Developing the Confidence of Anesthesia Providers with Neonates through Education

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Disclosure: The author has no commercial associations that might pose a conflict of interest in connection with this work.

Abstract

Neonates are a vulnerable population that pose unique challenges for anesthesia providers. Many anesthesia providers are not familiar with management techniques that are standards in neonatology. Poor neurological outcomes continue to plague this population even with advancements in medical management. By improving the confidence of anesthesia providers through education, the quality of care received by this vulnerable population should advance. Using a teaching model, a PowerPoint presentation was provided concerning hypotension, ventilation, endotracheal tube size and depth for neonates. A card was distributed to all participants containing neonatal standards for endotracheal tube size, depth and code drugs to have as a reference. After a review of the literature, this paper will provide material supporting the importance of continued neonatal education among nurse anesthetists.

Keywords: neonates, anesthesia, endotracheal tubes, hypotension, ventilation, education

Capstone Committee Signature Page

This Capstone Project is submitted in partial fulfillment of requirements for the degree of Doctor of Nurse Anesthesia Practice at Wolford College June 24, 2017.

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Developing the Confidence of Anesthesia Providers with Neonates through Education

Through the authors 15 years of experience, it has been noted that there is a lack of knowledge among anesthesia providers in the standard care of neonates. No one knows if the lack of knowledge about the physiological differences and how to manage them makes anesthesia providers uncomfortable when caring for this distinctive population. Neonatal physiology differs significantly from the physiology of adults. Thomas (2014) explained that these physiological differences alter the response, distribution, and metabolism of drugs. The reaction to anesthesia and surgery is also altered in neonates. These changes put the children at a higher risk for anesthetic complications. Many standards of neonatology are missing or imprecise in anesthesia textbooks. Review of pediatric anesthesia textbooks revealed vague suggestions on endotracheal tube size, hypotension, and ventilation. The lack of data in anesthesia literature limits the education of anesthesia providers on the key aspects of neonatal care.

A teaching model, designed by the author, was used to provide education to the nurse anesthetists to increase their confidence and comfort when caring for neonates. Administration of a questionnaire occurred prior to initiating the teaching guide. This survey assessed basic knowledge as well as provider comfort in the anesthetic care of neonates. Following the planned education, a second questionnaire was administered, and the results of the two surveys were compared to measure for enhanced knowledge. Knowledge empowers individuals and creates confidence. Thomas (2014) explained that understanding the impact of anesthesia and anticipating the potential risks may reduce morbidity and mortality of neonates undergoing anesthesia. Injury from anesthesia can occur because of altered physiologic responses. With an augmented understanding of neonatal physiology, patient care will improve for this vulnerable population.

Maintaining sufficient systemic blood pressure, proper ventilation, and acceptable fluid status is essential to prevent injury among this population (Vutskits, 2014).

PICO Statement

Neonates are a vulnerable population that requires special considerations when being anesthetized. Many anesthesia providers are not comfortable with caring for this population because of their size and unique physiological requirements (Thomas, 2014). Anesthesia literature contains limited recommendations for these infants, which makes it even more challenging for providers.

Will a presentation containing educational material on neonatal anesthesia, combined with a reference card, improve the confidence and knowledge of nurse anesthetists? The chosen population for this project was the nurse anesthetists at a level two pediatric trauma center. This project required the development and distribution of a teaching presentation and reference guide for neonatal anesthesia. The reference guide included recommendations based on neonatal standards. Comparisons for this project was the pre-and post-intervention surveys on knowledge and confidence of nurse anesthetists. The desired outcome of this project is improved knowledge and confidence in the anesthetic care of neonates.

Methods Used to Find Evidence

After meeting with the Palmetto Health Richland neonatologiists about the concerns associated with neonates that have received anesthesia, a meeting with the administration of the anesthesia department was conducted. During the meeting with management, options for my capstone were discussed and how it could best benefit our staff. The possibilities were discussed with Dr. Morrison to establish a plan that would meet the capstone requirements of Wolford College.

Completion of a thorough search utilizing PubMed, OVID, and Google Scholar databases occurred in August 2016 and again in February and March 2017. The initial search results were surveyed for relevant articles. The reference lists of the chosen articles were evaluated and pertinent articles, not found initially were then included. Search terminology included: "neonatal endotracheal tube size," "neonatal endotracheal tube depth," neonatal hypotension," "neonates and anesthesia," neonatal fluid resuscitation," "atropine use in neonates," and "teaching theories." Filters included humans and English text. From these searches, several articles were obtained that would aid in defining hypotension in neonates and how to treat the hypotension. The searches also revealed articles supporting the use of dopamine for hypotension.

Goldsmith, Karotkin, Keszler, and Suresh (2017), *Assisted Ventilation of the Neonate,* was used as a reference. This textbook offered the guidelines for intubation and endotracheal tube depth. The book also provided the literature support for the educational presentation. Ventilation challenges and strategies were also recommended in this text.

Results of Evidence Search

The initial search revealed 9764 articles; the articles were narrowed and articles not pertaining to neonates were excluded. The articles were then reviewed for content that applied to anesthesia. Many of the articles found during the initial search included the general pediatric population. Results utilized included one book, two meta-analyses, one randomized control trial, one prospective derivation, one retrospective study, four expert opinions, one survey and three descriptive studies.

Placing the incorrect size endotracheal tube can have detrimental effects on neonates. The neonatology department at Palmetto Health Richland, a level III neonatal intensive care unit (NICU), has described inappropriate endotracheal tube size and depth as a concern in infants that

have received anesthesia. The author reviewed a small sample of charts in the NICU at Palmetto Health Richland, (n=5) of 13 neonates requiring surgery during a one month period, four were found to have inappropriate size endotracheal tubes, and one was excluded because it was intubated before surgery. Three of the endotracheal tubes were placed too deep based on the weight of the babies. This chart review was discussed with anesthesia administration, who further discussed it with the chairman of the IRB committee. It was decided that the chart reviews could be conducted as a case study to determine if further evaluations were warranted without full IRB approval. Inappropriate endotracheal tubes size and depth can have detrimental effects to neonates requiring anesthesia. Poiseuille's law of resistance demonstrates that even a small change in radius causes a significant increase in pressure to maintain the same flow; therefore the radius of an endotracheal tube has an immense effect on resistance (Goldsmith et al., 2017). Manczur, Greenough, Nicholson, and Rafferty (2000) described how smaller endotracheal tubes increase the work of breathing by increasing resistance. An infant may not be able to overcome significant resistance when spontaneously breathing through an endotracheal tube that is too small. Neumann and von Ungern-Sternberg (2014) explain that the loss of tidal volume during volume targeted ventilation can be excessive and contribute to inaccurate measurements when placement of an endotracheal tube that is too small occurs. Loss of adequate tidal volume may lead to atelectasis from hypoventilation. Endotracheal tubes that are too large can produce airway edema, which creates resistance in the airways. Inappropriate sized endotracheal tubes also contribute to tracheal and laryngomalacia because of the position of the posterior plate of the trachea (Goldsmith et al., 2017). Sakhuja, Finelli, Hawes, and Whyte (2016) explained that poorly placed endotracheal tubes contribute to atelectasis, differential air

expansion and pneumothorax in neonates. The following chart contains the recommended endotracheal tube size and depth.

Table 1-Endotracheal tube size and depth

Weight (kg)	ETT size (mm)	ETT depth (cm)
<1	2.5	7
1-2	3.0	8
2-3	3.5	9
Above 3	4.0	10

*ETT = Endotracheal tube

The combination of altered lung physiology and limitations of gas machine ventilators makes adequate ventilation of neonates problematic in the operating room. Bachiller, McDonough, and Feldman (2008) explain that minute changes in tidal volumes can result in inadvertent hyper or hypoventilation. These unintentional changes in tidal volume can cause excessive pressure in the lungs resulting in barotrauma. Ventilation through a gas machine is dependent on the type of anesthesia circuit and machine used. The lung volumes delivered to the patient is influenced by fresh gas flows and the circuit compliance. End-tidal carbon dioxide is frequently inaccurate or difficult to measure in this population because of their rapid respiratory rate, low tidal volume and increased dead space (Neumann & von Ungern-Sternberg, 2014). Goldsmith et al. (2017) explained that neonates are prone to ventilation depression because of their naturally shifted carbon dioxide curve. Infants also consume twice as much oxygen as adults consume. This combined with a decreased functional residual capacity (FRC) makes them susceptible to hypoxia and apnea. Decreased surfactant production and small terminal airways increase the surface tension. According to LaPlace law, more pressure will be required to open

these airways, which will lead to barotrauma. The lack of surfactant also makes the airways vulnerable to collapse, decreasing the FRC and contributing to atelectotrauma. Wheeler, Klingenberg, Morley, and Davis (2011) described traditional neonatal ventilation as pressure limited ventilation, in which tidal volumes vary from breath to breath. The authors performed a meta-analysis on volume targeted ventilation (VTV), and the results demonstrated a significant improvement in chronic lung disease, pneumothoraces, hypocarbia and had less severe abnormal cranial ultrasounds. Many new anesthetic gas machines can provide VTV at volumes appropriate for neonates and can compensate for the resistance of anesthesia circuits. Goldsmith et al. (2017) discussed the importance of balanced oxygenation under anesthesia. Hypoxemia triggers the release of free radicals and results in reperfusion injuries. It is believed to be associated with the development of chronic lung disease, neurological impairments, retinopathy of prematurity and other pathological conditions in the neonate. Neonates have limited oxygen reserves, and hypoxemia produces anaerobic metabolism, increased lactic acid, cellular and organ failure.

The developing brains of neonates are vulnerable to various insults. Alterations in neonatal cerebral blood flow can lead to increased mortality and poor neurological outcomes. Vutskits (2014) explained that blood pressure management in neonates is a controversial topic. The definition of systemic hypotension is poorly defined, and the safest way to manage perceived abnormalities has not been established.. Razlevice, Rugyte, Strumylaite, and Macas (2016) explained that poor blood flow and oxygenation changes could affect the long-term outcomes of these fragile children. Although a normal physiological blood pressure range is not known, a mean blood pressure less than the infant's gestational age in weeks is most frequently used as the definition of hypotension (Sassano-Higgins, Friedlich, & Seri, 2011). This definition is not standard in the anesthesia literature; therefore premature infants are frequently volume

overloaded to treat perceived hypotension. Turner (2015) explained that unnecessary treatment of hypotension could be harmful to neonates. Decreased cardiac output can be the result of unnecessary fluid resuscitation because it increases peripheral vascular resistance. Goldsmith et al. (2017) explained that volume overload causes increased capillary leak in the lungs contributing to worsening of respiratory distress. The kidneys only function at eighty percent at four weeks of age, so neonates cannot compensate for fluid overload or dehydration. If hypotension persists, the use of a vasopressor should be considered. Pellicer, Bravo, Madero, Salas, Quero, and Cabanas (2009) explained how dopamine increased blood pressure and improved cerebral autoregulation. This increase in cerebral autoregulation can act as a counter to the depression of cerebral autoregulation that is associated with the use of anesthetic gasses. Razlevice, Rugyte, Strumylaite, and Macas (2016) found that cerebral desaturation was associated with hypotension in neonates under anesthesia

The literature searches uncovered that many of the practice in neonatology are old and supported by limited data, but they have been standards for more than 25 years. These standards are re-evaluated every five years by a panel of experts and modifications are made based on the evidence that is available. Razlevice et al. (2016) explained that morbidity and mortality among neonates are complex and multifactorial, so it is difficult to identify a single clinical problem that improves patient outcomes. This combined with being a protected population limits research conducted on neonates.

Methodology

Data Collection

The project included a pre-assessment survey (Appendix A) to assess basic knowledge and level of comfort among the nurse anesthetists. Participants included the nurse anesthetists

present during a one week period. A post-assessment (Appendix B) was administered immediately following the teaching presentation. The presentation was given at random times three days a week for two weeks. The intention of the presentation was to educate participants on the physiological differences, rationales, and standards of neonatal care. The post-assessment was administered to determine if any knowledge or comfort in care was gained from the presentation.

Results

The pre-assessment to obtain baseline data on the comfort and knowledge of nurse anesthetists was performed March 29, 2017-April 5, 2017. Distribution of 50 evaluations occurred, with 45 responses returned, equaling a 90% response rate. The mean comfort level of the nurse anesthetists was 2.91 (n=45). Close to half of the participants could identify hypotension in question two (47%; n=45). Question three of the pre-assessment demonstrated that most nurse anesthetists did not know the correct endotracheal tube size (6.6%; n=45). The final question showed that a small portion of the group was familiar with the appropriate depth of an endotracheal tube based on weight (31%; n=45).

An educational presentation was implemented followed by a post-assessment at various times from April 24- May 7, 2017. The population consisted of a convenience sample and did not involve of the exact population represented in the pre-assessment. A total of 50 evaluations were issued, and 35 were returned, equaling a 70% participation rate. The mean comfort level on the post-assessment was 4.22 (n=35). Nearly all the participants identified hypotension in question 2 of the post assessment (97%; n=35). Question three revealed that most people knew the correct size endotracheal tube (65%; n=35). Participants exhibited knowledge in the depth placement of

endotracheal tube on the post-assessment (82%; n=35). Each participant was also given a card containing table 1 and emergency medications (Appendix C).

Figure 2- Pre-assessment results

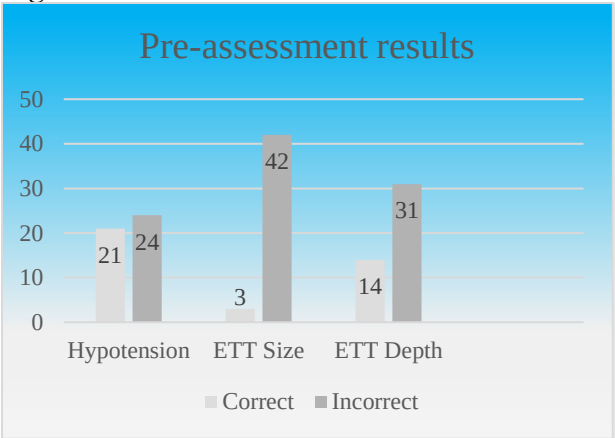
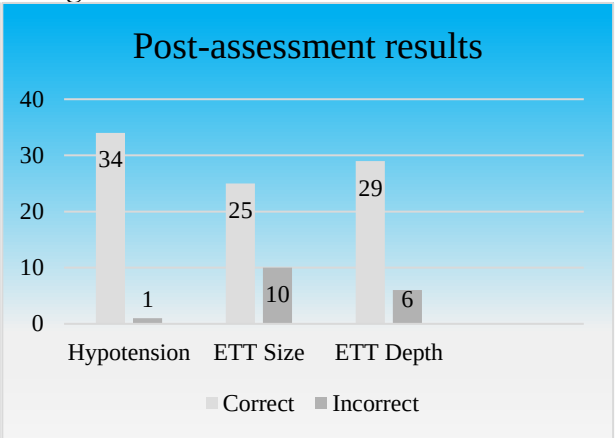


Figure 3-Post-assessment results



*ETT = Endotracheal tube

Discussion

The small sample of neonatal intubations, discussed in the introduction, identified a need for further investigation of the placement of endotracheal tube by anesthesia. The pre-assessment demonstrated both a lack of knowledge and confidence in the care of neonates by anesthesia providers. The presentation contained information that both the NICU staff and the anesthesia staff felt were critical to the anesthetic care of neonates. The post-assessment demonstrated substantial advances in each topic. Confidence in adjusting ventilator settings increased by a mean of 1.2%. Identifying hypotension based on an infant's gestational age increased by 50%. Choosing the correct sized endotracheal tube went from 6.6% to 65%, an increase of 58.4%. Correct endotracheal tube depth increased by 51%.

The number of participants was less in the post-assessment group, which could skew the results. The surveys were administered as a convenience sample, making the results less meaningful statistically.

Synthesis of Evidence

The fragile state of neonates puts them at higher risk for anesthesia. Many anesthesia providers lack the knowledge and confidence to provide quality care to this special population. Knowledge is an essential component of provider confidence and patient safety. Neonatal endotracheal tube size and depth standards have been part of neonatal literature for more than 25 years, and little research is available to confirm or contradict this information. Luten, Kahn, Wears, and Kissoon (2007) described using length measurements to determine the appropriate size endotracheal tube. The authors found that length was an accurate predictor of endotracheal tube size. Saboo, Dutta, and Sodhi (2013) claim that there is promise in suprasternal palpation for confirmation of intubation, but the only group that demonstrated higher correct placement rates was the neonatology fellow team.

Physiological changes in neonates alter their responses to anesthesia; Goldsmith et al. (2017) provided an overview of these changes. Wheeler et al. (2011) explained that VTV has proven to have substantial benefits over pressure control ventilation. VTV may have limited use in anesthesia because of the limitations of the anesthetic gas machines. New models of anesthetic gas machines have been developed with advanced ventilation modes that will allow incorporation of this technique into the care of neonates.

The treatment of hypotension is key to maintaining organ perfusion and improving neurological outcomes in premature babies. Anesthesia and surgery produce changes that affect the blood pressure and cerebral blood flow autoregulation. The use of fluids to treat hypotension need to be managed carefully, and the use of dopamine should be considered. The second search presented a more current article comparing definitions of hypotension. St. Peter, Gandy, and Hoffman (2017) did not identify any difference in the neurological outcomes based on the

definition of hypotension, but vasopressor therapy was recognized as an independent predictor of intraventricular hemorrhage and death. This was a retrospective study with only 188 participants. As discussed earlier, research is limited in this population and needs to be continued.

Proposed Change in Practice

Neonates are one of the most vulnerable and least understood populations in medicine. This, combined with a lack of adequate training for anesthesia personnel makes the perioperative period precarious for these infants. The purpose of this capstone project was to increase the knowledge and comfort in the care of neonates among anesthesia providers at a level II children's hospital. The pre-assessment supported the need for education among nurse anesthetists and the post-assessment exhibited noteworthy improvements in knowledge and comfort of care for neonatal anesthesia. This project accomplished the primary goal of increasing confidence and knowledge of anesthesia providers concerning neonatal anesthesia. These changes can decrease the risks associated with anesthesia to this population that is already fragile. The intent is that anesthesia providers implement this information into their practices when caring for a neonate. The participants were given a pocket card with material from the presentation, so that a reference was readily available. The implementation of the information provided could make anesthetic management less stressful for the providers and safer for the infants.

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Tables

Table 2.

Evidence Source Design level of evidence	N	Sample	Outcomes
Sassano-Higgins, S., Friedlich, P., & Seri, (2011) Meta-analysis Level I	1050	Infants	12 studies dopamine effects on MAP CI .76-.94 8 Studies dopamine effects Systolic CI .42-.94 7 studies Dopamine compared to dobutamine CI .2-.32 2 studies compared to colloid CI .41-.74 1 study compared to hydrocortisone CI .034-.67
Wheeler, K. I., Klingenberg, C., Morley, C. J., & Davis, P. G. (2011) Meta-analysis Level I	693	Infants	12 studies infants ventilated with volume targeted ventilation had decreased death and chronic lung rates
Saboo, A. R., Dutta, S., & Sodhi, K. S. (2013) RCT Level II	57	Newborns admitted to NICU	Suprasternal palpation demonstrated potential as a simple way of verifying endotracheal tube position.
Pellicer, A., Bravo, M. del C., Madero, R., Salas, S., Quero, J., & Cabañas, F. (2009) RCT Level II	113	Hypotensive Low birth weight neonates	Infants received dopamine or epinephrine for hypotension. No difference was noted between dopamine and epinephrine.
Luten, R., Kahn, N., Wears, R., & Kissoon, N. (2007) Prospective derivation Level III	104	Intubated infants and neonates	ETT leak was measured, a formula was developed based on length, weight and leak measurements. A prototype tape predictor was developed that can be used for emergency situations

St. Peter, D., Gandy, C., & Hoffman, S. B. (2017) Retrospective Level III	188	Neonates 24-28 weeks first 72 hours of life	Hypotension by both definitions was significant for death
Bachiller, P. R., McDonough, J. M., & Feldman, J. M. (2008) Level VI	4	Ventilator system on anesthesia gas machine	Ventilators that were capable of compensating for compliance could accurately deliver small tidal volumes. Those that did not have compliance compensation were less accurate.
Goldsmith, J., Karotkin, E., Keszler, M., & Suresh, G. (2017) Book Level VII		Neonates	Book on neonates
Turner, N. M. (2015) Expert Opinon Level VII		Neonates	Anesthetic management should focus on organ perfusion
Manczur, T., Greenough, A., Nicholson, G. P., & Rafferty, G. F. (2000) Level VII		Pediatric endotracheal tubes	Tube size 2.5-6mm inner diameter evaluated for changes in resistance Results: increased resistance with decreased diameter.
Oca, M. J., Becker, M. A., Dechert, R. E., & Donn, S. M. (2002) Level VII		Endotracheal tube size and resistance	Evaluation of endotracheal tubes used in NICU. Resistance was significantly higher in 2.5mm ETT
Vutskits, L. (2014) Expert opinion Level VII		Neonates	Neonatal cerebral blood flow

Thomas, J. (2014) Expert opinion Level VII		Neonate	Anesthesia for neonates recommendations
Neumann, R. P., & von Ungern-Sternberg, B. S. (2014) Expert opinion Level VII		Neonate	Neonatal lung physiology-ventilation
Sakhuja, P., Finelli, M., Hawes, J., & Whyte, H. (2016) Level VII	207	Neonatal practitioners	Canadian neonatology survey about how practitioners decide on the placement of endotracheal tubes in premature infants. The majority was weight +6

*NICU = neonatal intensive care unit

Appendix A

Pre-Assessment

1. How comfortable are you with adjusting the ventilator settings for neonates?
   (not comfortable) 1 2 3 4 5 (very comfortable)

2. When would you consider a 24-week gestation baby that is 1-day old hypotensive?

   A 33/19 (26)

   B 35/14 (23)

   C 31/18 (24)

3. What size endotracheal tube would you put in a baby that weighs 2.100kg?

   A. 2.5 mm

   B. 3.0 mm

   C. 3.5 mm

4. What would be appropriate tube depth for a baby weighing 1.200kg?

   A 7 cm

   B. 8 cm

   C. 9 cm

Appendix B

Post-Assessment

1. How comfortable are you with adjusting the ventilator settings for neonates?
   (not comfortable) 1 2 3 4 5 (very comfortable)

2. Which of the following BP's would indicate hypotension in a 1 day old that was born at 34 weeks?

A. 60/20 (33)

B. 56/24 (35)

C. 51/28 (36)

3. What size endotracheal tube would you place in an infant that weighs 1.2 kgs?

A. 2.5

B. 3.0

C. 3.5

4. What depth would you place an endotracheal tube for an infant who weighs 850 grams?

A. 7 cm

B. 8cm

C. 9cm

Appendix C

Neonatal endotracheal tube size and depth

Weight (kg)	Tube size (mm)	Tube depth (cm) at lip
Below 1	2.5	7
1-2	3.0	8
2-3	3.5	9
Above 3	3.5-4.0	10

Depth = weight + 6

Neonatal Code Drugs

Epinephrine (1:10,000) .01-.03 mg/kg (0.1-0.3 mL/kg) IV

Epinephrine (1:10,000): 0.03-0.1 mg/kg (0.3-1mL/kg) ET

NS/LR: 10 mL/kg over 5-10 min

Bicarbonate: 2 meq/kg @ 1meq/kg/min

Naloxone: 0.1mg/kg IV

Dopamine 75mg/25 mL: start @ 5mcg/kg/min

Calcium gluconate: 1mL/kg/dose IV

(Goldsmith et al., 2017)