-lead EKG	x
Pulse Oximeter	x
Resp Rate	x
NIBP	x
Arterial Line	
CVP	
$EtCO_2$	
PAP	
Temperature	

Mannequin: Infant

Environment: Referring hospital, standard resus room

Personnel: Referral center nurse – helpful with assigned tasks but no pediatric experience

Status Epilepticus Continued

AV Material:

	File Name
CXR	Not available
Labs	Pre-ETI (seizing) pH 7.15, pC02 60, BR -8, lytes (Ca and BS) 'N' Post-ETI; pH 7.33, pC02 38, BE -5

Case Intro:

8 month old boy with a runny nose for 24 hrs. He became increasingly lethargic overnight. This morning he was noted to be acting abnormally (not responding to his parents). Previously well. Arrived in local ED 3 hrs ago with generalized tonic clonic seizures. Convulsions stopped with PR valium, but odd movements started again 5 minutes prior to the arrival of the TT. Infant was protecting airway and moving spontaneously prior to re-onset of movement disorder. No Hx of medications or allergies. Last ate 6 hrs ago.

Notes for Facilitator:

- On arrival of the team, child is having episodes of stiffening, breathing at rate of 15 (erratic), saturations are 84% on NC 2lpm
- Eyes closed; has bilateral stiffening of legs and internal rotation of arms that is ***unassociated*** with stimulation; pupils 4 X 2 and reactive
- Other baseline vitals: HR 160, BP 90/50, T 39C
- Child feels warm peripherally (not flushed or dilated though); strong pulses
- Clear lung fields
- IV is not in place; no medications have been given in the last 5 minutes
- No obvious signs of trauma

Case Progression: (Include Significant Events and Triggers):

- On NRBM, 02 sats rise to 99%
- Is acceptable for infant to have breathing assisted; cricoid pressure needs to be provided, or abdomen decompressed via ng as abdomen gets noticeably larger over 2 minutes (increasing difficulty bagging, with 02 sats slowly drifting into mid 80's)
- If infant not bagged, 02 sats remain in 90's
- IV attempt fails; PR ativan is acceptable; if not, IO must be placed, and then treated with IV ativan
- With ativan, infant goes apneic
- Recheck of VS shows that although 02 sats are now mid-90s (assuming they start bagging with apnea), the BP has changed to 80/ 40 (no change in other VS)
- Scenario ends with child being intubated successfully (neuro RSI; with appropriate drugs), awaiting CXR for confirmation of ET posn

Status Epilepticus Continued

Expected/Critical Actions

- put on nrb mask to get 02 sats > 92%
- assisted BM ventilation (with cricoid) wih apnea
- stop seizure with pr or IO ativan
- modified neuro RSI technique
- ETT posn confirmed with clinical, EtC02, and ordering of CXR
- Blood C & S to be drawn, with first dose of broad spectrum antibiotics to be ordered
- Check CBG and blood sugar

Unacceptable Actions:

- Failure to contact medical control before treatment initiated
- Leave on NC 02
- failure to BM ventilate apnea
- failure to attempt d/c seizure
- hand ventilation with RR >30
- no VS check after intubation
- failure to check BS and Ca

SMART Learning Outcomes

- On initial assessment, participants will obtain a thorough history including questions regarding any cardiac diagnostic workups pending, if there are any sick contacts, if baby is still feeding well, etc. to assist with forming their differential diagnosis.

- Before initiating treatment, participants will demonstrate the ability to differentiate cardiogenic shock from other types of shock and respond with correct management (i.e. limited fluid resuscitation).

- Participants will demonstrate appropriate use of interdisciplinary supports and consultive services as evidenced by phoning cardiology, obtaining EKG, discussing case with medical control, etc. prior to preparing to depart on transport.

Cardiogenic Shock Due to Congenital Heart Disease

Adam Cheng, MD, FRCPC, FAAP
Mark Adler, MD

Learning Objectives

- Describe the signs and symptoms of an infant with cardiogenic shock.
- Demonstrate the management of circulatory failure due to cardiogenic shock.
  - Obtain a chest radiograph to confirm suspected cause of cardiac shock.
  - Use normal saline to expand circulatory volume in a limited manner.
  - Obtain consultative services urgently.

Simulator: Infant Simulator

Cardiogenic Shock Continued

Scenario Stage	Patient Condition	Intervention
STAGE 1	**History:** • Five-month-old boy with history of poor feeding and weight loss for past month • Sent from physician's office for evaluation • You are called to evaluate patient **Weight:** • 5 kg **Condition:** • Very unwell, gray, with respiratory distress **Physical Examination Findings:** • Temperature 37.3°C (99°F), HR 158/min, RR 58/min, oxygen saturation 91% in room air, BP 72/58 mm Hg • CNS: cries weakly, lays still in bed • CVS: pulses present centrally, weak peripherally • Respiratory: bilateral crackles, retractions • Abdomen: liver is firm and enlarged to the umbilicus in the midclavicular line • Extremities/skin: capillary refill approximately 3 s	**Take a History:** • No ill contacts • No upper respiratory tract infection symptoms, no diarrhea • Takes a long time to eat and tires out; sweats a lot with feeding • Was noted to have a "hole in the heart" on a prenatal ultrasonogram but had no murmur at birth—no follow-up was performed • No allergies • Reflux medications started for poor feeding • Approximately 0.5-kg weight lost during last 2 wk **Airway:** • Listen for breath sounds • Apply oxygen via nonrebreather mask at 15 L/min **Breathing:** • Apply monitors, including oxygen saturation and blood pressure • Auscultate chest and observe respiratory rate **Circulation:** • Assess pulse, HR, capillary refill, BP • Murmur and gallop rhythm heard • Ask nurse to obtain IV access • Ask for normal saline or lactated Ringer solution bolus of 5 or 10 mL/kg • Palpate abdomen for organomegaly as a sign of right heart failure

Intervention
Medical Management: • Order laboratory tests (CBC, electrolytes, venous blood gas, bedside glucose, consider infection laboratory work at this time as diagnosis not clear) • Order ECG and a chest radiograph

Cardiogenic Shock Continued

Condition:
- Condition is unchanged
- Venous gas reveals acidosis (pH 7.21, Pco_2 28 mm Hg, Po_2 32 mm Hg, base excess −16 mmol/L)
- Blood glucose level is normal
- Chest radiograph reveals marked cardiomegaly with pulmonary markings consistent with fluid overload

Physical Examination Findings:
- HR 163/min, RR 60/min, oxygen saturation 98% in 100% oxygen (if placed), BP 78/53 mm Hg
- Examination findings unchanged

REASSESSMENT OF THE PATIENT:

Circulation:
- Nurse cannot obtain IV access; intraosseous needle placed by participant
- Reassess HR, pulse, capillary refill, BP after bolus
- Call for cardiologist to consult and perform echocardiography; if not locally available, begin process of transferring patient
- Consider IV furosemide for fluid overload
- Consider afterload reduction (eg, milrinone)

Medical Management:
- Consider bicarbonate for acidosis

Condition:
- Patient stabilizes

Physical Examination Findings:
- HR 162/min, RR 52/min, BP 78/62 mm Hg, saturation 98% on nonrebreather mask

REASSESS THE PATIENT:

Disposition:
- Arrange for ICU admission or transport to tertiary care facility (depending on presenting facility resources)
- Obtain second IV access other than intraosseous access

Notes

1. Radiography can be performed via a simulator (some models support this) or as a "wet read" result communicated to the team noting the large heart and fluid overload.
2. The quality of cardiac and respiratory sounds varies considerably among simulator models. Comments from the nurse confederate can help clarify findings—"I listened at triage and thought I heard a loud murmur."

Common Pitfalls

- Misrecognition of patient as having respiratory distress due to reactive airway disease and administration of albuterol (salbutamol). Patient will get worse with this therapy.
- Misrecognition of patient as having sepsis, with excessive fluid delivery, resulting in increasing heart rate and respiratory rate and decreased oxygen saturations. Nurse confederate notes that the child "looks worse after that bolus."
  - Both of these problems occur when an inadequate history is obtained—the history provided is a clear indication of a primary cardiac cause.
- Treatment of patient without support of consultants. Echocardiography is an important step in management planning, and the initial steps in performing this test should be started as soon as possible.

Neonatal Simulation Scenarios
Hypovolemic Shock

SMART Learning Outcomes

- On initial assessment, participants will be able to correctly identify hypovolemic shock as evidenced by verbalizing at least three symptoms (delayed capillary refill, diminished peripheral pulses, mottling, low blood pressure, weak cry, etc. will be acceptable answers).

- Before the end of the scenario, participants will recognize the need for continued fluid resuscitation as evidenced by initiating second IV fluid bolus after vitals unsatisfactory (HR 170s, BP 65/48) on reassessment.

Topic: Hypovolemic Shock Infant

Author: Jon Duff **Date Updated:** October 23, 2012

Target Audience: Transport course

Medical Specialty: PICU

Level of Training:

Medical Students:

Nursing: Staff

Allied Health:

Learning Objectives:

1. To identify signs of hypovolemic shock and start emergency management
2. To function with other team members to treat the patient in the referral center.

Learning Objectives:

1. To identify signs of hypovolemic shock and start emergency management
2. To function with other team members to treat the patient in the referral center.

Monitors:

3-lead EKG	x
Pulse Oximeter	x
Resp Rate	x
NIBP	x
Arterial Line	
CVP	
$EtCO_2$	
PAP	
Temperature	

Mannequin: Infant

Environment: Referring hospital, standard resus room

Personnel: Referral center nurse – helpful with assigned tasks but no pediatric experience

Other Equipment:

AV Material:

	File Name
CXR	None
Labs	Baseline ABG: pH 7.32 pC02 35 p02 60 BE -12

Hypovolemic Shock Continued

Case Intro:

9 month old boy with vomiting and diarrhea for the past 2 days. Mother brought him into ED this morning as he was more lethargic and no longer taking a bottle. He is previously well. He arrived in the local ED 3 hours ago. He has an IV.

Notes for Facilitator:

- On arrival of the team, child is moderate to severe shock.
- Mild respiratory distress
- Weak cry; appears alert
- Vitals HR 185, BP 61/45, Temp 38.4, RR 50, Sats 95% on room air
- Child feels cool peripherally; very weak peripheral and central pulses; 5 sec cap refill; mottled
- IV is in place

Case Progression: (Include Significant Events and Triggers):

- Minimal improvement with first bolus of fluid – HR will drop to 170s, BP up to 65/48, RR down to 45
- With second bolus, HR will drop to 160s, BP up to 75/55, no further respiratory distress and more alert
- Scenario ends

Expected/Critical Actions	**Unacceptable Actions**
Rapid cardiopulmonary assessment	No assessment prior to history
Check IV	No reassessment after fluids
Start fluid bolus	Don't call home
Obtain further history	
Re-assess following first bolus	

Notes for helper:

9 month old boy admitted to your ED 3 hours ago. IV started by your ED physician and you've started a maintenance of D5W at 25 cc/hr. He was crying when he first came in but has now settled down. His parents have already got on a plane for Edmonton. As far as you know, he is previously well, no medications, no allergies, immunizations up to date. He has been sick for the last two days with vomiting and diarrhea, multiple episodes of each. He had been drinking okay until yesterday evening but has had nothing for almost 18 hours now. There is no blood in his vomit or stool.

SMART Learning Outcomes

- After this scenario, participants will be able to verbally identify at least three signs of septic shock. Acceptable responses will include: decreased peripheral perfusion, cool extremities, lethargy, capillary refill > 3 seconds, febrile, tachycardic or tachypneic, elevated lactate.

- By the end of the scenario, participants will demonstrate understanding of blood pressure management as evidenced by initiating fluid resuscitation ("to fill the tank") *prior* to starting infusion of pressor.

- During the scenario, participants will effectively work together as a team as evidenced by using closed loop communication, discussing plan of action ahead before starting interventions, asking for assistance as needed rather than trying to multi-task, etc.

Septic Shock

Adam Cheng, MD, FRCPC, FAAP
Mark Adler, MD

Learning Objectives

- Describe the signs and symptoms of an infant with septic shock.
- Demonstrate the management of circulatory failure due to sepsis.
  - Use of normal saline or lactated Ringer solution to expand circulatory volume.
  - Order and deliver a pressor to support blood pressure in a timely manner.
  - Recognize the need for hydrocortisone stress dosing for specific pediatric populations

Simulator: Infant Simulator

Septic Shock

Scenario Stage	Patient Condition
STAGE 1	**History:** • Seven-month-old boy, in treatment for acute lymphocytic leukemia presents with temperatures to 39.6°C (103.3°F) (temporal) • Decreased activity since yesterday • Chemotherapy last given 4 d ago, don't know what drugs were given • Triage nurse was worried how little he responded to her examination • You arrive to assess the patient **Weight:** • 7 kg **Condition:** • Very unwell, listless, feels warm over core but hands are cool **Physical Examination Findings:** • Temperature 39.6°C (103.3°F), HR 158/min, RR 36/min, oxygen saturation 96% in room air, BP 72/58 mm Hg • CNS: asleep, wakes briefly with painful stimulation • CVS: pulses present centrally, absent peripherally • Respiratory: clear • Abdomen: no hepatosplenomegaly • Extremities/skin: capillary refill >4 s, scattered petechiae

Intervention
Take a History: • No ill contacts • Has a double-lumen port • Has had one previous admission for fever and neutropenia at 1 month age • Vomited once en route to the ED • Takes trimethoprim-sulfamethoxazole 3 d per week, got ibuprofen at triage; is taking prednisone as part of his chemotherapy • Allergic to vancomycin (red man syndrome) **Airway:** • Listen for breath sounds, present • Apply oxygen via nonrebreather mask at 15 L/min **Breathing:** • Apply monitors, including oxygen saturation and blood pressure • Auscultate chest and observe respiratory rate **Circulation:** • Assess pulse, HR, capillary refill, BP • Ask nurse to access port • Ask for normal saline or lactated Ringer solution bolus of 20 mL/kg to be given quickly (push) **Medical Management:** • Order laboratory tests (CBC, electrolytes, coagulation studies, blood cultures, venous blood gas, bedside glucose)

Septic Shock Continued

Scenario Stage	Patient Condition	Intervention
STAGE 2	**Condition:** • HR remains elevated and BP is now 63/52 mm Hg • Nurse notes aloud, "His hands are just so cold." • Blood glucose level is normal if bedside glucose test was performed **Physical Examination Findings:** • HR 163/min, RR 36/min, oxygen saturation 98% in 100% oxygen (if placed), BP 63/52 mm Hg • CNS: barely responds to any stimuli • Respiratory: clear • CVS: clamped down and cool extremities • Abdomen: no hepatosplenomegaly	**REASSESSMENT OF THE PATIENT:** **Circulation:** • Reassess HR, pulse, capillary refill, BP after bolus • Order second bolus, also push • Order vasopressor (dopamine) to bedside ("That will take about 10–15 minutes to get from the pharmacy.") in anticipation of need later **Medical Management:** • Order antibiotics (broad spectrum to include coverage for pseudomonas, eg, ceftazidime or meropenem/imipenem)
STAGE 3	**Condition:** • "He doesn't seem much better." • Remains tachycardic after second bolus **Physical Examination Findings:** • Unchanged from stage 2 except that HR is now 150/min and BP is 66/52 mm Hg • Abdomen: no hepatosplenomegaly	**REASSESSMENT OF THE PATIENT:** **Circulation:** • Reassess HR, pulse, capillary refill, BP **Medical Management:** • Order third bolus of normal saline IV push • Begin dopamine as it arrives, titrates to improve BP (this happens when dopamine is running at 10 mcg/kg/min) • Order hydrocortisone stress dose given patient's daily prednisone (can ask for help with dosing) • Consult intensive care service
STAGE 4	**Condition:** • Patient improves **Physical Examination Findings:** • HR 148/min, BP 78/62/min, saturation 98% on 100% oxygen • Extremities feel warmer • Child is somewhat more alert	**REASSESS THE PATIENT:** **Disposition:** • Arrange for ICU admission or transport to tertiary care facility (depending on presenting facility resources)

Common Pitfalls

- Intravenous (IV) fluid for volume expansion is not delivered in a rapid and/or controlled manner.
  - IV "wide open" fluid administration can lead to very rapid infusion of a whole liter of fluid OR can result in underresuscitation if there is significant resistance to flow (small IV gauge). Infants and small children should always receive resuscitation fluids using either a pump or push to allow for observation and control of fluid delivery. Pressure bags can increase the likelihood of excessive fluid overload.
  - Pushing fluid is accomplished by attaching a three-way stopcock in line with the IV catheter and pulling fluid directly from the bag (step 1) and then switching the stopcock and pushing the fluid into the patient.
- Withholding antibiotics until either the patient improves or cultures and/or testing is complete. This infant is critically ill and antibiotics should be given as early as is practical.
- Failing to check a bedside glucose level. Hypoglycemia is a treatable cause of altered mental status, and ill infants with poor glycogen stores and a poor recent oral intake due to illness are prone to this condition.
- Waiting until the third bolus is started or finished to order pressors. Participants should recognize and anticipate that infant and pediatric pressor drips must be prepared individually for a patient's weight and are not stock items because these items are for adults. Depending on the institution, there might be a significant delay in preparation and delivery of pressor drips.

Neonatal Simulation Scenarios
Pneumonia

SMART Learning Outcomes

- Before performing high-risk interventions such as intubation, participants will demonstrate adequate safety checks. Acceptable actions will include: preparing different size laryngoscope blades, ensuring team is able to bag mask ventilate patient prior to starting pre-medication, double checking doses of pre-medication with team member, positioning patient to visualize airway, etc.

- After this scenario, participants will able to verbally identify at least three reasons to electively intubate for pre-transport stabilization. Acceptable responses will include: increased work of breathing, airway compromise, decreased level of consciousness, to reduce cardiac workload, apneic episodes, trauma to neck or facial area, etc.

Simulation Lab

Topic: Pneumonia, Lung tissue Disease

Author: Todd Mortimer

Date: Dec. 2015

Target Audience: RN, RRT Transport Team

Medical Specialty: PICU

Level of Training:

Learning Objectives

1. To identify an infant with lung tissue disease and to initiate emergency treatment.
2. To recognize and treat hypoxia.
3. To recognize and monitor the effectiveness of ventilation.
4. To recognize the indications for BMV and intubation.
5. To collaborate with other team members to assess, diagn treat the patient.

Mannequin: Infant

Environment: The referring health center, standard treatment room.

Personnel: Health center nurse. Helpful with assigned tasks but limited pediatric experience.

Other Equipment: Will require multiple oxygen sources.

Chest X-Ray: Shows LLL and RLL infiltrates

Case Introduction: A 4 month old (7 kg) boy brought into health center due to lethargy and poor feeding. The baby had been well until last week when he developed a cough and became easily fatigued when feeding. Mom also noticed increasing irritability and would not feed and looked greyish in color. The babies breathing became more labored when not feeding and Mom decided to bring him in. On arrival to the HC his vital signs were as follows:

HR 175, RR 64, NBP 70/50 and sats 88% on 3L NP oxygen. The infants previous medical history is unremarkable, term infant no complications. Has received his 2 month immunizations. Mother appears concerned.

Pneumonia Continued

1

On the transport monitor: HR rate 176, RR 65, Sats 89% on 3LNP, NBP 61/52, Temperature 39.7

Assess respiratory status, AE, adventitia and WOB

Central pulses are adequate, peripheral pulses weak, cap refill is approx. 3-4 sec. and some portions of the patient are mottled.

Establish peripheral IV, CBG, blood culture

Procure CBG and analyze, PaO2 60, PaCO2 60, pH 7.27, HCO3 20, LAC 2.5

Prepare a bolus of NS 20ml/kg (7kg) = 140 ml push

Support spontaneous ventilation with positive pressure ventilation and PEEP

Insert NG, decompress stomach and vent to atmosphere

Assess response to fluid bolus, no change in WOB, crackles and wheezes on auscultation, NBP improves to 75/35

Repeat NS fluid bolus of 10ml/kg, 70ml push

Prepare inhaled salbutamol nebulizer treatment (dose= 5mg, conc= 5mg/ml 1:1000, 1ml + 4ml NS = total volume of 5ml, carrier gas is oxygen).

Assess response to inhaled Salbutamol, no change in WOB or adventitia on auscultation, subcostal, intercostal, supraclavicular indrawing, tracheal tug and nasal flaring, and grunting, HR 175, RR 80, T 39.5

Repeat CBG and analyze, PaO2 60, PaCO2 66, pH 7.15, HCO3 20, LAC 2.5

Seek medical consultation

2

Continue to support spontaneous ventilation with BVM ventilation and PEEP. Use airway adjuncts such as oral airway or LMA appropriate for size if required.

Establish second peripheral IV

Prepare for endotracheal intubation, prepare medications such as Atropine (dose= .02mg/kg, conc= .4mg/ml, .1ml/kg, dose= 0.7cc), Etomidate (dose= .3mg/kg, conc= 2mg/ml, .15ml/kg, dose= 1.0cc), Rocuronium (dose=1mg/kg, conc= 10mg/ml, .1ml/kg, dose= 0.7cc)

Prepare 3.0, 3.5 cuffed and 4.0 cuffed ETT with stylet, CO2 detector, laryngoscope handle, #1 Miller blade, tincture of benzoin and tapes

Perform endotracheal intubation and capnometry to confirm ETT placement, document insertion depth, ventilate patient at a RR of 40-60 breaths per minute, auscultate to establish bilateral A/E, monitor capnography.

Confirm ETT placement with CXR if available

3

Secure ETT, document size, position at the gum, replace ETT connector with appropriate in line connector and catheter.

Prepare to support with mechanical ventilation, f 40, PIP <35 (or Vt 35-50ml), PEEP 7-10, FiO2 to keep Sats >94%.

End tidal CO2 loses waveform. (Check if attached, check patient chest rise and color, check tube position, inspect sample line for water and exchange).

Establish ventilator settings for a minimum of 15 minutes before repeating CBG (goal pH 7.25-7.35, recognizing permissive hypercapnia is expected).

CBG: PaO2 80 (FiO2 50%), PaCO2 50, pH 7.28, HCO3 21, LAC 2.0

Seek medical consultation

Prepare another fluid bolus, inhaled aerosol such as epinephrine or salbutamol and inotrope such as Nor-epinephrine.

Patient is being prepared for transport.

Case progression (include significant events and triggers):

- Respiratory distress
- Hypovolemic shock
- Respiratory failure
- Supportive BVM
- Intubation
- Mechanical ventilation
- Stabilize

Expected/ Critical Actions:

- Recognize increased WOB, grunting, mottled
- Recognize unstable hemodynamics, adressed shock
- Initiated aerosol treatment and assess

Neonatal Simulation Scenarios
Supraventricular Tachycardia

SMART Learning Outcomes

- By the end of this scenario, participants will feel prepared to manage neonates with supraventricular tachycardia as evidenced by verbalizing improved confidence with interpreting EKG rhythms.
- In this scenario, participants will demonstrate proper use of defibrillator by treating SVT with synchronized cardioversion using 0.5-2 J/kg
- By the end of this scenario, participants will initiate electric cardioversion within 1 minute of recognizing persistent SVT despite adenosine dose.

Topic: SVT

Author: Jonathan Duff **Date Updated: October 23, 2012**

Target Audience:

Medical Specialty:	Peds	ER	PICU	
Level of Training:		Senior	Fellow	Staff
Medical Students:				
Nursing:		Staff		Transport/CNS
Allied Health:				

Learning Objectives:

1. To identify the infant in cardiogenic shock and to initiate emergency treatment.
2. To recognize re-entry SVT and treat the unstable patient.
3. To function with other team members to treat the patient in the referral center.
4.

Monitors:

3-lead EKG	x
Pulse Oximeter	x
Resp Rate	x
NIBP	x
Arterial Line	
CVP	
$EtCO_2$	
PAP	
Temperature	

Mannequin: Baby

Environment: Referring hospital, standard resus room – will require defibrillator

Personnel: Referral center nurse – helpful with assigned tasks but no pediatric experience. Mother as well.

Supraventricular Tachycardia Continued

AV Material:

	File Name
CXR	Cardiomegaly CXR.jpg

Case Intro:

6 month old girl brought in by mother because of lethargy. The baby has been well until the last week when she has developed progressive feeding intolerance, fatigue during feeds. She has also noted some sweating during feeds. This morning, the baby would not feed and has lethargic and somewhat grey in colour so she was brought into ED. She looked somewhat better on arrival. On arrival in ED, her HR was 165, respiratory rate 55 and sats 94% on R/A. They don't have a BP. Otherwise well, no medications, no allergies, immunizations UTD. Mother is outside smoking.

Notes for Facilitator:

- Progressively more lethargic – now has GCS of E1, V2, M5 = 8.
- On the monitor – SVT at rate of 233, RR 60, Sats in low 90s, BP 61/35
- Weak peripheral pulses
- Team can try one dose of adenosine through the IV but it will not be effective, the bedside nurse comments that the IV has been "sluggish"
- Baby will respond to 2 J/Kg of synchronized cardioversion and return to sinus rhythm though baby remains tachycardic in the 180s with mild-moderate respiratory distress/subcostal indrawing and nasal flaring and more awake, crying
- BP up to 70s systolic after cardioversion
- CXR is available if they ask
- Baby doesn't require intubation
- Will respond to IV bolus though too much fluid will cause saturations to drop…
- Scenario ends when cardioversion performed and patient being packaged for departure..including 2nd IV, etc…

Expected/Critical Actions
Recognize SVT vs. sinus
Treat with synchronized cardioversion
Note of blood gas (normal)
Recognize possible cardiogenic shock

Unacceptable Actions:
Treat as sinus tachycardia
Delay in cardioversion

SMART Learning Outcomes

- Following this scenario, participants will be knowledgeable of the diagnosis of SVT as evidenced by verbal identification of at least three symptoms (i.e. lethargy, poor feeding, and rhythm characteristics such as rate >220, narrow QRS)
- Before the end of the scenario, participants will verbally recognize the patient as stable SVT and will choose alternative interventions to electric cardioversion such as vagal maneuver or adenosine.

Supraventricular Tachycardia

Adam Cheng, MD, FRCPC, FAAP
Mark Adler, MD

Learning Objectives

- Describe the signs and symptoms of an infant with supraventricular tachycardia.
- Demonstrate the management of stable supraventricular tachycardia using chemical cardioversion with appropriate monitoring.

Simulator: Infant Simulator

Scenario Stage	Patient Condition	Intervention
STAGE 1	**History:** • Seven-month-old girl with fussiness and poor feeding for approximately 1 day • No upper respiratory tract symptoms or fever • Sent from physician's office because of fast heart rate **Weight:** • 7 kg **Condition:** • Alert but cranky, pale **Physical Examination Findings:** • Temperature 36.9°C (98.4°F), HR 226/min, RR 36/min, oxygen saturation 98% in room air, BP 79/65 mm Hg • CNS: alert • CVS: pulses present • Respiratory: clear • Abdomen: liver edge approximately 2 cm below costal margin • Extremities/skin: capillary refill approximately 2 s	**Take a History:** • No ill contacts • No family history of heart problems • Given ibuprofen without relief but no cold medications • No allergies **Airway:** • Listen for breath sounds, present **Breathing:** • Apply monitors, including oxygen saturation and blood pressure • Apply oxygen mask • Auscultate chest and observe respiratory rate **Circulation:** • Assess pulse, HR, capillary refill, BP • Ask nurse to obtain IV access **Medical Management:** • Order an ECG • Attempt vagal maneuvers

Supraventricular Tachycardia Continued

STAGE 2	Condition: • HR remains elevated Physical Examination Findings: • HR 226/min, RR 36/min, oxygen saturation 100% in 100% oxygen (if placed), BP 81/68 mm Hg	REASSESSMENT OF THE PATIENT: Circulation: • Reassess HR, pulse, capillary refill, BP after bolus • Order adenosine • Describe to nurse confederate how to deliver medication when asked ("I am not sure how to give this medication.") • Prepare for conversion by: – Ensuring availability of defibrillator (might or might not connect pads)	– Having ECG machine connected and running during conversion attempt • Deliver first adenosine bolus (no or brief effect) after considering contacting cardiology or intensive care support personnel

Notes

1. Some institutions have specific guidelines about the presence of cardiology personnel at chemical cardioversion. If this is required, anticipation of this need should be discussed (calling as early as practical).
2. Simulating the patient monitor changes typically seen with cardioversion requires some practice and might not be an ideal representation of the clinical experience (eg, longer pause, delay in rhythm change on monitor). Testing of this effect on the planned device is recommended.

Common Pitfalls

- Problems with delivering the adenosine in a rapid push/rapid flush manner.
- Electrical cardioversion in this stable patient (less common).

Transport Considerations

- This patient was stable and only required adenosine. However, if unstable SVT, consider cardioverting (0.5-1 J/Kg) prior to transporting patient as this will be easier to perform in a facility than on helicopter/jet/ambulance –be sure to discuss this with medical control prior to initiating when possible
- When possible, be mindful of IV insertion site- when possible; use upper extremities for vascular access when giving adenosine, as this is closer to the heart. (Remember rapid push-rapid flush!)

Neonatal Simulation Scenarios
Metabolic Crisis: Hyperammonemia

SMART Learning Outcomes

- After the scenario, participants will have a better understanding of this infrequently seen neonatal condition as evidenced by being able to verbally identify at least 3 symptoms (i.e. vomiting, lethargy, hypoglycemic, acidotic, etc.) and at least two interventions (i.e. D10W infusion for hypoglycemia, correct the acidosis, IV fluid boluses to improve blood pressure, metabolics consultation, arrange for admission to ICU).

- At the end of the scenario, when reviewing blood gasses, participants will correctly verbalize the difference between acidosis (pH <7.35) and alkalosis (pH> 7.45).

Metabolic Crisis—Hyperammonemia

Adam Cheng, MD, FRCPC, FAAP
Mark Adler, MD
Debra Weiner, MD

Learning Objectives

- Describe the common causes of vomiting and lethargy in a neonate.
- Demonstrate the treatment of a neonate with altered mental status and suspected metabolic crisis.
  - Manage airway, breathing, and circulation.
  - Check appropriate laboratory test results—glucose at bedside, blood gas, and serum ammonia.
  - Treat hypoglycemia and confirm that treatment was effective.
  - Treat acidosis.
  - Arrange for treatment of hyperammonemia.

Scenario Stage	Patient Condition	Intervention
STAGE 1	**History:** • One-week-old with progressive poor feeding, vomiting, and lethargy for the past 3 d • Brought to ED by parents • Looks very unwell at triage, brought to resuscitation room • You are called to assess patient **Weight:** • 3 kg **Condition:** • Infant is pale and lethargic, looks unwell **Physical Examination Findings:** • Temperature 36.2°C (97.2°F), HR 165/min, RR 46/min, oxygen saturation 98% in room air, BP 75/40 mm Hg • CNS: eyes open spontaneously, pupils 3 mm and reactive bilaterally • CVS: pulses intact but weak Capillary refill 3 s • Respiratory: clear • Abdomen: soft and without hepatosplenomegaly • Extremities/skin: loose skinfolds, no bruising noted	**Take a History:** • Term, birth weight 3.3 kg, uncomplicated pregnancy, delivery • No medications or no allergies • Spitting up first few days of life, during last 3 d increased frequency and amount, today four times • Weight currently 10% less than birth weight • No fever, diarrhea, rash • No sick contacts or travel **Airway:** • Listen for breath sounds **Breathing:** • Apply monitors, including oxygen saturation and blood pressure • Auscultate chest and observe respiratory rate **Circulation:** • Assess pulse, HR, capillary refill, BP • Ask nurse to obtain IV access **Disability:** • Quick neurologic assessment (pupils, response to pain)

Metabolic Crisis Continued

STAGE 2

Condition:

- Infant minimally responsive to painful stimulus. Does not open eyes spontaneously, no verbalization/cooing

Physical Examination Findings:

- Temperature 36.2°C (97.2°F), HR 175/min, RR 52/min, oxygen saturation 94% in 100% oxygen, BP 70/30 mm Hg
- CNS: unresponsive, unconscious, pupils 3 mm and reactive bilaterally
- CVS: pulses intact but weak, capillary refill 4 s
- Respiratory: clear
- Abdomen: soft and without hepatosplenomegaly
- Extremities/skin: no bruising noted

STAGE 3

Condition:

- Neonate still unresponsive, does not open eyes spontaneously or to painful stimuli, no verbalization/cooing, intermittent jittering movements of both arms and stiffening suspicious for seizures

Physical Examination Findings:

- Temperature 36.2°C (97.2°F), HR 175/min, RR 52/min, oxygen saturation 94% in 100% oxygen, BP 70/30 mm Hg
- CNS: unresponsive, unconscious, pupils 3 mm and reactive bilaterally
- CVS: pulses intact but weak, capillary refill 4 s

Intervention

Medical Management:

- Order a bedside glucose, electrolytes, BUN, creatinine, LFTs, ammonia, blood gas, CBC, blood culture, urine, urine culture tests, blood to hold for possible additional studies
- Orders IV fluid bolus of 10 mL/kg of normal saline

REASSESSMENT OF THE PATIENT:

Airway:

- Maintain the airway: jaw thrust, chin lift, head tilt
- Suction vigorously
- Prepare intubation equipment

Breathing:

- Increase oxygen delivery to 100% by using nonrebreather
- Assist ventilations as required

Circulation:

- Ensure IV access two times
- Recheck HR, BP, capillary refill, pulses
- Cycle BP every 3–5 min

Medical Management:

- Laboratory test results come back:
  - Sodium 135 mmol/L, potassium 3.5 mmol/L, glucose 35 mg/dL (low)
- Administer D10W, 0.5 g/kg IV
- ABG: pH 7.05, Pco_2 30 mm Hg, Po_2 90 mm Hg, bicarbonate 8 mmol/L, base excess −20 mmol/L
- Ammonia, 350 µg/dL (205 µmol/L).
- WBC and hemoglobin level normal
- Metabolic or genetics consultation

REASSESSMENT OF PATIENT:

Airway: Intubation:

- Preoxygenation
- Premedication: IV atropine optional
- Cricoid pressure
- Sedation: discussion: etomidate vs other options: midazolam plus IV fentanyl
- Paralysis: IV rocuronium or IV succinylcholine
- Check tube placement with $ETCO_2$ detector, auscultation of chest, observation of chest rise, and order chest radiograph

Metabolic Crisis Continued

Intervention

Breathing:

- Reassess breathing
- Start to provide manual ventilation to the patient

Circulation:

- Reassess blood pressure, pulse, capillary refill
- Give IV normal saline bolus

Medical Management:

- Call for ICU consultation
- Order dose of lorazepam for suspected seizure
- Call for metabolism consultation if not already done
- Administer bicarbonate
- Arrange for hemodialysis, give sodium phenylacetate, sodium benzoate if hemodialysis will be delayed

Common Pitfalls

- Potential diagnosis of IEM is not considered until late, which increase the risk of long-term disease and/or death.
- Participants check and treat the glucose level but fail to obtain a follow-up glucose measurement. A high concentration of glucose is not always maintained with maintenance fluids.
- Acidosis is not treated.
- Ammonia is not checked.
- Failure to recognize and treat seizure.

Notes

1. Consider inborn error of metabolism (IEM) with, not after, other potential diagnoses. History and laboratory findings (hypoglycemia, acidosis, hyperammonemia, neutropenia, anemia) are most suggestive of organic acidemia. Other IEMs most likely to present with catastrophic decompensation in a neonate include aminoacidopathies, urea cycle defects, fatty acid oxidation defects, and mitochondrial disorders.
2. Recognize that results of a newborn screen might not be available at 1 week of age or that child might not have had a newborn screen.
3. Normal pregnancy, delivery, and examination findings are not uncommon with IEM.
4. Family history might be negative given autosomal recessive inheritance of most IEMs.
5. Physical examination findings usually normal except for acute manifestations of illness.
6. Manifestations of seizure in neonates might be subtle. For seizures unresponsive to conventional treatment, consider pyridoxine, folate, and/or biotin.
7. Perform laboratory tests to evaluate for IEMs before any treatment, including glucose or fluids. Initial laboratory tests include bedside glucose, electrolytes, blood urea nitrogen, creatinine, glucose, blood gas, complete blood cell count, blood culture, liver function tests, ammonia, urine, and urine culture. If hypoglycemia, acidosis, and/or hyperammonemia are present, send serum samples for amino acids, acylcarnitine profile, and ketones measurement and urine samples for organic acids and urine acylglycine measurement. Consider taking lactate and pyruvate samples. Blood samples for IEM studies can be sent on newborn screen filter paper. Lactate and pyruvate samples require special tubes.
8. Consultation with metabolism specialist recommended if laboratory test results support suspicion of IEM.
9. Bicarbonate to correct acidosis. No consensus on pH for which to give or dose; consider for pH less than 7.0 to 7.2.
10. Hemodialysis for hyperammonemia. Extracorporeal membrane oxygenation hemodialysis is faster than conventional dialysis but has increased risks in neonates. Sodium phenylacetate or sodium benzoate should be administered per package insert directions if there will be a delay in hemodialysis.

Neonatal Simulation Scenario
Hyperthermia

SMART Learning Outcomes

- Before the end of the scenario, participants will demonstrate awareness of possible sequelae to hyperthermia by discussing with one another at least two clinical issues they will need to watch for. Acceptable items include: electrolyte disturbances, rhabdomyolysis, or hypoglycemia.\

- By the end of this scenario, participants will feel more comfortable with intraosseous insertion as evidenced by verbalizing how to properly insert an IO (refer to manufacturer's instructions to evaluate), and when to use it (in resuscitation when unable to obtain intravascular access- limit to 2 attempts when in an urgent situation).

- By the end of the scenario, participants will have effectively responded to hyperthermia as evidenced by achieving a lowered temperature of at least 3 degrees using active cooling (i.e. cool cloths, ice packs, lowered room temperature, etc.)

Hyperthermia

Adam Cheng, MD, FRCPC, FAAP
Mark Adler, MD

Learning Objectives

- Recognize the features of environmental hyperthermia.
- Demonstrate the steps in the initial treatment of a hyperthermic infant.

Simulator: Infant Simulator

Hyperthermia Continued

Scenario Stage	Patient Condition	Intervention
STAGE 1	**History:** • Eight-month-old infant was unintentionally left in a car for 2 h; temperature outside was 32.2°C (90°F) • Child was apneic, pulseless, and cyanotic • CPR was initiated by paramedics with bag-mask ventilation. • Child brought to ED by paramedics with CPR in progress **Weight:** • 8 kg **Condition:** • Apneic and now with faint pulses (EMS reports pulse return at arrival) • Temperature 42°C (107.6°F), HR 185/min, RR 0/min, BP 62/50 mm Hg, oxygen saturation 93% (bag-mask) • Monitor: sinus tachycardia • CNS: obtunded, nonresponsive • Cardiovascular: capillary refill 6–7 s, weak pulse centrally • Respiratory: coarse crackles bilaterally • Abdomen: soft, no organomegaly • Skin: hot, dry	**Take a History:** • Previously healthy • No medications or allergies • Immunizations up to date • Paramedics have been doing CPR for 5 min **Airway:** • Continue bag-mask ventilation • Clear or suction the airway • Prepare for possible intubation (gathers equipment) **Breathing:** • Check oxygen saturation • Apply monitors • Auscultate chest • Check for adequacy of chest rise with bagging **Circulation:** • Apply monitors • Check pulse, capillary refill, BP • Establish IO access (IV attempts fail) • Give 20-mL/kg normal saline bolus • Order vasopressor (dobutamine vs dopamine, avoids primarily α-agonists) **Disability and Exposure:** • Check neurologic status • Remove clothes • Active cooling measures: cooling blanket, ice bags, lower room temperature, peritoneal lavage (latter rarely used) • Monitor rectal temperature

Hyperthermia Continued

		Intervention
STAGE 2	**Condition:** • Some cooling has occurred **Physical Examination Findings:** • Temperature 40.5°C (105°F), HR 169/min, RR 20/min (bagged), BP 65/59 mm Hg, oxygen saturation 98% • Monitor: sinus tachycardia • CNS: obtunded, nonresponsive • CVS: weak pulses • Respiratory: clear • Abdomen: soft • Skin warm and dry **Laboratory test results:** • Glucose level normal • Electrolytes (from laboratory or gas tests if ordered): sodi 148 mmol/L, potassium 4.6 mmol/L, chloride 110 mmol/L calculated bicarbonate 8 mmol/L, ionized calcium 1.01 mmol/L	**Medical Management:** • Order blood work: CPK, electrolytes, BUN, creatinine, CBC, LFTs, bedside glucose • Order ECG **REASSESSMENT OF THE PATIENT:** **Airway:** • May consider intubation • Bagged at rate of 8–10/min **Breathing:** • Not breathing spontaneously **Circulation:** • Place urinary catheter to assess renal function • Begin dobutamine or dopamine **Medical Management:** • Send urine sample for myoglobin/UA
STAGE 3	**Condition:** • Improvement **Physical Examination Findings:** • Temperature 39.6°C (103.3°F), HR 159/min, RR 10/min (bagged), BP 63/59 mm Hg, saturation 98% with 100% oxygen • Monitor: sinus tachycardia • CNS: unconscious • CVS: capillary refill 4 s, pulses weak • Respiratory: clear • Skin: warm **Laboratory test results:** • CPK, 400 IU/L; UA and hemoglobin	**REASSESS THE PATIENT:** **Airway:** • Reassess airway (considers intubation if not already done) **Breathing:** • Assess breathing **Circulation:** • Titrate pressors **Medical Management:** • Consider further management for possible rhabdomyolysis (furosemide and/or mannitol) • Notify critical care personnel

Scenario Stage	Patient Condition	Intervention
STAGE 4	**Disposition:** **Condition:** • Stable **Physical Examination Findings:** • Temperature 39.2°C (102.6°F), HR 155/min, RR 10/min (bagged), BP 63/59 mm Hg, saturation 98% with 100% oxygen • Monitor: sinus tachycardia • CNS: unconscious • CVS: capillary refill 3 s, pulses weak • Respiratory: clear • Skin: warm	• Arrange Disposition to ICU

Common Pitfalls

1. Lack of aggressive active cooling.
2. Failure to consider and look for sequelae of hyperthermia— electrolyte disturbances, hypoglycemia, rhabdomyolysis.

Neonatal Simulation Scenarios
Altered Mental Status

Altered Mental Status

Adam Cheng, MD, FRCPC, FAAP
Mark Adler, MD

Learning Objectives

- Describe the common causes of altered mental status in an infant.
- Demonstrate the treatment of an infant with altered mental status.
  - Assessing for possible ingestion.
  - Checking glucose at bedside.
  - Treating hypoglycemia and confirming that treatment was effective.

SMART Learning Outcomes

- By the end of this scenario, participants will demonstrate clear communication by using closed-loop feedback or SBAR format at least twice.
- By the end of this scenario, participants will be able to describe the presentation of hypoglycemia in neonates by verbalizing at least three of the following symptoms: jitteriness, altered mental status, poor feeding, lethargy, apnea, eye-rolling

Scenario Stage	Patient Condition	Intervention
STAGE 1	**History:** • Eleven-month-old found unresponsive, was with grandmother, who is his usual babysitter • Brought to ED by grandmother • Unresponsive at triage, brought to resuscitation bay • You are called to assess patient **Weight:** • 9 kg **Condition:** • Infant is pink and well-perfused but comatose **Physical Examination Findings:** • Temperature 37.2°C (99°F), HR 94/min, RR 28/min, oxygen saturation 98% in room air, BP 89/66 mm Hg • CNS: unresponsive to painful stimulation if given. Pupils 3 mm and reactive bilaterally • CVS: pulses intact • Respiratory: clear • Abdomen: soft and without hepatosplenomegaly • Extremities/skin: no bruising noted (if asked specifically)	**Take a History:** • No allergies • Patient takes no medications • No ill contacts • No idea at all what has happened • No history of trauma or fall • No other children in home • If asked specifically, grandmother takes oral sulfonylurea (glyburide), which she keeps in a bedside drawer **Airway:** • Listen for breath sounds **Breathing:** • Apply monitors, including oxygen saturation and blood pressure • Auscultate chest and observe respiratory rate **Circulation:** • Assess pulse, HR, capillary refill, BP • Ask nurse to obtain IV access **Disability:** • Quick neurologic assessment (pupils, response to pain)

Altered Mental Status Continued

Scenario Stage	Patient Condition	Intervention
STAGE 2	**Condition:** • Mental status unchanged • Blood glucose level is low if measured **Physical Examination Findings:** • Vitals unchanged	**Medical Management:** • Recognize and treat hypoglycemia (5 mL/kg D10W using the "rule of 50"—see note below) • Perform further ingestion laboratory tests (urine toxicology, acetaminophen [paracetamol], salicylates, ethanol, +/– digitalis levels)
STAGE 3	**Condition:** • Patient is now more awake and cries • HR 125/min, RR 28/min, BP 85/62 mm Hg, saturation 98% on room air	**Medical Management:** • Order recheck of glucose level in 15–30 min • Recognize need to provide supplementary IV glucose and admit due to long-acting oral diabetic agent **Disposition:** • Hospital or ICU for frequent IV glucose level checks

Identify all babies who are "at risk" for development of hypoglycemia based on any of the following criteria:

- Born at less than 37 weeks gestation
- Large for gestational age (LGA) with birth weight greater than the 90th percentile on the infant growth chart
- Small for gestational age (SGA) with birth weight less than the 10th percentile on the infant growth chart.
- Infant of diabetic mother (IDM)
- Infants at risk of having carnitine palmitoyl transferase-1 (CPT-1) deficiency, including those with known family history and all neonates of Inuit families.

Assess **all** newborns for symptoms of hypoglycemia (immediately and ongoing):

Mild Symptoms:	Severe Symptoms:
• Jitteriness or tremulousness	• Apnea or tachypnea
• Limpness, mild lethargy	• Seizures
• Difficulty feeding	• Cyanosis
• Eye rolling	• Cardiac failure / arrest
• Weak or high-pitched cry	• Episodes of sweating
	• Pallor
	• Hypothermia

Altered Mental Status Continued

For **infants with mild or no symptoms**: Glucometer glucose **1.8-2.5 mmol/L** and infant is ≥35 weeks gestation:

4.7.1 Give glucose gel 0.5 mL/kg AND,
4.7.2 Feed baby by breast or 5-10 mL/kg bottle formula or expressed breast milk.
4.7.3 Repeat glucometer glucose 1 hour after feed,
4.7.4 If glucometer glucose remains between 1.8-2.5 mmol/L repeat glucose gel, feed and repeat glucometer glucose 1 hour later.
If glucometer glucose ≥ 2.6 mmol/L, follow continued monitoring outlined in 4.5.
4.7.5 If glucometer glucose remains < 2.6 mmol/L after 2 doses of glucose gel, call care provider (in house) to order IV glucose maintenance and send TBS.
4.7.6 If glucometer glucose <1.8 mmol/L follow steps in 4.8.
4.7.7 Consider transfer to neonatal unit or neonatology consult for persistent hypoglycemia.

For **infants with severe symptoms** (as outlined in 4.2) with glucometer glucose 1.8-2.5 mmol/L and neonate is ≥35 weeks gestation **or for ANY glucometer glucose result <1.8 mmol/L** regardless of symptoms:

4.8.1 **Call Neonatology on call person immediately.**
4.8.2 **If symptomatic proceed to IV immediately as outlined in 4.8.4**
4.8.3 If glucose<1.8 without symptoms: give glucose gel 0.5 ml/kg. Feed baby. Repeat glucometer glucose 30 min after the glucose gel and call Neonatology with result.
4.8.4 Consider IV D10W at 80 mL/kg/24 hours and IV bolus D10W 2 mL/kg.
4.8.5 Repeat glucometer glucose 30 minutes after IV bolus and determine next steps with Neonatology based on result.

Transport Considerations

- When on transport, infant will be exposed to environmental stressors (noise, vibration, temperatures, etc.) which may contribute to faster consumption of blood glucose—discuss with medical control regarding an appropriate dextrose containing maintenance fluid to run during transport to avoid further drops in glucose.

Appendix C

Pre-Transport S.T.A.B.L.E.

S: Sugar and Safety

- Focus on prevention of sugar instability with appropriate IV fluid infusions (i.e.: D10W at 80ml/kg/day)
- Safety discussions to reduce preventable errors, (i.e. closed-loop communication, discuss the plan of care, etc.)

T: Temperature

- Recognizing contributing factors to neonatal temperature instability (particularly in cold climates, the isolette can be exposed to sub zero temperatures and chill the neonate inside if adequate heat is not supplied) and take action to help maintain thermoregulation and reduce heat-loss factors

A: Airway

- Review concerns for respiratory compromise such as diaphragmatic hernia, tracheoesophageal fistula, pneumothorax, etc., and have a low threshold for interventions such as intubation or chest tube insertion to prevent cardiorespiratory distress en route.

B: Blood Pressure

- Discuss blood pressure management goals prior to departure and draw up infusions for use as needed to avoid having to do so in an urgent situation en route
- For instance, if the neonate has already had 2x 20ml/kg NS boluses with minimal effect, anticipate the need for vasopressor support and plan accordingly

L: Labs

- Obtain when possible lab work to help determine the differential diagnoses so that the team can treat accordingly (i.e. changing ventilator settings based on most recent blood gas, or starting broad spectrum antibiotics with a rising lactate and WBC)

E: Emotional Support

- Provide emotional support to the neonate's family to assist with crisis management

The S.T.A.B.L.E mnemonic covered in Appendix B stems from
Taylor and Price-Douglas' (2008) continuing education program

Appendix D

Simulation Educational Toolkit Pre- and Post Evaluation

On a scale of 1-4 (strongly disagree-strongly agree) provide feedback on the following transport specific competencies. Section A of this form will be distributed before and after the simulation program. Sections B and C will be completed after the simulation. Please also provide any recommendations for how the education can be improved, or subject matter you would like added to the scenarios.

Section A

	Strongly Disagree (1)	**Disagree (2)**	**Agree (3)**	**Strongly Agree (4)**
1. My interdisciplinary communication is efficient and well-received				
2. I feel confident in performing neonatal patient assessments on transport				
3. The team dynamic is efficient and cooperative				
4. I am comfortable with low-frequency high-risk scenarios				
5. I am not apprehensive regarding unfamiliar patient diagnoses				
6. I feel confident in performing practical skills such as IV insertion, intubation, and cardioversion				
7. I am able to recognize signs of potential clinical deterioration and can perform preventative measures for such				
8. Pre-transport stabilization measures are integrated into my practice				
9. My approach to communication with facilities and providers is organized (i.e. SBAR format)				
10. I am able to prioritize what needs to be done first during crisis management and high-acuity patient situations				
11. My ability to obtain a thorough patient history is strong				
12. I use closed-loop communication to reduce potential for error				

Section B

How has simulation training improved your practice? Are there any topics you feel would be beneficial to add into training?

Compared to didactic instruction, do you feel that simulation provided a more thorough learning opportunity?

Do you feel that what you learned during the simulation training is easily translated into practice? If not, what could be improved during the scenarios to make the learning more realistic or useful in the transport setting?

Section C

I feel that the simulation training...

	Strongly Disagree (1)	Disagree (2)	Agree (3)	Strongly Agree (4)
1. Was intimidating and I felt uncomfortable or stressed during the scenarios				
2. Replicated real-life urgency or stress in crisis situations				
3. Provided an opportunity for self-reflection on what could be improved				
4. Included constructive feedback that was useful for improving my practice				
5. Was organized with learning objectives and clear evaluation standards				
6. Made me second-guess myself and I was afraid to make any mistakes.				
7. Included an appropriate variety of neonatal diagnoses that would warrant transportation				

Appendix E

SMART Objectives

S: Specific
M: Measureable
A: Achievable
R: Realistic
T: Time-phased

SMART Objectives for Overall Education Resource

- By the end of the simulation training, the overall mean score among participants for Section A will improve by at least 10 points.
- By the end of the simulation training, the overall mean score among participants for the communication questions in Section A (#s 1, 9, & 12) will improve by at least 50% between pre- and post assessments.
- By the end of the simulation training, the overall mean score for the skill proficiency, stabilization, and prioritization of care (Section A: question #s 6, 8, & 10) will increase on pre- and post scores by at least 50%.
- By the end of the simulation training program, the mean score for confidence in skill execution will increase on pre- and post scores by at least 50%.
- After the simulation training, there will be less than 10 responses in the “strongly disagree” category.

SMART Objectives for Educator Effectiveness

- By the end of each simulation, participants will meat at least two of the scenario objectives.
- After the simulation training, the overall score for Section C question #s 1 & 6 will be less than 4.
- Effective debriefing will be provided as evidenced by not more than 50% of participants scoring less than 2 on Section C question #s 3, 4, & 5 after the simulation training.
- The instructor will replicate real-life urgency among a variety of neonatal situations as evidenced by greater than 50% of participants scoring Section C questions #s 2 & 7 higher than 2.

The SMART Objectives in Appendix E stem from the Center for Disease Control and Prevention’s (CDC, 2009) *document on measureable outcomes*

Appendix E

Evaluation of High Fidelity Simulation for Aeromedical Transport Team Training:

Integrative Review

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Abstract

Background: Aeromedical transport teams provide life-saving interventions and access to critical care while en route to tertiary care facilities. Such teams operate in unfavorable environments and rely on a well-founded continuing education curriculum to maintain advanced competencies and strong team dynamics. Despite widespread appeal of simulation training for such purposes, scant literature exists for simulation's efficacy in the aeromedical setting. *Purpose:* To conduct an integrated literature review to examine aeromedical simulation's efficacy and cost-efficiency, and to explore whether clinical knowledge is retained and applied post aeromedical simulation. *Results:* Only five studies met this review's inclusion criteria. No statistically significant improvements were seen in cost-reduction (Dotson, Gustafson, Tager, & Peterson, 2018), scores of proficiency (Beeman & Orduna, 2018), or self-efficacy (Wright et al., 2006), when simulation was used in the aeromedical setting. Furthermore, no evidence was found to support learning retention (Bender, Kuszajewski, Borghese, & Muckler, 2018), or knowledge translation into practice (LeFlore & Anderson, 2008), post aeromedical simulation training. *Conclusion:* There is insufficient evidence to support the cost efficiency or efficacy of aeromedical simulation training. Further work is needed to overcome barriers to implement effective education for transport teams in order to ensure skill proficiency and competencies are upheld, and patient safety is maintained during aeromedical transport.

Key Words: Aeromedical transport team (AMT), aeromedical simulation, flight nursing, aeromedical education, transport team training

Evaluation of High Fidelity Simulation for

Aeromedical Transport Team Training: An Integrative Review

Introduction

Aeromedical transportation can help increase patient survival rates by improving access to life-saving interventions. However, patient safety on transport is dependent on aeromedical transport teams (AMT) being equipped with advanced practice skills and competencies- along with the adaptability necessary to maintain teamwork and expertise - in a resource-limited, hostile transport environment. Consistency in training methodology however is lacking as some AMTs will reason that operating theaters or cadaver labs are ideal for practicing advanced skills while others laud simulation training or practicums in critical care areas as superior training formats. Organizations such as the Air and Surface Transport Nurses Association (ASTNA) do set training and curriculum standards for AMTs, but there are no clear recommendations for a particular training format as gold standard (Holleran, 2009). This integrative review evaluates one AMT training format, high fidelity simulation, through identifying simulation's stated benefits, potential drawbacks, and existing research gaps.

AMTs are composed of specialized medical personnel who utilize fixed wing or rotor wing (helicopter) aircraft to transport critically ill patients to tertiary medical centres to receive life-saving care. In addition to the inherent risks of flying when faced with urgency (Loyd & Swanson, 2018; Zigmund, 2008), numerous stressors exist for the AMT and patient, such as extreme noise vibration and temperatures (Reksoprodio, Mulijadi, Trihapsoro, & Mulyawan, 2018), atmospheric pressure changes (Schierholz, 2010), and vestibular disturbances associated with rapid acceleration and deceleration (Bouchut, Lancker, Chritin, & Gueugniaud, 2011). The associated communication and concentration hindrances must be mitigated for the AMT to manage some of the highest levels of clinical acuity and provide safe patient care (Reimer & Moore, 2010). Researchers illustrate how simulation training allows such mitigation through improving overall team dynamics and communication (Bender & Kennally, 2016; LeFlore & Anderson, 2008).

AMTs must also be prepared to competently manage low-frequency, high-risk situations (Grisham et al., 2016; Lavine & Rabrich, 2018), which require swift recognition of and response to life-threatening complications (Quick, 2018). Neonatal AMTs for instance may encounter rare diagnoses with significant mortality rates such as diaphragmatic hernia (1 in 4000 births, 30% mortality) or left hypoplastic heart syndrome (2-3 in 10,000 births, certain death if untreated) (Fruitman, 2000; Rathod, 2018; Zalla, Stoddard, & Yoder, 2015). The inverse relationship between lower incidence rates of certain diagnoses and increased adverse outcomes due to clinician unfamiliarity with such strengthens the case for simulated scenarios to help ensure relevant proficiency is maintained and skills can be practiced in a safe environment (Cross & Wilson, 2009).

Given the need for transport clinicians to demonstrate advanced competencies and skills in challenging environments, high quality training is warranted. Although simulation training is often touted as the gold standard for clinician training (Bruno et al., 2016; Haas, 2017; Miledar, 2014) - with widespread use among various clinical disciplines and settings (Bensfield, Olech, & Horsley, 2012; Gordon, Oriol, & Cooper, 2004; Lateef, 2010; Kim, Park, & Shin, 2016; Salem, 2015) very few studies have been conducted to evaluate the use of simulation in a transport environment (Stroud et al., 2013). Furthermore, data on whether knowledge is retained or easily translated into practice post simulation training is insufficient (Quick, 2018). The lack of empirical support for simulation's efficacy, coupled with the steep costs associated with running a simulation program (Lapkin & Levett-Jones, 2011), merit further investigation to the efficacy of simulation.

Materials and Methods

A literature review was undertaken to assess the evidence for high fidelity simulation as the most effective form of education for AMTs. To explore this concept, the following questions were asked:

1. What evidence exists to support simulation training as an effective and cost-efficient form of aeromedical education?
2. Is there evidence that demonstrates learning retention and knowledge translation into practice following simulation training for AMTs?

The studies and information presented in this review stem from CINAHL, Cochrane, Scopus, and PubMed databases using the following key words: flight transport, aeromedical education, high fidelity simulation, medevac education, simulation cost-utility, and flight nursing. Various Boolean operators and MeSH terms are used, and exclusion criteria included: studies before 2000, studies that do not explicitly address aeromedical education, and qualitative studies. After reading the abstract of each study, if deemed applicable to the key question in this review, the complete study was analyzed.

The primary author, an experienced aeromedical transport nurse, collaborated with a medical librarian to complete the review. Initially, 104 abstracts were reviewed but very few were research studies or had relevance to this review's purpose. The vast majority of aeromedical simulation literature consists of articles or qualitative papers that discuss general benefits of simulation training, compare simulation with other instructional formats, or describe the use of simulation in medical settings (i.e., obstetrics, anesthesia, advanced cardiac life support, etc.) other than aeromedicine (Crofts, Bartlett, Ellis, Hunt, Fox, & Draycott, 2008; Vadnais, Dodge, Awtrey, Ricciotti, Golen, & Hacker, 2013; Wayne, Siddall, Butter, Fudala, Wade, Feinglass, & McGaghie, 2006). An array of articles also describes effective facilitation of simulation scenarios and/or documents self-reported learner satisfaction with simulation (Agha, Alhamrani, & Khan, 2015; Omer, 2016; Roh, Lee, Chung, & Park, 2013).

While a number of studies provide cost-benefit analyses of simulation (Fletcher & Wind, 2013; van de Ven et al., 2017), or demonstrate knowledge retention and knowledge translation into practice (Akhu-Zaheya, Gharaibeh, & Alostaz, 2013; Madani et al., 2016 Reznick & MacRae, 2006), very few explicitly address these items in the aeromedical setting.

Results

In total, only five studies met the inclusion criteria for this integrative review and could adequately answer the two questions the authors sought to answer. We found three studies that address the efficacy and cost-utility of simulation training in the aeromedical environment (Beeman & Orduna, 2018; Dotson, Gustafson, Tager, & Peterson, 2018; Wright et al., 2006), and two that look at whether aeromedical simulation training leads to learning retention (Bender, Kuszajewski, Borghese, & Muckler, 2018) or knowledge translation into practice (LeFlore & Anderson, 2008)

Discussion

Evidence to Support Simulation Training

To adequately prepare AMTs to perform in a crisis-oriented environment, education that is immersive and realistic is considered best practice (Campbell & Dadiz, 2016). Indeed, current literature demonstrates that instruction through didactic delivery provides insufficient assessment of a clinician's ability to manage a scenario; and simulation is listed as a superior option of training (Martin, Bekiaris, & Hansen, 2017; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011), especially with objective structured clinical examinations integrated throughout the curriculum (Fenton & Leslie, 2009).

The support for simulation training is also evident in the number of governing bodies that support this form of education. For example, the Medical Council of Canada, the National League for Nursing, and the National Board for Respiratory Care recognize the benefits of simulation training (Jeffries, 2012) and utilize simulation as part of their licensure process (NBRC, 2018; MCC, 2019). For a transport specific lens, the Commission on Accreditation of Medical Transport Systems (CAMTS) supports simulation training as the only acceptable alternative to clinical rotations for meeting accreditation learning objectives (CAMTS, 2018).

Simulation training has been shown to improve communication and teamwork (LeFlore & Anderson, 2008). This is essential given the sub-optimal environments and immense levels of stress AMTs often operate under. Additionally, improvements in communication and teamwork are integral since strong team dynamics are directly correlated with optimal patient care (Schmutz & Manser, 2013). Communication as a matter of importance to patient safety is made salient by the Joint Commission on Accreditation of Health Care Organization citing ineffective communication in the top three root causes of all sentinel events since 2004 (Wong, 2015). Moreover, breakdowns in communication or teamwork are listed among the strongest predictors for adverse events in healthcare (Lingard et al., 2004; Manser, 2009; Müller, Jürgens, Redaèlli, Kingberg, Hautz, & Stock, 2018; Pronovost et al., 2006; Weaver, Dy, & Rosen, 2014).

In addition to strengthening team dynamics and communication, Bender and Kennally (2016) laud the opportunities available for improving skill proficiency, ensuring transport equipment functions properly, and providing opportunities to identify potential safety issues when training is done through simulation. For AMTs, Atwood, Peeples, and Donovan (2011) argue that education is most successful when delivered through simulation as it provides a more realistic practice of advanced skills and assessments.

As well, simulation training is linked with high levels of learning satisfaction (Alinier, Hunt, Gordon, & Harwood, 2006; Beeman & Orduna, 2018; Feingold, Calaluce, & Kallen, 2004; Guhde, 2011; LeFlore & Anderson, 2008), and is identified as the preferred training method among 99% of flight nurses in De Jong, Dukes, Dufour, and Mortimer's (2017) cross-sectional study. Dotson et al. (2018), however, stress that the positive regard for simulation is rooted in subjective self-report feedback from participants, and is largely devoid of measurable results on efficacy, knowledge retention, or cost efficiency in the aeromedical setting in particular.

Despite the widespread appeal of simulation, appraisals of this educational format lack empirical assessments that utilize objective measures. Indeed, much of the literature consisted of articles that were merely descriptive of simulation in nature describing simulation; articles praising simulation's benefits without specifically assessing for mechanisms between simulation and claimed benefits (Cross & Wilson, 2009); and/or articles reviewing simulation's use in a highly specific setting (Atwood et al., 2011; Winn, 2010). Very few research articles ultimately met this review's criteria of empirical analysis that yields methodologically robust links between aeromedical-specific simulation and its often claimed desirable outcomes. Indeed, only three articles assessed simulation's efficacy in an aeromedical setting (Beeman & Orduna, 2018; Bender et al., 2018; Wright et al., 2006), and only two assessed learning retention and knowledge translation into practice (Bender et al., 2018, and LeFlore & Anderson, 2008, respectively).

Efforts to Implement Aeromedical Simulation Training

Recognizing the potential benefits of simulation training on clinician performance and how the unfavorable conditions on aeromedical transport warrant quality education, Alfes and Mannaci (2014) sought to design a flight simulation centre for nurses. Not surprisingly, substantial costs are cited in their plan, including over half a million dollars of improvements and adaptations to an existing helicopter for their training facility. Their presentation cites only one other aeromedical simulation centre of similar scope - St John's Rescue Academy in Hanover, Germany - given the financial implications of such improvements. What Alfes and Mannaci (2014) fail to provide in their outline is an objective evaluation plan for the simulation's efficacy, start-up cost estimates, or a proposed budget for program sustainability. This is concerning as decisions to implement simulation programs should be informed by formal cost-utility analyses to understand the learner outcomes possible, and at what cost (Lapkin & Levett-Jones, 2011).

Researchers recently presented an aeromedical simulation case series (Grisham et al., 2016) where they claim to have improved the feasibility of such training and overcome previously identified barriers such as insurmountable costs (Wright et al., 2006) by utilizing portable audiovisual equipment and wirelessly controlling the simulation mannequin while in the air. However, Grisham et al. (2016) fail to present any monetary figures for their study to illustrate the cost saving measures and do not acknowledge how other constraints (i.e., pilot availability, cost of fuel and aircraft maintenance, etc.) are managed. As well, this case series has a number of limitations including insufficient number of exercises (n=4) from which conclusions are drawn from, no comparison in cost between their aeromedical simulation and other forms of training, and no objective measure of their simulation's efficacy (Grisham et al., 2016). This therefore adds little substantial evidence to the existing literature, does not address the cited issues of feasibility and efficacy of aeromedical simulation, and sheds light on the need for further research.

Impediments to Simulation's Success in Aeromedicine

Complicating the matter of simulation training for AMTs are the unique barriers and challenges that exist in the complex transport setting. For example, the success of simulation training is often attributed to its realism (Boet et al., 2011; Jeffries, 2016; Jeffries, Dreifuerst, & Haerling, 2018; Li, 2016), but situating the learning atmosphere in the aeromedical transport environment involves unique challenges such as insurmountable costs, availability of pilots and aircraft, and unnecessary exposure to inherent dangers of flying (Wright et al., 2006). Campbell and Dadiz (2016) explain that for training to be realistic, transport teams must be challenged to perform critical care interventions in tight spaces or while being exposed to turbulence and noise, such as in a moving helicopter. While this would provide optimal training, taking the simulation into a transport atmosphere is not always feasible. Not surprisingly, in a survey sent to members of the three largest professional transport organizations, Association of Air Medical Services, Air and Surface Transport Nurses Association, and the Association of Critical Care Transport, very few respondents reported receiving simulation training in their mode of transport, such as an aircraft simulator, despite 74% asserting this would be very beneficial (Alfes, Steiner, & Rutherford-Hemming, 2016).

Knowledge Retention and Translation into Practice

Simulation has been linked with knowledge durability and improved patient outcomes in some medical areas, but there is a relative paucity of aeromedical specific research on simulation's efficacy (Patterson & Geis, 2013). For example, skill proficiency was maintained 6-14 months post-simulation for the management of labor and delivery emergencies, and cardiac resuscitation in obstetrics and Advanced Cardiac Life Support training, respectively (Crofts, Bartlett, Ellis, Hunt, Fox, & Draycott, 2008; Vadnais, Dodge, Awtrey, Ricciotti, Golen, & Hacker, 2013; Wayne, Siddall, Butter, Fudala, Wade, Feinglass, & McGaghie, 2006). However, when Bender et al. (2018) used a repeated measures design to evaluate simulation training in aeromedicine, knowledge was not sustained for longer than three months as evidenced by the statistically significant ($p=0.01$) decline in pre ($M= 0.63$; $SD= 0.10$) and post-test results ($M= 0.55$; $SD= 0.07$). As well, when LeFlore and Anderson (2008) compared initial simulation training among neonatal transport teams with simulation training one year later, there were no statistically significant improvements in behavioral (i.e., delegation of responsibility: $p=0.64$; planning for potential problems: $p=0.4$) or technical skill (i.e., obtaining vascular access: $p= 0.1$; effective bag-mask ventilation: $p=0.75$) performance. Despite high levels of learning satisfaction reported in this study (mean score >4.0 on a 1-5 Likert scale), their findings suggest poor application of knowledge obtained from simulation (LeFlore & Anderson, 2008).

According to O'Connell, De Jong, Dufour, Millwater, Dukes, and Winik's (2014) integrative review on aeromedical simulation training, research gaps exist on which aspects of simulation lead to effective training, knowledge retention and application. Further research is therefore warranted to determine how to design simulation training for AMTs that will lead to sustained knowledge and AMTs applying said knowledge into practice.

Aeromedical Simulation Feasibility and Efficacy

In Beeman and Orduna's (2018) study, proficiency scores are compared between AMTs who received computer-based training (CBT) and instructor-based simulation training on an actual aircraft. High levels of learner satisfaction and improved proficiency are seen with the aircraft simulation with 100% of participants preferring aircraft simulator over CBT and a statistically significant difference in proficiency evaluation scores following the training (CBT: mean score 54.1; aircraft simulator: mean score 61.6; $p = 0.045 \leq 0.05$). Despite these favorable results of aircraft simulation, Beeman and Orduna (2018) warned these findings should be interpreted cautiously due to numerous limitations of their study (i.e., small sample size $n=30$ obtained with convenience sampling, normal population distribution parameters unmet, variable baseline demographics, and poor control of confounding factors such as levels of experience). The researchers also admit that given the substantial cost of running aeromedical simulation, further research with stronger study designs is warranted to assess the efficacy of this training (Beemand & Orduna, 2018).

Dotson et al.'s (2018) and Wright et al.'s (2006) studies on aeromedical simulation benefits and feasibility make the necessity of cost-utility analyses of aeromedical simulation programs more salient. Dotson et al. (2018) compare standard aeromedical training with aeromedical simulation training and look specifically at the overall cost and the number of orientation flights trainees needed prior to being deemed independent AMT clinicians. This study reveals no statistically significant difference in the number of orientation flights ($p=0.35$) with aeromedical simulation and the reduction in overall cost of training was not significant ($p=0.16$). Similarly, when Wright et al. (2006) explore AMT self-efficacy pre-and post-aeromedical simulation training, no statistically significant improvement was seen in AMT confidence ($p > 0.234$). Furthermore, researchers admitted to substantial monetary ($400 per simulation scenario, which does not include start-up or maintenance expenditures) and personnel (22 hours and 3 hours of instructor and pilot time respectively per session) cost (Wright et al., 2006). These two studies clearly illustrate the financial barriers to aeromedical simulation feasibility and pose the question whether the benefits outweigh the costs.

Despite the implementation barriers for aeromedical simulation, it is imperative that further work is done to overcome these hindrances to ensure optimal training is available for AMTs (Alfes & Manacci, 2014). Unique challenges AMTs face when providing patient care are numerous and include equipment disruption with turbulence, inability to hear monitor alarms or auscultate assessments with excessive noise on flights, significantly increased time required to perform advanced life support interventions, and constrained mobility (Alfes & Manacci, 2014; Swickard & Manacci, 2012; Thomas, Stone, Bryan-Berge, & Hunt, 1994). To safely provide care to critically ill patients on aeromedical transport, strong continuing education curricula rooted in best practice are warranted.

Conclusion

AMTs are tasked with maintaining strong skill execution, team dynamics, and patient assessment proficiency to provide safe care during transport of critically ill patients. To adequately maintain such elite levels of ability, strong continuing education curricula that are rooted in evidence-based best practice are necessary. Despite commendation of simulation as the gold standard for such training across most spheres of healthcare, limited research has been conducted on its use in the aeromedical setting. This integrative review demonstrates the need for further research on aeromedical simulation's efficacy and cost-efficiency in particular. As well, further work is needed to explore which attributes of simulation are linked to knowledge retention and translation into practice, as evidence for such in the aeromedical simulation literature was poor. This review exemplifies the deficiency of literature in the aeromedical simulation domain, and suggests two distinct directions - aeromedical simulation's efficacy and cost-efficiency, and whether this training leads to learning retention and knowledge translation into practice- to steer further research.

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