Implementing a Neuro-Bundle in a Level III Neonatal Intensive Care Unit

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A DNP Project Manuscript
Submitted in Partial Fulfillment of the Requirements for the
Doctor of Nursing Practice Degree

University of Maryland School of Nursing
May 2019

Abstract

Background: Intraventricular hemorrhage (IVH) is a complication primarily associated with preterm birth, specifically those born before 32 weeks gestation and weighing less than 1500 gram. With increasing survival rates for the most premature infants, IVH rates have remained stagnant at approximately 20% with severe IVH at approximately 5%. The incidence of IVH is highest within the first 24 hours of life and approximately 90% of cases occur within the first 3 days of life. IVH is associated with long term neurologic consequences such as hydrocephalus, seizures, and cerebral palsy. Midline positioning and minimal handling as part of a bundle-intervention have been proven to decrease the incidence of IVH.
Local Problem: This Level III NICU recognizes the risk IVH poses to its patients and wants to put in place all measures that will improve their outcomes. Prior to Implementation the unit did not utilize a neuro-bundle for IVH prevention. The purpose of this project was to implement a neuro bundle consisting of midline positioning and minimal handling for the first 72 hours of life for preterm infants born before 32 weeks and weighing less than 1500 grams.
Interventions: A quality improvement project measuring nursing education and utilization of a neuro-bundle was implemented in a Level III NICU in a community hospital in Baltimore, Maryland. The project took place over a 14 week period. The first 2 weeks consisted of a pre-survey and nursing education module to be completed via the hospital's online education system. This was followed by the implementation of the neuro-bundle during weeks 3-13 and concluded with a post-implementation survey during week 14 to evaluate the change in practice. During implementation, a checklist was completed for each infant meeting criteria for the neuro-bundle. The checklist documented midline positioning, minimal handling, reasons for not adhering to the bundle, and other pain/stress reducing techniques that were used.
Results: The bundle was utilized for 94% of babies admitted to the NICU meeting inclusion criteria. For those whom the neuro-bundle was utilized, midline position was maintained 97.59% of the time and minimal handling was used 86.4% of the time with pain/stress minimizing measures used 100% of the time. Only a single baby in the project had an IVH.
Conclusion: Use of a neuro-bundle has been proven to decrease IVH rates. The neuro-bundle was successfully implemented and during this time the IVH rate was low. More information is needed to quantify the benefits since the sample size and duration of the project were small. The unit should continue to monitor the use of the neuro-bundle and its associated outcomes.

Implementing a Neuro Bundle: A Quality Improvement Project in a Level III NICU

Introduction

Background

Intraventricular hemorrhage (IVH) is a complication primarily associated with preterm birth, specifically babies born before 32 weeks gestation and with a weight less than 1500 grams (Crowell, 2017; Kenet, Kuperman, Strauss, & Brenner, 2011; Soul, 2017). IVH is a brain bleed that originates in the germinal matrix. The germinal matrix is an active site of cell proliferation and as a result it is highly vascularized (Inder, Perlman, & Volpe, 2018). This cellular activity peaks at approximately 28 weeks gestation and then rapidly declines with complete involution of the germinal matrix by 36 weeks gestation. Additionally, the vasculature of the germinal matrix consists of large, endothelial lined vessels which are fragile and likely to hemorrhage (Ballabh, 2014; Inder et al., 2018; Soul, 2017). The development of IVH can be linked to fluctuations in cerebral blood flow, with infants displaying a fluctuating pattern of cerebral blood flow more likely to develop an IVH than an infant with a stable cerebral blood flow pattern (Inder et al., 2018). Preterm infants do not have the ability to regulate cerebral blood flow and increases and decreases can be seen in response to a variety of factors including pain and stress, routine handling, hypoglycemia, and respiratory distress syndrome (Ballabh, 2014; Inder et al., 2018).

The severity of the IVH is graded based on the presence of blood; including how much and where (Inder et al., 2018). A grade I bleed is a hemorrhage in the germinal matrix alone. In a grade II bleed, the hemorrhage extends to the lateral ventricles without dilation of the ventricles. A grade III bleed involves a hemorrhage occupying more than 50% of the ventricle with ventricular dilation. A grade IV IVH is a periventricular hemorrhagic infarction with bleeding in the parenchyma. Grade III and IV bleeds are collectively referred to as severe IVH. The

incidence of IVH is highest within the first 24 hours of life and progression may occur within the first 72 hours; approximately 90% of cases occur within the first 3 days of life. (Allen, 2013; Szpecht, Szymankiwicz, Nowak, & Gadzinowski, 2016).

Significance of Problem

With increasing survival rates for the most premature infants, IVH rates have remained at approximately 20% with severe IVH at approximately 5% (Inder et al., 2018). The more premature infants have a higher risk of developing more severe grades of IVH, with a ten-fold higher risk of grade III-IV. IVH is associated with long term neurologic consequences such as hydrocephalus, seizures, and cerebral palsy; the more severe the IVH the higher the risk of neurologic deficits (Ballabh, 2014; Malusky & Donze, 2011). Furthermore, the development of IVH is associated with an additional cost of $53,600 for the initial hospitalization of a preterm infant (Malusky & Donze, 2011).

The national rate for preterm birth in 2015 was 9.6% with 1.6% being <32 weeks gestation (National Center for Health Statistics, 2018). Maryland's premature birth rates are above the national average at 10% and 1.8% and Baltimore City's rates are higher than the State average at 13% and 2.7%. This project was implemented in a level III NICU in a community hospital. This hospital is a member of the Vermont Oxford Network (VON), a nonprofit collaboration of healthcare professionals working together to change the landscape of neonatal care (VON, 2018). The VON collects data on very low birth weight infants from its participating centers and analyzes it to facilitate quality improvement projects. IVH rates are one of the datasets collected and analyzed by the VON. The national rate of IVH in 2016 among VON participating centers was 25.3% and the rate of severe IVH was 8.1%. This unit's rates were below the national average at 21.3% for any IVH and 4.3% for severe IVH. While this NICU

has low IVH rates, the neonatologists, neonatal nurse practitioners (NNP), and nursing staff recognize that IVH is a significant problem for the population they treat and wish to do anything that is in their control to minimize the risks.

Neuro-bundles consisting of midline positioning and minimal handling have been shown to decrease the incidence and severity of IVH (Chiriboga, Cortez, Pena-Ariet, Makker, Smotherman, Gautam,…Hudak, 2019; Christ, Barber, Murray, Dunleavy, Stoller, Taha,…Posencheg, 2015; Schmid, Reister, Mayer, Hopfner, Fuchs, & Hummler, 2013). Midline positioning requires the baby's head to remain midline at all times; the baby can be in a supine or side lying position. Minimal handling consists of clustering cares as well as minimizing painful and stressful interventions. Clustering care does not apply to emergency interventions. If clustering of cares cannot be achieved due to medical necessity, measures should be used to minimize pain and stress. This can be achieved through swaddling, maintaining boundaries, and shielding eyes from light.

Project Purpose

The purpose of this DNP project was to implement a neuro-bundle consisting of midline positioning and minimal handling in a level III Neonatal Intensive Care Unit (NICU). The short term goal of this project was for the nurses to implement the neuro-bundle. In order for this to be achieved, the nurses completed an on-line education module with the desired goal of an 80% completion rate by the end of week 2. The remainder of the healthcare team including neonatologists, nurse practitioners, respiratory therapists, occupational therapists, and physical therapists were educated about the neuro-bundle prior to its implementation. The desired outcome for this project was for the nurses to utilize the neuro-bundle for 75% of preterm infants who met the inclusion criteria. The long term goals of this project are for documentation to

transition to the Electronic Health Record (EHR) and to see a decrease in the IVH rate; overall and severe.

Theoretical Framework

The implementation of the neuro-bundle was guided by the Knowledge to Action (KTA) Framework. The KTA framework is comprised of two components: knowledge creation and the action cycle. Knowledge creation involves utilizing research findings and synthesizing and recommending practice change. The action cycle is a seven phase guide to implementing an evidence based program (EBP) (Graham & Tetroe, 2010; Straus, Tetroe, & Graham, 2013).

The two components of the KTA framework can either take place sequentially or simultaneously (Graham & Tetroe, 2010). In the case of implementing this neuro-bundle in the NICU the two phases took place sequentially. The problem was identified that preterm infants less than 32 weeks and weighing less than 1500 grams are at an increased risk for developing IVH. Interventions were then identified through a literature review supporting the implementation of a neuro-bundle consisting of midline head positioning and minimal handling to prevent IVH.

The action cycle provides a step by step guide of how to successfully implement the neuro-bundle. The 7 steps of the action cycle are: i) identify a problem ii) adapt knowledge use to local context iii) assess barriers to knowledge use iv) select, tailor, and implement interventions v) monitor knowledge use vi) evaluate outcomes vii) sustain knowledge use (Graham & Tetroe, 2010). In order to address the problem, a neuro-bundle was be implemented in a Level III NICU to reduce the incidence of IVH. This was accomplished with the help of stakeholders and unit champions. The project leader utilized site visits and phone calls to monitor adherence to the neuro-bundle and implemented changes in real time to maximize

implementation. Outcomes were evaluated by monitoring neuro-bundle usage for short term goals and looking at the VON data on IVH incidence for long term goals. As a way to sustain the program, a staff nurse has agreed to take over the program after implementation and met with the project leader to discuss her role and possible changes that need to take place.

Literature Review

The focus of this literature review was the evidence that supported the implementation of a neuro bundle consisting of midline positioning and minimal handling in a Level III NICU. First, a brief analysis of the literature presented. This is followed by a synthesis of the data supporting midline positioning and minimal handling. The data that supports the use of this neuro bundle varies in study design and outcomes. See Table 1 for the complete evidence table.

Analysis

Christ and Colleagues (2015) implemented a quality improvement project to reduce the incidence of severe IVH in preterm infants less than or equal to 30 weeks gestation. They implemented a bundle including midline positioning and minimal handling for the first week of life. The authors found that following implementation the monthly rate of severe IVH decreased from 8.3% to 5.1%. A disadvantage of this study is that only the abstract is published and it does not list the sample size or if the decrease in IVH is statistically significant.

In a quality improvement project in a Level III NICU, Chiriboga and Colleagues (2019) sought to decrease their unit's severe intracranial hemorrhage (ICH) rate. They implemented an ICH bundle addressing admission temperature, delivery room resuscitation, and minimizing excessive stimulation with clustered care and midline positioning. The project took place over four years and included 281 infants and resulted in a significant decrease in severe ICH from 24% to 9.7%.

Coughlin (2011) developed five core measures for providing age appropriate developmental cares. These recommendations were based on a comprehensive evidence review and a successful implementation in two pilot studies. These studies demonstrated that with consistent implementation of these core measures neonatal morbidity can be reduced. Building on these core measures Coughlin (2015) provided evidence-based recommendations and guidelines that when implemented have been proven to reduce morbidity and mortality. Included in these recommendation are midline positioning for infants less than 32 weeks gestation and minimal handling for all NICU babies.

Davis, Berger, & Chock (2016) reviewed obstetrical and neonatal practices that have been shown to have a neuroprotective effect on the developing brain, including midline head positioning and minimal handling. The authors found that midline head positioning maintains a constant cerebral blood flow by not impeding venous blood flow and minimal handling and avoidance of stressful situation may be beneficial in decreasing IVH rates.

In an evidence based expert opinion Kaspar & Rubart (2016) recommend the implementation of neuroprotective strategies such as midline head positioning to prevent IVH and other brain injuries. A review of neonatal literature shows that midline head positioning prevent elevations in cerebral blood flow and other head positions are associated with fluctuation in cerebral blood flow that contribute to the risk of IVH development.

Malusky & Donze (2011) performed a systematic review to evaluate the current evidence supporting midline head positioning in infants less than 32 weeks gestation to prevent IVH. The existing literature shows no negative adverse effects noted when midline positioning was used. The authors recommend midline head positioning for the first 72 hours of life.

In a repeated measure research design, Peng, Bachman, Jenkins, Chen, Chang, Chang, & Wang (2009) studied the relationship between environmental stress and stress response in 37 preterm infants. The authors found there was a statistically significant relationship ($p<0.05$) between environmental stress and a change in vital signs as well as specific stress behaviors. A disadvantage of this study is that it did not mention the specific gestational age of the infants studied, just that they were premature.

Romantsik, Calevo, & Bruschettini (2017) performed a Cochrane review that evaluated midline head positioning in preterm infants less than or equal to 32 weeks gestation. The results demonstrated no difference between midline and other positioning.

Schmid, Reister, Mayer, Hopfner, Fuchs, & Hummler (2013) performed an interventional cohort study on 454 infants less than 30 weeks gestation or weighing less than 1500 grams. A bundle of measures including minimal handling and midline positioning was evaluated to determine the efficacy of reducing IVH in general and specifically to impact severe IVH (grade 3-4). The authors found that the incidence of IVH decreased from 22.1% to 10.5% ($p=0.002$) and the incidence of severe IVH decreased from 9.1% to 3.7% ($p=0.037$) supporting the use of midline positioning and minimal handling.

Synthesis

Midline positioning is recommended for infants <32 weeks gestation for the first 72 hours of life (Davis et al., 2016; Malusky & Donze, 2011). Midline head positioning has been shown to maintain constant cerebral blood flow by not impeding jugular blood flow (Davis et al., 2016; Kaspar & Rubarth, 2016). Other head positions are associated with fluctuations in cerebral blood flow contributing IVH. Midline positioning and minimal handling as part of a

bundle-intervention has been proven to decrease the incidence of IVH (Chiriboga et al., 2019; Christ et al., 2015; Schmid et al., 2013).

Routine care is associated with circulatory fluctuations that can lead to IVH; by providing neuroprotective care such as minimal handling, we can decrease the incidence of IVH (Kaspar & Rubarth, 2016). With minimal handling and the avoidance of stressful and painful situations the neurologic outcomes of preterm infants can be improved (Coughlin, 2011,2016; Davis et al., 2016; Peng et al., 2009).

Implementation Plan

Design, Sample, and Setting

A quality improvement project measuring the effectiveness of nursing education and implementation of a neuro-bundle was implemented in a Level III NICU in a community hospital in Baltimore, Maryland. A neuro-bundle consisting of midline positioning and minimal handling (see Appendix A for neuro-bundle guideline) was utilized in the first 72 hours of life for all preterm infants born prior to 32 weeks gestation and weighing less than 1500 grams. The sample size for the project was 17. Eighteen infants were admitted to the NICU that met inclusion criteria. The gestational age ranged from 23 3/7 to 30 3/7 weeks gestation. With birth weights of 650 to 1610 grams. A single infant was excluded from the project since he was transferred to this hospital at 2 days of life.

Procedures and Timeline

The project took place over a 14 week period and included a pre-implementation survey, education, implementation, and a post-implementation survey. The pre-implementation survey (Appendix B) was used to assess the nurses' knowledge about IVH and neuro-bundles as well as

their practice prior to implementation. The pre-implementation survey was linked to the education module (Appendix C) and available to the nurses during weeks one and two.

The nursing education reviewed the pathophysiology of IVH and the purpose and benefits of implementing a neuro-bundle. After completing the education, a completion report was generated. Additionally, the remainder of the healthcare team, including neonatologists, nurse practitioners, respiratory therapists, occupational therapists, and physical therapists learned about the neuro-bundle including their role in its implementation.

At the conclusion of the nursing education, the neuro-bundle was implemented during weeks three through thirteen. Each baby who met criteria for the neuro-bundle had a bundle at his/her bedside containing the supplies needed to maintain midline positioning and aid in minimal handling/stimulation as well as a copy of the guideline and paper checklists that were completed for each set of cares (Appendix D). The bundles consisted of supplies that were used in the NICU and were put together by the project leader to aid the nurses in implementing the neuro-bundle. The nurses filled out the checklist documenting the gestational age and birth weight of the baby as well as midline positioning, clustering of cares, and utilizing measures to minimize pain and stress.

During week fourteen a post-implementation survey (Appendix E) was released via the on-line education system. The nurses evaluated the process improvement by completing the survey.

Data Collection and Analysis

Pre-implementation surveys were released with the education via the online education system at the start of week one. A survey using a 5-point Likert scale was used to assess the nurses' knowledge about IVH and neuro-bundles. The project leader entered data from the surveys

into an excel spreadsheet and central tendencies were calculated for each item. Following completion of the education module, the project leader generated a completion report that provided the number of as well as the percentage of nurses who completed the education. The data was recorded in an excel spreadsheet.

Implementation took place from week three through thirteen. During implementation of the neuro-bundle, checklists were completed by the nurses with cares. The data was entered into an excel spreadsheet by the project leader. Demographic data about the infants was collected including the infants' gestational age and weight. Use of the neuro-bundle was measured by calculating the number of babies admitted to the unit that met criteria compared to the number of babies for whom nurses utilized the neuro-bundle. For babies whom the neuro-bundle was not utilized, the use of pain/stress preventing measures was collected as well as factors that contributed to lack of compliance.

At the completion of the QI project, a post-implementation survey using the same 5-point Likert scale as in the pre-implementation survey was released via the on-line education system to asses if there was a change in nurses' knowledge as well as well as to get the nurses opinions on the success of the project. The project leader entered data collected into an excel spreadsheet and calculated central tendencies. Answers to the pre and post were compared using t-test to see if there was an increase in perceived knowledge and if the increase was statistically significant.

Measures to Protect Human Rights

In the process of performing this quality improvement project, all efforts to protect human subjects were made. All patient information was de-identified. All data collected was stored in a locked file cabinet or in a password protected computer. Approval from the University of Maryland Institutional Review Board for a non-human subject research

determination was obtained and the proposal was reviewed and approved by the organization's review board.

Results

Prior to the initiation of this QI project, the unit did not utilize a neuro-bundle. A neuro-bundle consisting of midline positioning and minimal handling was implemented in a Level III NICU. The bundle consisted of midline positioning and minimal handling for the first 72 hours of life for infants less than 32 weeks gestation and weighing less than 1500 grams. In order to maximize the success of the project, a pre-implementation education module was utilized to educate the nurses. The success of the education was measured using a pre and post survey.

The pre-survey, education module, and post survey were assigned to 56 full time and part time nurses of the NICU. Nursing experience ranged from one year to 41 years with the mean number of years of experience being 15.7 for the pre-survey and education module and 15.3 years for the post survey. The majority of the nurses had been in practice for >15 years and none of the nurses had <1 year experience. See Table 2 for breakdown of years of experience. The desired outcome was for 80% of the nurses to complete the surveys and education module. 49 nurses (87.5%) completed the pre-implementation survey and education module while only 31 nurses (55.4%) completed the post-implementation survey.

The pre and post surveys assessed nursing knowledge on IVH and neuro-bundles prior to and after completing an education module. The survey was developed by the project leader for the purpose of evaluating the bundle and was not tested for reliability and validity. The questions were asked on a 5 point Likert scale which enabled the perceived knowledge of the nurses to be measured. The answers were compared and the difference in the mean score analyzed using an independent t-test with equal variance (α=0.05). The specific questions that were evaluated

were: 1.How familiar are you with the pathophysiology of IVH? Pre-survey (M=2.98, SD=0.72) and post-survey (M=3.68, SD=0.65); t= -4.37, P<0.001. 2. How familiar are you with the role of the germinal matrix? Pre-survey (M=2.45, SD=0.84) and post-survey (M=3.23, SD=0.84); t= -4.01, P=<0.001. 3. How familiar are you with why the germinal matrix is susceptible to hemorrhage? Pre-survey (M=2.67, SD=0.80) and post-survey (M=3.71, SD=0.74); t= -5.81, P=<0.001. 4. How often are you likely to use pain/stress minimizing measures when performing routine cares or painful procedures? Pre-survey (M=4.22, SD=0.71) and post-survey (M=4.58, SD=0.62); t= -2.28, P=0.013. 5. How often do you/likely are you to ask another nurse for help when repositioning a baby? Pre-survey (M=2.43, SD=0.89) and post-survey (M=3.55, SD=1.03); t= -5.16, P=<0.001. The change in mean score was statistically significant for all the questions; the P-value was <0.05. (Table 3)

The implementation took place over 12 weeks. During this time, 18 babies were admitted to the NICU that were less than 32 weeks gestation. A single baby was excluded from the project due to the fact that he was a transfer from an outside hospital on day of life 2 and the neuro-bundle is only utilized from birth until day of life 3. Six infants were male and 11 were female with gestational age ranging from 23 3/7 weeks to 30 3/7 weeks and birth weight ranging from 650 grams to 1610 grams. See Table 4 for a complete breakdown of demographic information for the infants included in the QI project.

The project was successful with the neuro-bundle utilized for 16 of the 17 babies (94%) admitted to the NICU during implementation. The neuro-bundle consisted of two parts; midline positioning and minimal handling. For each set of cares that the checklist was completed, midline positioning was maintained 97.6% of the time. The reasons given for not maintaining the midline positioning were for IV placement and being on an Oscillator. It was recommended

to utilize two nurses when repositioning infants, in order to maintain midline position. This was done 56.03% of the time. The nurses reported they knew when they needed help repositioning the baby.

Minimal handling was accomplished by clustering cares out to every 4 to 6 hours and utilizing pain/stress minimizing strategies during handling. Minimal handling in the form of cares every 4 to 6 hours was performed 86.4% of the time. The reasons for not performing minimal handling were all related to the worsening status of the infant requiring immediate intervention. During the time that minimal handling was unable to be achieved, the nurses' utilized pain/stress minimizing interventions 100% of the time. The pain/stress minimizing interventions included shielding eyes, maintaining boundaries, and administering pain medication when appropriate.

As part of the unit's protocol, infants born at <32 weeks receive screening head ultrasounds to monitor for IVH. The IVH rate for the infants who participated in this project was 5.9% with a 0% rate of severe IVH. There was only a single case of grade II IVH and the remainder of the babies had no IVH (Figure 1).

Discussion

The project was successful with a few unintended barriers identified along the way. The pre and post surveys allowed for the comparison of knowledge and practice before and after implementation. However, there was a lower response rate for the post-survey due to the high census making it more difficult for nurses to take time to complete the survey.

The education module resulted in a better understanding of IVH and the benefits of midline positioning and minimal handling. As a result, the nurses are more likely to use the

different aspects of the neuro-bundle when caring for their patients. Additionally, the IVH rate for the babies included in the project demonstrated a decrease in incidence of IVH.

The single baby for whom the neuro-bundle was not utilized was born when the hospital went live with a new EHR. At the time of admission, the nurses were extremely overwhelmed with the new charting system. With the help of the nurse educator and charge nurses, the project continued without incident and all subsequent babies admitted to the NICU utilized the neuro-bundle.

Of the babies for whom the neuro-bundle was utilized, only a single baby was not maintained in midline position the entire 72 hours. This baby required respiratory support via High Frequency Oscillatory Ventilation that prevented the baby from being in midline position. This barrier was not anticipated, but at the same time was unavoidable. The nurses utilized the neuro-bundle for this baby in the best way they could. They provided minimal handling when appropriate and utilized pain/stress minimizing strategies at all times. This baby was also, the only baby who developed an IVH over the course of implementation.

These results are consistent with the evidence presented in the literature review. However, the decrease in IVH cannot be viewed as a cause and effect relationship as there are many other factors that contribute to IVH risk. While the initial results of this project support the utilization of a neuro-bundle, they are limited by the short timeline and small sample size.

Conclusion

The short term goals of this project were met with 87.5% (goal: 80%) of nurses having completed the education module and the neuro-bundle being utilized for 94% (goal: 75%) of infants meeting inclusion criteria. Furthermore, a low IVH rate was seen during implementation.

The data supports the continued use of the neuro-bundle in the NICU. Through its continued use, the neuro-bundle will enable a larger sample size to be followed and IVH rates to be seen.

The long term success of the neuro-bundle would be aided by the addition of a single location to document on all aspects of the neuro-bundle in one location. This will make it easier for the nurses to document as well as for tracking compliance and outcomes. The unit may also want to consider utilizing the education module as part of their new hire and yearly competencies. This will enable the nurses to stay aware of the neuro-bundle and its benefits.

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Tables

Table 1

Evidence Review Table

Author, year	Study objective/intervention or exposures compared	Design	Sample (n)	Outcomes studied (how measured)	Results	Level and Quality Rating
Chiriboga, Cortez, Pena-Ariet, Makker, Smotherman, Gautam,…Hudak, 2019	To reduce the incidence of severe intracranial hemorrhage (ICH) in infants <30 weeks gestation from 24% to 11%	Quality improvement	Preterm infants <30 weeks gestation admitted to the NICU (n=281).	Using a p-chart to compare the pre and post ICH rate	A sustained reduction in ICH was seen over 4 years from 24% to 9.7% ($p<0.01$).	4-A
Christ, Barber, Murray, Dunleavy, Stoller, Taha,…Posencheg, 2015	To reduce the incidence of severe IVH in preterm infants <30 weeks gestation	Quality improvement	Preterm infants <30 weeks gestation admitted to the NICU.	The number of severe and overall IVH (%). Overall compliance with midline head positioning and admission huddle (%).	Average monthly rate of severe IVH decreased from 8.3% to 5.1% Admission Huddle rate increased to 100%	4-C
Coughlin, 2016	To provide evidence-based practice guidelines to improve short and long-term for infants and families.	Evidence-Based Practice Guidelines	All patients in the NICU	Guidelines and recommendation are provided for each of the 5 core measures included in trauma informed care.	The implementation of evidence based guidelines has been proven to reduce morbidity and mortality. The latest evidence and implementation strategies are presented to assist in providing age-appropriate, trauma-informed care in the NICU.	1-A

Coughlin, 2011	To provide evidence based clinical guideline for age appropriate care to premature and critically ill hospitalized infants	Clinical Practice Guideline	All patients in the NICU	There are 5 core measures in providing age appropriate developmental care in the NICU. Recommendations are based on a comprehensive evidence review and two pilot studies.	Consistent implementation demonstrates a reduction in neonatal morbidities including IVH. The core measures meet the requirements of the Joint Commission to provide age-specific care across the lifespan.	1-A
Davis, Berger, & Chock, 2016	Review obstetric an neonatal practices that have been shown to have a neuroprotective effect on the developing brain	Literature Review/Expert Opinion		Reduction of IVH rates to improve neurologic outcomes	Midline head position has been shown to maintain a constant cerebral blood flow by not impeding jugular venous blood flow. Minimal handling and avoiding stressful situations may be beneficial. More research is needed.	7-C
Kaspar & Rubarth, 2016	The implementation of neuroprotective strategies are necessary to prevent IVH and other brain injuries	Expert opinion/evidence Based	Premature infants	Circulatory fluctuations can be seen in routine caregiving, these fluctuations can lead to IVH in critically ill preterm infants. Overstimulation can increase blood pressure and increase cerebral blood flow leading to IVH. Midline head position prevents elevations in cerebral blood flow and has been shown to decrease intracranial pressure. Head positions other than midline can be associated with fluctuations in cerebral blood flow contributing to the risk of IVH.	By providing neuroprotective care to prevent cerebral blood flow and blood pressure fluctuations we can decrease the incidence of IVH and have better outcomes for preterm infants and their families.	7-B

Malusky & Donze, 2011	Guideline for the institutional implementation of developmental care in the Neonatal Intensive Care Unit	Systematic Review	Preterm infants ,32 weeks gestation	Evaluate the current evidence and determine if midline head position for infants <32 weeks gestation prevents IVH.	Implementation of midline head position recommended for infants <32 weeks gestation for the first 72 hours of life – no adverse effects noted	1-B
Peng, Bachman, Jenkins, Chen, Chang, Chang, & Wang, 2009	The relationship between environmental stressors and stress responses of preterm infants in the NICU	Repeated measure research design	Preterm infants (n=37)	Environmental stress (increased sound, light, nursing interventions)- measured using a likert scale Stress biobeahvioral response: physiologic stress signals (HR, RR, and O2 sats), measured using cardiorespiratory monitor; and behavioral stress response (sleep-wake states, self-regulatory behaviors, and behavioral stress cues),	There was statistically significant (P<.05) relationship between environmental stress and change in vital signs. There was a statistically significant (P<.05) relationship between environmental stress and specific stress behavior	3-B
Romantsik, Calevo, & Bruschettini, 2017	To assess if midline head position is effective in preventing IVH in infants <32 weeks gestation	Systematic review (Cochrane Review)	Preterm infants born at ≤32 weeks gestation.	Is midline head positioning more effective in preventing or extending IVH than any other head position	Not enough evidence to show a positive or negative effect of midline head position.	1-C

Schmid, Reister, Mayer, Hopfner, Fuchs, & Hummler, 2013	To evaluate if a bundle of measures including minimal handling (clustering cares, no baths, prevent noise, etc.) and midline head positioning would reduce the incidence of IVH	Interventional cohort study	Preterm infants born <30 weeks gestation or weighing <1500 grams. Before intervention (n = 263) Intervention (n= 191)	The incidence of IVH and high grade IVH(%).	Incidence of IVH fell from 22.1% to 10.5% (p = 0.002) Incidence of severe IVH (grade 3-4) fell from 9.1% to 3.7% (p = 0.037).	4-A

Table 2

Years of Experience of Nurses

	Pre (n=49)	Post (n=31)
Mean	15.7	16.3
Median	14	11
	N (%)	N (%)
<1	0 (0)	0 (0)
1-5	13 (26.5)	7 (22.5)
6-10	6 (12.2	8 (25.8)
11-15	7 (14.3)	4 (12.9)
>15	23 (46.9)	12 (38.7)

Table 3

Pre and Post-Implementation Survey Results

	Pre (n=49)	Post (n=31)
How familiar are you with the pathophysiology of IVH?		
	N (%)	N (%)
Mean	2.98	3.68
1	0	0
2	11 (22.45)	0
3	30 (61.22)	7 (22.58)
4	6 (12.22)	21 (67.74)
5	2 (4.08)	2 (6.45)
How familiar are you with the role of the germinal matrix?		
	N (%)	N (%)
Mean	2.45	3.23
1	7 (14.29)	1 (3.26)
2	17 (34.70)	4 (12.90)
3	21 (42.86)	14 (45.16)
4	4 (8.16)	11 (35.48)
5	0	1 (3.26)
How familiar are you with why the germinal matrix is susceptible to hemorrhage?		
	N (%)	N (%)
Mean	2.67	3.71
1	4 (8.16)	0
2	14 (28.57)	0
3	25 (51.02)	14 (45.16)
4	6 (12.22)	12 (38.71)
5	0	5 (16.13)
How often do you/ likely are you to use pain/stress minimizing measures when performing routine cares or painful procedures?		
	N (%)	N (%)
Mean	4.22	4.58
1	0	0
2	1 (2.04)	0
3	5 (10.20)	2 (6.45)
4	25 (51.02)	9 (29.03)
5	18 (36.73)	20 (64.52)
How often do you/likely are you to ask another nurse for help when repositioning a baby?		
	N (%)	N (%)
Mean	2.43	3.55
1	8 (16.32)	0
2	17 (34.70)	6 (19.35)
3	19 (38.78)	8 (25.81)
4	5 (10.20)	11(35.48)
	0	6 (19.35)

Table 4

Infant Demographics (n=17)

	N(%)
Sex	
Male	6 (33.33)
Female	11 (61.11)
Gestational Age	
<28 weeks	7 (41.18)
28-32 weeks	10 (58.82)
Birth Weight	
<1000 grams	6 (33.33)
1000-1500 grams	9 (52.94)
>1500 grams	2 (11.76)

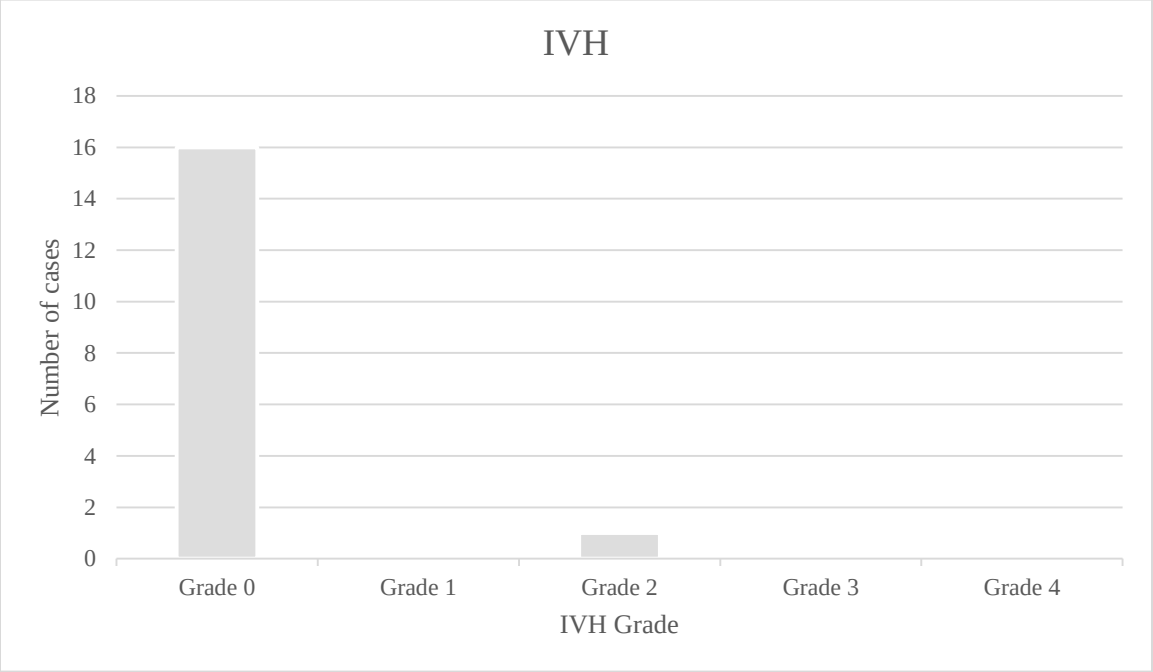

Figure 1. Number of cases of IVH by grade

Appendix A: Neuro-bundle Guideline

Guideline for Implementing Neuro-Bundle Targeted Population: Preterm infants <32 weeks and weighing <1500 grams, the first 72 hours of life		
Practice Recommendations	**Rationale**	
Midline Positioning	Prevent cerebral blood flow fluctuations, maintaining jugular venous flow.	1. Maintain head in midline position, baby can be placed supine or side-lying. 2. Head maintained in midline position during position changes: use 2 nurses to reposition baby 3. Head maintained in midline position for kangaroo care: use 2 nurses to transfer baby, have baby in side lying position.
Minimal Handling	Minimize pain and stress. Routine care is associated with stress which is associated with increased cerebral blood flow.	1. Cluster cares Q4-6 hours if appropriate. 2. Healthcare team work together to minimize the number of times the baby is handled. 3. Use swaddling and other non-pharmacologic interventions (boundaries; shield eyes from light) when performing painful procedures.

Appendix B: Pre-implementation Survey

IVH Questionnaire

Pet's name:_____

# of years as a RN:_____

All questions will be answered on a scale 1 to 5 with 1 meaning never/not at all and 5 meaning always/very.

1. How familiar are you with the pathophysiology of IVH?

   1 2 3 4 5

2. How familiar are you with the role of the germinal matrix?

   1 2 3 4 5

3. How familiar are you with why the germinal matrix is susceptible to hemorrhage?

   1 2 3 4 5

4. How familiar are you with the use of neuro-bundles for IVH prevention?

   1 2 3 4 5

5. How familiar are you with why midline positioning is thought to prevent IVH?

   1 2 3 4 5

6. How familiar are you with why minimal handling/ pain and stress-minimizing is thought to prevent IVH?
   1 2 3 4 5

7. How often do you use pain/stress minimizing measures (swaddling, maintaining boundaries, shielding eyes from light) when performing routine cares or painful procedures?
   1 2 3 4 5

8. How often do you ask another nurse for help when repositioning a baby?

   1 2 3 4 5

Appendix C: Education Plan

I. Powerpoint/online module

A. Background

1. IVH Pathophysiology

2. Significance of problem

B. Project Purpose

1. Short term goals

2. Long term goals

C. Implementation

1. Setting

2. Target population

3. Guideline/ evidence based practice

a) Midline positioning

b) Minimal handling

(1) Pain/stress minimizing measures

Appendix D: Neuro-Bundle Checklist

Neuro-Bundle Checklist

Patient Label

Date: _____ Shift: □ day □ night

Gestational Age:_____ Birthweight:_____grams Day of Life:_____

Was midline positioning maintained? □Yes □No

Was the baby positioned with the help of a second nurse? □Yes □No

Was minimal handling utilized? □Yes □No

What interval was used between cares? _____

What prevented the recommended interval from being used?

□ apnea/bradycardia event

□ acute worsening of respiratory status

□ other: _____

What non-pharmacologic measures were utilized to minimize pain/stress?

□ swaddling

□ maintaining boundaries

□ shielding eyes from light

□ other: _____

For Project Leader

IVH □ yes □ no

Appendix E: Post-implementation Survey

Neuro-Bundle Questionnaire

Pet's name:_____

# of years as an RN:_____

All questions will be answered on a scale 1 to 5 with 1 meaning never/not at all and 5 meaning always/very.

1. How helpful was the education module?

   1 2 3 4 5

2. How familiar are you with the pathophysiology of IVH?

   1 2 3 4 5

3. How familiar are you with the role of the germinal matrix?

   1 2 3 4 5

4. How familiar are you with why the germinal matrix is susceptible to hemorrhage?

   1 2 3 4 5

5. How often are you likely to use pain/stress minimizing measures (swaddling, maintaining boundaries, shielding eyes from light) when performing routine cares or painful procedures?
   1 2 3 4 5

6. How likely are you to ask another nurse for help when repositioning a baby?

   1 2 3 4 5

7. How well did you think the implementation went?

   1 2 3 4 5

8. What changes would you make? _____

   _____