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Comparing Methods of Determining Insertion Length for Placing Gastric Tubes in Children 1 Month to 17 Years of Age

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Abstract

Purpose—To compare three methods of predicting the gastric tube insertion length in children 1 month to 17 years of age: age-related, height-based (ARHB); nose-ear-xiphoid (NEX); and nose-ear-mid-umbilicus (NEMU).

Design and Methods—Randomized controlled trial. Children were randomly assigned to the ARHB, NEX, or NEMU groups. Tubes placed high were considered to be misplaced.

Results—There were significant differences in percentages of correctly placed tubes, with ARHB and NEMU being more accurate than NEX.

Practice Implications—NEX should no longer be used as a gastric tube insertion-length predictor. Either ARHB or NEMU should be used.

Search Terms

Children; enteral feeding; feeding tube

Feeding by a nasogastric/orogastric (NG/OG) tube is preferred when the gastrointestinal tract is intact and the need for assisted feeding is expected to be short term (< 30 days; Kirby, Delegge, & Fleming, 1995). When tubes are out of place, children can be seriously harmed, causing increased morbidity and occasionally death. Gastric tubes are improperly positioned if the feeding orifices are located in the respiratory tract or esophagus or past the pylorus (Khilnani, 2007). Preliminary studies in children by our research team show that between 21% and 44% of these tubes are placed incorrectly (Ellett & Beckstrand, 1999; Ellett, Maahs, & Forsee, 1998). With the current emphasis on safety of hospitalized patients, these error rates are unacceptably high (Institute of Medicine, 2001; 2003; 2010).

Review of Current Evidence for Practice

Much of the previous research on predicting the length to insert NG/OG tubes has been done in infants (Tedeschi, Atimer, & Warner, 2004; Weibley, Adamson, Clinkscales, Curran, &

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Bramson, 1987; Ziemer & Carroll, 1978). In brief, these researchers found the NG/OG tube placement error rate varied from 5% to 55.6%. Two studies found that direct distance nose-ear-xiphoid (NEX) was too short in predicting the length to insert NG/OG tubes (Weibley et al.; Ziemer & Carroll). One study showed direct distance nose-ear-mid-umbilicus (NEMU) to be too short (Weibley et al.), while another study showed NEMU to be reasonably accurate (Tedeschi et al., 2004). See Ellett et al. (2011) for a more comprehensive review of these studies.

Scalzo, Tominack, and Thompson (1992) reviewed the radiographs of 14 of 36 children ranging in age from 8 months to 16 years needing a large-bore gastric tube inserted in an emergency room for lavage as the initial treatment for toxic substance ingestion. The placement method was unspecified, and radiographs were not done in the other 22 children. They stated that 7 of 14 (50%) of these tubes were malpositioned with the most common problem (6 of 7) being “excess tube insertion, stretching the stomach inferiorly towards the pelvis” (Scalzo et al., 1992, p. 581). The other tube was malpositioned in the esophagus above the gastroesophageal junction (GEJ). The authors considered lavage tubes to be properly placed when they were “well within the body of the stomach with the distal end superimposing the left upper abdominal quadrant on radiograph and without the tip impinging on the wall of the stomach” (Scalzo et al., 1992, p. 582). They suggested using an adaptation of Strobel, Byrne, Ament, and Euler’s (1979) previously published formula for esophageal pH probe placement: $OG = 9.7 \text{ cm} + (0.226 \times \text{length of child in cm})$ or $NG = 8 \text{ cm} + (0.252 \times \text{length of child in cm})$. Scalzo and colleagues (1992) tested these formulae prospectively in only 6 randomly selected children (age range not provided) and found that 5 of 6 tubes were well positioned in the stomach according to their criteria. One tube had the most proximal suction port at the gastroesophageal junction (GEJ).

Klasner, Luke, and Scalzo (2002) conducted a randomized double-blind, controlled trial involving 89 children ranging in age from 6 months to 18 years needing gastric intubation in the emergency room. Children were stratified (tall, medium, and short) according to percentile height using standard growth curves and were block randomized. Of the children, 45 were assigned to the height-based graphic method using regression equations of Scalzo and colleagues (1992) and 44 were assigned to what is standardly called the NEMU method in which insertion length “was estimated by measuring the distance from the nose or mouth to the earlobe, to a point midway between the xiphoid process and the umbilicus” (Klasner et al., 2002, p. 269). Note that the authors referred to this method as the NEX method in their 2002 publication; however, to be consistent with standard terminology (which is what is being utilized in the current paper) it will be referred to as the NEMU method. The researchers reported that three of the tubes, which were all in the NEMU group, were found to be outside the confines of the stomach; the exact position of these three tubes was not reported. They reported that tubes inserted using a nomogram based on height (graphic method) had a smaller mean distance from the center of the stomach compared to the NEMU method and showed less variability. The radiographs were reviewed by two blinded pediatric emergency room physicians. A definition of the center of the stomach was “the midpoint between the lower esophageal sphincter or diaphragm and pylorus” (Klasner et al., 2002, p. 270).

Beckstrand, Ellett, and McDaniel (2007) conducted a prospective descriptive study in which the potential of 20 external measures including NEX, NEMU, age, height, and weight were examined as possible insertion length predictors in 494 children, 2 weeks to 19 years of age, undergoing upper gastrointestinal endoscopy or esophageal manometric studies. Regression equations using height in age groups (age-related height-based [ARHB]), derived independently of the Klasner and colleagues (2002) graphic method discussed above, were found to be the best predictors of optimal placement of the endoscope or manometric probe

in the stomach. The researchers concluded that age-specific regression equations using the child's height/length have the potential to predict accurately the distances to the body of the stomach in 98.8% of children younger than 100 months of age and in 96.5% of children older than 100 months. The next best choice was the NEMU length. The Beckstrand et al. (2007) study did not clinically validate their proposed ARHB equations in a new cohort.

Although NEX has been shown to be too short in previous studies, a telephone survey of 113 Level II and III nurseries in five Midwestern states published in 1996 by Shiao and DiFiore found that 98% of nurses continued to use the direct NEX distance to calculate tube insertion distance. Because of the continued use of NEX as an insertion-length predictor, the mixed results from the three studies testing NEMU, and the need to test the ARHB equations clinically, the current study was undertaken.

Purpose

The results being presented herein were part of a larger study examining gastric tube placement in 276 children including neonates. The purpose of the study reported here was to compare the error rates of three existing methods of predicting the correct gastric tube insertion length in 103 children 1 month to 17 years of age: ARHB, NEX, and NEMU.

Methods

Design

A single-blind, randomized controlled trial was conducted. The children were randomly assigned to have their NG/OG tube inserted using one of the three insertion-length predictors: ARHB, NEX, or NEMU. The statisticians (third and sixth authors) used a computer-generated stratified block randomization strategy in which stratification was by use of acid-inhibiting medication (needed for a different aim of this trial) and age group (1–28 months, 29–100 months, and 101–204 months). The random assignments were delivered to the research nurses in sequentially numbered opaque sealed envelopes. Envelopes were opened just prior to inserting the NG/OG tube to determine which method to use.

Recruitment

Children were recruited from three Midwestern hospitals. All children hospitalized on one of the participating units requiring an NG/OG tube to be inserted were eligible unless: (a) their staff physicians refused consent, (b) their medical condition could drastically affect their gastric acid-secreting ability (e.g., Zollinger-Ellison Syndrome or congenital achlorhydria), (c) they had had previous gastric surgery resulting in removal of part of the stomach, or (d) the NG/OG tube ordered by the physician had orifices further than 3 cm from the tip of the tube. Exclusion criterion (b) was needed for another aim of this study; a manuscript reporting these results is in preparation.

Procedures

This study was approved by the appropriate institutional review board and the hospitals/units in which the study was conducted. Two research associates were trained in all aspects of data collection by the principal investigator (PI, first author) using a written protocol. They collected approximately 83% of the data. Other research nurses were trained by the two research associates using the same protocol and collected the other 17% of the data. The PI evaluated each research nurse prior to giving him/her permission to collect data independently. Inter-rater reliability was collected between each trained data collector and the PI with approximately every 15th child per nurse. A research associate or research nurse obtained anthropometric data from the child. In children younger than 2 years of age, length was obtained by marking with a washable marker on the underlying sheet the length from

the most distal border of the head to the most distal border of the heel held perpendicular to the leg with the child lying supine and flat, and then measuring the marked length with a paper tape measure after the child had been moved to the side of the sheet to allow accurate measurement. In children younger than or equal to 2 years of age, a standing height was obtained using a stadiometer with the child's head horizontal. NEX and NEMU were measured by stretching the tube to be inserted from the tip of the nose to the bottom of the earlobe and next to the xiphoid process (NEX) and then to the observed midpoint between the xiphoid process and the umbilicus (NEMU). In addition, birth date, term/preterm status, gestational age, weight, and acid-inhibiting medication use were obtained from the medical records of all children. For children younger than 3 years of age, corrected age was calculated by subtracting the number of weeks/days premature from the chronological age in weeks/days (March of Dimes Foundation, 2010) and used for the stratification and in the ARHB equations.

The nurse caring for the child was consulted to determine the standard method for inserting tubes (nasally or orally) in children in the specific unit. Enrolled children were then randomly assigned to have their tubes inserted using one of the three existing insertion-length predictors: NEX, NEMU, or ARHB. The following ARHB equations were used (Beckstrand, 2005):

$$\begin{aligned} \text{OG tube insertion distance} &= 13.3 \text{ cm} + 0.19(\text{HT}_{\text{cm}}) \text{ if 1 to 28 months of age} \\ &= 16.8 \text{ cm} + 0.19(\text{HT}_{\text{cm}}) \text{ if 29 to 100 months of age} \\ &= 15.1 \text{ cm} + 0.22(\text{HT}_{\text{cm}}) \text{ if } > 100 \text{ months of age} \\ \text{NG tube insertion distance} &= 14.8 \text{ cm} + 0.19(\text{HT}_{\text{cm}}) \text{ if 1 to 28 months of age} \\ &= 18.3 \text{ cm} + 0.19(\text{HT}_{\text{cm}}) \text{ if 29 to 100 months of age} \\ &= 16.6 \text{ cm} + 0.22(\text{HT}_{\text{cm}}) \text{ if } > 100 \text{ months of age} \end{aligned}$$

Measurements from all three insertion length methods were obtained on all children. The tube was then inserted using the randomly assigned insertion-length predictor distance by the research nurse. The nurse temporarily taped the tube in place.

Shortly after placement of the tube, an abdominal radiograph was obtained to show the internal location of the tube. Once the radiograph was read by a pediatric radiologist, physician, or pediatric nurse practitioner (based on unit policy) using their normal criteria, the tube length was adjusted as necessary prior to use based on the healthcare provider's recommendation.

Radiographs

Currently an abdominal radiograph provides the only consistently valid and reliable evidence of the internal location of NG/OG tubes, and it was considered the "gold standard" for initial placement in this study. All radiographs taken after initial placement of the tube were reviewed at a later time by a single board-certified pediatric radiologist (second author), who was blinded as to the method used to estimate the required length of the tube. For each radiograph the location of the tip of the tube was classified into one of four locations:

1. Tube tip in the esophagus (if the tube tip was in the esophagus, then it was noted if the lower end of the tube was straight or curled back on itself with the tip pointing towards the head),
2. Tube tip in the region of the GEJ,
3. Tube tip in the stomach, or
4. Tube tip in the pylorus or the duodenum.

In addition, the length of tube below the diaphragm was measured when the tip was clearly visible. This was measured from the junction of the diaphragm with the left side of the adjacent vertebral body to the tip of the tube.

Definition of Correct Placement

For the primary analysis, only tubes that were placed too high with the tube tip in the esophagus or GEJ were considered to be placed incorrectly, and tubes placed in the stomach, pylorus, or duodenum were considered correctly placed. This decision was made because, based on prior experience of the research team, it was known that tubes placed the same distance below the GEJ tended to either curve to the left along the greater curvature of the stomach or to the right into or through the pylorus into the duodenum by chance. As a secondary analysis, a more strict definition of correctness was used whereby the tube tip was required to actually be in the stomach.

Data Analysis

Descriptive statistics were calculated, including means and standard deviations for continuous variables and number and percent in each category for categorical variables. One-way analysis of variance (ANOVA) models were used to compare child characteristics such as ethnicity/race, gender, age, and height across the three insertion methods. Chi-square tests or Fisher's exact tests as appropriate for small sample sizes were used to compare the categorical child characteristics (see Table 1). All analyses were performed on an intention-to-treat basis. For the primary objective, chi-square tests were used to compare the correct placement rates between the insertion methods. Following a significant overall comparison of the three methods, pairwise comparisons were made using chi-square tests or Fisher's exact tests. Logistic regression was used to model misplacement to obtain confidence interval estimates for odds ratios (both crude and adjusted for the two stratification factors) comparing the three methods. A t-test was used to compare the measurement lengths between stomach and intestinal placements for tubes deemed long enough to enter the intestine.

Results

Children were recruited from three Midwestern hospitals. A total of 1,087 children, ages 1 month to 17 years, met inclusion criteria. Only in 55.2% of the children ($n = 600$) did physicians agree to allow the family to be approached regarding study participation. Reasons given for physician's refusal included that the child was too ill and/or had a complicated social situation. Also, in a few cases the staff physician was not available to give permission. In 22.0% (132/600) of children in which physician permission was received to approach the family, parent(s) provided written informed consent; reasons given for refusal included radiation exposure of radiograph for research purposes and that the child had already been through too much. In addition, children 7 years of age and older also needed to give written assent to participate. A few children refused. The final overall recruitment rate was 17.2% (representing 78.0% of children whose parents provided informed consent) because in some cases the child's condition improved allowing progression to oral feeding, the unit was too busy for nurses to allow study participation, children were discharged home with the tube in place after parental consent was received but before the child could participate in the study, or the child refused. Figure 1 shows the CONSORT flow diagram of the study. Because of the limited information allowed to be collected prior to written parental consent and a signed HIPAA form, it was not possible to test whether children participating in this study differed significantly from those who did not.

The sample consisted of 103 hospitalized children (1 month to 17 years of age) requiring placement of an NG/OG tube. There were 101 NG tubes and 2 OG tubes placed in children. Because only two OG tubes were inserted during this study, the OG regression equations could not be separately tested. There were 36 tubes placed by the ARHB method, 35 by the NEMU method, and 32 by the NEX method. There were no significant differences among the three insertion methods on child characteristics including ethnicity/race, gender, and age (see Table 1).

Of the tubes inserted, 97.1% using NEMU, 88.9% using ARHB, and 59.4% using NEX were correctly placed in the stomach, duodenum, or pylorus regions (see Table 2). During insertion three tubes curled back on themselves in the esophagus, leaving the tip of the tube near the entrance to the respiratory tract. These placement errors would not have been known prior to feeding the children through these tubes without the abdominal radiograph required as part of this study. Based on the intention-to-treat principle, these cases were treated as tube placement errors when calculating the error rate. The differences in percentages of correctly placed tubes among the three methods was significant (chi-square = 18.09 $p = .0001$), with both NEMU and ARHB being more accurate than NEX (NEMU chi-square = 14.43, $p = .0001$, phi coefficient = -0.46 [large effect]; ARHB chi-square = 7.87, $p = .005$, phi coefficient = -0.34 [large effect]). There was no statistically significant difference between ARHB and NEMU (Fisher's exact $p = .357$). Assuming the true percentages of correct placements in the stomach/duodenum/pylorus were as observed in this study, there was 97% power to detect an association between placement method and correct placement using a chi-square test (two-sided, level of significance .05). Conservatively using Fisher Exact tests (two-sided, level of significance .017) to estimate power for all pair-wise differences, there was 93% power when comparing NEX to NEMU, but only 57% power when comparing NEX to ARHB, and 4% power when comparing NEMU to ARHB.

From a logistic regression model, the estimated odds ratios (unadjusted) for NEX compared to NEMU and ARHB was 23.26 (95% CI 2.82–191.88) and 5.47 (95% CI 1.56–19.22) respectively, indicating that if NEX rather than NEMU or ARHB was used as the insertion-length predictor, the odds were 23.26 or 5.47 times greater that the tube would be misplaced on insertion, leaving the tip and/or pores in the esophagus or GEJ. Adjusting for the two stratification factors, use of acid-inhibiting medications ($p = .2935$) and age group ($p = .3270$), did not substantially change the results. In addition, use of the stricter definition of treating only tubes actually placed in the stomach as correctly placed was explored. Using the stricter definition, the percentage of correctly placed tubes decreased from 97.1% to 85.7% using the NEMU method (see Table 2). This change did not result in significant differences in the results between the two definitions.

To demonstrate in this sample that tubes placed the same distance below the GEJ tend to either curve to the left along the greater curvature of the stomach or to the right into or through the pylorus into the duodenum by chance, we first determined the minimal distance a tube could be inserted into the stomach before it could possibly reach the pylorus/duodenum region. In a separate study, the pediatric radiologist measured the distance between the GEJ and the pylorus of 200 children ages 1–204 months chronological age undergoing upper gastrointestinal barium (UGI) studies for medical reasons in 2009 (Cohen, Ellett, Perkins, & Lane, 2011). This sample was utilized because both the GEJ and pylorus are visible on UGI radiographs using contrast but are not visible on the abdominal radiographs without contrast that are routinely done for determining the location of NG/OG tubes. In the 77 children in the youngest age group (1–28 months), the mean distance was 6.0 cm, the median was 5.5 cm, and the standard deviation was 2.8 cm, and, although there was a large standard deviation due to the differences in the shape of the stomach, the 11.6

cm distance (mean + 2 standard deviations) between the GEJ and pylorus was supported as in the complete sample of 200, 89% of the distances measured less than or equal to 11.6 cm. The 11.6 cm value represented the mean + 2 standard deviations in the youngest age group, which is a conservative estimate as the older age categories have larger values. In a post hoc analysis in the current study, there were 14 children who had measurements from the diaphragm to the tip along the curvature of the tube over 11.6 cm that would indicate the tube was potentially long enough to enter the pylorus/duodenum regions. No difference ($p = .7246$ in this curved length was seen on average between the 13 tubes that stayed in the stomach [mean $\pm$ sd: 14.8 ± 3.0]) and the 1 that entered the pylorus/duodenum region (mean = 14.8).

Discussion

A major finding from this randomized clinical trial involving 103 children was that 97% of NG/OG tubes using NEMU, 89% using ARHB, and only 59% using NEX were correctly placed in the stomach, duodenum, or pylorus regions and 86% of NG/OG tubes using NEMU, 89% using ARHB, and 59% using NEX were correctly placed in the stomach only. This means that 41% of tubes inserted using NEX were placed with the tube tip ending either in the esophagus or GEJ. Both NEMU and ARHB were statistically superior to NEX as an NG/OG tube insertion-length predictor in children regardless of which definition of tube placement error (less or more restrictive) was used. These results are similar to those of Beckstrand and colleagues (2007), who, in a descriptive study involving a large sample of children, also found ARHB and NEMU to be the superior NG/OG tube insertion-length predictors when compared to NEX. Klasner and colleagues (2002) found the graphic method using height to be superior to NEMU.

Based on the results of four studies in children (Beckstrand et al., 2007; Klasner et al., 2002; Weibley et al., 1987; Ziemer & Carroll, 1978), NEX should no longer be used as an insertion length predictor for placing NG/OG tubes in children because of the significant risk of the tube tip and orifices ending in the esophagus or the GEJ, increasing the likelihood of the child aspirating feeding formula.

Figure 2 allows the healthcare provider a way to implement the ARHB method. To use, first choose the appropriate part of the table based on whether an NG or OG tube is to be inserted and the child's age. Next find the child's length in column 1 and then determine the recommended length to insert the tube in the same row horizontally in column 2. Alternatively, the regression equations can be entered into the hospital's computer system or in personal digital assistants allowing healthcare providers the ability to insert the child's height/length and obtain the desired NG or OG tube insertion length.

Clearly tubes with a length in the stomach less than the distance from the GEJ to the pylorus could not pass through the pylorus. In this study, the fact that only 1 of 14 tubes that were long enough to enter the pylorus/duodenum region actually did pass through the pylorus suggested that errors in estimating desired total tube length were extremely important if the length was too short (tube tip would be in the esophagus or GEJ) but probably not of great importance if the estimated tube length was too long.

Limitations

One limitation of this study was the low recruitment rate of 17.2%. The vulnerability of the population and the multiple layers of protective gatekeepers made recruitment difficult. A second limitation was that there was lack of power to detect differences between ARHB and NEMU.

How Do I Apply This Evidence to Nursing Practice

Abdominal radiographs have been recommended by several research groups to determine tube placement in adults and children (Ellett et al., in press; Gharib, Stern, Sherbin, & Rohrmann, 1996; Walsh & Banks, 1990). The authors agreed that radiographic verification at the time of initial NG/OG tube placement or tube change is necessary in children to ensure that the tube has not been misplaced by curling in the esophagus or ending in the esophagus, pylorus, or duodenum. This radiograph should be read by an appropriately trained healthcare provider prior to using the tube for feeding or medication instillation. Institution-specific policies will need to be evaluated based on the best available evidence from this and other studies, keeping in mind the goal of keeping children who have NG/OG tubes safe.

NEX with an error rate of 41% should no longer be used as an NG/OG tube insertion-length predictor in children. Either NEMU or ARHB for NG tubes should be used. NEMU should be measured from the tip of the nose to the ear lobe to the observed midpoint between the xiphoid and the umbilicus. A chart to facilitate use of the ARHB equations is provided in Figure 2. Although use of either the NEMU or ARHB insertion-length predictor is more likely to place the NG/OG tube in the stomach, there is still an 11.1% – 14.3% error rate if the more restrictive definition of correct tube placement (in the stomach) is used.

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Figure 1. CONSORT Flow Diagram

Note: ^a ARHB is the age-related, height-based regression equation.

^b NEMU is the distance from the nose to the ear to the mid-umbilicus.

^c NEX is the distance from the nose to the ear to the xiphoid.

NG TUBE

NG TUBE INSERTION LENGTH - **NEWBORN to 28 MONTHS** OF CORRECTED AGE

DETERMINE LENGTH OF CHILD AND INSERT TUBE THE SPECIFIED INSERTION LENGTH IN THE SAME ROW:

Child's Length (cm)	Insertion Length (cm)	Child's Length (cm)	Insertion Length (cm)
44.5 - 47.0	23.5	73.5 - 76.0	29.0
47.5 - 49.5	24.0	76.5 - 78.5	29.5
50.0 - 52.0	24.5	79.0 - 81.0	30.0
52.5 - 54.5	25.0	81.5 - 83.5	30.5
55.0 - 57.5	25.5	84.0 - 86.5	31.0
58.0 - 60.0	26.0	87.0 - 89.0	31.5
60.5 - 62.5	26.5	89.5 - 91.5	32.0
63.0 - 65.5	27.0	92.0 - 94.0	32.5
66.0 - 68.0	27.5	94.5 - 97.0	33.0
68.5 - 70.5	28.0	97.5 - 98.5	33.5
71.0 - 73.0	28.5		

Prediction equation: $\text{insertion length(cm)} = 14.8 \text{ cm} + 0.19 \times \text{height(cm)}$

NG TUBE INSERTION LENGTH - **29 to 100 MONTHS** OF AGE (CORRECTED AGE < 36 MONTHS)

DETERMINE LENGTH/HEIGHT OF CHILD AND INSERT TUBE THE SPECIFIED INSERTION LENGTH IN THE SAME ROW:

Child's Length/Height (cm)	Insertion Length (cm)	Child's Length/Height (cm)	Insertion Length (cm)	Child's Length/Height (cm)	Insertion Length (cm)
78.0 - 78.5	33.0	100.0 - 102.0	37.5	123.5 - 126.0	42.0
79.0 - 81.0	33.5	102.5 - 104.5	38.0	126.5 - 128.5	42.5
81.5 - 83.5	34.0	105.0 - 107.5	38.5	129.0 - 131.0	43.0
84.0 - 86.5	34.5	108.0 - 110.0	39.0	131.5 - 133.5	43.5
87.0 - 89.0	35.0	110.5 - 112.5	39.5	134.0 - 136.5	44.0
89.5 - 91.5	35.5	113.0 - 115.5	40.0	137.0 - 139.0	44.5
92.0 - 94.0	36.0	116.0 - 118.0	40.5	139.5 - 141.5	45.0
94.5 - 97.0	36.5	118.5 - 120.5	41.0	142.0 - 144.0	45.5
97.5 - 99.5	37.0	121.0 - 123.0	41.5	144.5 - 145.0	46.0

Prediction equation: insertion length(cm) = 18.3 cm + 0.19*height(cm)

NG TUBE INSERTION LENGTH - **>100 to 204 MONTHS** OF AGE

DETERMINE HEIGHT OF CHILD AND INSERT TUBE THE FOLLOWING SPECIFIED INSERTION LENGTH IN THE SAME ROW:

Child's Height (cm)	Insertion Length (cm)	Child's Height (cm)	Insertion Length (cm)	Child's Height (cm)	Insertion Length (cm)
78.0 - 80.0	34.0	121.5 - 123.0	43.5	164.5 - 166.5	53.0
80.5 - 82.0	34.5	123.5 - 125.5	44.0	167.0 - 168.5	53.5
82.5 - 84.5	35.0	126.0 - 127.5	44.5	169.0 - 171.0	54.0
85.0 - 87.0	35.5	128.0 - 130.0	45.0	171.5 - 173.0	54.5

87.5 - 89.0	36.0	130.5 - 132.0	45.5	173.5 - 175.5	55.0
89.5 - 91.5	36.5	132.5 - 134.5	46.0	176.0 - 177.5	55.5
92.0 - 93.5	37.0	135.0 - 137.0	46.5	178.0 - 180.0	56.0
94.0 - 96.0	37.5	137.5 - 139.0	47.0	180.5 - 182.0	56.5
96.5 - 98.0	38.0	139.5 - 141.5	47.5	182.5 - 184.5	57.0
98.5 - 100.5	38.5	142.0 - 143.5	48.0	185.0 - 187.0	57.5
101.0 - 102.5	39.0	144.0 - 146.0	48.5	187.5 - 189.0	58.0
103.0 - 105.0	39.5	146.5 - 148.0	49.0	189.5 - 191.5	58.5
105.5 - 107.0	40.0	148.5 - 150.5	49.5	192.0 - 193.5	59.0
107.5 - 109.5	40.5	151.0 - 152.5	50.0	194.0 - 196.0	59.5
110.0 - 112.0	41.0	153.0 - 155.0	50.5	196.5 - 198.0	60.0
112.5 - 114.0	41.5	155.5 - 157.0	51.0	198.5 - 200.5	60.5
114.5 - 116.5	42.0	157.5 - 159.5	51.5	201.0 - 202.5	61.0
117.0 - 118.5	42.5	160.0 - 162.0	52.0	203.0 - 205.0	61.5
119.0 - 121.0	43.0	162.5 - 164.0	52.5	205.5 - 207.0	62.0

Prediction equation: insertion length(cm) = 16.6 cm + 0.22*height(cm)

OG TUBE

OG TUBE INSERTION LENGTH - **NEWBORN to 28 MONTHS** OF CORRECTED AGE

DETERMINE LENGTH OF CHILD AND INSERT TUBE THE SPECIFIED INSERTION LENGTH IN THE SAME ROW:

Child's Length	Insertion Length	Child's Length	Insertion Length
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(cm)	(cm)	(cm)	(cm)
44.5 - 47.0	22.0	73.5 - 76.0	27.5
47.5 - 49.5	22.5	76.5 - 78.5	28.0
50.0 - 52.0	23.0	79.0 - 81.0	28.5
52.5 - 54.5	23.5	81.5 - 83.5	29.0
55.0 - 57.5	24.0	84.0 - 86.5	29.5
58.0 - 60.0	24.5	87.0 - 89.0	30.0
60.5 - 62.5	25.0	89.5 - 91.5	30.5
63.0 - 65.5	25.5	92.0 - 94.0	31.0
66.0 - 68.0	26.0	94.5 - 97.0	31.5
68.5 - 70.5	26.5	97.5 - 98.5	32.0
71.0 - 73.0	27.0		

Prediction equation: insertion length(cm) = 13.3 cm + 0.19*height (cm)

OG TUBE INSERTION LENGTH - **29 to 100 MONTHS** OF AGE (CORRECTED
AGE < 36 MONTHS)

DETERMINE LENGTH/HEIGHT OF CHILD AND INSERT TUBE THE SPECIFIED
INSERTION LENGTH IN THE SAME ROW:

Child's Length/Height (cm)	Insertion Length (cm)	Child's Length/Height (cm)	Insertion Length (cm)	Child's Length/Height (cm)	Insertion Length (cm)
78.0 - 78.5	31.5	100.0 - 102.0	36.0	123.5 - 126.0	40.5
79.0 - 81.0	32.0	102.5 - 104.5	36.5	126.5 - 128.5	41.0
81.5 - 83.5	32.5	105.0 - 107.5	37.0	129.0 - 131.0	41.5
84.0 - 86.5	33.0	108.0 - 110.0	37.5	131.5 - 133.5	42.0
87.0 - 89.0	33.5	110.5 - 112.5	38.0	134.0 - 136.5	42.5

89.5 - 91.5	34.0	113.0 - 115.5	38.5	137.0 - 139.0	43.0
92.0 - 94.0	34.5	116.0 - 118.0	39.0	139.5 - 141.5	43.5
94.5 - 97.0	35.0	118.5 - 120.5	39.5	142.0 - 144.0	44.0
97.5 - 99.5	35.5	121.0 - 123.0	40.0	144.5 - 145.0	44.5

Prediction equation: insertion length(cm) = 16.8 cm + 0.19*height(cm)

NG TUBE INSERTION LENGTH - **>100 to 204 MONTHS OF AGE**

DETERMINE HEIGHT OF CHILD AND INSERT TUBE THE SPECIFIED INSERTION LENGTH IN THE SAME ROW:

Child's Height (cm)	Insertion Length (cm)	Child's Height (cm)	Insertion Length (cm)	Child's Height (cm)	Insertion Length (cm)
78.0 - 80.0	32.5	121.5 - 123.0	42.0	164.5 - 166.5	51.5
80.5 - 82.0	33.0	123.5 - 125.5	42.5	167.0 - 168.5	52.0
82.5 - 84.5	33.5	126.0 - 127.5	43.0	169.0 - 171.0	52.5
85.0 - 87.0	34.0	128.0 - 130.0	43.5	171.5 - 173.0	53.0
87.5 - 89.0	34.5	130.5 - 132.0	44.0	173.5 - 175.5	53.5
89.5 - 91.5	35.0	132.5 - 134.5	44.5	176.0 - 177.5	54.0
92.0 - 93.5	35.5	135.0 - 137.0	45.0	178.0 - 180.0	54.5
94.0 - 96.0	36.0	137.5 - 139.0	45.5	180.5 - 182.0	55.0
96.5 - 98.0	36.5	139.5 - 141.5	46.0	182.5 - 184.5	55.5
98.5 - 100.5	37.0	142.0 - 143.5	46.5	185.0 - 187.0	56.0
101.0 - 102.5	37.5	144.0 - 146.0	47.0	187.5 - 189.0	56.5
103.0 - 105.0	38.0	146.5 - 148.0	47.5	189.5 - 191.5	57.0
105.5 - 107.0	38.5	148.5 - 150.5	48.0	192.0 - 193.5	57.5
107.5 - 109.5	39.0	151.0 - 152.5	48.5	194.0 - 196.0	58.0
110.0 - 112.0	39.5	153.0 - 155.0	49.0	196.5 - 198.0	58.5
112.5 - 114.0	40.0	155.5 - 157.0	49.5	198.5 - 200.5	59.0
114.5 - 116.5	40.5	157.5 - 159.5	50.0	201.0 - 202.5	59.5
117.0 - 118.5	41.0	160.0 - 162.0	50.5	203.0 - 205.0	60.0
119.0 - 121.0	41.5	162.5 - 164.0	51.0	205.5 - 207.0	60.5

Prediction equation: insertion length(cm)= 15.1 cm + 0.22*height(cm)

Figure 2.
Length to insert nasogastric/orogastric (NG/OG) tubes based on child's height/length

Table 1

Comparison of patient characteristics by three placement methods

	ARHB (<i>n</i> = 36)	NEMU (<i>n</i> = 35)	NEX (<i>n</i> = 32)	<i>p</i> -value
Gender, <i>n</i> (%)				.5726
Male	20 (55.6%)	19 (54.3%)	14 (43.8%)	
Female	16 (44.4%)	16 (45.7%)	18 (56.3%)	
Age ^a (mo), <i>n</i> (%)				.9667
1–28 months	16 (44.4%)	15 (42.9%)	15 (46.9%)	
29–100 months	15 (41.7%)	14 (40.0%)	11 (34.4%)	
101–215 months	5 (13.9%)	6 (17.1%)	6 (18.8%)	
Term, <i>n</i> (%)				.6403
Preterm	28 (77.8%)	27 (77.1%)	22 (68.8%)	
Full term	8 (22.2%)	8 (22.9%)	10 (31.3%)	
Length (cm), mean ± <i>SD</i>	92.5 ± 30.3	94.9 ± 31.4	95.2 ± 33.1	.9251
Race, <i>n</i> (%)				.7418 ^b
Caucasian	29 (80.6%)	28 (80.0%)	29 (90.6%)	
African American	3 (8.3%)	4 (11.4%)	2 (6.3%)	
Other	4 (11.1%)	3 (8.6%)	1 (3.1%)	
Ethnicity, <i>n</i> (%)				.7749 ^b
Hispanic	2 (5.6%)	3 (8.6%)	1 (3.1%)	
Non-Hispanic	34 (94.4%)	32 (91.4%)	31 (96.9%)	
Acid-inhibiting medication use, <i>n</i> (%)				.8794
On	10 (27.8%)	9 (25.7%)	10 (31.3%)	
Not on	26 (72.2%)	26 (74.3%)	22 (68.8%)	
Tube type, <i>n</i> (%)				.7601 ^b
NG	35 (97.2%)	35 (100.0%)	31 (96.9%)	
OG	1 (2.8%)	0 (0.0%)	1 (3.1%)	

Note:

^a Age is corrected if < 36 months.^b *p*-value is from the Fisher's exact test.

ARHB is the age-related, height-based regression equation, NEMU is the distance from the nose to the ear to the mid-umbilicus, NEX is the distance for the nose to the ear to the xiphoid, NG is a nasogastric tube, OG is an orogastric tube

Table 2

Radiographic location of NG/OG tube by insertion-length predictors

	ARHB (<i>n</i> = 36)	NEMU (<i>n</i> = 35)	NEX (<i>n</i> = 32)	<i>p</i> -value
Placement in Stomach/Duodenum/Pylorus	32 (88.9%)	34 (97.1%)	19 (59.4%)	.0001 ^{a,b}
Placement in Stomach	32 (88.9%)	30 (85.7%)	19 (59.4%)	.0056 ^{a,b}

Note

^a
p-value comparing NEX and NEMU < 0.05^b
p-value comparing NEX and ARHB < 0.05

ARHB is the age-related, height-based regression equation, NEMU is the distance from the nose to the ear to the mid-umbilicus, NEX is the distance for the nose to the ear to the xiphoid, NG is a nasogastric tube, OG is an orogastric tube