

## Table of Contents

Clinical Question . . . . .	306.e2
Background and Significance . . . . .	306.e2
Methods . . . . .	306.e2
Summary of Literature Review . . . . .	306.e4
Description of Decision Options/Interventions and the Levels of Recommendations. . . . .	306.e8
References . . . . .	306.e8
Appendix 1: Evidence Table . . . . .	306.e10
Appendix 2: Other Resources Table . . . . .	306.e15
Appendix 3: Study Selection Flow Chart and Inclusion/Exclusion Criteria. . . . .	306.e16
Synopsis . . . . .	306
Authors . . . . .	307
Acknowledgments . . . . .	308

## Clinical Question

In patients having gastric tubes inserted in the emergency department setting, which bedside technique is best for confirmation of accurate placement immediately after tube insertion compared to radiograph?

## Background and Significance

Gastric tube (GT) placement is a common bedside procedure performed by registered nurses in the emergency department (ED). Although often considered an innocuous procedure, incorrect GT placement can result in serious and even lethal complications such as respiratory distress or death. The standard of care requires verification of the GT placement prior to its use to minimize complications resulting from incorrect placement. Radiographic verification is the preferred method of confirmation (Leschke, 2003), and is considered by many to be the gold standard, especially for feeding tubes (Ellett, 2004; Ellett, et al., 2014; Elpern, Killeen, Talla, Perez, & Gurka, 2007; Kearns & Donna, 2001). However, bedside methods are commonly used as a proxy for radiographic verification when large bore GTs are inserted due to the associated cost, time delay, and radiation exposure. In addition, a radiographic test cannot be performed by the bedside nurse. It has been well documented for more than 20 years that auscultation, a common bedside method, is often inaccurate (Metheny, Stewart, & Mills, 2012); however, it is still widely practiced. Additional bedside testing methods should also be considered by the bedside clinician, including testing of gastric pH, bilirubin, and carbon dioxide (Ellett et al., 2014). This Clinical Practice Guideline (CPG) aims to evaluate various bedside GT placement verification methods as alternatives to radiography.

## Methods

This CPG was created based on a thorough review and critical analysis of the literature following the multiple literature searches performed for its two previous updates (2014 and 2017). In the original CPG publication, initial searches were limited to English language articles on human subjects from October 2005 through 2010. The original limitation to the preceding five years for literature was found to be inadequate. As a result, the time frame was expanded to 1994 and an author search performed for Metheny's publications because of the seminal nature of her work. With recent CPG revisions, additional comprehensive literature searches were completed in 2014 and 2017 to identify articles relevant to the topic. For the current revision, the following databases and repositories were searched: MedlinePlus, CINAHL, Cochrane - British Medical Journal, Agency for Healthcare Research and Quality, and the National Guideline Clearinghouse. Searches were conducted using the search terms: nasogastric tubes, tube placement determination, gastric tubes, gastric tube placement confirmation, gastric tube placement, and nasogastric tubes, catheters and tubes. In addition, the reference lists in the selected articles were scanned for pertinent research findings. Research articles from ED settings, non-ED settings, position statements, and guidelines from other sources were also reviewed. Clinical findings and levels of recommendation regarding patient management were made by the CPG Committee according to ENA's classification of levels of recommendation for practice (Table 1) (Melnyk & Fineout-Overholt, 2015). The articles reviewed to formulate the recommendations in this CPG are described in Appendix 1.

**Table 1. Levels of Recommendation for Practice**

<b>Level A Recommendations: High</b>
<ul style="list-style-type: none"> <li>• Reflects a high degree of clinical certainty</li> <li>• Based on availability of high quality level I, II, and/or III evidence rated using the Melnyk and Fineout-Overholt grading system (Melnyk &amp; Fineout-Overholt, 2015)</li> <li>• Based on consistent and good quality evidence; has relevance and applicability to emergency nursing practice</li> <li>• Is beneficial</li> </ul>
<b>Level B Recommendations: Moderate</b>
<ul style="list-style-type: none"> <li>• Reflects moderate clinical certainty</li> <li>• Based on availability of Level III and/or Level IV and V evidence rated using the Melnyk and Fineout-Overholt grading system (Melnyk &amp; Fineout-Overholt, 2015)</li> <li>• There are some minor inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice</li> <li>• Is likely to be beneficial</li> </ul>
<b>Level C Recommendations: Weak</b>
<ul style="list-style-type: none"> <li>• Has limited or unknown effectiveness</li> <li>• Level V, VI, and/or VII evidence rated using the Melnyk and Fineout-Overholt grading system (Melnyk &amp; Fineout-Overholt, 2015 - Based on consensus, usual practice, evidence, case series for studies of treatment or screening, anecdotal evidence, and/or opinion)</li> </ul>
<b>Not Recommended for Practice</b>
<ul style="list-style-type: none"> <li>• No objective evidence or only anecdotal evidence available, or the supportive evidence is from poorly controlled or uncontrolled studies</li> <li>• Other indications for not recommending evidence for practice may include:             <ul style="list-style-type: none"> <li>◦ Conflicting evidence</li> <li>◦ Harmfulness has been demonstrated</li> <li>◦ Cost or burden necessary for intervention exceeds anticipated benefit</li> <li>◦ Does not have relevance or applicability to emergency nursing practice</li> </ul> </li> <li>• There are certain circumstances in which the recommendations stemming from a body of evidence should not be rated as highly as the individual studies on which they are based. For example:             <ul style="list-style-type: none"> <li>◦ Heterogeneity of results</li> <li>◦ Uncertainty about effect magnitude and consequences</li> <li>◦ Strength of prior beliefs</li> <li>◦ Publication bias</li> </ul> </li> </ul>

## Summary of Literature Review

### GASTRIC TUBES

Gastric tubes may be inserted nasally or orally. Regardless of the insertion route, GTs are used for multiple indications in the ED. Large- and small-bore gastric tubes have been designed to meet treatment needs. Large-bore GTs, which are inserted via the nose or mouth and guided into the stomach, are considered for short term use and aid in the removal of stomach contents and the instillation of liquids or medications. Small-bore GTs, also known as feeding tubes, are advanced through the gastrointestinal track via the stomach into the small intestine, remain in place for a longer period of time, and are reserved for the instillation of enteral nutrition, liquids, and medications. Large-bore GTs, not feeding tubes, are typically inserted in the ED.

Most studies of bedside verification methods for gastric tube insertion focus on small-bore feeding tubes. A limited number of studies conducted in ED settings using large-bore GTs are also included in this review. The most common bedside verification methods can be categorized as non-aspirate or aspirate. Non-aspirate methods include auscultation, carbon dioxide detection, transillumination, ultrasound, and magnetic detection; aspirate methods are visual characteristics, pH, bilirubin, combination pH/enzyme tests, and additional enzyme tests.

### NON-ASPIRATE METHODS

#### *Auscultation*

Verification of GT placement solely by auscultation, which involves instillation of air into the tube while simultaneously listening with a stethoscope over the epigastric region for the sound of air, is no longer recommended. Multiple studies have demonstrated that using auscultation alone as a GT placement verification method is not reliable (Boeykens, Steeman, & Duysburgh, 2014; Ellett, Croffie, Cohen, & Perkins, 2005; Metheny, Reed, Berglund, & Wehrle, 1994; Yardley & Donaldson, 2010). Pursuit of a reliable, valid, bedside verification method for GT placement has led researchers to investigate alternative methods to auscultation.

#### *Carbon Dioxide Detection Monitoring*

Misplacement of the GT into the pulmonary system warrants immediate detection to prevent respiratory complications. Studies using CO<sub>2</sub> detection methods (CO<sub>2</sub> monitoring/capnography) were conducted to determine if these accurately detect incorrect GT placement (Burns et al., 2006; Elpern et al., 2007). Burns et al. (2006) reported 100% agreement between colorimetry and capnography in the identification of CO<sub>2</sub> when the GT was placed with CO<sub>2</sub> detection monitoring in 130 adult medical intensive care unit patients undergoing large bore GT placement. Twenty-seven percent of participants experienced insertion failure and GT misplacement was correctly identified by capnography in all patients (Burns et al., 2006). Gastric tube insertion failures were associated with a nasal insertion route ( $p = 0.03$ ) and among spontaneously breathing/non-intubated patients ( $p = 0.01$ ). In a study completed by Elpern et al. (2007), capnometry and air insufflations/auscultation were compared to abdominal radiograph for accuracy in detecting misplaced GTs during initial insertion in 91 adult critical care and telemetry patients. Using abdominal radiography, a 100% success rate in placing the GT into the stomach was reported. Capnometry when compared with abdominal radiographs, identified 16% of GTs as incorrectly placed in the pulmonary tract; similarly, there were 5% misidentifications by air insufflation/auscultation (Elpern, 2007). The likelihood of false readings does not immediately jeopardize patient safety, but does require the use of additional verification methods to ensure correct tube location. Study limitations included small sample sizes and adult-only study populations.

Chau, Lo, Thompson, Fernandez, and Griffiths (2011) conducted a meta-analysis of eight studies to determine if the use of capnometry accurately detected GT placement. These authors concluded that in adult patients, carbon dioxide detection was an effective method for differentiating between tube placement in gastric and pulmonary systems, and that there is evidence to support the use of capnography or colorimetric capnography for detection of proper GT placement. Study limitations included different index tests used by different authors in the review and the majority of the studies excluded patients who were mechanically ventilated. Ellett et al. (2014) suggested that the optimal method of ensuring proper GT placement in children is to use a combination of capnography and analysis of gastric aspirate via point-of-care bedside testing (POCT). Limitations of the Ellett et al. (2014) study include small sample size and no unsuspected respiratory placements. As in the adult cases, signs and symptoms of respiratory distress are a primary indication to remove an incorrectly located tube.

Further research is needed to determine the role of carbon dioxide in GT placement detection. Carbon dioxide detection and monitoring equipment is commonly found in the ED because of its use with endotracheal intubation and sedation; research to support its use with GT placement in the ED remains limited, however.

### *Transillumination and Magnetic Detection*

Research has also been conducted to determine the feasibility of transillumination or magnetic detection for GT placement verification. Rulli et al. (2007) studied a fiber optic method for GT placement and verification. A flexible fiber optic cable was inserted into the GT of 16 patients, 8 adults and 8 children, who were undergoing a surgical procedure. Transillumination of the epigastric abdominal area was used to indicate correct placement of the GT. Gastric tube placement was confirmed in 100% of the patients. While the study was highly relevant, limitations included small sample size, lack of commercially available equipment, and the operating room practice setting.

Magnetic detection was used to determine the position of the GT in 88 volunteer subjects aged 18–75 years (Tobin, Gonzales, Golden, Brown, & Silverstein, 2000). A commercial feeding tube was modified by substituting a magnet for the tungsten weights in the tip of the GT. Prototype magnet detectors determined real-time GT location, orientation, and depth of the distal end of the feeding tube. Gastric tubes were determined by fluoroscopy to be below the diaphragm 100% of the time. A prospective blinded study of 134 patients compared four GT verification methods: electromagnetic technique, auscultation, aspiration, and pH (Kearns & Donna, 2001). When used to identify GT placement, the electromagnetic method was correct 90% of the time, compared with 53% for the aspiration method. Several study limitations included lack of commercially available equipment for magnetic field detection, a laboratory setting, and the lack of testing for GTs errantly placed in the pulmonary system. Magnetic detection is primarily used for feeding tube insertion and is not recommended for use in the ED as primary confirmation of GT placement.

### *Ultrasound*

Evidence has emerged over the last several years regarding the use of ultrasound as an alternative for confirming gastric tube placement in adults (Atalay et al., 2016; Kim, So, Jeong, Choi, & Park, 2012; Lin et al., 2017). Many EDs now have ultrasound equipment readily available; using it as a tool for tube placement verification may therefore be feasible. In studies performed using ultrasound as a confirmation method for tube placement, radiologists or other physicians performed the ultrasound (Atalay et al., 2016; Kim et al., 2012; Lin et al., 2017). In order for nurses to be able to perform and interpret this GT confirmation technique, adequate training must be in place that involves verification of competency. Further, changes in institutional policies are needed to shift this method of tube placement verification into the nurses' scope of practice. This

technique may be promising for verification of feeding tube placement, however there is limited data on its use with large-bore GTs in the ED setting (Atalay, 2016; Kim et al., 2012; Lin et al. 2017).

A systematic review and meta-analysis investigating the diagnostic accuracy of ultrasonography for detecting GT placement was conducted by Lin et al. (2017). Utilizing the Cochrane Collaboration recommendations for systematic reviews, five studies met inclusion criteria. The total pooled sample size was 420 cases of adult patients undergoing NG tube placement. Statistical evaluation yielded a sensitivity of 0.93 (95% CI 0.87–0.97) and a specificity of 0.97 (95% CI 0.94–0.98), indicating that using ultrasound to confirm correct GT placement may be useful (Lin et al., 2017).

Kim et al. (2012) investigated the effectiveness of using bedside verification methods to confirm placement of GTs for adults in the ED with altered levels of consciousness. In this study, all patients (N = 47) had GT placement verified by auscultation, gastric aspirate with pH testing, bedside ultrasound, and chest X-ray. Gastric tube placement was correct in 44 of the 47 patients. Correct placement was confirmed by bedside ultrasound in 38 patients (sensitivity 86.4%). Of the 3 three patients with the tube incorrectly placed, ultrasound was able to identify incorrect placement in two cases (specificity 66.7%). Testing of pH identified the correct position in 31 of 34 cases tested (sensitivity of 91%) and incorrect position in two cases (specificity 66.7%). Correct placement was identified by auscultation in 44 patients (sensitivity 100%) and incorrect placement in one case (specificity 33.3%). The authors concluded that ultrasound is useful to confirm GT placement in patients with decreased level of consciousness, with the recommendation that if other means of testing do not indicate gastric placement, a chest X-ray should be performed (Kim et al., 2012).

### ASPIRATE METHODS

Tests evaluating aspirate content offer an alternative method for verifying GT placement. Visual inspection and biochemical markers such as pH, bilirubin, and enzymes were the most frequent aspirate methods used to study GT placement. Visual inspection of aspirate involves differentiating between the appearance of those from the stomach, small intestine, and lungs. Metheny et al. (1994) reported that critical care nurses were able to differentiate between gastric and intestinal aspirate 90.47% of the time yet were unable to distinguish between gastric and pulmonary aspirate.

Several studies investigated the use of biochemical markers (pH, bilirubin, pepsin, and trypsin) to determine GT placement (Christensen 2001; Ellett et al., 2005; Kearns & Donna 2001; Metheny et al., 1994; Metheny et al., 1997; Metheny et al., 1999; Metheny & Titler, 2001; Phang, Marsh, Barlows, and Schwartz, 2004). Biochemical marker threshold values varied among the studies (ranging from gastric pH values of less than 3.9 up to 7, and bilirubin less than 5 milligrams per deciliter) to differentiate GT placement in the stomach versus the pulmonary system. Participants in these studies received acid suppressive therapy and tube feedings, both of which influence gastric pH. Reliability of pH testing to determine tube placement within the gastrointestinal tract ranged from 84% (Stock, Gilbertson, & Babl, 2008) to 97% (Metheny, Smith, and Stewart, 2000), compared to bilirubin test reliability of 91% (Metheny et al., 1999), pepsin enzyme reliability of 91.2%, and trypsin enzyme reliability of 91.8% (Metheny et al., 1997). Study results reported an alteration in pH test results for patients receiving acid suppression medication. In fact, Taylor and Clemente (2005) reported a 58% reduction in pH confirmation of GT placement for patients receiving acid-inhibiting medications.

Ellett et al. (2014) prospectively compared the predictive validity of pH, bilirubin, and carbon dioxide to detect correct placement of GTs in 276 children aged 24 weeks to 212 months; all patients also received radiographic exams. The researchers concluded that measurement of pH, bilirubin, and CO<sub>2</sub> did not detect a misplaced GT. Lack of gastric aspirate does not ensure that the GT is improperly placed (Ellett et al., 2014). The tube may be in the proximal portion of the stomach or may have collapsed during the aspiration attempt (Ellett, et al., 2014).

[Metheny et al. \(2000\)](#) reported combined test results of pH greater than 5 and bilirubin less than 5 milligrams per deciliter successfully identified 98.6% of the 141 cases as gastric placement. Bilirubin, pepsin, and trypsin testing are typically performed in the laboratory, hence these are not bedside point-of-care methods. There is limited information on the use of urine bilirubin test strips for bedside verification ([Metheny et al., 2000](#)).

[Gilbertson, Rogers, and Ukoumunne \(2011\)](#) conducted a prospective observational study where they sought to determine a reliable and practical pH value to confirm GT placement in pediatric patients older than 4 weeks receiving enteral nutrition. These researchers reviewed 4330 gastric aspirate samples from 645 patients. They concluded that a pH of less than 5 would simplify the process for confirmation of GTs, and that when pH was greater than or equal to 5, further investigation with radiographic examination was needed.

In two prospective studies, [Anderson, Carr, Harbinson, and Hanna \(2016\)](#) concluded that a combination of gastric lipase and pH tests demonstrated accurate placement of GTs. The initial study was conducted to develop a point-of-care test (POCT) to check gastric aspirate for lipase. This test was used to increase the accuracy of verification of GT placement at the bedside. A subsequent study determined the reliability of the POCT test. In a sample of 36 patients at a tertiary referral acute teaching hospital in the UK, the pH test had a sensitivity of 65.7% with 100% specificity, and the sensitivity of lipase was 97.2% with 100% specificity. New findings indicate that lung aspirate does not contain gastric lipase, and false negatives for pH due to acid-reducing medications were corrected by the lipase test ([Anderson, et al., 2016](#)). Limitations to the study include small sample size, inaccuracy in patients without a gastric fundus, and the lack of availability of gastric lipase testing.

## COMBINED NON-ASPIRATE AND ASPIRATE METHODS

### *Algorithmic Approach*

The rate of GT placement confirmation accuracy increases when aspirate methods are combined with non-radiological verification methods rather than relying on a single bedside method for verification of tube placement ([Metheny & Titler, 2001](#)). [Metheny and Titler \(2001\)](#) recommend an algorithm for newly inserted large-bore GT placement verification, beginning with auscultation and followed by pH and visual inspection of aspirate. This literature supports the use of a combination of methods for bedside verification of GT placement; however, Metheny and Titler suggest additional research is needed to determine which methods are the most accurate and in what sequence they should be used.

## Description of Decision Options/Interventions and the Levels of Recommendations

Description of Decision Options/Interventions and the Level of Recommendation		
Verification Methods	Radiographic examination (X-ray or CT scan) remains the gold standard for verifying gastric tube placement prior to instillation of any substance (Ellett, et al., 2014; Elpern, Killeen, Talla, Perez, & Gurka, 2007; Kearns & Donna, 2001; Phang, Marsh, Barlows, and Schwartz, 2004).	A
	There is moderate evidence to support the use of pH testing of gastric tube aspirates as a component of multiple-method bedside verification for gastric tube placement (Christensen 2001; Ellett et al., 2014; Gilbertson, 2011; Metheny et al., 1989; Metheny, Reed, Berglund & Wehrle, 1994; Metheny et al., 1997; Metheny, Smith & Stewart, 2000; Phang et al., 2004; Stock et al., 2008; Taylor & Clemente, 2005).	B
	Bedside ultrasound guidance is supported by the literature (Kim et al., 2012; Lin et al., 2017).	B
	There is some evidence to support the use of carbon dioxide detection for bedside verification of gastric tube placement (Anderson et al., 2016; Burns et al., 2006; Chau et al., 2011).	C
	There is some evidence to support the use of gastric lipase testing for bedside verification of gastric tube placement if this product becomes commercially available (Anderson et al., 2016).	C
	Use of auscultation as a single verification method is unreliable in determining gastric tube placement (Christensen, 2001; Kearns and Donna, 2001; Metheny & Titler, 2001).	N/R
	Use of transillumination and magnetic detection requires equipment that may be difficult to obtain and its use as a single bedside verification method for gastric tube placement requires further study (Kearns and Donna, 2001; Rulli et al., 2007; Tobin, Gonzales, Golden, Brown & Silverstein, 2000).	I/E

Level A (High)	Based on consistent and good quality of evidence; has relevance and applicability to emergency nursing practice.
Level B (Moderate)	There are some minor inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice.
Level C (Weak)	There is limited or low-quality patient-oriented evidence; has relevance and applicability to emergency nursing practice.
N/R	Not recommended based upon current evidence.
I/E	Insufficient evidence upon which to make a recommendation.
N/E	No evidence upon which to make a recommendation.

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## Appendix 1. Evidence Table

Reference	Purpose/Hypothesis	Design/Sample Setting	Variables/Measures Analysis	Findings/Implications	Quality of Evidence	Level of Evidence
Anderson, O., Carr, R., Harbinson, M., & Hanna, G. (2016). Development and validation of a lipase nasogastric tube position test. <i>BMJ Open Gastroenterology</i> , 3 (e000064). doi:10.1136/bmjgast-2015-000064	<p>Purpose of Study:</p> <ol style="list-style-type: none"> <li>To develop and validate an NG tube position test that was compatible with non-acidic gastric aspirates using human gastric lipase to lower the pH of gastric aspirates on pH test paper.</li> </ol>	<p>Design:</p> <p>Two prospective studies: a development phase looking at human gastric lipase activity and a validation phase trialing lipase test vs. pH.</p> <p>IRB: Approval obtained from UK National Health Service research ethics committees. Development phase:</p> <p>Sample: 34</p> <p>Population: Consecutive adult patients undergoing major upper-gastrointestinal surgery involving one-lung ventilation. Blinded results. Validation phase: NG feeding tube aspirates from 36 consecutive adult patients receiving NG feeding tube.</p>	<p>Variables: Development phase: pH and human gastric lipase activity measured. pH measured using pH test paper by Merck. Gastric lipase activity measuring using 718 STAT Titrino. pH &lt; or equal to 5.5 indicates tube correctly placed; any human gastric lipase activity indicated correct tube placement. Using results, created lipase test using coated pH test paper from Merck with tributyrin. Validation phase: CXR or trial by use (position already confirmed by previous methods) if chest X-ray not indicated. Aspirate from NG tube taken within 30 minutes of CXR. Used standard test paper with 0.5 increments (Merck) and simultaneously tested lipase test. Papers read at 1 minute.</p>	<p>Findings: Accuracy of the lipase test greater than pH (extended McNemar's test <math>\chi^2 = 11</math> with 2 df, <math>p &lt; 0.05</math>). Sensitivity of the lipase test greater than pH (<math>\chi^2 = 9.091</math> with 1 df, <math>p &lt; 0.05</math>). 95% CI for the difference between the sensitivities was 17.3 to 47.5%.</p> <p>Implications: Fresh gastric contents aspirated from lung could give false positive on both tests. Recommend use of CXR in patients at risk for aspiration pneumonia to check placement. Use of antacid medications affects pH results and lipase test could substitute as daily placement check.</p>	I	III
Burns, S. M., Carpenter, R., Blevins, C., Bragg, S., Marshall, M., Browne, L., ... Truitt, J. D. (2006). Detection of inadvertent airway intubation during gastric tube insertion: Capnography versus a colorimetric carbon dioxide detector. <i>American Journal of Critical Care</i> , 15(2), 188–195.	<p>Purpose of Study:</p> <ol style="list-style-type: none"> <li>To compare accuracy of colorimetry vs. capnography in determining GT placement in lung.</li> <li>To describe variables that correlate with inadvertent GT airway intubation.</li> </ol> <p>Hypothesis/Theoretical Framework:</p> <ol style="list-style-type: none"> <li>Colorimetric CO<sub>2</sub> detector will indicate the presence of CO<sub>2</sub> as accurately as capnography.</li> <li>Variables that will correlate with inadvertent GT intubation of lungs include mental status, insertion route, tube type, ETT intubation vs. tracheostomy, mechanical ventilation.</li> </ol>	<p>Design:</p> <p>Non-experimental</p> <p><math>N = 52</math> misplaced tubes out of 195 GT insertions (130 patients)</p> <p>Randomization: No</p> <p>Convenience sample: Yes</p> <p>Population: Adult MICU patients</p> <p>Setting: Urban acute care hospital</p> <p>IRB approval: Yes (expedited); no consent required)</p>	<p>Statistical analysis appropriate: Yes</p> <p>Descriptive statistics and Pearson <math>\chi^2</math></p> <p>Instrument:</p> <ol style="list-style-type: none"> <li>Portable capnograph (Novamatrix Model 610)</li> <li>Colorimetric Indicators (Pedi-Cap)</li> <li>Soft bore tube, size 12 F (Tyc Healthcare/Kendall)</li> <li>Salem sump tube (Bard Medical), size 14–16F</li> </ol>	<p>Findings/Hypothesis:</p> <ol style="list-style-type: none"> <li>100% agreement between colorimetry and capnography in identifying CO<sub>2</sub> when the tube was inserted into an endotracheal tube in situ (<math>n = 5</math>)</li> <li>Insertion failure: 27 % of attempts failed per capnometer (disposable sensor detected CO<sub>2</sub> in all failures)</li> </ol> <p>For attempts which failed, statistically significant associations noted in nasal (vs. oral) insertion route (<math>p = 0.03</math>), and spontaneously ventilated (vs. mechanically ventilated patients) (<math>p = 0.01</math>). No significant differences were noted in these cases in mental status or tube type.</p> <p>Limitations: Small number of attempts to determine agreement between techniques (<math>n = 5</math>).</p> <p>Small number of failures may not be a sufficient to determine contributing factors.</p> <p>Only adult-sized tubes were used — smaller tubes might prevent airflow through the tube leading to false negative.</p>	I	VI
Chau, J. P., Lo, S. H. S., Thompson, D. R., Fernandez, R., & Griffiths, R. (2011). Use of end-tidal carbon dioxide detection to determine correct placement of nasogastric tube: A meta-analysis. <i>International Journal of Nursing Studies</i> , 48, 513–521. doi:10.1016/j.ijnurstu.2010.12.004	<p>Purpose:</p> <ol style="list-style-type: none"> <li>To review the diagnostic accuracy of end-tidal carbon dioxide detection in detecting inadvertent airway intubation and verifying correct placement of NG tubes.</li> <li>System analysis of GT placement. Clinical trials that evaluated the diagnostic accuracy of the colorimetric capnometry or capnography in detecting inadvertent airway intubation and differentiating between respiratory and GI tube placement in adults were included.</li> <li>Publications that compared index tests with either radiography, direct visualization or direct endoscopic guidance, aspiration of stomach content, or auscultation of air were included. Publications that evaluated the incidence of tube placement, the ability of the index test to identify correct placement of the NG tubes, and the ability of the index test to identify respiratory placement of NG tubes were included.</li> </ol>	<p>Meta-analysis</p> <p>Sample: 8 studies included Total of 456 patients</p> <p>Setting: Inpatient, intensive care</p>	<p>Measures: Colorimetric capnometry, capnography</p> <p>Sensitivity and specificity of colorimetric and capnography</p>	<p>Findings: Sensitivity and specificity of colorimetric and capnography: The pooled results for sensitivity, specificity, positive and negative likelihood ratios were 0.99, 0.99, 57.30 and 0.05 respectively. The use of colorimetric capnometry or capnography had a sensitivity ranging from 0.88 to 1.00, specificity 0.95 to 1.00, positive likelihood ratio 15.22 to 283.35, negative likelihood ratio 0.01 to 0.25. A summary ROC curve was constructed and showed an area under the curve was 0.9959.</p> <p>Implications: These results indicate that the use of capnography or colorimetric capnometry is an effective method in differentiating between respiratory and GI tube placement for adult patients. The results also suggest that these two methods have a satisfactory agreement with the reference standard. - 7 trials.</p>	II	I

<p>Ellett, M. L. C., Cohen, M. D., Croffie, J. M. B., Lane, K. A., Austin, J. K., &amp; Perkins, S. M. (2014). Comparing bedside methods of determining placement of gastric tubes in children. <i>Journal for Specialists in Pediatric Nursing, 19</i>, 68–79. doi:10.1111/jspn.12054</p>	<p><b>Purpose:</b> To compare the predictive validity of pH, bilirubin (bili), and CO<sub>2</sub> to detect correct placement of GTs in pediatric patients.</p>	<p><b>Design:</b> Prospective comparative design – secondary analysis <b>IRB approval:</b> Yes <b>Sample:</b> N = 276, 24 weeks gestation to 212 months Convenience sample Adequate racial/ethnic diversity <b>Setting:</b> Inpatient hospital units (5 midwestern hospitals)</p>	<p><b>Measures:</b> After placement, each tube was tested using the Novamatrix capnography device until waveform stable for 1 min of CO<sub>2</sub>. Then aspirate was tested for pH (pH meter and pH paper) and presence of bili (urobilinogen test strip), and all compared to radiographic exam. <b>Appropriate statistical analysis:</b> Sensitivity, specificity, PPV, NPV for non-stomach placement for each type of measure Descriptives: pH cut off at 5 for fasting, 6 for non-fasting</p>	<p><b>Findings:</b> “Thus, if using lack of ability to obtain aspirate as an indication of misplacement, the sensitivity, specificity, PPV, and NPV would be 34.9%, 94.8%, 66.7%, and 83.1%” regarding aspirate and placement. <b>For the pH testing:</b> “The specificity was 91.9% and negative predictive value 80.9%. Using the pH cutoff of 6 recommended by Metheny et al. (2000) for the 82 fed children, the sensitivity was 2/9 (22.2%), and the positive predictive value was 2/11 (18.2%, Table 2). The specificity was 87.7% and negative predictive value 90.1%.” <b>Billirubin and CO<sub>2</sub> data not presented.</b> <b>Conclusions:</b> CO<sub>2</sub> and billirubin not sufficient data, pH effective when compared to X-ray</p>	<p>II</p>	<p>VI</p>
<p>Elpern, E. H., Killeen, K., Talla, E., Perez, G., &amp; Gurka, D. (2007). Capnometry and air insufflation for assessing initial placement of gastric tubes. <i>American Journal of Critical Care, 16</i>(6), 544–550.</p>	<p><b>Purpose:</b> 1. To compare the accuracy of capnometry and air insufflations with radiography to detect GT placement. 2. To determine the occurrence of false positives and false negatives with air insufflations and capnometry (specific to large bore tubes).</p>	<p><b>Sample:</b> N = 91 GT placements (69 patients) <b>Randomization:</b> No <b>Convenience sample:</b> Yes <b>Population:</b> Adult pts. In MICU or intermediate care unit <b>Setting:</b> Urban acute care hospital <b>IRB approval:</b> Yes</p>	<p><b>Statistical Analysis is appropriate:</b> Yes SPSS version 7.5 (e.g. Relative Risk Ratios, p value, confidence interval) <b>Instrument:</b> Salem Sump Tube(s) <b>Capnometer (Easy Cap II, Nellcor Puritan Bennett)</b></p>	<p><b>Findings:</b> No lung GT placements. Unable to document false-negatives. 16% false positives with capnometry; 5% with insufflations. <b>Limitations:</b> Convenience sample limited to adults from ICU and intermediate care of one facility. Study limited to initial placement only. Unsure of effectiveness of techniques for repeated checks of GT placement. <b>Comments:</b> Pg. 545 In discussing Metheny’s work states (without reference to a source) “... pH testing is not recommended in place of radiographic confirmation because of the difficulty of obtaining aspirates; the overlap in pH values of lung, gastric, and intestinal aspirates; and possible effects of acid-inhibiting medications on pH values.” This is a misrepresentation of Metheny’s conclusions or a different interpretation of her findings. <b>Generalizability:</b> Not generalizable – no control, randomization. Sample limited to acute, intermediate pts. <b>Relevance to practice:</b> Highly relevant <b>Feasibility:</b> Feasible, readily available, inexpensive, and easy to use equipment</p>	<p>II</p>	<p>IV</p>
<p>Gilbertson, H. R., Rogers, E. J., &amp; Ukoumunne, O. C. (2011). Determination of a practical pH cutoff level for reliable confirmation of nasogastric tube placement. <i>Journal of Parenteral &amp; Enteral Nutrition, 35</i>(4), 540–544. doi:10.1177/0148607110383285</p>	<p><b>Purpose:</b> 1. To simplify the confirmation of GT placement and assist in standardization of GT guidelines for all health services to ensure safer feeding practices for all children on GT feeds. 2. To help determine a reliable and practical pH value to confirm GT placement without increasing the risk of not identifying a misplaced GT.</p>	<p><b>Design:</b> Prospective observational study <b>IRB:</b> Approved by the Institutional Ethics Committee <b>Sample:</b> A total of 4,330 gastric aspirate samples (96% NG) were collected from 645 patients. <b>Population:</b> Pediatric inpatients older than 4 weeks receiving enteral nutrition (NG or gastrostomy) were recruited over 9 months at a tertiary pediatric hospital in Melbourne – inpatient and ICU.</p>	<p><b>Statistical analysis is appropriate:</b> Yes</p>	<p>Using pH ≤ 4 as a cutoff point was identified as impractical, with slightly more than two-thirds of NG tube-fed patients in this study meeting this criterion. <b>Results suggest that a more practical yet still conservative cutoff of pH ≤ 5 would be more appropriate. This should simplify the confirmation of NG tube placement and ensure safer feeding practices for all children on NG tube feedings.</b> <b>When pH levels are &gt; 5, further investigation via the gold standard methodology of radiographic examination is warranted.</b></p>	<p>I</p>	<p>VI</p>

<p>Kearns, P. J., &amp; Donna, C. (2001). A controlled comparison of traditional feeding tube verification methods to a bedside, electromagnetic technique. <i>Journal of Parenteral and Enteral Nutrition</i>, 25(4), 210–215. doi:10.1177/0148607101025004210</p>	<p><b>Purpose of Study:</b> To compare diagnostic test characteristics of four GT confirmation methods: auscultation, pH, visual inspection of aspirate, or electromagnetic technique.</p>	<p><b>Design:</b> Prospective, blinded, multisite trial including ward and ICU patients from four acute care hospitals</p> <p><b>Population:</b> Total of 113 patients ages 18 and older completed entire protocol. Total of 134 GT (small bore) placements in study.</p> <p><b>IRB:</b> Yes</p>	<p><b>Statistical analysis is appropriate:</b> Yes</p>	<p><b>Agreement with X-ray confirmation of placement (mean % of observations):</b> Auscultation: 84 Aspiration: 50 pH: 56 Electromagnetic: 76</p> <p>Electromagnetic and visual inspection identified 100% of GT above the diaphragm. Aspiration unsuccessful in making a determination 53% of the time. Electromagnetic device successful 90% of time.</p>	<p>I</p>	<p>II</p>
<p>Kim, H. M., So, B. H., Jeong, W. J., Choi, S. M., &amp; Park, K. N. (2012). The effectiveness of ultrasonography in verifying the placement of a nasogastric tube in patients with low consciousness at an emergency center. <i>Scandinavian Journal of Trauma Resuscitation and Emergency Medicine</i>, 20(38), 1–6. doi:10.1186/1757-7241-20-38</p>	<p><b>Purpose:</b> To compare verification of NG tube placement using auscultation, pH of gastric contents, and ultrasound (US) with chest X-ray</p>	<p><b>Design:</b> Prospective study</p> <p><b>IRB:</b> Approved by Bioethics Committee at the Catholic University of Korea</p> <p><b>Sample:</b> 47 adult patients with low consciousness who required NG tube placement</p> <p><b>Setting:</b> ED</p>	<p><b>Variables:</b> Auscultation, pH testing (litmus strip) of tube aspirate and US completed (by 2 emergency medicine specialists) in random order after tube insertion. Final confirmation of placement via CXR by emergency medicine specialist who did not perform the US.</p> <p><b>Analysis:</b> Sensitivity, specificity, PPV, NPV, Cohen's kappa coefficient reported</p>	<p><b>Findings:</b> 44 patients verified with tube in stomach, 3 tubes in esophagus. Auscultation sensitivity 100%, specificity 33.3 (tube suggested to be in stomach when really in esophagus). 3 patients incorrectly diagnosed with placement based on pH analysis due to anti-ulcer medication (2) and alkali poisoning (1). US sensitivity (86.4%), specificity(66.7%) and PPV (97.4%). US failed to verify placement in 6 patients.</p> <p><b>Implications:</b> US useful for confirming results of auscultation after GT insertion. CXR should be performed if unable to verify gastric placement via US. Authors recommended verifying first with auscultation then with US.</p>	<p>II</p>	<p>IV</p>
<p>Lin, T., Gifford, W., Yutao, L., Xiuqun, Q., Xuelian, L., Juan, W., ... Ken, C. (2017) Diagnostic accuracy of ultrasonography for detecting nasogastric tube (NGT) placement in adults: A systematic review and meta analysis. <i>International Journal of Nursing Studies</i>, 71, 80–88. doi:10.1016/j.ijnurstu.2017.03.005</p>	<p><b>Purpose:</b> To review the evidence regarding accuracy of verification of NG tube placement by ultrasonography in adults compared with X-ray.</p>	<p><b>Design:</b> Systematic review and meta-analysis of observational studies</p> <p><b>Sample:</b> Total of 5 studies involving 420 patients</p>	<p><b>Variables:</b> Forest plot used to display true positives, true negatives, false positives, and false negatives.</p> <p><b>Analysis:</b> Calculated specificity, and sensitivity with 95% confidence interval. Appropriate for design.</p>	<p><b>Findings:</b> All included studies published after 2012. Overall quality of studies good. Ultrasound was performed in two studies after testing gastric aspirates with pH paper, introducing possible bias. Pooled results: Sensitivity 0.93 (CI 0.87–0.97), specificity 0.97% (95% CI 0.23–1.00). Positive likelihood ratio 28.60 (95% CI 0.32–2527.92), negative likelihood ratio 0.07 (95% CI 0.03–0.15). Moderate between-study heterogeneity.</p> <p><b>Implications:</b> Ultrasound yields good diagnostic performance in predicting good NG tube placement; however, there is insufficient evidence to give a strong recommendation for use.</p>	<p>I</p>	<p>V</p>
<p>Metheny, N., Williams, P., Wiersema, L., Wehrle, M. A., Eisenberg, P., &amp; McSweeney, M. (1989). Effectiveness of pH measurements in predicting feeding tube placement. <i>Nursing Research</i>, 38(5), 280–285. doi:10.1097/00006199-198909000-00005</p>	<p><b>Hypothesis 1:</b> Gastric and intestinal placement of feeding tubes can be differentiated by testing pH of aspirates.</p> <p><b>Hypothesis 2:</b> Gastric and respiratory placement of newly inserted feeding tubes can be differentiated by testing pH of aspirate.</p>	<p><b>Sample:</b> 188 patients aged 2197 years from 4 acute care hospitals (94 with small bore NG feeding tubes, 87 with nasointestinal tubes)</p> <p>8Fr Dobbhoff or 10Fr Entriflex tubes, pH paper and meter</p> <p>X-ray confirmed placement</p> <p>75% of feeding tubes placed at the bedside, 25% placed under fluoroscopy</p>	<p>Gastric pH w/o H2 antagonists: 1.0 thru 4.0</p> <p>Gastric pH w H2 antagonists: 1.0 thru 5.5</p> <p>Intestinal pH 6.0 or greater</p> <p>Respiratory pH 7.0 or greater</p>	<p>Correlation between pH paper and pH meter 0.984 gastric (<math>t = -4.05</math>, <math>p &lt; 0.001</math>); 0.963 intestinal (<math>t = -4.64</math>, <math>p &lt; 0.001</math>)</p> <p>Gastric pH ranges w and w/o H2 antagonists confirmed, thus Hypothesis 1 upheld</p> <p>Hypothesis 2 not adequately tested (only 1 case of respiratory-placed tube able to be tested).</p>	<p>I</p>	<p>IV</p>
<p>Metheny, N., Reed, L., Berglund, B., &amp; Wehrle, M. A. (1994). Visual characteristics of aspirates from feeding tubes as a method for predicting tube location. <i>Nursing Research</i>, 43(5), 282–287. doi:10.1097/00006199-199409000-00005</p>	<p><b>Purpose:</b> To determine characteristics of tube placed in GI vs. respiratory tract and to determine to what extent nurses are able to judge placement based on the visual characteristics of aspirate.</p> <p><b>Significance:</b> Highly clinically significant</p> <p><b>Problem Statement:</b> None stated</p> <p><b>Research Questions:</b> None stated</p> <p><b>Hypothesis/Theoretical Framework:</b> No hypothesis tested</p>	<p><b>Design:</b> Descriptive</p> <p><b>Sample:</b> Convenience <math>N = 880</math> aspirates — 444 from stomach, 448 from intestine — conducted by 30 acute care nurses in urban hospital setting.</p>	<p><b>Variables:</b> 1. Characteristics of aspirates from GI and respiratory tract — aspirates photographed</p> <p>2. Nurses' identification of likely location based on visual characteristics — observation of photographs</p> <p><b>Analysis:</b> Appropriate level of analysis was conducted, using descriptive statistics and <math>t</math> tests</p>	<p>Nurses' ability to identify 50 gastric and intestinal aspirates improved significantly after reading a list of suggested characteristics of feeding tube aspirates (81.33–90.47%, <math>p &lt; 0.0001</math>, and 64.07–71.53%, respectively). However, nurses were often unable to identify respiratory aspirates; the accuracy of their predictions decreased after reading the list of suggested characteristics (from 56.67% to 46.11%). The appearance of aspirates is often helpful in distinguishing between gastric and intestinal placement, but is of little value in ruling out respiratory placement.</p>	<p>I</p>	<p>VI</p>

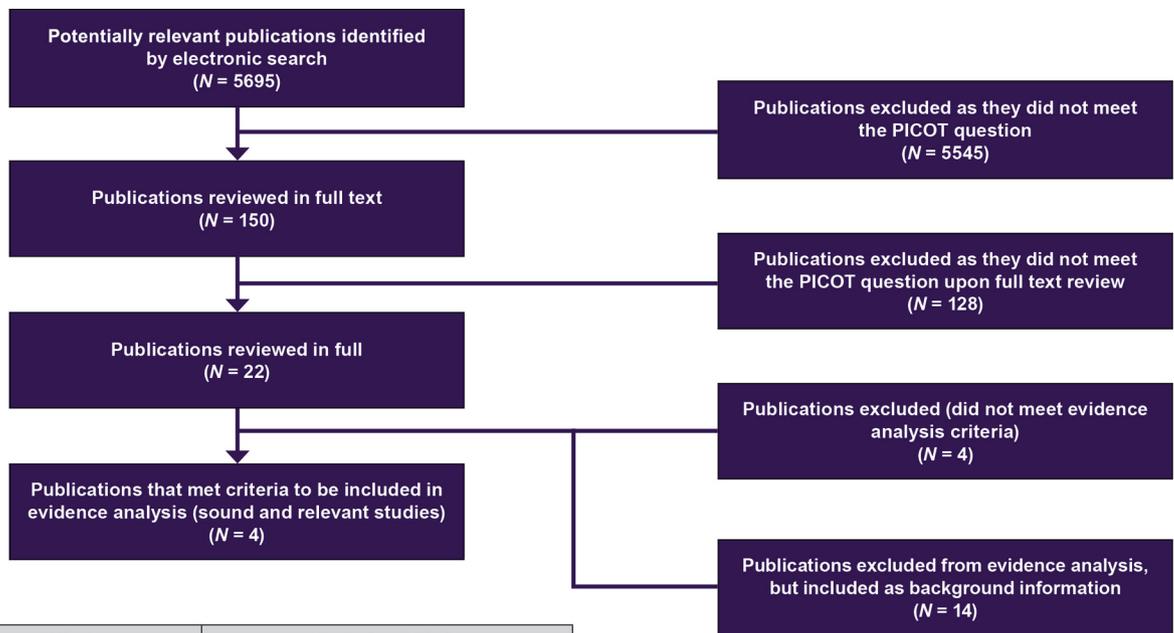
<p>Metheny, N. A., Stewart, B. J., Smith, L., Yan, H., Diebold, M., &amp; Clouse, R. E. (1997). pH and concentrations of pepsin and trypsin in feeding tube aspirates as predictors of tube placement. <i>Journal of Parenteral and Enteral Nutrition, 21</i>(5), 279–285. doi:10.1177/0148607197021005279</p>	<p>Research questions: “To describe the usual concentration of bili in aspirates from newly inserted feeding tubes and to determine the extent to which these measures can contribute to pH alone in correctly predicting feeding tube location.” Hypothesis/theoretical framework: Bili will be higher in intestinal contents than gastric and will be absent from tracheobronchial and pleural aspirate – High bili + high pH will indicate intestinal placement – No bili + high pH will indicate respiratory placement – Either no or low bili + low pH will indicate gastric placement</p>	<p>Design: Samples tested for pH and bili concurrently and within 5 min of radiograph taken to confirm tube placement. Excluded pts who received oral or tube antacids within 4 hr, other oral or tube admin. meds within 1 hr, oral or tube feeding within 4 hr, previous gastric surgery or trauma, grossly bloody samples Sample: <i>N</i> = 587 samples over 3 years NG = 209 Nasointestinal = 228 Tracheobronchial = 126 (from suctioning) Pleural = 24 (during thoracentesis) Population: Adult (14–93 years), acutely ill with newly inserted small-bore feeding tube Setting: Five acute care hospitals, urban, various inpt. units</p>	<p>Variables: Tests: pH, bilirubin Sites: Lung, gastric, intestinal Analysis: ANOVA, <math>\chi^2</math></p>	<p>Findings: Mean pH lung = 7.73 Mean pH stomach = 3.9 Mean bili lung = 0.08 Mean bili stomach = 1.28 Mean bili intestine = 12.73 pH &gt; 5 + bili &lt; 5 correctly identified all respiratory placements pH &gt; 5 + bili &gt; 5 correctly identified 75% of intestinal placements pH &lt; 5 + bili &lt; 5 identified 66%+ of gastric placements pH + bilirubin can be used to rule out respiratory placement Clinically feasible in the ED only with a valid bedside test for bilirubin</p>	<p>I</p>	<p>IV</p>
<p>Metheny, N. A., Smith, L., &amp; Stewart, B. J. (2000). Development of a reliable and valid bedside test for bilirubin and its utility for improving prediction of feeding tube location. <i>Nursing Research, 49</i>(6), 302–309. doi:10.1097/00006199-200011000-00002</p>	<p>Purpose: To test efficacy of bili test-strip compared with colorimetric scale and lab measure. Also, to determine effectiveness of pH and bili test strips in predicting feeding tube locations and determine rater agreement between nurses using the two techniques. Hypotheses: 1. Bili test strip and Vbili scale will agree with lab bili 2. Agreement between nurses using Vbili and test strip will be adequate 3. High bili associated with NI vs. NG tubes 4. Negligible or neg. bili from tracheobronchial or pleural area 5. High bili/high pH = intestinal placement 6. High pH/low bili = resp. placement. 7. Low pH/low bili = gastric placement.</p>	<p>Design: Non-experimental correlational Sample: Nonrandomized sample <i>N</i> = 631 acutely ill adults in urban acute care hospital setting</p>	<p>Variables: pH, bili via test strip, visual scale and lab, inter-nurse scoring of test strip and Vbili scale. Radiograph obtained within 5 minutes of specimen retrieval. Analysis: Appropriate for level of variables Analysis was conducted using Pearson's <i>r</i> correlation, ANOVA, and Crosstabs.</p>	<p>Findings: 1. Strong correlation between test strip, visual scale, and lab bili 2. 91% agreement on dichotomous bili level less than 5 or 5 and over 3. pH and bili combinations highly sensitive and specific for tube locations (GT, IT, lung) Limitations: Findings not applicable to pts. receiving feeds. Further testing of both the test strips and visual scale warranted before widely used. Feasibility: Highly feasible if bili test strips become commercially available.</p>	<p>I</p>	<p>VI</p>
<p>Phang, J. S., Marsh, W. A., Barlows, T. G., &amp; Schwartz, H. I. (2004). Determining feeding tube location by gastric and intestinal pH values. <i>Nutrition in Clinical Practice, 19</i>(6), 640–644. doi:10.1177/0115426504019006640</p>	<p>Purpose: To evaluate pH values of aspirates from feeding tubes to differentiate between gastric and intestinal tube placement.</p>	<p>Design: Descriptive Randomization: Yes (no control group) Sample: <i>N</i> = 82 ventilator-supported pts. Setting: Acute care hospital IRB: Yes</p>	<p>Statistical analysis is appropriate: Yes (<math>\chi^2</math>, <i>t</i> tests, descriptive statistics) Instruments: 8 fr feeding tube Hand-held pH meter Fluoroscopy</p>	<p>Findings: Although pH value was reliable predictor of GT placement, pH alone demonstrated a sufficiently low sensitivity to suggest that it should be used in combination with radiographic confirmation.</p>	<p>I</p>	<p>VI</p>
<p>Rulli, F., Galata, G., Villa, M., Maura, A., Ridolfi, C., Grande, M., &amp; Farinon, A. M. (2007). A simple indicator of correct nasogastric suction tube placement in children and adults. <i>Endoscopy, 39</i>(Suppl 1), E237–E238. doi:org/10.1055/s-2007-966613</p>	<p>Purpose: To determine the validity of flexible fiberoptic cable inserted into GT to assess correct GT placement in children and adults. Research questions: Not stated Hypothesis/theoretical framework: Not stated</p>	<p>Design: Flexible fiberoptic cable inserted into GT, transillumination of abd used to indicate correct placement. Variables: Independent variable: NA Dependent variable: NA Validity <i>N</i> = 16 Randomization: N Convenience sample: Y Population: 16 patients undergoing surgical procedures Setting: Urban acute care hospital IRB approval: N</p>	<p>Statistical analysis is appropriate: NA (e.g. relative risk ratios, <i>p</i> value, confidence interval) Instrument: 1.3 mm diameter fiberoptic cable connected to a cold light source</p>	<p>Findings: Epigastric areas of all patients were transilluminated and liquid aspirant obtained from all patients' tubes. Intraoperative confirmation was achieved in all patients. Limitations: Sample size and distribution (8 children and 8 adults all scheduled for similar operative procedures) No mention of patient size Generalizability: Not generalizable Relevance to practice: Highly relevant Feasibility: If larger-scale effectiveness studies supported the use of this technique it is feasible, assuming equipment is available and training of staff is conducted.</p>	<p>III</p>	<p>VI</p>

<p>Stock, A., Gilbertson, H., &amp; Bahl, F. E. (2008). Confirming nasogastric tube position in the emergency department: pH testing is reliable. <i>Pediatric Emergency Care, 24</i>(12), 805–809. doi:10.1097/PEC.0b013e31818eb2d1</p>	<p><b>Purpose:</b> To determine if pH is an accurate method for confirmation of GT placement in pediatric ED pts. with gastroenteritis.</p> <p><b>Research questions:</b> No explicitly stated-purpose</p> <p>Investigate if gastric aspirates can be routinely obtained after GT placement and if pH is a reliable tool in GT placement confirmation.</p>	<p><b>Design:</b> Prospective, observational study</p> <p><b>Sample:</b> Convenience <i>N</i> = 404 Not randomized</p> <p><b>Population:</b> children with or without gastroenteritis in the ED</p> <p><b>Setting:</b> Urban ED</p> <p>IRB approval: Y</p>	<p><b>Variables:</b> not manipulated</p> <p><b>Outcomes of interest:</b> Presence of aspirate and pH Vomiting within 24 hours of admission Number of GT attempts Complications GT position in pts. who received radiographs Use of sedation for GT placement Comorbid conditions</p> <p>Statistical analysis is appropriate: Confidence intervals, Wilcoxon rank sum test (e.g. relative risk ratios, <i>p</i> value, confidence interval)</p> <p><b>Instrument:</b> Case record form-data collection Chart review Radiograph review</p>	<p><b>Findings:</b> Aspirate present in most pt (&gt; 97%). Most participants had gastroenteritis. No difference in pH for gastroenteritis vs. non-gastroenteritis. Tube placement confirmed by pH alone in &gt; 84%. pH higher than 4 was associated with incorrect placement; however, all pt. did not receive radiograph for confirmation. Just over 5% required &gt; 1 insertion attempt; and there were just over 3% with minor adverse events associated with GT placement. No major adverse effects were observed.</p> <p><b>Limitations:</b> Generalizability. Not generalizable – no RCT, no sample size calculation. Single trained unblinded abstractor for chart reviews. Radiographs not obtained for confirmation in all cases – assumed in place if no respiratory distress. Variable experience in nurses inserting GT</p> <p><b>Relevance to Practice:</b> Highly relevant</p> <p><b>Feasibility:</b> pH testing at bedside is feasible and well within the scope of nurses' practice.</p>	<p>III</p>	<p>VI</p>
<p>Taylor, S. J., &amp; Clemente, R. (2005). Confirmation of nasogastric tube position by pH testing. <i>Journal of Human Nutrition and Dietetics, 18</i>(5), 371–375. doi:10.1111/j.1365-277X.2005.00635.x</p>	<p>1. What is the appropriate hospital population for assessing the pH-testing method to determine NG tube placement? Number of pts. on H2 blockers/PPI and methods of GT confirmation.</p> <p>2. How does pH testing compare using different pH strips?</p>	<p><b>Design:</b> Two-phase observational study</p> <p><b>Phase 1:</b> <i>N</i> = 52 patients (1-day survey of all pts requiring NG and NI feeding within a geographic area)</p> <p><b>Phase 2:</b> 6 types of pH strips, number of testers unknown</p> <p><b>Sample:</b> Randomization: No Convenience: Yes</p> <p><b>Population:</b> ICU and ward pts., ages not stated</p> <p><b>Setting:</b> Urban acute care hospital, Bristol, UK</p>	<p>IV = Phase 1: PPI and H2 blocker usage; IV = Phase 2: pH color and numeric test strips DV = NG tube placement verification</p>	<p><b>Findings:</b> pH strips more reliable than litmus paper; pH strip testing unreliable in 29% of patients with NG tubes receiving PPI or H2 blocker</p> <p><b>Limitations:</b> feeding tube placement; observational study, unknown tester sample</p> <p><b>Comments:</b> Limitations of pH test strips for pts. receiving PPI or H2 blocker. If patients could swallow, they were given acidic drinks and then pH tested. This increased the population in which pH testing was possible from 58% to 71%.</p>	<p>I</p>	<p>VI</p>
<p>Tobin, R. W., Gonzales, A. J., Golden, R. N., Brown, M. C., &amp; Silverstein, F. E. (2000). Magnetic detection to position of human nasogastric tubes. <i>Biomedical Instrumentation and Technology, 34</i>(6), 432–436.</p>	<p><b>Purpose:</b> To evaluate a prototype magnetic system to determine proper tube location and compare it to fluoroscopy.</p>	<p><b>Design:</b> Commercial feeding tubes modified by substituting magnets for the tungsten weights</p> <p>Prototype magnetic detectors determined real-time location, orientation, and depth of distal end of the tube. Fluoroscopy used to confirm tube location below the diaphragm.</p> <p><b>Sample:</b> <i>N</i> = 88 tube placements in 22 volunteer subjects aged 18–75</p> <p><b>Setting:</b> Research laboratory</p>	<p>Descriptive data with no statistical analysis</p>	<p><b>Findings:</b> All placements were determined to be below the diaphragm by magnetic localization and confirmed by fluoroscopy</p> <p><b>Limitation:</b> No respiratory placements were evaluated</p> <p><b>Feasibility:</b> Commercial product does not exist; currently not feasible in the clinical setting</p>	<p>I</p>	<p>VI</p>

**Appendix 2. Other Resources Table**

Reference	Research Purpose	Conclusions
American Association of Critical-Care Nurses (2016). Initial and ongoing verification of feeding tube placement in adults. <i>Critical Care Nurse</i> , 36(2), e8–e13. doi:10.4037/ccn2016141	AACN practice alert citing best practices and EBP.	This article reviews current recommendations for initial and ongoing feeding tube verification in adults. Recommend using a minimum of 2 bedside techniques to assess placement during insertion and can use these bedside techniques to determine if radiography needed.
Atalay, Y. O., Aydin, R., Ertugrul, O., Gul S. B., Polat, A. V., & Pasku, M. S., (2016). Does bedside sonography effectively identify nasogastric tube placements in pediatric critical care patients? <i>Nutrition in Clinical Practice</i> , 31(6), 805–809. doi:10.1177/0884533616639401	Evaluate efficiency of US related to placement verification and comparison with X-ray.	Sensitivity 100% with US and X-ray with no misplaced NG tube. Initial confirmation via auscultation, then X-ray performed followed by US completed by physician.
Cincinnati Children's (2011). Patient services NGT/OGT placement confirmation Best Evidence Statement (BEST). Retrieved from <a href="https://www.cincinnatichildrens.org/-/media/cincinnati%20childrens/home/service/janderson-center/evidence-based-care/recommendations/type/confirmation%20of%20nasogastric%20tube%20ngt%20placement">https://www.cincinnatichildrens.org/-/media/cincinnati%20childrens/home/service/janderson-center/evidence-based-care/recommendations/type/confirmation%20of%20nasogastric%20tube%20ngt%20placement</a>	Guideline looking at best evidence for confirmation of placement; best evidence for predicting tube placement length.	1. Radiological verification is primary recommendation for GT placement for children who are high risk to prevent aspiration. Non-radiologic verification can be used for pediatric patients not high risk for aspiration. 2. Recommend pH of less than 5 for gastric aspirate. 3. Tube length can be predicted for children > 2 wks. of age using the height-taped (Broslow-type) method rather than the nose-ear-xiphoid method. Nose-ear-mid-umbilicus method preferable for tube length prediction over nose-ear-xiphoid method.

## Appendix 3. Study Selection Flow Chart and Inclusion/Exclusion Criteria



Inclusion Criteria	Exclusion Criteria
Studies published in English	Studies not published in English
Studies involving human subjects	Non-human studies
January 2013 - December 2016	Studies not in the timeframe listed
Studies addressing the PICOT question	Studies not addressing the PICOT questions

The following databases were searched: PubMed, Ovid, Medline Plus, CINAHL, Cochrane - British Medical Journal, Agency for Healthcare Research and Quality (AHRQ; [www.ahrq.gov](http://www.ahrq.gov)), and the National Guideline Clearinghouse ([www.guidelines.gov](http://www.guidelines.gov)).

Search terms included: nasogastric tubes, tube placement determination, gastric tubes, gastric tube placement, gastric tube placement confirmation, nasogastric catheters and tubes, and ultrasound.

## Synopsis

### CLINICAL QUESTION:

In patients having gastric tubes inserted in the emergency department setting, which bedside technique is best for confirmation of accurate placement immediately after tube insertion compared to radiograph?

### PROBLEM:

Gastric tube (GT) placement is a common bedside procedure performed by registered nurses in the emergency department (ED). Although often considered an innocuous procedure, incorrect GT placement can result in serious and even lethal complications such as respiratory distress or death. The standard of care requires verification of the GT placement prior to its use to minimize complications resulting from incorrect placement. Radiographic verification is the preferred method of confirmation (Leschke, 2003) and is considered by many to be the gold standard (Anderson et al., 2016; Ellett, 2004; Ellett et al., 2014; Elpern, Killeen, Talla, Perez, & Gurka, 2007; Kearns & Donna, 2001). However, bedside methods are commonly used as a proxy for radiographic verification when large bore GTs are inserted due to the associated cost, time delay, and radiation exposure. In addition, a radiographic test cannot be performed by the bedside nurse. It has been well documented for almost 20 years that a common bedside method (auscultation) is often inaccurate; however, it is still widely practiced (Metheny, Stewart, & Mills, 2012). This Clinical Practice Guideline (CPG) aims to evaluate various bedside gastric tube placement verification methods as an alternative to radiography.

Description of Decision Options/Interventions and the Level of Recommendation		
VERIFICATION METHODS	Radiographic examination (X-ray or CT scan) remains the gold standard for verifying gastric tube placement prior to instillation of any substance (Ellett, et al., 2014; Elpern, Killeen, Talla, Perez, & Gurka, 2007; Kearns & Donna, 2001; Phang, Marsh, Barlows, and Schwartz, 2004).	A
	There is moderate evidence to support the use of pH testing of gastric tube aspirates as a component of multiple-method bedside verification for gastric tube placement (Christensen 2001; Ellett et al., 2014; Gilbertson, 2011; Metheny et al., 1989; Metheny, Reed, Berglund & Wehrle, 1994; Metheny et al., 1997; Metheny, Smith & Stewart, 2000; Phang et al., 2004; Stock et al., 2008; Taylor & Clemente, 2005).	B
	Bedside ultrasound guidance is supported by the literature (Kim et al., 2012; Lin et al., 2017).	B
	There is some evidence to support the use of carbon dioxide detection for bedside verification of gastric tube placement (Anderson et al., 2016; Burns et al., 2006; Chau et al., 2011).	C
	There is some evidence to support the use of gastric lipase testing for bedside verification of gastric tube placement if this product becomes commercially available (Anderson et al., 2016).	C
	Use of auscultation as a single verification method is unreliable in determining gastric tube placement (Christensen, 2001; Kearns and Donna, 2001; Metheny & Titler, 2001).	N/R
	Use of transillumination and magnetic detection requires equipment that may be difficult to obtain and its use as a single bedside verification method for gastric tube placement requires further study (Kearns and Donna, 2001; Rulli et al., 2007; Tobin, Gonzales, Golden, Brown & Silverstein, 2000).	I/E

Level A (High)	Based on consistent and good quality of evidence; has relevance and applicability to emergency nursing practice.
Level B (Moderate)	There are some minor inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice.
Level C (Weak)	There is limited or low-quality patient-oriented evidence; has relevance and applicability to emergency nursing practice.
N/R	Not recommended based upon current evidence.
I/E	Insufficient evidence upon which to make a recommendation.
N/E	No evidence upon which to make a recommendation.

ENA Clinical Practice Guidelines (CPGs) are evidence-based documents that facilitate the application of current evidence into everyday emergency nursing practice. CPGs contain recommendations based on a systematic review and critical analysis of the literature about a clinical question. CPGs are created following the rigorous process described in ENA's Requirements for the Development of Clinical Practice Guidelines. The purpose of CPGs is to positively impact patient care in emergency nursing by bridging the gap between practice and currently available evidence.

Access the full CPG at: [www.jenonline.org](http://www.jenonline.org)

## Authors

### ENA Clinical Practice Guideline Committee

Marylou Killian, DNP, MS, RN, CEN, FNP-BC (2017)  
Nancy Erin Reeve, MSN, RN, CEN (2017)  
Andie Slivinski, DNP, RN, ACNS-BC, CEN (2017-2018)  
Judith Young Bradford, DNS, RN, FAEN, *Chairperson* (2017-2018)  
Annie Horigan, PhD, RN, *Chairperson-elect* (2017-2018)  
Susan Barnason, PhD, RN, APRN, CNS, CS, CEN, CCRN, FAEN, FAAN (2018)  
Andi Foley, DNP, RN, CEN, ACCNS-AG (2018)  
Mindi Johnson, DNP, RN, CPN (2017)  
Janet Kaiser, MSN, BSN, RN, CEN (2018)  
Robin MacPherson-Dias, MS, BSN, RN, CEN, CCRN, TCRN (2018)  
Jean A. Proehl, MN, RN, CEN, CPEN, TCRN, FAEN, FAAN (2018)  
Stephen J. Stapleton, PhD, MSN, MS, RN, CEN, FAEN (2017-2018)  
Anna Maria Valdez, PhD, MSN, RN, CEN, CFRN, CNE, FAEN (2017)  
Mary Alice Vanhoy, MSN, RN, CEN, CPEN, NREMT-P, FAEN (2017-2018)  
Mary Ellen Zaleski, DNP, RN, CEN (2017)

### ENA Board of Directors Liaisons:

Gordon Gillespie, PhD, DNP, RN, CEN, CPEN, CNE, PHCNS-BC, FAEN, FAAN (2018)  
Jean A. Proehl, MN, RN, CEN, CPEN, TCRN, FAEN, FAAN (2017)

### Methodologist:

Jessica Bishop-Royse, PhD, MS (2017-2018)

### Staff Liaisons:

Lisa Wolf, PhD, RN, CEN, FAEN, *Director, Institute of Emergency Nursing Research (IENR)* (2017)  
Altair Delao, MPH, *Senior Associate, IENR* (2017-2018)

### Administrative Staff:

Leslie Gates, *Sr. Administrative Assistant, IENR* (2017-2018)

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2010 ENA Emergency Nursing Resources Committee

2015 ENA Clinical Practice Guidelines Committee

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Michael D. Moon, PhD, MSN, RN, CNS-CC, CEN, FAEN, Chairperson

Paul R. Clark, PhD, MA, RN

Warren Frankenberger, PhD, MSN, RN, CCNS

Kathleen E. Zavotsky, PhD, RN, ACNS-BC, CEN, CCRN, FAEN

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