8-20-2021

Neonatal Orogastric & Nasogastric Tube Placement: Evidence Based Improvement Prospectus

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Summer 8-20-2021

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NURS 660: Quality Improvement and Outcomes Management Practicum

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May 2, 2021

Abstract

Problem: Variation in gastric tube placement practice has resulted in incorrect placement depth, resulting in four gastric tube perforations in a level III neonatal ICU within the last year. Gastric perforations have increased infant length of stay, increased surgical interventions, delay in oral feeding, increased hospital cost, and potentially lower family satisfaction with care.

Context: IHI's 5 Why's: Finding the Root Cause identified a lack of standardization in policy and practice and lack of consistent staff education as the primary reason for misplaced gastric tubes. Additionally, a cost-benefit analysis projected the estimated cost of additional infant length of stay for gastric perforations to be between $3,000 to $138,000, which does not include surgical cost or additional treatment costs for gastric perforation-related complications.

Interventions: Infant measurements were collected by measuring infants from the corner of the mouth to the earlobe for orogastric tubes, insertion site nare to the earlobe for nasogastric tubes, earlobe to the xiphoid process, and xiphoid process to umbilicus. Infant x-rays were assessed to determine appropriate gastric tube placement. They were then compared to the most appropriate insertion method for placement, including NEX, NEX +1, NEX +2, NEMU, and weight-based methods.

Measures: The primary measure of the gastric tube initiative is to have zero gastric perforations and see an improvement in gastric tube placement on x-rays on the initial insertion attempt.

Results: Since initial gastric tube insertion method education, it was identified that 42.6% of gastric tubes were incorrectly placed. Thus, a weight-based trend identified the need to use a different gastric tube insertion method for each weight class. The NEMU method presented too deep for infants less than one kilogram, and the NEX method was too shallow for infants weighing more than two kilograms. Additionally, the weight-based formula for gastric tube insertion proved to place tubes in 92.6% of insertion attempts incorrectly.

Conclusion: The proposed gastric tube measurement guidelines include using the NEX method for infants weighing less than one kilogram, using the NEX +1 method for infants weighing between one to two kilograms, and using the NEMU method of infants weighing more than two kilograms. At this time, the weight-based method should not be used to guide practice as there is insufficient evidence to support the correct placement of orogastric tubes, and infants on oxygen therapy and intravenous therapy have been excluded from previous studies.

Keywords: gastric tube insertion, nasogastric tube, orogastric tube, NEX method, NEMU method, NEX +1 method, NEX +2 method, weight-based method, infant weight.

Neonatal Orogastric & Nasogastric Tube Placement: Evidence Based Improvement

Neonatal gastric perforations are uncommon, life-threatening events in newborns that typically require surgical intervention and lead to a prolonged hospital stay and increased premature complications. The reported incidence of neonatal gastrointestinal perforations is 1 in 5,000 live births, and 7% are neonatal gastric perforations. While gastric perforations' etiology remains unclear, some of the risk factors include premature infants, low birth weight infants, stomach overdistension, bag-mask ventilation, and gastric tube placement (Iacusso et al., 2018). Orogastric and nasogastric tubes are commonly used in neonates and infants in neonatal ICUs to provide nutrition, medication, and gastric decompression (Lin et al., 2019). According to hospital policy and the infant-driven feeding protocol, infants do not begin cueing to feed until 33 weeks gestational age and thus have feeding tubes in place until they develop eating skills.

Problem Description

Despite gastric perforations being uncommon events, a level III neonatal ICU in Santa Clara County has experienced four neonatal gastric perforations within the last year. Upon reviewing x-rays of these infants, two things were noted. First, gastric perforations occurred along the stomach's greater curvature, and second, the gastric tubes were placed too deep, thus perforating the stomach wall. A systematic literature review conducted by Iacusso et al. states that gastric perforations caused by overdistension alone occur along the stomach's lesser curvature (2018). All four of the infants diagnosed with gastric perforations had some form of surgical interventions and feeding complications, thus prolonging hospital length of stay due to gastric perforation-related complications, including infection due to increased susceptibility.

Furthermore, after reviewing other neonatal x-rays on the unit, it was determined that misplaced gastric tubes, too shallow or too deep, were common trends in the NICU. Thus, a baseline staff assessment was conducted, and it was determined that nurses are not using the same or proper measurement technique. Incorrectly placed gastric tubes are not uncommon. In reality, a study conducted by Quandt et al. reports that 59% of gastric tubes were incorrectly placed in neonates (Lin et al., 2019). Currently, a wide variety of measurement techniques exist to place gastric tubes accurately in the infant's stomach. However, according to CPQCC, the best method to measure accurate gastric tube placement is to measure from the nare to the ear lobe to the midway point between the xiphoid process and umbilicus, also known as the NEMU method. CPQCC also states that orogastric tubes should be measured from the corner of the mouth and not the nare, which has been an inconsistent practice at a Santa Clara county-level III NICU (Wight et al., 2018).

Although the best verification method to ensure gastric tube placement is x-rays, it causes too much radiation exposure for neonates and infants. Since infants may have tubes in place for a long time based on their gestational age and frequently pull out their feeding tubes, checking gastric tube placement using x-ray is not feasible (Lin et al., 2019). Despite staff re-education on the CPQCC methods, gastric tube misplacement is continuously noted on infant x-rays. Inconsistent gastric tube placement methods place major concerns as some infants are discharged to home on gastric tube feedings, and thus families are educated by staff nurses. Suppose correct gastric tube measurement practice is not instilled in the NICU. In that case, infants are at risk for gastric perforation, and infants discharged to home are at risk for emergency room readmission. Thus, it is imperative to correct tube misplacement and establish effective education.

Available Knowledge

PICO Question

In neonates, preterm, and term infants, is the NEMU, NEX, or weight-based calculation measuring method the most accurate for correct placement of orogastric and nasogastric tubes at every insertion attempt?

Literature Synthesis

An extensive successful evidence search regarding measuring gastric tube insertion length techniques was completed using various databases, from which five-level I A to II B studies were chosen as displayed in Appendix A. Among the chosen studies, a study conducted by Dias et al. (2020) concluded that the best practice for measuring proper nasogastric tube placement is using a weight-based formula, which proved to be 91.5% accurate compared to the NEMU method, which was merely 67.5% accurate. Although the study conducted by Dias et al. (2020) suggests using a weight-based formula for correct nasogastric tube insertion, there is a significant drawback as the study does not include the full range of infant weights. Dias et al. (2020) included a generalized category of infants weighing <1500 grams. However, it is essential to consider that ventilated patients were excluded, and only included infants who can breathe on their own were included in this study. Neonatal infants often require some form of ventilation or oxygenation and often weigh less than 1500 grams, which in this study excludes a significant population that requires gastric tube insertion. Furthermore, only nasogastric tube measurement and placement were included, excluding orogastric tube measurement, often used in ventilated infants (Dias et al., 2020).

Parker et al. (2018) conducted a systematic review analyzing eight studies of six different feeding tube insertion determining length methods, including various NEX methods, NEMU method, the age-related height based (ARHB), and weight-based method. The systematic review concluded that although the NEMU method caused incorrect feeding tube placement in at least

10% of insertion attempts, it is still considered the most reliable method to insert feeding tubes at correct anatomical placement. Furthermore, the NEX method was even less accurate as gastric tubes placed using the NEX method were incorrectly placed by up to 59%. There is limited data to suggest whether weight-based or ARHB related formulas would lead to accurate placement. Further research should be conducted as height is subjective, and weight must be recorded accurately (Parker et al., 2018).

As mentioned in the systematic review by Dias et al. (2017), weight-based and height-based equations seem to be reliable measures of gastric tube insertion placement. However, there is a lack of experimental studies using these methods. Thus, weight and height formulas should not be used as a single reference but rather as a supporting measure in decision making. Therefore, the best-recommended practice for gastric tube placement measurement uses the NEMU method with additional confirmation by using height or weight-based formulas (Dias et al., 2017; Kato et al., 2020). Additionally, Kato et al. (2020) conducted a study using weight-based and height-based formulas and found that the formulas proved accurate placement in infants weighing greater than 1kg. However, among infants weighing less than 1kg, the predicted insertion length would be too deep.

Additionally, after analyzing the presented evidence, it is clear that the NEX method produces a high placement error-index. Therefore, the NEX method should not be used as a measurement technique. The study conducted by Reiche et al. (2017) further concludes that even the modified NEX method produces an error-index rate of up to 31.7%. Currently, many facilities continue to use the NEX method or modified NEX method in clinical practice. Nevertheless, there is an absence of scientific evidence supporting the use of the NEX method for nasogastric and orogastric tube placement (Reiche et al., 2017). Thus, the NEX method must be highly discouraged in clinical practice.

Rationale

Lewin's model for change (see Appendix B) and IHI's model for improvement (see Appendix C) to initiate change were used to guide this evidence-based project to improve orogastric and nasogastric tube feeding placement among infants. Initially, using the first part of the IHI's model for improvement to address the aim of the project to reduce misplacement of gastric tubes, establishing measures such as analyzing radiographs, and selecting change by first analyzing literature and choosing the best method to implement change in practice (IHI, n.d.a). Additionally, Lewin's model for change includes three stages known as unfreeze, change, and refreeze. During the unfreeze stage, there is a recognition that something is imperfect. Thus, prior beliefs in measurement techniques must be altered so that new behaviors can be implemented successfully. The change stage comes after that, meaning others are being persuaded that the current process is harmful to infants, evidence by the occurrence of four gastric perforations due to misplaced tubes. Thus, this project is currently experiencing the change stage in which valuable information and input are being gathered to lead to the desired outcome. The last stage, known as refreezing, involves implementing the change as a new habit once it has successfully gone through the PDSA cycle, ensuring that the implemented change will remain over time (Udod & Wagner, 2018).

Specific Project Aim

This project aims to place infant feeding tubes correctly and eradicate gastric perforations among infants of all gestational ages and weight caused by misplaced feeding tubes by identifying the most accurate feeding tube measurement technique using the best available evidence by July 31, 2021.

Context

In solving the gastric tube misplacement problem, the problem must be truly understood rather than immediately seeking a solution as a unit. When facilities immediately seek a solution rather than identifying the root cause or understanding the situation, one cause may be identified when it is merely another symptom. Thus, to identify the root causes of misplaced gastric tubes, IHI's *5 Why's: Finding the Root Cause* (see Appendix D) was used to identify the best cause of action in correcting and sustaining change to prevent misplacement (IHI, n.d.b). Using IHI's *5 Why's: Finding the Root Cause* identified the leading two causes of misplaced gastric tubes: a lack of standardization in policy and practice and lack of consistent staff education. Based on the *5 Why's* findings, the *Gastric Tube Charter* (see Appendix E) was developed to collaborate with the lead medical providers and the NICU clinical nurse specialist. The team would collectively analyze the collected data and educate bedside staff on proper practice and standardize practice into a policy for reference.

Additionally, a SWOT analysis (see Appendix F) was conducted to identify the strengths, weaknesses, opportunities, and threats of implementing policy and practice change for the entire unit. Some of the most compelling opportunities to implement a gastric tube policy are decreased infant length of stay, decreased cost, and decreased chances of litigation against the unit and healthcare practitioners. Additionally, there is no extra cost to train the staff in using new practices as all necessary equipment is already being used in the NICU. The staff training education can be completed during staff huddles or each shift, creating no additional cost. However, two of the greatest threats to implementing the new practice are the staff resistance to change and the potential of unchanged or increase in misplaced gastric tubes as the measurement method nurses use at the bedside cannot be monitored at all times.

Despite these threats, the strengths and opportunities outweigh the risks and threats supported by the cost-benefit analysis (see Appendix G). The cost-benefit analysis was conducted by identifying the average length of stay, based primarily on gestational age, reported by March of Dimes, and based on birth weight, which CPQCC reported. The average NICU hospitalization costs reported by March of Dimes does not include the cost of gastric perforations as those are not an expected neonatal diagnosis but an adverse event. Additionally, data on the average cost of gastric perforations and associated complications has not been reported. Therefore, the projected total cost was calculated using the average length of stay, one to forty-six days, from studies conducted by Byun et al. (2014) and Elrouby (2019) multiplied by the average daily cost for hospitalized infants at $3,000 a day reported by Kornhauser and Schneiderman (2010). Thus, using this calculation, additional infant length of stay for gastric perforation is projected to cost at least an additional $3,000.00 to $138,000.00 and does not include surgical cost or additional treatment costs for gastric perforation-related complications.

Intervention

As conveyed in Appendix H, several methods have been implemented either individually or in combination to insert gastric tubes in the correct place on the first insertion attempt. Many research studies have assessed and compared the NEX method, the NEMU method, currently known as the best practice. The weight-based method has shown promising results for correct placement, but further research must be conducted (Dias et al., 2020). Although there is a lack of research on modified NEX methods, many neonatal ICUs use the NEX plus one-centimeter measurement or NEX plus two-centimeters measurement method for inserting gastric tubes. However, a systematic review with a meta-analysis conducted by Parker et al. (2018) discusses the use of NEX plus one and NEX plus two methods.

Modified NEX methods proved to be 74% effective when NEX plus one centimeter was used for infants weighing less than 1000 grams, and NEX plus two centimeters was used for infants weighing 1000 grams or more. Thus, modified NEX methods will also be included in evaluating best practices based on infant weights.

Although the NEMU method is best supported by evidence, it is essential to assess all measuring methods to determine best practices for each infant based on weight. The NEMU method may place gastric tubes too deep in infants weighing less than 1200 grams. X-rays will be reviewed of every infant who has a gastric tube in place and receives routine x-rays. Infant measurements will be taken within three days when the x-ray was taken, measuring the infant from the corner of the mouth to the earlobe, or nare to earlobe for nasogastric tubes, earlobe to the xiphoid process, then xiphoid process to umbilicus. Upon reviewing x-rays to determine if the orogastric and nasogastric tube is placed correctly, the charted tube placement depth will be recorded and compared to the infant's measurements. If the gastric tube is placed too deep or shallow, a ruler on x-ray review will be used to measure the distance the tube should be pulled back or pushed in for proper placement. Once the tube is placed in the mid-stomach, the placement depth number will be compared to infant measurements of the same insertion depth number to determine the best measurement technique among NEMU, NEX, NEX 1, NEX 2, and weight-based method. Infant weights will also be used to determine if weight-based calculations also place the gastric tube at the correct insertion depth for insertion depth verification and reference.

Study of the Intervention

Once staff education has been completed and the policy has been standardized, the clinical nurse specialist and the lead RN will continue to review x-rays to trend a pattern in increased gastric tube placement on the initial insertion attempt. Misplaced gastric tube x-rays will be counted, and the data from the reviewed x-rays will display whether the goal for proper tube placement on the initial insertion attempt has been achieved. The NICU will also monitor gastric perforation cases at least quarterly, keeping track of the number of cases per year. Additionally, the lead practitioners and clinical nurse specialist will review x-rays during infant rounds and be vocal about incorrect tube placement at the bedside, thus correcting misplaced gastric tubes promptly, further preventing gastric perforations. Suppose gastric tubes continue to be misplaced or are increasingly misplaced after unit comprehensive education has been conducted and standardized policy has been implemented. In that case, the team must repeat the PDSA cycle to find better methods for sustainment.

Measures

The outcome measure for the gastric tube placement initiative is to improve gastric tube insertion placement on initial insertion attempt and create uniform standards of practice, eliminating bedside variation in technique. Additionally, families with infants being discharged home with gastric tubes will have consistent education by all staff members reinforced by standardized unit gastric tube education directed explicitly at families. Most importantly, after instilling the education plan, the neonatal ICU expects to have zero gastric perforations related to gastric tube placement, decreasing adverse outcomes and hospital length of stay (see Appendix I). Healthcare providers also must understand the importance of tube placement on x-ray because even the most accurate measuring technique, the NEMU method, has an error index of at least 10% up to 32.5% (Parker et al., 2018; Dias et al., 2020).

The neonatal ICU expects to see an increase in proper tube placement on x-rays to 90% on initial insertion attempts (see Appendix I). Furthermore, the proper gastric tube placement initiative's goal is to increase patient safety and improve team performance that eliminates conflicting information when educating families, preventing emergency room readmissions. Another goal is to have 100% of staff nurses using the correct measurement to insert gastric tubes and have 100% of patients with accurately documented gastric tube depths (see Appendix I). As a method to sustain policy and practice changes, an educational post-test (see Appendix J) will be given to nurses to assess the provided education's efficacy, which then is used to assess if the current sustainment methods are sufficient for practice change.

Ethical Considerations

There was no conflict of interest noted among the staff members, patients, families, or neonatal practice leaders in assessing and preparing the unit for change regarding gastric tube placement. In reviewing x-rays and correcting gastric tube placement, no infants were used as test subjects to attempt new practices. All gastric tube depth modifications were done merely by reviewing x-rays as a routine procedure. The gastric tube placement initiative was created to prevent infant harm and decrease adverse outcomes; thus, all infants received a standard care routine. Additionally, since none of the infants were directly tested using various methods, signed consent was not required. Complete confidentiality and privacy were also maintained as the infant x-rays were not shared with anyone who was not directly involved in each patient's care. Using the University of San Francisco's *Evidence-Based Change of Practice Project Checklist* (see Appendix K), the gastric tube placement initiative was determined to be a quality improvement project. Thus, it does not require an Institutional Review Board review.

The two primary Jesuit values of education that drove the gastric tube initiative are cura personalis and magis. Cura personalis involves caring for the personal department of the whole person, which is essential as the NICU infants are unable to communicate their needs and heavily rely on medical professionals to provide the best care. Magis means to strive for the better and striving for excellence. Magis does not mean that we must always do or give more to the point of exhaustion but rather to improve care by discerning the greater good. In representing magis, a simple improvement solution was created to reduce adverse neonatal infant outcomes (Regis University, n.d.). Furthermore, under provision seven in the ANA Code of Ethics, nurses in all roles and settings advance the profession through scholarly inquiry and improving standard development. The gastric tube project aims to standardize the gastric tube insertion process by contributing to scholarly inquiry and implementing professional practice standards (American Nurses Association, 2015). The gastric tube placement initiative aims to standardize orogastric and nasogastric placement measurement methods to ensure accurate gastric tube placement based on the best available evidence and practice. The University of San Francisco School of Nursing and Health Professions Clinical Nurse Leader program approved this quality improvement initiative.

Outcome Measure Results

Fifty-four gastric tubes were assessed on x-ray, including fifty-three orogastric tubes and one nasogastric tube among infants weighing between 0.61 kilograms to 4.675 kilograms as displayed in Appendix L. Six infants were weighing less than one kilogram, thirty infants weighing between one kilogram to two kilograms, and eighteen infants weighing more than two kilograms (see Appendix M). Upon assessing x-rays, 42.6% of gastric tubes were placed either too deep or too shallow, but the data shows that the insertion error decreased as infants increased in size. According to infant weights and measurements, 66.7% of infants weighing less than one kilogram resulted in the NEX method being the best gastric tube insertion technique as only two infants required the NEX +1 method. The one-to-two-kilogram weight class was more challenging to decipher, as 10% of the sample required the NEX method, 60% required the NEX

+1 method, 13.3% required the NEX +2 method, and 16.7% required the NEMU method. Infants weighing greater than two kilograms did not have any infants requiring the NEX method. Instead, they had 11.1% of infants requiring the NEX +1 method, 33.3% requiring the NEX +2 method, and 55.6% requiring the NEMU method.

Additionally, the weight-based method was calculated using the nasogastric and orogastric weight-based method formulas, displayed in Appendix H, to analyze whether weight-based calculations match all infants' best insertion depth. Among the fifty-four samples, only one sample was a nasogastric tube. After analyzing the weight-based measurements (see Appendix L), fifty infant weight-based insertion measurements were miscalculated by 0.5 cm to 5 cm compared to optimal insertion depth, meaning weight-based calculations incorrectly predicted insertion depth 92.6% of the time. However, four infant measurements were up to 0.2 cm within range of best gastric tube insertion depth determined by x-ray. Thus, the weight-based measurement method displayed significant variance in estimating insertion depth with no evident correlation to infant weight.

Discussion

Summary

Appendix M presents a clear trend: as an infant grows, the measurement technique being used changes, such that no infants greater than two kilograms require the NEX method for best insertion depth as the NEX method would be too shallow. Additionally, infants weighing less than one kilogram do not qualify for NEX +2, and NEMU measuring methods as those methods place the gastric tube too deep. Furthermore, the variation in insertion depth technique within weight range becomes more prominent as infants reach closer to the next weight category (see Appendix L). Many nurses use the NEMU method for all gastric tube insertions, which could result in gastric tubes being placed too deeply in infants weighing less than one kilogram. Since gastric tube error rates decreased as infant size increased, the NEMU method was appropriate for inserting gastric tubes. Thus, the best gastric tube insertion measurement technique should be based on an infant weight range category.

Practice Considerations

While many studies suggest a weight-based measurement technique as the potential best practice, the collected data does not support that change. As mentioned, Appendix L clearly shows variation in the weight-based insertion depth and the best insertion depth based on an x-ray. Thus weight-based measurement method must be studied more before implementing the method in current practice. A significant consideration is that previous studies have suggested using a weight-based measuring method for inserting nasogastric tubes. However, 98% of the collected data includes the use of orogastric tubes. Parker et al. (2018) mention the importance of recording accurate infant weights before using the weight-based measurement method for gastric tube placement. Inaccurate infant weights may cause the significant variation experienced using the weight-based calculation in the collected data. Orogastric tubes were inserted in 98% of infants in the given dataset due to having oxygen therapy and, in some cases, the addition of intravenous therapy. Thus the recorded infant weights may not have been accurate due to the weight of oxygen and intravenous apparatus. Thus, weight-based formulas must be studied more before implementation, especially in infants weighing less than two kilograms and infants with oxygen therapy. The collected data further confirms Dias et al.(2017) findings, which concluded that the orogastric tube weight-based formula only predicted poorly placed orogastric tubes 60% of occurrences.

Another important consideration is understanding the growth and development of micro-preemies compared to the growth of a term infant. Infant body proportions may vary significantly of micro-preemies adjusted to term gestational age compared to an infant born term. Kato et al. (2020) further state that the weight-based measurement formula presented in Appendix H places gastric tubes too deep in infants weighing less than 1000 grams. In future studies, it is essential to analyze the weight distribution of micro-preemies corrected to term gestational age and the potential effects on gastric tube placement using NEX, NEMU, and weight-based methods. Height-based methods may be a future implication of practice, especially for micro-premies since weight distribution varies. However, height is subjective and may produce a significant variance in measurement and thus requires more research before implementation (Dias et al., 2017).

Conclusion

While the gastric tube initiative has increased placement awareness and the importance of x-ray review in the neonatal intensive care unit, a significant variation in insertion measurement and technique remains. Thus, based on Appendix M, the proposed practice guidelines to eliminate variation in practice is to use the NEX method for infants weighing less than one kilogram, the NEX +1 method for infants weighing between one kilogram to two kilograms, and using the NEMU method for infants weighing greater than two kilograms. Furthermore, weight-based calculations should not be used in guiding practice for gastric tube insertion since there is significant variance in appropriate depth compared to the recommended depth based on weight. Additionally, there is insufficient data to insert gastric tubes using weight-based formula among infants weighing less than one kilogram.

Creating standardized guidelines of practice will eliminate insertion method variance as a factor of gastric perforations. Furthermore, there will be standardized education for all staff and family members alike, preventing new staff confusion. Thus family members will be educated uniformly, decreasing the chances of readmission. The gastric tube initiative has the potential to spread to other Kaiser facilities once the presented data has been approved by the neonatology team, which includes the unit manager, the neonatologists, and the clinical nurse specialist. Uniform education will be created and presented to all bedside staff to address any questions and barriers to the proposed changes. Once the gastric tube standards of practice have been approved, the team will continue to gather data to determine if there has been an improvement in gastric tube insertion placement on x-ray and continue to monitor for gastric perforations. The key to sustainability for the gastric tube initiative is to have full support from the neonatal leadership team. The leadership team can then address unit fear of practice change and create sustainable change.

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Appendix A

Gastric Tube Evaluation Table

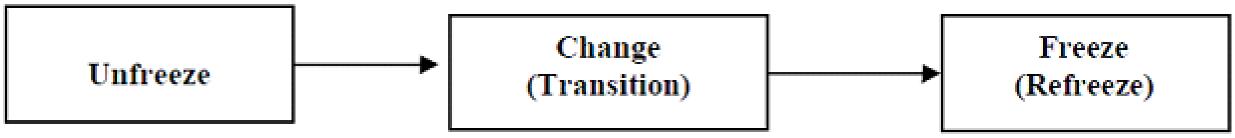
Study	Design	Sample	Outcome/Feasibility	Evidence rating
Parker, L. A., Withers, J. H., & Talaga, E. (2018). Comparison of neonatal nursing practices for determining feeding tube insertion length and verifying gastric placement with current best evidence. *Advances in Neonatal Care*, *18*(4), 307-317. 10.1097/ANC.0000000000000526	Systematic Review with meta-analysis	Included 8 studies: n=919 feeding tube insertion length n=194 feeding tube placement verification	Provides insight for the most accurate gastric tube insertion method. Compares accuracy of various gastric tube placement methods. Useful in guiding unit practice.	L II A
Dias, F. S. B., Jales, R. M., Alvares, B. R., Caldas, J. P. S., Carmona, E. V. (2020). Randomized clinical trial comparing two methods of measuring insertion length of nasogastric tubes in newborns. *Journal of Parenteral and Enteral Nutrition*, *44*(5), 912-919. 10.1002/jpen.1786	Randomized Control Trial	n=162	Compares the accuracy of two methods of measuring nasogastric tube insertion lengths among infants. Compared a weight-based formula and the well-known NEMU method. Useful in determining guidelines for upcoming gastric tube placement practice.	L I A
Dias, F. S. B., Emidio, S. C. D., Lopes, M. H. B. M., Shimo, A. K. K., Beck, A. R. M., & Carmona, E. V. (2017, July 10). Procedures for measuring and verifying gastric tube placement in newborns: An integrative review. *Revista Latino-Americana de Enfermagem, 25*(e2908), 1-13.	Systematic Review with Meta-analysis	Included 17 studies: Total n= 3,000 Ranging from preterm	Compares NEMU and NEX method for best gastric tube placement practice. Briefly introduces weight and height-based formulas for measurement, which will be more	L II A

http://dx.doi.org/10.1590/1518-8345.1841.2908		infants to adults.	prominent in the future. Useful in determining which method is more effective at which age.	
Kato, Y., Hirata, K., Oshima, Y., & Wada, K. (2020, April). Weight-based estimation of insertion length of the nasogastric tube in extremely low birth-weight infants. *Advances in Neonatal Care*, *20*(2), E31-E34. 10.1097/ANC.0000000000000692	Prospective study: Quasi experiment	n=152 patients	Compared gastric tube placement prediction using the NEMU method and weight or height-based formulas to predict appropriate NG tube insertion length. Useful in understanding weight as a measurement factor as infants are weighed every day and can be a more reliable measure. Used 2 different formulas one for an infant weighing less than 1kg and a different formula for those weighing greater than 1kg.	L II A

Reiche Andre, R., Quiroz de Souza Mendes, C., Ferreira Machado Avelar, A., & Ferreira Gomes Balieiro, M. M. (2017, November 29). Enteral tube placement in newborns according to the modified measurement technique. *Acta Paulista de Enfermagem*, *30*(6), 590-597. https://doi.org/10.1590/1982-0194201700083	Prospective study: Quasi experimental	n=28 infants total of 60 radiographs reviewed	Discusses the modified NEX method to measure gastric tube placement. Modified NEX disregards the orifice the tube will be placed and measures from the tip of the nose to ear lobe to xiphoid process.	L II B not an effective sample size and method has an error index of 31.7%

Appendix B

Kurt Lewin's Change Management Model



Stage 1: Unfreeze

Unfreezing requires recognition that something is imperfect, leading individuals and the microsystem to alter prior beliefs to implement new behaviors. Unfreezing includes discovering a method to assist individuals and microsystems to transition from old behavior, overcoming resistance, and group conformity.

Stage 2: Change (Transition)

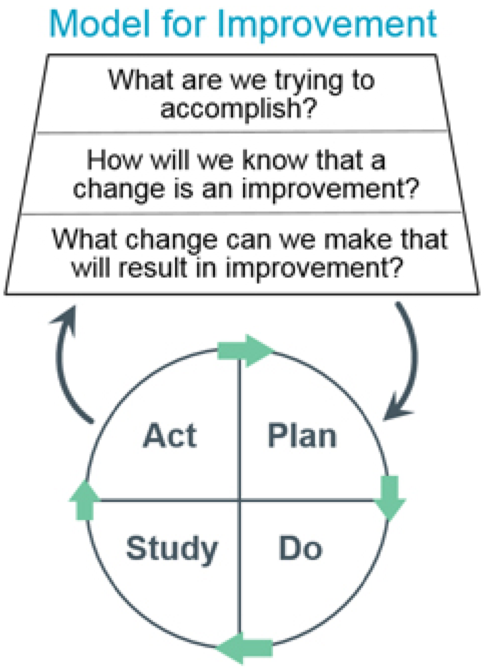
The change phase involves transitioning thoughts, feelings, and behaviors by persuading others that current beliefs are not beneficial and giving perspective to the problem. In order to get past the change phase, microsystems must have a supportive team and clear communication.

Stage 3: Freeze (Refreeze)

The change is now established as a new practice, and it must be ensured that this practice will be sustained.

Appendix C

IHI's Model for Improvement



IHI's model for improvement is set in two parts, including three fundamental questions which can be approached in any sequence, followed by the PDSA cycle. The three fundamental questions include setting aims, establishing measures, and selecting changes. The PDSA cycle is used to test changes in a work setting to determine if the change has led to an improvement. A change is tested by planning the change, trying the change, observing the results and acting on what has been learned.

Appendix D

Patient Safety Essentials Toolkit: 5 Why's Finding the Root Cause of a Problem

EVENT. What happened? Define the problem as an *event*:

Four gastric tube perforations have occurred in the Neonatal ICU within the past year

PATTERN. What's been happening? Define the problem as a pattern by selecting a poor performance factor:

Gastric tubes have been placed too deeply or too shallow, tubes are not replaced within the recommended time frame, and many x-rays are overlooked for gastric tube placement.

STRUCTURE. Why is it happening? What are the tangible and intangible structures determining the results we see?

1. Gastric tube misplacement: too deep or too shallow
2. Inconsistency in gastric tube measurement techniques
3. Gaps and lack of verification process: x-ray is the only method
4. Lack of educational resources
5. Lack of standardization and policy

ACTION. What are the implications for action? What can you do to change the results?

Working with the interim clinical nurse specialist to develop an education plan for nurses at bedside after conducting a thorough evidence-based review of literature to identify best practice. Once changes have been identified, staff nurses will be educated in various modes ie. powerpoint, bedside hands on teaching, huddles before each shift, and in the monthly NICU newsletter. After staff have been thoroughly educated and additional gaps have been identified, unit practice expectations will be solidified in the gastric tube policy.

Appendix E

Gastric Tube Project Charter

Title: Measuring Proper Orogastric and Nasogastric Tube Placement in Neonates and Infants

Global aim: To standardize orogastric and nasogastric placement measurement methods to ensure accurate gastric tube placement based on best available evidence and practice by December 2021 in a level III neonatal intensive care unit in a Santa Clara hospital.

Specific Aim: To improve orogastric and nasogastric tube placement upon initial insertion attempt, bringing awareness of tube placement on x-ray, and preventing gastric perforations. Orogastric and nasogastric tubes will be correctly placed 90% of the time, and all staff members will measure and educate uniformly using the same measurement method supported by the best available evidence.

Background information/rationale for project: Neonatal gastric perforations are uncommon, life-threatening events that typically require surgical interventions leading to prolonged hospital stays and increased premature complications. Neonatal gastrointestinal perforations occur in 1 in 5,000 live births, in which merely 7% are neonatal gastric perforations (Iacusso et al., 2018). Although gastric perforations are rare, a Santa Clara level III has had four gastric perforations due to deep gastric tube placement. Furthermore, after reviewing other neonatal x-rays on the unit, it was determined that misplaced gastric tubes, too shallow or deep, were common trends in the NICU. A study conducted by Quandt et al. reported that 59% of gastric tubes are incorrectly placed in neonates and infants (Lin et al., 2019). Currently, the NEMU method is considered the best method to measure and insert gastric tubes. However, the NEMU method has an error index of up to 32.5% (Dias et al., 2020). Thus, it is essential to assess all measuring methods to determine best practice for each infant based on weight, as the NEMU method may place gastric tubes too deep in infants weighing less than 1200 grams.

Sponsors:

NICU Manager	Jennifer Mora
Clinical Nurse Specialist	Christinne Retta

Goals for the project:

This project's two primary goals are to eliminate gastric perforations caused by deeply placed gastric tubes and increase the accuracy of gastric tube placement on initial placement attempt to 90%.

1. To gather data that will define which measurement method is most accurate for gastric tube placement on infants of all weights
2. Create an education plan to educate all staff members regarding tube placement
3. Education provided will lead to nurses placing gastric tubes uniformly; thus parents will be taught uniformly

4. Gastric tube placement policy will be updated with the correct measurement techniques for infants of all weight.

Measures: outcome, process, balancing

Each infant receiving abdominal x-rays and has a gastric tube in place will be measured from the corner of the mouth, or nare for nasogastric tubes, to the earlobe, earlobe to the xiphoid process, and xiphoid process to the umbilicus. Tube placement will be confirmed on x-ray and compared to the gastric tube depth measurement to determine which measurement technique places the tube at correct placement. The measurement techniques that will be assessed by x-ray comparison include NEMU, NEX, modified NEX methods, and weight-based measurement, as displayed in Appendix A. If a tube is placed too deep or shallow, the ruler feature on x-ray review will be used to measure the distance the tube needs to be pushed in deeper or be pulled back. The measurement after using the ruler tool will be used as final gastric tube placement and compared to one of the measurement techniques by adding up infant measurements taken during the same day. Outcome measurements will be based on infant x-ray reviews. Infant x-rays will be reviewed and assessed for tube placement after gastric tube placement education is completed. Misplaced gastric tube x-rays will be counted, and the data from the reviewed x-rays will display whether the goal for proper tube placement on the initial insertion attempt has been achieved. The NICU will also monitor gastric perforation cases at least quarterly, keeping track of the number of cases per year.

Team members:

RN (Leader)	Jessica Nagra
Clinical Nurse Specialist (Co-lead)	Christinne Retta
NICU Manager	Jennifer Mora
Staff Nurses	
MD’s	

Appendix F

Gastric Tube Placement SWOT Analysis

Internal or Present

Positive or Benefit / **Negative or Cost**

Strengths	Weaknesses
• Uniform education and implementation plan for the entire staff • Eliminates discrepancy between staff members • Enough training staff for the unit • Decreases chances of gastric perforations • Standardizing gastric tube equipment	• All staff must be trained to a new method • Difficult to monitor staff insertion techniques • Inconsistent infant measurements
Opportunities	**Threats**
• Increased compliance with patient safety initiatives • Uses less resources in a long-term projection • Decreased chances for infant readmissions to the emergency room • Decreases secondary long-term complications • Decreases infant length of stay • Cost efficient • Decreases chances of litigation	• Staff resistance to change • Increased gastric tube misplacement

External or Future

Appendix G

Cost Benefit Analysis

NICU Average Length of Stay		**Average cost per hospitalization according to March of Dimes**	**Gastric Perforation Additional LOS**	**Average U.S. Neonatal ICU bed cost**	**Projected total cost**
Based on birth weight			1 to 46 additional days on average	$3,000 per day for all gestational ages	
Weight <1000 grams	79 days	N/A ($237,000 projected cost based on daily NICU bed cost)			**$240,000 to $375,000**
Based on gestational age					
<32 weeks	46.2 days	$280,811			**$283,811 to $418,811**
32-33 weeks	20.3 days	$102,182			**$105,182 to $240,182**
34-36 weeks	9.8 days	$51,083			**$54,083 to $192,083**
37-38 weeks	5.9 days	$37,137			**$40,137 to $175,137**
39-41 weeks	4.9 days	$19,771			**$22,771 to $157,771**
42+ weeks	6.5 days	$47,882			**$50,882 to $185,882**

Projected total cost was calculated by adding the possible additional length of stay, 1 to 46 days, at $3,000 per day to the average cost per hospitalization according to March of Dimes. March of Dimes does not have data available for average NICU cost for infants weighing less than 1000 grams. Thus, the average cost for infants weighing less than 1000 grams was predicted by multiplying the average length of stay to the average U.S. NICU cost.

Appendix H

Gastric Tube Placement Measurement Techniques

Nasogastric NEMU: nare to earlobe to midway point between xiphoid process and umbilicus Orogastric NEMU: corner of the mouth to earlobe to midway point between xiphoid process and umbilicus	Nasogastric: Nare to earlobe measurement + earlobe to xiphoid process measurement + half of the xiphoid process and umbilicus measurement Orogastric: corner of mouth to earlobe measurement + earlobe to xiphoid process measurement + half of the xiphoid process and umbilicus measurement
Nasogastric NEX: nare to earlobe to xiphoid process Orogastric NEX: corner of the mouth to earlobe to xiphoid process	Nasogastric: nare to earlobe measurement + earlobe to xiphoid process measurement Orogastric: corner of the mouth to earlobe measurement + earlobe to xiphoid process measurement
Modified NEX 1: Nasogastric NEX: nare to earlobe to xiphoid process plus 1 cm Orogastric NEX: corner of the mouth to earlobe to xiphoid process plus 1 cm	Nasogastric: nare to earlobe measurement + earlobe to xiphoid process measurement +1 centimeter Orogastric: corner of the mouth to earlobe measurement + earlobe to xiphoid process measurement + 1 centimeter
Modified NEX 2: Nasogastric NEX: nare to earlobe to xiphoid process plus 2 cm Orogastric NEX: corner of the mouth to earlobe to xiphoid process plus 2 cm	Nasogastric: nare to earlobe measurement + earlobe to xiphoid process measurement +2 centimeters Orogastric: corner of the mouth to earlobe measurement + earlobe to xiphoid process measurement + 2 centimeters
Weight based method: Infant weight used for both measurements	Nasogastric: 3 x infant weight in kg + 13 Orogastric: 3 x infant weight in kg + 12

Appendix I

Measurement: Outcomes, Process, Balancing

Measure	Data Source	Target
Outcome		
% of patients with correctly placed gastric tubes on initial insertion attempt	HealthConnect Phillips x-ray application	90%
% of gastric perforations due to deeply placed gastric tubes	HealthConnect Phillips x-ray application	0%
Process		
% of nurses using the correct measurement method to insert gastric tubes	Post-test data Bedside teaching/rounding HealthConnect Phillips x-ray application	100%
% of patients with accurately documented gastric tube depths	HealthConnect Phillips x-ray application	100%
Balancing		
No increase in shallow gastric tube placements	HealthConnect Phillips x-ray application	Within 6 months

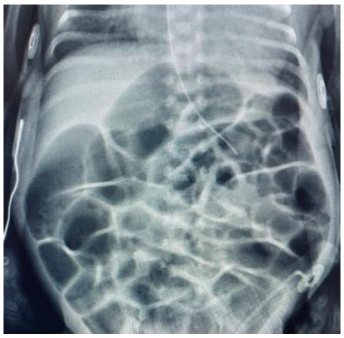
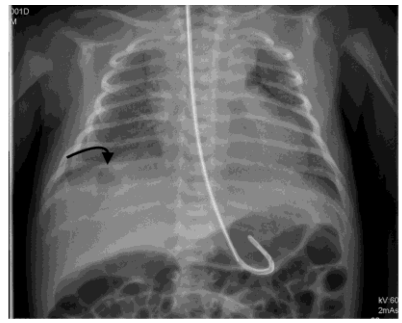
Appendix J

Gastric Tube Placement Post-Test

1. What is the best measurement technique to place gastric tubes?

    a. NEX b. NEMU c. Modified NEX d. Weight based calculation

2. Which X-ray shows appropriate gastric tube placement?

    a.  b.  c. 

3. Which measurement method is correct for placing an orogastric tube?

    a. Tip of those nose to earlobe to xiphoid process

    b. Corner of the mouth to tragus to xiphoid process

    c. Corner of the mouth to earlobe to xiphoid process

    d. Corner of the mouth to earlobe to the middle of xiphoid process and umbilicus

4. What is the greatest risk of gastric tubes being placed too deep?

    a. Gastric perforation b. Reflux c. Aspiration d. Vomiting

5. What is the best verification technique for proper gastric tube placement?

    a. Auscultation

    b. Residual

    c. Confirmation with weight-based formula

    d. X-ray

6. Additional comments or questions?

Appendix K

Evidence-Based Change of Practice Project Checklist

Instructions: Answer YES or NO to each of the following statements:

Project Title:	**YES**	**NO**
The aim of the project is to improve the process or delivery of care with established/ accepted standards, or to implement evidence-based change. There is no intention of using the data for research purposes.	x	
The specific aim is to improve performance on a specific service or program and **is a part of usual care**. ALL participants will receive standard of care.	x	
The project is **NOT** designed to follow a research design, e.g., hypothesis testing or group comparison, randomization, control groups, prospective comparison groups, cross-sectional, case control). The project does **NOT** follow a protocol that overrides clinical decision-making.	x	
The project involves implementation of established and tested quality standards and/or systematic monitoring, assessment or evaluation of the organization to ensure that existing quality standards are being met. The project does **NOT** develop paradigms or untested methods or new untested standards.	x	
The project involves implementation of care practices and interventions that are consensus-based or evidence-based. The project does **NOT** seek to test an intervention that is beyond current science and experience.	x	
The project is conducted by staff where the project will take place and involves staff who are working at an agency that has an agreement with USF SONHP.	x	
The project has **NO** funding from federal agencies or research-focused organizations and is not receiving funding for implementation research.	x	
The agency or clinical practice unit agrees that this is a project that will be implemented to improve the process or delivery of care, i.e., **not** a personal research project that is dependent upon the voluntary participation of colleagues, students and/ or patients.	x	
If there is an intent to, or possibility of publishing your work, you and supervising faculty and the agency oversight committee are comfortable with the following statement in your methods section: *"This project was undertaken as an Evidence-based change of practice project at X hospital or agency and as such was not formally supervised by the Institutional Review Board."*	x	

ANSWER KEY: If the answer to **ALL** of these items is yes, the project can be considered an Evidence-based activity that does NOT meet the definition of research. **IRB review is not required. Keep a copy of this checklist in your files.** If the answer to ANY of these questions is **NO**, you must submit for IRB approval.

*Adapted with permission of Elizabeth L. Hohmann, MD, Director and Chair, Partners Human Research Committee, Partners Health System, Boston, MA.

Appendix L

Gastric Tube Placement Measurement Data

Date of X-ray	Birth Wt (kg)	Current Wt (kg)	corner of mouth to ear (cm)	ear to xyphoid (cm)	Xyphoid to umbilicus (cm)	Depth inserted (cm)	X-ray confirmation	Comments	Method	Best insertion Depth	Method matches X-ray?	Weight based measurement
2/4/21	0.55	0.61	3.5	7.5	4	14	deep	repogle tube	NEX	11	yes	13.83
2/4/21	0.67	0.63	4	7	4	11	mid stomach		NEX	11	yes	13.89
2/7/21	0.55	0.67	4	7.5	4.5	13, EDI 13.5	deep		NEX	11.5	yes	14
2/9/21	0.55	0.71	4	7.5	4.5	12	good placement		NEX	11.5	yes	14.13
2/7/21	0.67	0.74	4	7	4	12	mid stomach		NEX +1	12	yes	14.22
5/10/21	0.89	0.92	4.5	7	4.5	12.5	good position		NEX +1	12.5	yes	14.76
3/4/21	0.55	1.03	5	8	5	14 & 14.5	good, too deep	double OG 8Fr, 5 Fr	NEX +1	14	yes	15.09
5/7/21	1.06	1.06	4	8.5	4	14	too deep	pull back 1 cm	NEX +1	13	off by 0.5	15.18
3/5/21	0.55	1.08	5	8	5	14	Shallow	Last two show variance	NEX +1	14	yes	15.24
2/4/21	0.82	1.105	5	7.5	5	12.5	mid stomach		NEX	12.5	yes	15.3
5/4/21	1.21	1.135	5	8	5	15	too deep	pull back 1 cm	NEX +1	14	yes	15.4
4/6/21	1.29	1.18	5	9	5.5	13	shallow	advance 2 cm	NEX +1	15	yes	15.5
4/5/21	1.29	1.29	5	9	5.5	15	good placement		NEX +1	15	yes	15.87
4/5/21	1.29	1.29	5	9	5.5	13	too shallow	advance 2 cm	NEX +1	15	yes	15.87
4/5/21	1.29	1.29	5	9	5.5	15	good placement		NEX +1	15	yes	15.87
3/31/21	0.67	1.34	5	8	5	8 Fr 14; 5 Fr 15	good placement		NEX +1, +2	15	yes	16.02
3/31/21	1.02	1.36	5	9	6	16.5	too deep	pulled back one	NEX +1	15.5	off by 0.5	16
4/24/21	1.36	1.36	4.5	8	5	14.5	good placement		NEX +2	14.5	yes	16
4/1/21	1.02	1.37	5	9	6	16	mid stomach		NEX +2	16	yes	16.11
4/24/21	1.38	1.38	4.5	8	5.5	15	good placement		NEMU	15.25	yes	16.14
6/13/21	1.55	1.43	5	9	5	17	too deep	pull back 1.5	NEX +1	15.5	yes	16.29
4/4/21	1.02	1.45	6	8.5	6.5	14.5	good placement		NEX	14.5	yes	16.35
4/5/21	1.02	1.45	6	8.5	6.5	14.5	good placement		NEX	14.5	yes	16.35
5/6/21	1.72	1.5	5	8	6	15	pull back 0.5		NEX +1	14.5	off by 0.5	16.5
5/8/21	1.62	1.62	5	9	6	16	deep	pull back 1cm	NEX +1	15	yes	16.86
4/20/21	1.67	1.64	6	9	4.5	16	good placement		NEX +1	16	yes	16.92
4/19/21	1.67	1.67	6	9	4.5	16	good placement		NEX +1	16	yes	17
4/25/21	1.29	1.68	5	10	6	17	deep	pull back 1 cm	NEX +1	16	yes	17.04

5/9/21	1.72	1.69	6	8	5	15	good placement	good placement	NEX +1	15	yes	17.07
6/9/21	1.095	1.78	5.5	10	6	17.5	good placement	good placement	NEX +1	17.5	off by 0.5	17.34
5/8/21	1.795	1.795	6.5	8	5	18	deep **NG**	pull back 1 cm	NEMU	17	yes	18.38
4/2/21	0.55	1.83	6	8	6	17.5	too deep	pulled back to 17	NEMU	17	yes	17.49
3/30/21	0.55	1.835	5	7.5	5	17.5	too deep	10 Fr Replogle, pull back 2	NEMU	15	yes	17.5
4/5/21	0.55	1.84	6	8	6	17	good placement		NEMU	17	yes	17.5
5/24/21	1.915	1.915	6	9	6	18	too deep	pull back 1 cm	NEX +2	17	yes	17.7
4/10/21	0.55	2.08	6.5	8	6	17.5	slightly deep	pull back 0.5 cm	NEMU	17	yes	18.24
4/24/21	2.24	2.11	5.5	10.5	5	18	too deep	pull back 1 cm	NEX +1	17	yes	18.33
4/25/21	2.24	2.11	5.5	10.5	5	17	good placement		NEX +1	17	yes	18.33
4/24/21	2.41	2.41	6	10	7	18	good placement		NEX +2	18	yes	19.23
4/1/21	1.81	2.43	6	9	7	17	good placement		NEX +2	17	yes	19.29
2/4/21	0.7	2.45	6	9	7	18	mid stomach		NEMU	18.5	yes	19.35
4/27/21	2.41	2.495	6	10	7	18	shallow	push in 1 cm	NEMU	19	off by 0.5	19.5
4/27/21	2.41	2.495	6	10	7	21	deep	pull back 1 cm	NEMU	20	off by 0.5	19.5
4/28/21	2.41	2.495	6	10	7	20	good placement		NEMU	20	off by 0.5	19.5
4/26/21	2.41	2.515	6	10	7	18	good placement		NEX +2	18	yes	19.5
5/6/21	2.505	2.65	7.5	9	7	19	good placement		NEX +2	18.5	off by 0.5	20.95
2/8/21	2.7	2.75	6	11	5	20	deep	pulled back 18.5	NEX +2	19	yes	20.25
4/2/21	3.175	2.795	7 og, 8 ng	10	6	20	good placement	OG	NEMU	20	yes	20
4/17/21	2.73	2.83	6.5	10.5	7	19	good placement		NEX +2	19	yes	20.49
4/10/21	2.945	2.945	5.5	10	5.5	18	good placement		NEMU	18.25	yes	20.8
3/29/21	3.08	3.08	6	9	7.5	19	good placement		NEMU	19	yes	21.24
4/14/21	3.145	3.145	6.5	11.5	7	22	good placement		NEMU	21.5	off by 0.5	21.4
3/30/21	4.445	4.675	7	10	8	23	too deep	pulled back to 20	NEMU	21	NEX +3	26

Appendix M

Gastric Tube Weight Based Measuring Method Results

Weight	Total Sample	Measuring Method							
		NEX	%	NEX +1	%	NEX +2	%	NEMU	%
<1 kg	6	4	66.7%	2	33.3%	0		0	
1kg-2kg	30	3	10%	18	60%	4	13.3%	5	16.7%
>2kg	18	0		2	11.1%	6	33.3%	10	55.6%

A total of fifty-four gastric tubes were reviewed on x-ray, identifying correct gastric placement. After correct gastric tube positioning was identified, insertion depth was compared to a measuring technique. Thus, the correct measuring technique was identified along with the infant's weight range category to determine the method required to for correct placement based on infant weight. Total percentage of method used was then calculated to estimate the best measuring method per weight range to trend pattern and further make a recommendation for practice change.