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Following the Evidence

Enteral Tube Placement and Verification in Neonates and Young Children

Patricia Clifford, MSN, RNC-NIC; Lauren Heimall, MSN, PCNS-BC;
Lori Brittingham, MSN, CNS-ACCNS-N; Katherine Finn Davis, PhD, RN

ABSTRACT

Enteral tube placement in hospitalized neonates and young children is a common occurrence. Accurate placement and verification are imperative for patient safety. However, despite many years of research that provides evidence for a select few methods and clearly discredits the safety of others, significant variation in clinical practice is still common. Universal adoption and implementation of evidence-based practices for enteral tube placement and verification are necessary to ensure consistency and safety of all patients. This integrative review synthesizes current and seminal literature regarding the most accurate enteral tube placement and verification methods and proposes clinical practice recommendations.

Key Words: children, enteral feeding, feeding tube, nasogastric tube, neonates

Enteral tubes are commonly used in hospitalized neonates and pediatric patients as a means to deliver nutrition and medication by the naso- or orogastric route. Safe and effective use of these tubes is achieved by ensuring correct placement and appropriately verifying location before each use. Despite evidence to guide nursing practice in the placement and verification of enteral tubes, outdated and unsafe practices are common. Multiple authors reported that significant variations exist for verification of enteral tube placement.[1–3] A recent prevalence study, which included more than 60 pediatric hospitals, found the verification method most commonly used was aspiration with inspection, followed by auscultation, assessing measurement markings, gastric pH, and x-ray studies.[3]

Optimal positioning of enteral tubes is within the body of the stomach, below the esophageal junction. Depending on the definition of malposition, error rates range from 21% to 56%.[4–7] Errors in initial placement, and those related to displacements that occur over time, can lead to deleterious consequences and result in serious patient harm. Enteral tubes located in the esophagus, or placed inadvertently in the lungs, can lead to apnea, bradycardia, desaturations, and aspiration. Tubes placed unintentionally near the pyloric junction and in the duodenum can cause malabsorption, diarrhea, dumping syndrome, and inadequate weight gain. Several published case studies have revealed incidents of perforations of the esophagus and the stomach by misplaced enteral tubes, especially in low-birth-weight infants.[8,9]

Although methods of predicting enteral tube insertion length and verifying position following placement have been widely explored in the literature, standardized methods have not been widely adopted. This integrative review synthesizes current and seminal literature regarding the most accurate enteral tube placement and verification methods in neonatal and pediatric patients and makes recommendations for clinical practice.

METHODS

Information sources

An initial literature search was conducted between May and August 2014, using the electronic databases of

Author Affiliation: Department of Nursing, The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania.

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Corresponding Author: Patricia Clifford, MSN, RNC-NIC, Department of Nursing, The Children's Hospital of Philadelphia, 34th St and Civic Center Blvd, Philadelphia, PA 19104 (Clifford@email.chop.edu).

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the Cumulative Index to Nursing and Allied Health Literature (CINAHL), MEDLINE, and PubMed, for studies published between January 2009 and June 2014. Only articles written in English were considered. Search terms included the following: nasogastric, orogastric, enteral tube, gastric tube, feeding tube, and premature and were limited by patient age of 0 to 18 years. In addition to the literature, national enteral tube guidelines, practice alerts, and neonatal guidelines were reviewed. Reference lists from literature in our initial search yielded seminal articles back to 1993 that were deemed important to include.

Critical appraisal of articles

The expanded literature search yielded 56 pediatric and adult articles and 7 national guidelines dating from 1993 to 2014. We further examined only the articles and guidelines that met our inclusion criteria of specifically addressing gastric enteral tube placement and verification methods. We excluded articles that did not directly involve or were not applicable to neonates and/or young children. After identifying the 28 articles appropriate for inclusion, the literature was critiqued using the Johns Hopkins Nursing evidence appraisal system.[10] Each article was independently reviewed by one of the authors. Any disagreements regarding the critiques were resolved by a subset of authors who reviewed the article in question and reached agreement. The strength of evidence ranged from level I (highest) to level V (lowest). Two of the articles were randomized controlled trials (level I) and the remaining articles were quasi-experimental (level II), nonexperimental (level III), clinical practice guidelines (level IV), or literature reviews and expert opinions (level V). Quality-of-evidence ratings of A (high), B (good), and C (low/major flaw) were also assigned (see Table 1).

FINDINGS

Placement of tubes

Several methods exist for determining the appropriate insertion length when placing an enteral tube. The NEX method measures the enteral tube length from the *n*ares to the *e*ar and then to the *x*iphoid (NEX) process. Although used for many years, this method has not been validated in the literature and multiple studies have demonstrated that tubes placed using this method are often malpositioned, most frequently in the esophagus.[5,12,14,16] For the age-related height-based (ARHB) method, heights in age groups are used to determine tube depth placement. This method requires potentially time-consuming and error-prone mathematical calculations and, although successful in adults and children, has been minimally studied only in the neonatal population.[5,12]

Minimal insertion length has been studied as a means to ensure gastric tube placement in infants weighing less than 1500 g.[19] In addition, Freeman and colleagues[18] proposed a weight-based formula for estimating enteral tube insertion length in infants. These methods may be useful in improving the accuracy of tube placement, especially when combined together with other methods. However, both studies demonstrated limitations and these methods require further investigation and validation.

The currently recommended practice is the NEMU method, which measures from the *n*ares to the *e*ar, to the distance halfway between the xiphoid process and the umbilicus, referred to as the *m*id-*u*mbilicus area. This method has demonstrated consistent placement of enteral tube portholes within the body of the stomach.[12,28,30] The location of tube portholes varies on the basis of the manufacturer. Ensuring gastric placement of all portholes is necessary to avoid the risk of complications that may result from misplacement. National guidelines, including those set by the American Academy of Pediatrics Neonatal Resuscitation Program[33] and the National Association of Neonatal Nurses,[34] currently recommend the NEMU placement method (see Figure 1).

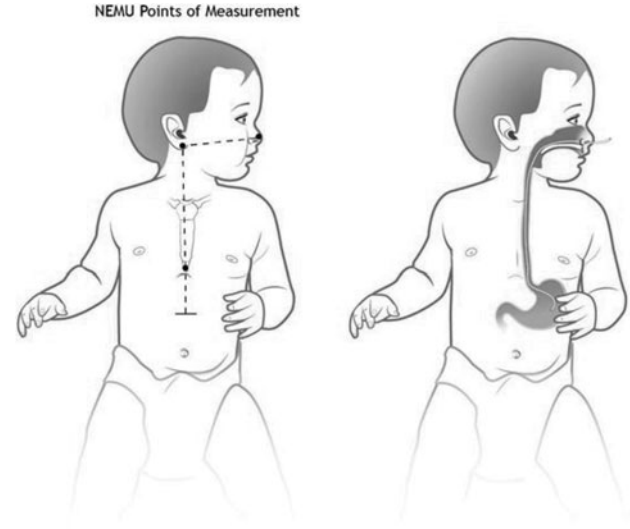

Figure 1. NEMU points of measurement. Printed with permission from The Children's Hospital of Philadelphia. NEMU indicates nose-ear-mid-xiphoid-umbilicus. Printed with permission from The Children's Hospital of Philadelphia.

Table 1. Table of evidence for methods of enteral tube placement and verification in neonates and young children

Reference	Population	Findings	Comments/ limitations	Strength[a] and quality[b] rating
American Association of Critical-Care Nurses (2009)[11]	Adult literature	During insertion, use multiple methods of verification including pH, capnography, aspirate appearance, signs of respiratory distress Auscultation and water bubbling methods are unreliable Radiographs should be obtained for all new NG/OG tubes prior to the first use Check location every 4 h by assessing mark at the NG/OG tube exit site, routine radiographs, aspirate volumes and appearance, and pH Obtain a radiograph if doubt in placement	Practice Alert	IV-A
Beckstrand et al (2007)[12]	498 participants, 2 wk-19 y	Compared accuracy of prediction of gastric NG/OG tube length between ARHB and morphologic methods The ARHB method was found to be 98.8% accurate in children aged 0.5-100 mo NEMU is the next most accurate method	Large convenience sample, but limited by geography, race, and small number of neonates	III-A
Burns et al (2006)[13]	130 adults, 195 NG/OG tube insertions	Standard insertion of the NG/OG tube was done with capnography while monitoring for the presence of CO_2 Capnography was found to be effective in detecting the presence of CO_2 during placement of the NG/OG tube	Inadvertent airway intubation occurred at a rate of 27%	II-B
de Boer et al (2009)[7]	452 neonates, 326 radiographs	47.5% of NG tubes were inaccurately placed (40.5% too deep, 7.1% too high)	NG tubes were placed via technique described as "nose to ear to stomach"	III-B
Ellett (2004)[4]	Pediatric and adult literature	NG tube placement should be confirmed by aspirating fluid and testing pH If pH <5, the NG tube is presumed to be in the stomach If pH >5 in children, obtain a radiograph to confirm the correct placement	Some references are dated	V-B
Ellett et al (2005)[14]	72 participants, 3 d-7 y	Aspirate was obtained in 94.4% of subjects pH was not affected by acid inhibitors ($P = .61$) pH ≤5 correctly predicted 85% accuracy for gastric placement	No power analysis for sample size Cutoff of pH = 5 chosen from the latest published value	III-A

(*continues*)

Table 1. **Table of evidence for methods of enteral tube placement and verification in neonates and young children (*Continued*)**

Reference	Population	Findings	Comments/ limitations	Strength[a] and quality[b] rating
Ellett et al (2007)[15]	7 premature infants, 2-60 d, 25-20 wk GA	Capnography measurements were taken via each ET and NG/OG tube All NG/OG tube readings were zero, indicating nonrespiratory placement NG/OG tube placement was confirmed via radiography following capnography	Small sample size Demonstrated the effectiveness of capnography in confirming nonrespiratory placement of the NG/OG tube but not useful in determining where outside the respiratory tract the tube is placed	III-B
Ellett et al (2011)[5]	173 neonates	Accuracy of placement in the stomach for each method: NEMU (90.9%), ARHB (78.0%), NEX (60.6%) NEMU is more accurate than ARHB for correct placement in the stomach ($P = .0002$) ARHB is not significantly different from NEX for correct placement in the stomach ($P = .06$) NEX should not be used	Low recruitment rate (15.4%; and only 9 neonates were <1500 g) Lacked power to detect differences between ARHB and NEMU	I-B
Ellett et al (2012)[16]	103 participants, 1 mo-17 y (46 within age range, 1-28 mo)	Accuracy of placement in the stomach for each method: NEMU (85.7%), ARHB (88.9%), NEX (59.4%) NEMU and ARHB are statistically superior to NEX ($P = .006$) NEX error rate was 41%	Low recruitment rate (17.2%) Lacked power to detect differences between ARHB and NEMU Chart provided to facilitate use of the ARHB equation	I-B
Ellett et al (2014)[17]	276 participants, 24 wk GA-212 mo	Difficult to make CO_2 conclusions, as no suspect respiratory misplacement occurred Inability to obtain aspirate is a superior method for identifying when the NG/OG tube is placed in the stomach or not compared with pH, bilirubin, and CO_2 (sensitivity 34.9 and PPV 66.7%)	Draws upon data from a larger randomized controlled trial Small sample size in some categories Some data breakdown for neonate vs children >1-mo old	III-B
Freeman et al (2012)[18]	87 infants, 23-42 wk GA, 218 radiographs	The authors developed a novel weight-based formula for predicting NG/OG tube insertion length that correctly predicted 60% and 100% of the misplaced OG and NG tubes, respectively	Single-center study Not possible to analyze interobserver variability Weight-based formula may be helpful when used in association with current methods	III-C

(*continues*)

Table 1. **Table of evidence for methods of enteral tube placement and verification in neonates and young children (*Continued*)**

Reference	Population	Findings	Comments/ limitations	Strength[a] and quality[b] rating
Gallaher et al (1993)[19]	Infants, 23-31 wk PCA, 171 OG tube placements	Minimal insertion lengths for adequate intragastric positioning of the OG tube in VLBW infants were established by correlating adequate position on the radiograph with OG tube insertion length for VLBW infants, according to specific weight ranges	Single-center study	III-B
Gilbert and Burns (2012)[20]	60 participants, newborn to 18 y	Measuring CO_2 via capnometry during blind NG/OG tube placement in children is effective in detecting inadvertent placement into the lung 52 attempts did not result in color change (87%), 8 resulted in color change (13%)	Convenience sample Color change does not definitively mean that the NG/OG tube is in the lung	III-B
Gilbertson et al (2011)[21]	645 pediatric participants, 4330 gastric samples; 19 ICU participants, 65 ET aspirate samples; 3 mo-5 y	pH was tested on gastric and ET aspirates Gastric aspirate color was also recorded Aspirates of patients receiving acid reducers demonstrated only slightly higher pH levels than aspirates of patients who did not receive acid-reducing medication A pH of $\leq$5 yielded 77% and 90% correct gastric placement rates in participants taking or not taking acid reducers, respectively Recommended use pH of $\leq$ 5 for 90% accuracy of gastric placement	No power analysis for sample size Small sample size for the ET aspirate group	III/A-B
Irving et al (2014)[22]	Pediatric and adult literature	Methods of verifying NG tube placement outside of a radiograph are 80%-85% successful Healthcare workers should avoid complacency Two main issues identified: initial placement and ongoing verification		IV-A

(*continues*)

Table 1. **Table of evidence for methods of enteral tube placement and verification in neonates and young children (*Continued*)**

Reference	Population	Findings	Comments/ limitations	Strength[a] and quality[b] rating
Longo (2011)[1]	Pediatric and adult literature	Use multiple methods of verification if radiographs not obtained: pH, visual inspection of aspirate, auscultation (secondary), marking the NG tube (secondary) Check verification with initial placement, before intermittent feeding, before medication, and once a shift with continuous feedings Found variability in clinical practice methods of verification	Search strategy not specified	V-B/C
Metheny et al (1999)[23]	39 neonates, 90 gastric aspirates	Gastric pH mean = 4.32, intestinal mean = 7.80 Examined concentrations of pepsin and trypsin and bilirubin Gastric pH elevated in the presence of feeding but not statistically significant (4.66 vs 3.92; $P = .07$)	Sample size not calculated	III-B
Metheny and Meert (2004)[24]	Adult literature	With small-bore NG/OG tubes, patients have fewer symptoms when inserted Using only color of aspirate is not recommended Appropriate pH range of paper is 1-10 pH is most helpful when low	Search strategy not specified	V-A
National Association of Children's Hospitals (2012)[25]	Pediatrics	Immediately discontinue o Insertion of an air bolus with auscultation over the abdomen to assess/verify NG tube placement Consider discontinuing o NEX as a predictor of NG tube insertion length Consider x-ray verification o When indicated for high-risk situations, difficult placement, when other nonradiologic methods are not confirmatory	Patient Safety Action Alert	IV-A
National Patient Safety Agency (UK) (2005)[26]	Neonates	Recommend routine pH testing for verification No routine radiographs due to risks with radiation exposure Do not use auscultation, absence of respiratory distress, or monitoring of bubbling from the NG/OG tube		IV-A

(*continues*)

Table 1. **Table of evidence for methods of enteral tube placement and verification in neonates and young children (*Continued*)**

Reference	Population	Findings	Comments/ limitations	Strength[a] and quality[b] rating
National Patient Safety Agency (UK) (2011)[27]	Adults, children, and infants	Recommended NEX The NG tube must be radio-opaque and have centimeter markings pH as first-line verification, radiographs as second-line verification pH must be 1-5.5 to use the NG tube or verified via radiographs Verify at insertion, before each feed or medication, and at least once daily Do not use auscultation	Does not pertain to neonatal patients	IV-B
National Guideline Clearinghouse (2011)[28]	Pediatric and adolescent literature	Radiographs should be used to determine NG/OG tube placement in patients who are at high risk for aspiration or when nonradiologic methods are not feasible or results are unclear Nonradiologic verification methods should be used to confirm placement of the NG/OG tube in patients who are not considered at high risk for aspiration using aspirate pH ≤5 to confirm gastric placement For children >2 wk, ARHB is more accurate than NEX or NEMU	Provides algorithm for placement and verification	IV-A
Nyqvist et al (2005)[29]	60 infants, 2970 tube feeds with 1840 aspirates	A positive pH reaction occurred in 97% with volumes of 0.01-22 mL Difficult to obtain aspirates in infants GA <32 wk and with respiratory problems pH is recommended as a complementary verification method	Convenience sample	III-B
Peter and Gill (2009)[2]	10 pediatric sites across Women's and Children's Hospitals Australasia	pH ≤5.5 verified placement in the stomach NG tube verification practices across the 10 sites were extremely variable Having a comprehensive risk assessment and a standardized flowchart helped with decision making	Unsure if the neonate population was included	V-B

(*continues*)

Table 1. **Table of evidence for methods of enteral tube placement and verification in neonates and young children (*Continued*)**

Reference	Population	Findings	Comments/ limitations	Strength[a] and quality[b] rating
Quandt et al (2009)[6]	Neonates, GA 25-42 wk, 381 radiographs	41% of the NG tube were correctly positioned In 61% of the incorrect placements, the NG tube was within the stomach but too deep and along the greater curvature	Used the NEX method for placement length	III-B/C
Tedeschi et al (2004)[30]	38 infants, GA 25-35 wk, 43 radiographs	Radiographs were examined following NG tube placement using NEMU 95% of tubes were placed in the stomach	Single-center study	V-B
Wallace and Steward (2014)[31]	Neonates and infants	The NEX method for measuring NG/OG tube insertion should not be used A variety of evidence-based methods should be used including pH and radiography Units should create a standardized approach to placing and caring for the NG/OG tube in neonates and infants		V-B
Westhus (2004)[32]	56 children, newborn-14 y	When pH <6 and aspirate color is clear, tan, or green, the clinician can be somewhat confident that the NG/OG tube is placed in the stomach (specificity 100%, sensitivity 70%, and PPV of 100%) Testing for pepsin and trypsin concentrations are out of the realm of clinical practice No difficulty obtaining aspirates	No sample size calculation	III-B

Abbreviations: ARHB, age-related-height-based; ET, endotracheal; GA, gestational age; ICU, intensive care unit; NG, nasogastric; NEMU, nose-ear-mid-xiphoid-umbilicus; NEX, nose-ear-mid-xiphoid; OG, orogastric; PCA, postconceptual age; PPV, positive predictive value; VLBW, very low birth weight.

[a]Strength of evidence: level I, randomized controlled trials; level II, quasi-experimental studies; level III, nonexperimental studies; level IV, clinical practice guidelines; level V, literature reviews and expert opinions.

[b]Quality of evidence ratings: A, high; B, good; C, low/major flaw.

Tube placement verification methods

Verification of correct tube placement prior to each use is imperative. Currently, only one method, x-ray study, provides 100% accuracy in determining enteral tube tip location[4,11,14,18,22] and is considered the criterion standard by which to compare other verification methods.[31,35] A variety of other methods have been studied, but none afford the conclusive findings that an x-ray study provides. Patients receive a minimal amount of radiation from single x-ray exposure; however, the potential cumulative effect from multiple x-ray exposures for enteral tube verification may cause harm. Therefore, other methods of verification are important to consider for patients with long-term, indwelling enteral tubes.

Multiple methods exist for verification of enteral tube placement. Determining the pH of tube aspirate is one method. Adequate pH measurement requires the use of pH paper with a scale range of 1 to 10, as a larger range does not provide the sensitivity needed. The American Association of Critical-Care Nurses[11] recommends an x-ray study for initial enteral tube placement verification and pH measurements of 5 or less for subsequent placement verification. The pH of the gastrointestinal tract varies depending upon location. Gastric contents usually have a pH of 1 to 4 and most often 5 or less.[21,23] An enteral tube aspirate pH of 6 or greater usually indicates intestinal placement, but pulmonary and esophageal aspirates may also yield a high pH.[14] The esophageal aspirate of a patient with reflux may demonstrate a low pH if gastric acid refluxes up to the tip of a tube placed proximal to the stomach. Determining pH can be difficult if insufficient gastric aspirate is obtained for testing. Lack of gastric fluid may be caused by decreased gastric motility or may indicate gastric tube misplacement. A study by Ellett and colleagues[14] demonstrated an ability to aspirate fluid for pH testing in approximately 94% of subjects.

Feedings and medications may alter gastric pH. Most infant formulas have a pH of approximately 6.6, and when mixed with gastric secretions, can raise pH measurements of aspirates,[22] although the difference is not statistically significant.[23] The pH of breast milk ranges from 7.0 to 7.4, depending on the age of the infant.[36] Fasting neonates have a mean pH of 4.3.[23] The use of H_2-blocking agents has raised concern regarding the accuracy of pH testing. Aspirates of patients receiving H_2 blockers demonstrated only slightly higher pH levels than the aspirates of subjects who did not receive H_2-blocking medication, and the pH remained 5 or less.[31] Ellett and colleagues[14,17] compared the gastric pH values of children receiving acid-blocking medications with those of children not receiving such medications. The authors found no significant difference in the pH aspirate between the 2 groups and also found that the feeding method—fasting, bolus, intermittent, or continuous—did not alter the mean pH.

Appearance of gastric aspirate is often used in addition to assessing the pH method for determining tube placement. Aspirate color is most helpful in determining if the tube is located in the stomach or intestine (see Table 2). Intestinal aspirates are usually green due to the presence of bile. Clear, tan, or off-white aspirate may indicate gastric or tracheobronchial secretions. Secretions from the pleural space are usually pale white or yellow, similar to the color of gastric secretions.[24,29] Aspirate color may vary, depending on the timing of the sampling in relation to the last feeding. Flushing an enteral tube with water may yield a clear fluid, which could indicate a gastric or tracheobronchial aspirate.

Assessment of respiratory distress at the time of placement may or may not indicate that an enteral tube has entered the respiratory tract. Respiratory placement of enteral tubes is rare in the pediatric population[14,17]; however, misplacement must be ruled out because of the devastating consequences. Placement of small-bore tubes, such as those used in neonatal and pediatric patients, often produces no respiratory distress if misplaced. Patients who are severely debilitated or unconscious often fail to elicit any sign of respiratory distress when tubes are placed in the respiratory tract.

Marking the exterior of the tube at the time of measurement and placing that marking at the lip or nares is a common practice. Checking that the marking has not moved does not indicate that an initially properly placed tube has not migrated or coiled, thus changing the position of the tube and rendering it unsafe for use. This method should only be used in addition to other more reliable methods.[1,11]

The auscultation method for tube placement verification involves air insufflation into the enteral tube while a nurse listens for the "swoosh" sound of air entering the stomach. This method has repeatedly proven unreliable, as it is impossible to distinguish with great certainty if air sounds are originating from the abdomen, lung, or esophageal region.[11,14,19,26,27,35] In 2012, the Child Health Patient Safety Organization[25] recommended the

Table 2. Aspirate color table

Type of aspirate	Color of aspirate
Gastric	Clear, tan, off-white, pale yellow
Intestinal	Green
Pleural space	Pale white or yellow
Tracheal	Clear, tan, off-white

discontinuation of auscultation as a method for enteral tube placement verification due to the high incidence of misplaced tubes associated with this method.

Tube placement verification with suboptimal evidence

Testing enteral tube aspirate for bilirubin and gastric enzymes has also been studied. Both of these tests help differentiate if an enteral tube is gastric or postpyloric.[32] Aspirates that test positive for bilirubin should indicate that the enteral tube is postpyloric. However, a study performed by Ellett and colleagues[17] found that some aspirate samples containing bilirubin were obtained from an enteral tube that was gastric on radiographs rather than the expected postpyloric placement. Testing for gastric enzymes pepsin and trypsin is accurate in determining gastric placement,[32] but these tests are performed in a laboratory, not at the bedside, thus decreasing feasibility.

Capnography and capnometry use carbon dioxide (CO_2) detection to determine enteral tube location. Capnography detects a CO_2 waveform emitted from an enteral tube and can indicate misplacement in the respiratory tract. Monitoring occurs as the tube is placed, first in the midesophagus. Absence of a CO_2 waveform allows the nurse to assume that the tube is not in the respiratory tract and the tube can then be advanced to the appropriate centimeter marking for gastric placement.[13,15] Capnography has not been adequately studied in the neonatal and pediatric populations. Capnometry uses an end-tidal CO_2-detecting device attached to the end of an enteral tube. Color change indicates the presence of CO_2, hence placement in the respiratory tract. Researchers have demonstrated success in using capnometry in infant and pediatric studies.[20] As with capnography, capnometry does not determine correct placement in the stomach since the tube can be located anywhere along the gastrointestinal tract.

LIMITATIONS

This integrative review has a few limitations. The major limitation is the lack of purely neonatal evidence. We included all neonatal literature that is appropriate and available. Most of the literature includes a large age range, from neonates up to and including adults. In addition, the studies we do have are mostly lower levels of research.

DISCUSSION

Evidence-based methods of placement and verification of enteral tubes should be the cornerstone of nursing practice. However, significant variation exists for both practices.[31] Research demonstrates that placement of enteral tubes using the NEX method accounts for up to 21% of tubes being malpositioned.[14] Use of the NEX method allows for the highest risk for misplacement and aspiration among the methods reviewed. National organizations and safety groups have emphatically stated that the NEX method should not be used.[11,25,26,28,34] The NEMU method is the safest and most accurate method for placement in neonates and young children. A study with neonates by Ellett and colleagues[5] indicate that both the ARHB and NEMU methods have an accuracy of 100% and 92%, respectively, for placement in the stomach, duodenum, or pylorus region. There was no statistical difference for correctly placed tubes in the stomach using the ARHB (78%) or NEMU (91%) method. Research in children older than 1 month also showed that the ARHB and NEMU methods were superior to the NEX method and again there was no statistical difference in the findings between the 2 methods.[16] The ARHB method requires accurate length measurement and use of complex mathematical calculations, which may limit feasibility.[16] Nursing staff would also need formal education and practice to use this method for enteral tube placement. Evidence supporting the NEMU method has been available for the past 30 years, yet many neonatal units continue to use the NEX method.

A combination of methods will provide the nurse with information needed to verify placement. Studies support that a gastric aspirate pH of 5 or less indicates correct tube placement in the stomach 92% of the time.[14,21] The inability to aspirate secretions may indicate that the tube is not in the stomach. In this case, the tube should be removed and replaced. Examining the color of aspirate may help rule out intestinal placement. Once initial tube placement has been verified, marking the tube at the lip or nares in conjunction with other methods will allow the nurse to ascertain if the tube subsequently dislodges.[1,11] Assessing the patient's reaction to the insertion of the tube is an additional assessment method. Coughing, gagging, and a brief drop in heart rate are common during tube placement; however, these symptoms usually resolve quickly. When spontaneous recovery does not occur, the tube should be removed and reinserted. Patients with neurologic impairment that prevents protective cough and gag reflexes, or patients receiving medications such as heavy sedation or paralytics, require radiographs to verify correct initial placement. Verification of tube placement should occur prior to each feed. A radiograph should be obtained at any point during the placement verification process if there is a concern regarding enteral tube location. Auscultation is no longer an acceptable

method for determining placement and should not be used, as it is not possible to determine that the sound of air insufflated into the tube is originating from the stomach.

Verifying correct placement of an enteral tube is a complex process. Radiography is the criterion standard but is not a practical method for verifying placement prior to each tube use. As no other single verification method provides the accuracy of a radiograph, combining 2 or more methods may provide nurses with the information they need to feel confident that an enteral tube is in the correct location.[1,11,31] Use of a decision tool, such as an algorithm (see Figure 2), may provide a standardized, evidence-based approach for safe and effective use of enteral tubes in neonates and young children. Once the recommendations presented here are implemented into daily practice by interdisciplinary care teams, it is important to use quality improvement methods to frequently monitor the unit's success. Unit-specific data collection allows measurement of how the unit is doing in following best practice. Deviation from the standard will be evident in the data and will enable the unit to anticipate any patient safety issues that may occur or provide ongoing education that may be needed.

CONCLUSION

Placement of enteral tubes is a daily practice in neonatal and pediatric units, yet development and implementation of an evidence-based national consensus for placement and location verification of these tubes have not occurred. Accurate placement is critical to the safe and effective use of enteral tubes. A tube that is placed too high (in the esophagus or lungs), or too deep (at or beyond the pylorus), can have significant detrimental effects on the patient. Enteral tubes should be placed using the NEMU method. Obtaining a radiograph is the ideal method for verifying placement, but this method is not practical on a routine basis. Aspirating gastric

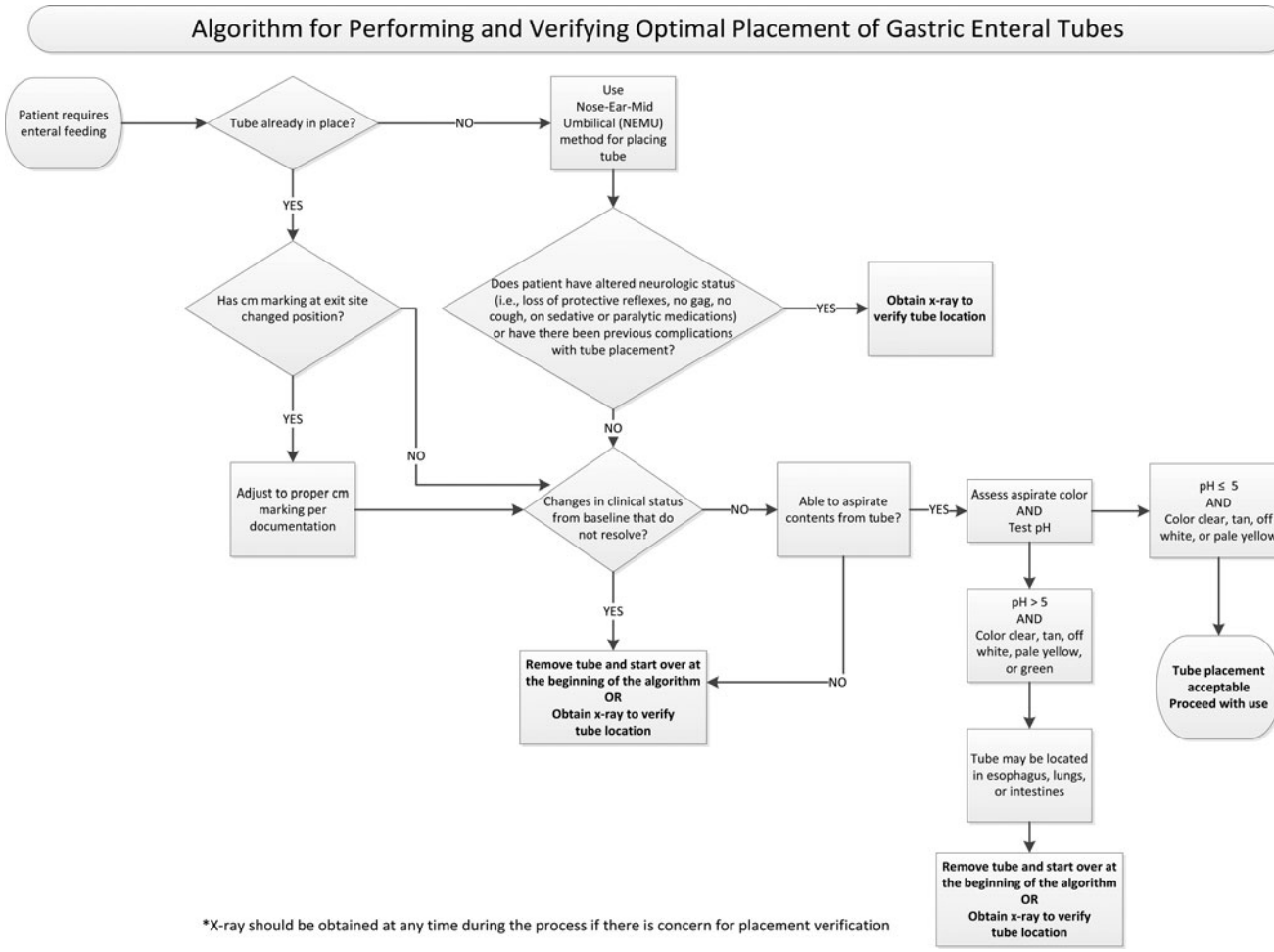

Figure 2. Algorithm for performing and verifying optimal placement of gastric enteral tubes.

content to examine color and test pH, along with verifying nonmigration of the tube by assessing markings, is a combination that will assist the nurse in making an informed verification of enteral tube placement and ensure safe, effective practice.

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