

Indicators of Tubesite During Feedings

Norma A. Metheny, Renée Schnelker, Joan McGinnis, Georgia Zimmerman, Carolyn Duke, Barbara Merritt, Mary Banotai, Dana A. Oliver

Abstract: Nurses are forced to make decisions about feeding tube position at regular intervals during the delivery of tube feedings; failure to detect an improperly positioned feeding tube can have serious consequences. This study was designed to determine the extent to which specific indicators could singularly and collectively differentiate between gastric and small-bowel placement in patients with nasally or orally inserted small-bore feeding tubes. Indicators were the length of tubing extending from the tube's insertion site as well characteristics of aspirates withdrawn from the feeding tube (volume, appearance, and pH). A total of 201 critically ill tube-fed patients participated in the study for a period of 2–3 days. Among the inclusion criteria were an order for the blind insertion of a small-bore feeding tube, orders to start continuous feedings, and radiographic confirmation of tube location. Five times daily, the following variables were measured: (a) length of tubing extending from the insertion site, (b) volume of aspirate from the feeding tube, (c) appearance of the aspirate, and (d) pH of the aspirate. At the time of entry into the study, 85 patients had gastric feeding tubes and 116 patients had small-bowel feeding tubes. A total of 2,754 concurrent measurements of the variables were attempted; sufficient fluid for pH testing and color description was obtained in 74.2% of the attempts from gastric tubes and in 62.2% of the attempts from small-bowel tubes. Univariate analysis showed that all four of the variables described above were able to differentiate between gastric and small bowel tube sites. A multivariate, forced entry, logistic regression model was able to correctly classify tube site in 81% of the predictions. A variety of easy-to-use bedside methods can be used with a moderate degree of confidence to distinguish between gastric and small-bowel tube placement during continuous feedings.

To ensure patient safety, nurses must regularly confirm that feeding tubes have remained properly positioned during the delivery of feedings. The most serious outcome of a malpositioned feeding tube is aspiration. Upward displacement of a feeding tube's ports from the small bowel into an atonic stomach increases aspiration risk. The upward displacement of any feeding tube's ports into the esophagus significantly increases aspiration risk. A less likely occurrence is migration of a gastric feeding tube into the small bowel; in this situation, intolerance to the feedings can result. Misplaced feeding tubes must be identified early so that complications can be prevented.

Although ample research has been conducted on methods to confirm correct placement of newly inserted tubes, much less is known about how to determine whether a tube has remained properly positioned after feedings have begun. This study was designed to determine the extent to which a variety of easy-to-make bedside assessments could be used to predict tube location in 201 critically ill patients receiving continuous feedings over 2–3 days. Bedside assessments are especially important because it is not feasible to obtain daily radiographs to monitor tube position. Variables included in the study were (a) length of tubing extending from the insertion site, (b) volume of aspirate from the feeding tube, (c) appearance of the aspirate, and (d) pH of the aspirate. Findings were compared with radiographic reports of tube location; in this way, the efficacy of each method was evaluated singularly and in combination with the other three methods.

Literature Review

External Length of Tubing

At the time of radiographic confirmation of tube site, a frequent recommendation is to mark the tube at the point where it exits the nose or mouth (Guenther & Silkroski, 2001; Metheny & Titler, 2001). The external length of tubing usually increases if the tube is partially pulled out. It is not uncommon for an agitated patient to tug at a feeding tube or for tension to be applied to the tube during movement in bed.

While observing for a change in tube length is a reasonable action, there are no published studies regarding this method's efficacy in detecting malpositioned feeding tubes.

Aspirate Volume

Because small-bowel residual volumes are usually much lower than gastric residual volumes (Day et al., 2001), observing serial residual volumes may be helpful in detecting dislocated feeding tubes (Bliss & Lehmann, 1999; Metheny, Schallom, & Edwards, 2004). Proponents of this method

believe that a sudden sharp increase in residual volumes could signal the upward displacement of a feeding tube's ports from the small bowel into the stomach. Although this seems reasonable, there are no research-based reports that confirm the efficacy of this method.

Aspirate Appearance

In a study of 28 gastrointestinal aspirates from critically ill tube-fed children, Gharpure, Meert, Sarnaik, and Metheny (2000) reported that all the 18 gastric aspirates were colorless or white with a curdled appearance (due to the interaction between gastric acid and enteral formula), while 7 of the 10 aspirates from the small bowel were bile-stained (Gharpure et al., 2000). Less encouraging results were reported from a population of adult critically ill adults receiving continuous feedings. Sixty-two of 80 aspirates from the feeding tubes had the appearance of unchanged formula, regardless of a gastric or small bowel feeding site. When bile staining was observed in 18 cases, however, the probability of small-bowel placement was high; 14 bile-stained specimens were from small-bowel tubes, but only 4 were from gastric tubes (Metheny & Stewart, 2002).

Classifying aspirate appearance is a subjective activity, and the success of the classification likely depends on the experience of the clinician (Gharpure et al., 2000; Metheny, Reed, Berglund, & Wehrle, 1994). There is evidence that the ability to use aspirate appearance to determine tube location improves with training (Metheny et al., 1994).

Aspirate pH

In a fasting state, gastric pH is typically much lower than small-bowel pH. If enteral feedings are in progress, however, the formula tends to buffer gastric and small-bowel secretions to near neutral pH levels. Despite this buffering action, there are reports that gastric pH remains lower than small bowel pH during continuous feedings. For example, investigators found that 18 gastric aspirates from tube-fed children had a mean pH of 5 (range from 3.8 to 6.4); in contrast, they found that 10 small-bowel aspirates from tube-fed children had a mean pH of 6.6 (range 4.5–12.0; Gharpure et al., 2000). Similar results were found in a group of 80 continuously tube-fed adult patients; the mean gastric pH was 5.7 ± 0.1 , compared with 6.6 ± 0.1 in the small bowel (Metheny et al., 2002). However, the extent to which a dichotomized pH level (such as >6 or ≤ 6) is helpful in distinguishing between gastric and small-bowel tube placement during continuous feedings remains unclear.

Objective

This study was designed to determine the extent to which indicators could singularly and collectively differentiate between gastric and small-bowel feeding tube placement in critically ill, tube-fed adults with nasally or orally inserted small-bore feeding tubes. The indicators included the following:

- centimeters of tubing extending from the insertion site
- volume of aspirate observed during residual volume measurements
- appearance of aspirate observed during residual volume measurements
- pH of aspirate observed during residual volume measurements.

Sample

This study is a component of a larger study designed to detect aspiration in critically ill, mechanically ventilated tube-fed patients. The sample in this study comprised 201 critically ill tube-fed subjects with a mean age of 52.7 ± 1.4 years (range 18–90 years). Eighty-five of the participants started with gastric feeding tubes, and 116 started with small-bowel feeding tubes. Most (98.4%) of the subjects received either an H₂ receptor antagonist or a proton pump inhibitor. Inclusion criteria for this segment of the study were (a) admission to one of five critical care units in a Midwestern medical center, (b) orders for a blind insertion of a small-bore feeding tube, (c) orders to start continuous feedings, and (d) radiographic confirmation of tube site before feedings were started. Most participants were recruited from neuromedicine and neurosurgery or trauma and surgery services.

Methods

Approval was obtained from the appropriate institutional review body, and informed consents were obtained from the patients or their legal guardians. Research nurses were present from 8 am until midnight (7 days per week) over 14 months to collect data. Before collecting data independently, all the research nurses received training from the study's project director. Each patient's participation in the study extended over a period of 2–3 days.

Following radiographic confirmation of the newly inserted tube's position, continuous feedings were started. The following observations were made five times daily (8 am, noon, 4 pm, 8 pm, and midnight) during each patient's enrollment in the study: (a) length of tubing extending from the insertion site, (b) volume of aspirate withdrawn from the feeding tube, (c) appearance of the aspirate, and (d) pH of the aspirate. Multiple measurements were necessary during the study period to assess for tube movement. Because of the nature of the study, the research nurses were not always blinded to the original site of the feeding tube.

Measurement of External Length of Tubing

The length of tubing extending from the insertion site was measured with a disposable centimeter tape near the time of radiographic confirmation of tube site; subsequent measurements were compared with this value. No attempt was made to control for the patients' heights; instead, the patients served as their own controls in relation to changes in external tubing length. All the tubes used in the project were 10 Fr in diameter; most were 109 cm in length.

Measurement of Aspirate Volume

The flow of enteral formula was paused temporarily for residual volume measurements. Following the insufflation of 30 mL of air through the tube by a 60-mL syringe, fluid was withdrawn until no more could be obtained. The fluid was measured in the calibrated syringe or a calibrated beaker before being returned to the patient; 1 mL was saved for pH testing. In accordance with the study protocol, volumes less than 200 mL were returned to the patient; the remainder was discarded. The bedside nurse, however, determined whether the protocol needed to be adjusted. In two situations in which the aspirate volume exceeded 200 mL, the entire amount was returned to the patients because medications had recently been administered via the tubes.

Description of Aspirate

The research nurse who collected the fluid specimen determined which of the following color categories most closely described the aspirate: (a) unchanged enteral formula, (b) gastric appearance (curdled formula, off-white with sediment, green, brown, or bloody), or (c) small bowel appearance (clear golden-yellow that is thicker than water, yellow-brown, or greenish-brown). These color classifications were based on previously reported information on the appearance of feeding tube aspirates (Metheny et al., 1994; Metheny et al., 2002; Gharpure et al., 2000).

Measurement of Aspirate pH

A drop of the aspirate was placed on a colorimetric pH strip (ColorpHast® pH 0–14, EMD Chemicals Inc, Gibbstown, NJ), and a visual reading was made within 1 minute to identify pH. Previous studies have documented the accuracy of these test strips in comparison with concurrent pH-meter readings (Metheny et al., 1989).

Data Analysis

Results from all the measurements were compared with radiographic documentation of feeding tube site at the time of insertion and again on subsequent days when additional radiographic reports were available. Radiographs were available for all the patients at the time of tube insertion; 93 radiographic reports were available on the second day and 87 were available on the third day. Descriptive statistics (frequencies, means \pm standard error, and ranges) were used to report the findings. Non-parametric tests were used to make comparisons of specific categories of aspirate volume and to compare changes in length of external tubing in tubes that did and did not become displaced. Univariate assessment of the association between the four predictors and tube location was performed. A multivariate, forced entry, logistic regression was performed to identify which of the proposed characteristics could best be used to predict tube location.

Results

A total of 2,754 concurrent measurements of the external tube length and aspirate volume were made. Sufficient fluid for pH testing and color description was obtained in 74.2% of the attempts from gastric tubes and in 62.2% of the attempts from small-bowel tubes. See Table 1 for a univariate assessment of the extent to which the four predictors were successful in predicting tube site (gastric versus small bowel).

The distal tips of 24 of the 116 feeding tubes originally positioned in the small bowel were shown by radiography to be displaced upward in the gastrointestinal tract (23 into the stomach and 1 into the

esophagus). The distal tip of 1 of the 85 tubes originally positioned in the stomach was shown by radiography to be displaced into the esophagus. None of the feeding tubes migrated from the stomach to the small bowel. Eight nasogastric tubes, however, were removed and replaced by small bowel feeding tubes when persistently high gastric residual volumes were observed; these patients remained in the study.

External Length of Feeding Tube

As shown in Table 1, the mean length of tubing extending from gastric tubes was significantly more than that extending from small-bowel tubes. The mean increase in external tubing length of the 23 small-bowel tubes that displaced upward into the stomach was 13.7 ± 1.9 cm (range 0–33 cm). One of the displaced small-bowel tubes had no change in external tube length; instead, coiling of this tube increased in the stomach.

An increase of 32 cm was found in the external length of the small bowel tube that displaced upward into the esophagus. Similarly, an increase of 12 cm was found in the external length of the gastric tube that displaced upward into the esophagus. Although tubes that remained correctly positioned had some variation in their external length, the change was minimal compared to that observed in the 25 cases in which tubes were dislodged. For example, the mean change in external tubing length in the correctly positioned tubes was 2.19 ± 0.112 ; in contrast, the mean change in external tubing length of the dislocated tubes was 14.32 ± 1.92 ($p < .001$).

Aspirate Volume

The volume of fluid aspirated from gastric tubes ranged between 0 and 425 mL, while the volume aspirated from small bowel tubes ranged between 0 and 90 ml. As shown in Table 1, the mean volume of aspirates from gastric tubes was almost 4 times more than the mean volume obtained from small bowel tubes. An aspirate volume ≤ 10 mL was more likely to have been from a small bowel feeding tube than from a gastric feeding tube (85.4% versus 66.5%, $p < .001$). In contrast, an aspirate with a volume ≥ 50 mL was more likely to have been from a feeding tube in the stomach than from one in the small bowel (12.7% versus 0.5%, $p < .001$).

To compare aspirate volumes in patients in which feeding tubes became displaced, the maximum value in each site was compared. Using this technique, an increase in aspirate volume was observed in 17 of the 23 cases in which small bowel tubes displaced upward into the stomach; the mean increase was 50.7 ± 16.5 mL (range 10–330 mL). As indicated earlier, two tubes displaced into the esophagus. The tube that moved upward from the stomach into the esophagus had a change in volume from 15 to 1 mL, respectively. The tube that dislocated upward from the small bowel into the esophagus had a change in volume from 2 to 0 mL, respectively.

Aspirate Color

As shown in Table 1, approximately three-fourths of the aspirates were classified as having the appearance of unchanged formula; these classifications were about evenly distributed among small-bowel and gastric patients. Of the 216 aspirates with a gastric color, 96.8% were from gastric tubes ($p < .001$). Of the 243 aspirates with a small bowel color, 90.9% were from small-bowel feeding tubes ($p < .001$).

A change to a gastric color was observed in seven of the 23 cases in which small bowel tubes displaced upward into the stomach. An aspirate obtained from a feeding tube displaced upward from the stomach into the esophagus had the appearance of unchanged formula.

Aspirate pH

The mean pH in the stomach was lower than that found in the small bowel (6.4 versus 6.8, $p < .001$). Approximately 37% of the gastric aspirates had pH values ≤ 6 , whereas only 21% of the small-bowel aspirates had values that low ($p < .001$).

Nine of the 23 cases in which feeding tubes were displaced from the small bowel into the stomach were accompanied by a change in pH from 7 to ≤ 5 ; an additional two situations were observed in which the pH changed from 6 to ≤ 5 . In the remaining 12 patients, the aspirates' pH values were 7 in both sites. A pH of 7 was observed in the aspirate obtained from a tube that became displaced from the stomach into the esophagus.

Combination of Variables

A multivariate, forced entry, logistic regression analysis was performed to identify which of the characteristics presented in Table 1, singularly or in combination, could best be used to predict tube location. The Nagelkerke r^2 of 0.64 approximates the predictive strength of the model when the combination of the

length of tubing and volume and color of the aspirate was used collectively to predict tube site. The model excluded dichotomized pH as a factor, despite its univariate ability to distinguish between gastric and small-bowel tube sites. Approximately 81% of the predictions were correctly classified when using tubing length, aspirate volume, and aspirate appearance for tube site prediction; 83% were correctly classified in the stomach and 70% were correctly classified in the small bowel (Table 2).

Discussion

Significant differences were found between gastric and small bowel tubes in relation to external tube length, aspirate volume, aspirate appearance, and aspirate pH. These differences can be helpful in determining whether a feeding tube has dislocated from its intended site. Although none of the methods evaluated in this study was 100% effective, each is simple to perform and carries no risk. Changes observed in tube length, aspirate volume, aspirate appearance, and aspirate pH in feeding tubes that became displaced from their intended sites help to demonstrate how the methods can be applied.

Marking a tube at the exit site at the time of radiographic confirmation of correct placement requires little effort and can alert caregivers when a feeding tube has been partially dislocated. As noted above, tube length increased in 24 of the 25 tube displacements. Of course, it is possible for a tube to dislocate without a change in tube length when there is coiling of the tube in the stomach; this happened once in this study.

Serial observations of aspirate volume are easy to make and can also provide valuable information about tube site. As indicated earlier, an aspirate volume <10 ml was more likely to have been from a small-bowel feeding tube than from a gastric feeding tube, while an aspirate with a volume >50 ml was more likely to have been from a feeding tube than in the stomach as opposed to the small bowel. A potential problem with small-bore feeding tubes is difficulty in withdrawing fluid for residual volume measurements and pH testing. However, using the air insufflation method described above to facilitate fluid aspiration, we were able to obtain fluid during approximately three-fourths of our attempts from gastric tubes and two-thirds of our attempts from small-bowel tubes.

Because residual volume measurements are routinely made every 4 hours in most acute care settings, it is easy to observe aspirate appearance. Although the efficacy of this method is limited because aspirates obtained during continuous feedings usually have the appearance of unchanged formula, it can provide useful data when an aspirate has a distinctive appearance. As indicated above, when a gastric color was observed, most (96.8%) of the aspirates were from the stomach; conversely, when a small-bowel color was observed, most (90.9%) of the aspirates were from the small bowel.

Serial observations of the aspirates' pH can also provide useful information about tube site. As indicated above, a decrease in aspirate pH to a level of 5 or less was observed in 11 of the 23 situations in which small-bowel tubes dislocated into the stomach. When such a change is observed in the presence of one or more other indicators of tube dislocation, it may signal the need for a radiograph determining whether that a small-bowel tube has remained in the correct location.

Implications

Nurses are encouraged to observe the external length of feeding tubes at regular intervals. This simple observation is possible in all tube-fed patients and may yield useful information that can help determine whether the tube has remained in its desired location. Observing the appearance and volume of aspirates from feeding tubes, although not possible in all situations, also provides valuable clues as to a feeding tube's location. Thus, these observations are also highly recommended. Although pH testing is very helpful in determining tube location in fasting patients, its use in continuously fed patients is somewhat limited, primarily because of the buffering of gastric juice by enteral formula. The strength of a single indicator increases if one or more other indicators are simultaneously present. If bedside assessments are inconclusive, a radiograph may be needed to determine the tube's location. Nurses are encouraged to review abdominal and chest radiography reports obtained during routine care because these reports sometimes include valuable information about feeding tube location.

Limitations

This study had several limitations. First, radiographs were not consistently available on the second and third days of the study. Second, data were collected by multiple research nurses; thus, vari-

ance in the measurements was more likely than if the data had been collected by a single individual. However, to guard against this, all the nurses underwent an orientation period and worked with experienced data collectors before working independently. In addition, the measurements required for the study were relatively simple and well within the scope of usual nursing practice. All the data collectors were experienced nurses; most of them had a critical care background. A third limitation was that inter-rater reliability was not measured; this was because only one research nurse was generally available during most of the measurements. Cost restraints prevented having multiple nurses present.

Summary

Ensuring that a feeding tube has remained in its desired position during continuous feedings is an important nursing task. The findings of this study suggest that a variety of simple bedside methods can be used with a moderate degree of confidence to distinguish between gastric and small bowel tube placement during continuous feedings. Replication of the study is recommended in a larger sample of critically ill patients as well as in less acutely ill patients. In addition, replication of the study is recommended in patients receiving intermittent feedings; it is probable that pH testing would yield more beneficial results in these individuals (especially if performed immediately before the next scheduled feeding).

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