



CLINICAL PRACTICE GUIDELINE:

Gastric Tube Placement Verification

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?

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Background/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, gastric tube misplacement can result in serious and even lethal complications such as respiratory distress or death. The standard of care requires placement verification of the gastric tube prior to its use in order to minimize complications resulting from misplacement. Radiographic verification is considered the preferred method of confirmation (Leschke, 2004) and is considered the “gold standard” by many, especially for feeding tubes (Araujo-Preza, Melhado, Gutierrez, Maniatis, & Castellano, 2002; Ellet, 2004; 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 (Metheny, Stewart, & Mills, 2012); however, it is still widely practiced. This Clinical Practice Guideline (CPG) aims to evaluate various bedside gastric tube placement verification methods as an alternative to radiography.

Methodology

This CPG was created based on a thorough review and critical analysis of the literature following [ENA's Requirements for the Development of Clinical Practice Guidelines](#). Via a comprehensive literature search, all articles relevant to the topic were identified. The following databases were searched: PubMed, eTBLAST, CINAHL, Cochrane - British Medical Journal, Agency for Healthcare Research and Quality, and the National Guideline Clearinghouse. Searches were conducted using the search terms of: nasogastric tubes, tube placement determination, gastric tubes, gastric tube placement confirmation, gastric tube placement, and nasogastric tubes + catheters and tubes. Initial searches were limited to English language articles on human subjects from 2005 – October, 2010 and 2010 - 2014. This five year search limit was found to be inadequate so the time frame was expanded to 1994 and a specific search was performed for Metheny's publications because of the seminal nature of her work. In addition, the reference lists in the selected articles were scanned for pertinent research findings. Research articles from emergency department settings, non-ED settings, position statements and guidelines from other sources were also reviewed. Clinical findings and levels of recommendations regarding patient management were made by the Clinical Practice Guideline Committee according to ENA's classification of levels of recommendation for practice ([Table 1](#)). The articles reviewed to formulate the recommendations in this CPG are described in [Appendix 1](#).

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Table 1. Levels of Recommendation for Practice

Level A recommendations: High
<ul style="list-style-type: none"> • Reflects a high degree of clinical certainty • Based on availability of high quality level I, II and/or III evidence available using Melnyk & Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2005) • Based on consistent and good quality evidence; has relevance and applicability to emergency nursing practice • Is beneficial
Level B recommendations: Moderate
<ul style="list-style-type: none"> • Reflects moderate clinical certainty • Based on availability of Level III and/or Level IV and V evidence using Melnyk & Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2005) • There are some minor or inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice • Is likely to be beneficial
Level C recommendations: Weak
<ul style="list-style-type: none"> • Level V, VI and/or VII evidence available using Melnyk & Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2005) - Based on consensus, usual practice, evidence, case series for studies of treatment or screening, anecdotal evidence and/or opinion • There is limited or low quality patient-oriented evidence; has relevance and applicability to emergency nursing practice • Has limited or unknown effectiveness
Not recommended for practice
<ul style="list-style-type: none"> • No objective evidence or only anecdotal evidence available; or the supportive evidence is from poorly controlled or uncontrolled studies • Other indications for not recommending evidence for practice may include: <ul style="list-style-type: none"> ◦ Conflicting evidence ◦ Harmfulness has been demonstrated ◦ Cost or burden necessary for intervention exceeds anticipated benefit ◦ Does not have relevance or applicability to emergency nursing practice • 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"> ◦ Heterogeneity of results ◦ Uncertainty about effect magnitude and consequences, ◦ Strength of prior beliefs ◦ Publication bias

Summary of Literature Review

Gastric Tubes

Gastric tubes (GT) may be inserted nasally, i.e. nasogastric tubes, or orally, i.e. orogastric tubes. Regardless of the insertion route all are GTs so this term will be used throughout the document. The main reasons for inserting a GT in the emergency department are to decompress the stomach and remove stomach contents; to prevent aspiration and minimize nausea/vomiting; or to instill liquids or medications (Christensen, 2001). Two categories, large and small bore gastric tubes have been designed to meet these treatment needs. For example, large bore GTs are considered for short term use and aid in the removal of stomach contents and the instillation of liquids or medications. In contrast, small bore GTs, also known as feeding tubes, remain in place for a longer period of time and are reserved for the instillation of enteral nutrition, liquids and medications. Thus, large bore GTs, not feeding tubes, are typically inserted in the emergency department.

Treatment needs guide the decision about the location of the tip of the gastric tube. A large bore gastric tube is inserted via the nose or mouth and guided into the stomach. Whereas, a small bore gastric tube is advanced through the stomach into the small intestine. Because anatomical changes associated with growth and development occur; patient age and size are also considered when determining the depth of insertion and size of the gastric tube selected (Cincinnati Guidelines, 2009).

Although most studies of gastric tube bedside verification methods focus on small bore feeding tubes; the limited numbers of studies conducted in emergency department settings using large bore gastric tubes 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, and magnetic detection; aspirate methods are visual characteristics, pH, bilirubin, and enzyme tests.

Non-Aspirate Methods

Auscultation

The auscultatory method involves instillation of air into the tube while simultaneously listening with a stethoscope for a sound of air over the epigastric region. Auscultation alone continues to be used by nurses currently caring for neonates (Cincinnati Guidelines, 2009), pediatric patients (de Boer, 2009) and adults (Metheny, 2012) despite its proven unreliability as a single verification method (Ellett, 2005; Metheny, 1994; Neuman, 1995; Metheny, 1999; Yardley & Donaldson, 2010). Results from a 2006 on-line survey of 1,600 nurses indicated that 65% used the auscultation verification method most of the time (Nursing, 2006). Guidelines published by Cincinnati Children's Hospital (2009) reported only 60-80% reliability with auscultation as a single verification method. An American Association of Critical Care Nurses (AACN) practice alert in 2007 suggested abandoning the auscultatory method for gastric tube placement verification due to its unreliability. Thus, pursuit of a reliable, valid, bedside verification method for gastric tube placement has led researchers to investigate methods other than auscultation.

Carbon Dioxide Detection Monitoring

Misplacement of the gastric tube into the pulmonary system warrants immediate and accurate detection. Studies using CO₂ detection methods (CO₂ monitoring/capnography) were conducted to identify a method that detects gastric tube misplacement (Burns et al., 2006; Elpern et al., 2007). Burns and colleagues (2006) reported 100% agreement between colorimetry and capnography in the identification of CO₂ when the gastric tube was placed inside an endotracheal tube (in situ). Further, 130 adult medical intensive care unit patients underwent large bore GT placement and insertion failure or GT misplacement, was correctly identified by capnography, in 52 patients (a rate of 27%) (Burns, et al. 2006). Gastric tube insertion failures were associated with nasal insertion route ($p = 0.03$) and among spontaneously breathing/non-intubated patients ($p = 0.01$). The small number of misplaced GTs limits the generalizability of the study results.

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 (Elpern, 2006). Elpern and colleagues reported a 100% success

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rate in placing the GT into the stomach. However, when compared with abdominal radiographs, 16% of correctly placed GTs via capnography were false positives (indicated to be in the pulmonary track but actually in the GI tract) and there were 5% false positive results with air insufflation/auscultation (Elpern, 2007). While a false positive reading does not immediately jeopardize patient safety, it does require the use of additional verification methods to ensure tube location. Study limitations included sample size, adult-only study population, and false positive readings.

Further research is needed to determine the role of carbon dioxide detection in GT placement. Carbon dioxide detection and monitoring equipment is commonly found in the emergency department because of its use with endotracheal intubation and sedation, however its use with GT placement in the emergency department remains under studied. Interestingly, two GT verification algorithms (Cincinnati, 2009; Metheny, 2001) do not include the carbon dioxide detection method. Instead, both of these algorithms suggest the nurse listen for air movement and/or observe for respiratory distress signs and symptoms to detect the misplacement of the GT. Chau and colleagues (2011) conducted a meta-analysis of eight studies to determine if the use of capnometry to detect if GT placement was accurate. These authors concluded that in adult patients, there is evidence to support the use of capnography or colometric capnography for detection of proper gastric tube placement. They concluded that carbon dioxide detection was an effective method for differentiating tube placement between gastric and pulmonary systems.

Transillumination and Magnetic Detection

Research has also been conducted to determine the feasibility of using transillumination or magnetic detection for GT placement verification. One study utilized a fiberoptic method for GT placement verification (Rulli, 2007). A flexible fiberoptic 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 detect position of GT in 88 volunteer subjects, aged 18-75 years (Tobin, 2000). A commercial feeding tube was modified to substitute a magnet for the tungsten weights in the tip of the GT. Prototype magnet detectors determined real-time GT location, orientation and depth of distal end of the feeding tube. Gastric tubes were determined, by fluoroscopy, to be below the diaphragm 100% of the time. A prospective blinded trial of 134 patients compared four GT verification methods: electromagnetic technique, auscultation, aspiration and pH (Kearns & Donna, 2001). Electromagnetic and aspiration method identified tubes above the diaphragm. Electromagnetic method successfully identified GT placement 90% of the time compared to 53% successful placement using aspiration. Several study limitations included lack of commercially available equipment for both GT and magnetic field detector, laboratory setting, and lack of testing of misplacement of GT in the pulmonary system.

Ultrasound

Ultrasound is clinically feasible because many EDs now have bedside ultrasound units, but research is necessary to validate this method for large-bore GTs in the ED setting. There are limited data emerging regarding the use of ultrasound for confirmation of gastric and feeding tube placement in adults (Nikandros, Skampas, Theodorakopoulou, Ioannidou, Theotokas, & Armaganidis, 2006; Vigneau, Baudel, Guidet, Offenstadt, & Maury, 2005). While this technique looks promising for verification of feeding tube placement, there are no data on the use of this verification method for large bore GTs in the ED setting.

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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 involved differentiating appearance of the aspirate obtained from the stomach, small intestine, and lung contents. Metheny and colleagues (1994) reported that critical care nurses were able to differentiate between gastric and intestinal aspirate appearances 90.47% of the time ($p < 0.01$); yet were unable to distinguish between gastric and pulmonary aspirate. Reliable verification methods are needed to determine tube misplacement into the pulmonary system since this is the most common and potentially lethal site for misplacement.

Several studies investigated the biochemical markers of pH, bilirubin, pepsin, and trypsin for GT placement (Cincinnati, 2009; Ellett, 2005; Kearns & Donna 2001; Metheny, 1989, 1994, 1997, 1999; Metheny & Titler, 2001; Phang, Marsh, Barlows, & Schwartz, 2004; Stock, Gilbertson & Babl, 2008; Taylor & Clemente, 2005). Small bore feeding tubes were utilized in all studies. A combination of small bore feeding tubes and large bore GT for decompression were utilized in the Stock, Gilbertson, & Babl, 2008 study and the Cincinnati guidelines, which address large bore tubes. In addition, study populations often included patients receiving acid inhibiting medications.

Biochemical marker threshold values varied among the studies ranging from a gastric pH value of less than 3.9 to 7 and bilirubin less than 5 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, 2000), compared to bilirubin test reliability of 91% (Metheny, 1999), pepsin enzyme reliability of 91.2% and trypsin enzyme reliability of 91.8% (Metheny, Stewart, Smith, & Yan, 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 and colleagues (2014) prospectively compared the predictive validity of pH, bilirubin and carbon dioxide to detect correct placement of gastric tubes in 276 children aged 24 weeks to 212 months; all patients had radiographic exams as well. The authors found that measuring pH, bilirubin, and CO₂ of tube aspirate was not as helpful in determining a misplaced gastric tube. Instead, the authors concluded that the best predictor of a misplaced gastric tube, was the inability to obtain tube aspirate.

Research in 2000 by Metheny and colleagues, reported the combined test results of pH greater than 5 and bilirubin less than 5 successfully identified 98.6% of the 141 cases as gastric placement. Laboratory-based testing of bilirubin, pepsin and trypsin, limit their use as bedside point of care methods. There is limited information using urine bilirubin test strips for the purpose of bedside verification (Metheny, Stewart, Smith, & Yan, 2000) while bedside testing of gastrointestinal enzymes awaits development.

Gilbertson and colleagues (2011) conducted a prospective observational study where they sought to determine a reliable and practical pH value to confirm gastric tube 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 < 5 would simplify the confirmation of gastric tubes and that when pH was > 5 , further investigation with radiographic examination, the gold standard, was needed.

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Combined Non-Aspirate and Aspirate Methods

Algorithmic Approach

The rate of GT placement accuracy increases when combining non-radiological verification methods rather than reliance on a single bedside verification method (Cincinnati, 2009; Metheny, 2001). Metheny (2001) recommends an algorithm for GT placement verification. Metheny's algorithm for newly inserted large-bore GT begins with auscultation followed by pH and visual inspection of aspirate. The Cincinnati guidelines (2009) also use an algorithm consisting of non-aspirate and aspirate verification methods of auscultation, visual, and pH testing. Study results indicated GT placement achieved a probable accuracy of 97-99% when using auscultation, visual aspirate inspection, and aspirate pH testing (Cincinnati, 2009). There is evidence to support use of a combination of methods of bedside verification for GT placement; however 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 Level of Recommendation

Conclusion and recommendations about initial GT placement bedside verification methods in the emergency department:

1. Radiographic examination (x-ray or CT scan) remains the gold standard for verifying gastric tube placement prior to instillation of any substance. **Level A: High** (Cincinnati Children's Hospital Medical Center, 2009; Ellett, et. al., 2014; Cincinnati Children's Hospital Medical Center, 2009; Fernandez, et. al., 2010; Jones, et. al., Kunis, et. al., 2007; 2003; Phang, et. al., 2001)
2. Use of pH testing of GT aspirates as a component of a multiple method bedside verification for GT placement is supported by the literature. **Level B: Moderate** (Christensen, et. al., 2001; Ellett, et. al., 2014; Ellett, 2004; Phang, et. al., 2001; Stock, et. al. 2008; Tho, et. al., 2006)
3. There is some evidence to support the use of carbon dioxide detection for bedside verification of GT placement. **Level C: Weak** (Burns, et. al., 2006; Cincinnati Children's Hospital Medical Center, 2009; Ellett, et. al., 2014; Elpern, et. al., 2007)
4. Use of auscultation as a single verification method is unreliable in determining GT placement. **Not recommended** (Christensen et. al., 2001; Cincinnati Children's Hospital Medical Center, 2009; Jones, et. al., 2003; Kearns, et. al., 2001; Metheny, et. al., 2001)
5. Use of transillumination and magnetic detection requires equipment that may be difficult to obtain and its use as a single bedside verification method for GT placement requires further study. Level I/E: **Insufficient Evidence** (Kearns, et. al., 2001; Rulli, et. al., 2007)

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Appendix I: Evidence Table

Reference	Purpose/Hypothesis	Design/Sample Setting	Variables/Measures Analysis	Findings/Implications	Quality of Evidence	Level of Evidence
Burns, S. M., Carpenter, R., Blevins, C., Bragg, S., Marshall, M., Browne, L., Perkins, M., Bagby, R., Blackstone, K., & Truwit, 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><u>Purpose:</u> 1. Compare accuracy of colorimetry vs. capnography in determining GT placement in lung, and 2. Describe variables that correlate with inadvertent GT airway intubation</p> <p><u>Hypotheses:</u> 1. Colorimetric CO detector will indicate the presence of CO₂ as accurately as capnography does. 2. Variables that will correlate with inadvertent GT intubation of lungs include mental status, insertion route, tube type, ETT intubation vs. tracheostomy, mechanical ventilation.</p>	<p><u>Design:</u> Non-experimental. N = 52 misplaced tubes out of 195 GT insertions (130 patients). Non-randomized convenience sample.</p> <p><u>Population:</u> Adult MICU patients.</p> <p><u>Setting:</u> Urban Acute Care Hospital. IRB-approved.</p>	<p>Appropriate statistical analysis: descriptive statistics and Pearson X²</p> <p><u>Instrument:</u></p> <ol style="list-style-type: none"> 1. Portable capnograph (Novamatrix Model 610) 2. Colorimetric Indicators (Pedi-Cap) 3. Soft bore tube, size 12 F (Tyco Healthcare/Kendall) 4. Salem sump tube (Bard Medical), size 14F-16F. 	<p><u>Findings:</u> Hypothesis</p> <ol style="list-style-type: none"> 1. 100% agreement between colorimetry and capnography in identifying CO₂ when the tube was inserted into an endotracheal tube in situ (n = 5) 2. Insertion failure: 27 % of attempts failed per capnometer (disposable sensor detected CO₂ in all failures). For attempts which failed, associations noted in nasal (vs. oral) insertion route (p=0.03), and spontaneously breathing (vs. mechanically ventilated patients) (p=0.01). No significant differences were noted in these cases in mental status or tube type. <p><u>Limitations:</u> Small number of attempts to determine agreement between techniques (n = 5). Small number of failures may not be a sufficient number to determine contributing factors. Only adult sized tubes were used – smaller tubes might prevent airflow through the tube leading to false negative.</p>	I	VI

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Appendix I: Evidence Table

Reference	Purpose/Hypothesis	Design/Sample Setting	Variables/Measures Analysis	Findings/Implications	Quality of Evidence	Level of Evidence
Chau, J.P.C., 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.	<p><u>Purpose of Study:</u></p> <p>1. To review the diagnostic accuracy of end-tidal carbon dioxide detection in detecting inadvertent airway intubation and verifying correct placement of nasogastric tubes. 2. 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. 3. Publications that compared index tests with either radiography, direct visualization or under 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, the ability of the index test to identify respiratory placement of NG tubes were included.</p>	<p>Meta-Analysis</p> <p>IRB Approved</p> <p><u>Sample:</u> 8 studies included. Total of 456 patients.</p> <p><u>Setting:</u> Inpatient, intensive care.</p>	<p><u>Measures:</u> Colorimetric capnometry, capnography, Sensitivity and specificity of colorimetric and capnography.</p>	<p><u>Findings:</u> “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, and 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><u>Implications:</u> Results indicate 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

CLINICAL PRACTICE GUIDELINE:

Gastric Tube Placement Verification

Appendix I: Evidence Table

Reference	Purpose/Hypothesis	Design/Sample Setting	Variables/Measures Analysis	Findings/Implications	Quality of Evidence	Level of Evidence
Cincinnati Children's Hospital Medical Center. (2009, April 27). <i>Best evidence statement (BESt): Confirmation of nasogastric tube placement in pediatric patients</i> . Retrieved from: www.guidelines.gov	<p>"To provide recommendations for the prediction of nasogastric tube (NGT) length and confirmation of NGT placement."</p> <p>In pediatric and adolescent patients who require an NGT,</p> <ol style="list-style-type: none"> 1) Are multiple non-radiological verification methods (auscultation and aspiration methods) compared to radiological verification methods, as accurate in confirming NGT placement? 2) Are gastric aspirates, obtained under clinical conditions (i.e. patients who are fed or fasting, on or off acid-suppression medication), with a pH<6, compared to a pH<5, more accurate in confirming NGT placement? 3) Are tube length predictions using age-related height-based (ARHB) methods, compared to nose-ear-xiphoid (NEX) morphological measurements, more accurate in predicting NGT length?" 	<p><u>Best evidence statement:</u></p> <p>"Neonatal, pediatric, and adolescent patients who require NGT for feeding or gastric decompression."</p> <p>No differentiation between small bore and large bore tubes.</p> <p>Pediatric acute care hospital</p>	Length of tube Verification methods for placement of tube	<p>1) Strongly recommended that NG tube length be predicted as follows: a.) In patients ≤ 8 years 4 months of age, use age-related height-based methods. b.) In neonates, patients >8 years 4 months of age, patients with short stature, or if unable to obtain an accurate height, use morphological measurements. Morphological measurements frequently under-predict tube length. The most accurate morphological measures include nose-ear-mid-xiphoid-umbilicus predictions for patients >8 years 4 months of age, those with short stature or if unable to obtain an accurate height. For neonates the evidence is limited for best morphological measurement. 2) Strongly recommended that multiple non-radiological verification methods be used to confirm placement of an NGT in neonatal, pediatric and adolescent patients. Methods include: a.) Gastric auscultation: Auscultation as a verification method is 60%-80% reliable. b.) Aspirate pH testing: Use an aspirate pH<6 to confirm NGT placement for neonatal, pediatric and adolescent patients, when obtained under clinical conditions that include fed or fasting patients and those on and off acid-suppression medications. c.) Visual inspection of aspirate: Visual inspection is less accurate than pH to confirm placement. Use in addition to testing aspirate pH. Aspirate colors are specific to the intended placement location. d.) Aspirate testing of enzyme levels for bilirubin, pepsin and trypsin: highly accurate but limited to laboratory assessment. e.) CO2 monitoring: CO2 monitoring is another reliable method but requires a capnograph monitor and is used to determine incorrect tube placement in the respiratory tract. When aspirate and non-aspirate verification methods are used in combination to confirm NGT placement, the post-test probability for accuracy increases to 97-99%, approaching the radiological gold standard of 99%</p> <p>3) Strongly recommended that radiological verification is used when non-radiological methods are conflicting or patients are considered high risk which includes: a.) Patients in pediatric and cardiac intensive care units. b.) Patients exhibiting an altered level of consciousness. c.) Patients with swallowing problems</p>	I	V

CLINICAL PRACTICE GUIDELINE:

Gastric Tube Placement Verification

Appendix I: Evidence Table

Reference	Purpose/Hypothesis	Design/Sample Setting	Variables/Measures Analysis	Findings/Implications	Quality of Evidence	Level of Evidence
Ellett, M.L.C., Cohen, M.D., Croffie, J.M.B., Lane, K.A., Austin, J.K. & Perkins, S.M. (2014). Comparing bedside method of determining placement of gastric tubes in children. <i>Journal for Specialists in Pediatric Nursing</i> , 19, 68-79. doi: 10.1111/jspn.12054	<u>Purpose of Study:</u> Compare the predictive validity of pH, bilirubin and CO2 to detect correct placement of gastric tube in pediatric patients.	<u>Design:</u> prospective comparative design- secondary analysis IRB Approved <u>Sample:</u> N= 276, 24 weeks gestation to 212 months. Convenience sample. Adequate ethnic diversity. <u>Setting:</u> Inpatient units (5 Midwestern hospitals)	<u>Measures:</u> After placement each tube was tested until waveform stable for 1 min of CO2 using the Novametric capnography device. Then aspirate was tested for pH (pH meter and pH paper) and presence of bilirubin (urobilinogen test strip) and all compared to radiographic exam. <u>Appropriate Statistical Analysis:</u> Sensitivity, specificity, PPV, NPV: for non-stomach placement for each type of measure. Descriptives: pH cut off at 5 for fasting, 6 non-fasting	<u>Findings:</u> “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%.” regards to aspirate and placement. For the pH testing: “The specificity was 91.9% and negative predictive value 80.9%. Using Metheny et al (2000) recommended pH cutoff of 6 for the 82 fed children, the sensitivity was 2/9 (22.2%), and the positive predictive value was 2/11 (18.2%). The specificity was 87.7% and negative predictive value 90.1%.” Bilirubin: data not presented. CO2: data not presented. Conclusions: CO2 and bilirubin not sufficient data, pH yes- and compared to x-ray.	II	VI
Elpern, E. H., Killeen, K., Talla, E., Perez, G., & Gurka, D. (2007). Capnometry and air insufflation for assessing initial placement of gastric tubes. <i>American Journal of Critical Care</i> , 16(6), 544-549.	1. Compare accuracy of capnometry and air insufflations with radiography to detect GT placement 2. Determine occurrence of false positives and false negatives with air insufflations and capnometry (specific to large bore tubes)	N = 91 GT placements (69 patients) Non-randomized convenience sample of adult pts. in MICU or intermediate care unit of an urban acute care hospital IRB-approved.	<u>Appropriate statistical analyses is:</u> relative risk ratios, p value, confidence interval Instrument: Salem Sump Tube(s), Capnometer (Easy Cap II, Nellcor Puritan Bennett)	<u>Findings:</u> No lung GT placements. Unable to document false-negatives. 16% false positives with capnometry; 5% with insufflations. Limitations: Convenience sample limited to adults in one facility from ICU and intermediate care. Study limited to initial placement only. Unsure of effectiveness of techniques for repeated checks of GT placement. <u>Comments:</u> 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. Not generalizable-no control, randomization. Sample limited to acute, intermediate pts. Highly relevant to practice Feasible, readily available, inexpensive, and easy to use equipment.	II	VI

CLINICAL PRACTICE GUIDELINE:

Gastric Tube Placement Verification

Appendix I: Evidence Table

Reference	Purpose/Hypothesis	Design/Sample Setting	Variables/Measures Analysis	Findings/Implications	Quality of Evidence	Level of Evidence
Gilbertson, H. R., Rogers, E. J., & Ukoumunne, O. C. (2011). Determination of a Practical pH Cutoff Level for Reliable Confirmation of Nasogastric Tube Placement. <i>J of Parenteral & Enteral Nutrition</i> , 35,540-544. DOI: 10.1177/0148607110383285	1. To simplify the confirmation of NGT placement and assist in standardization of NGT guidelines for all health services to ensure safer feeding practices for all children on NGT feeds. 2. To help determine a reliable and practical pH value to confirm NGT placement, without increasing the risk of not identifying a misplaced NGT.	Prospective observational study. IRB-approved. 4,330 gastric aspirate samples (96% nasogastric) were collected from 645 patients. Pediatric inpatients older than 4 wks receiving enteral nutrition (nasogastric or gastrostomy) were recruited over 9 months at a tertiary pedi hosp in Melbourne - inpt and ICU.	Statistical Analysis is Appropriate: Yes	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. 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. When pH levels are >5 , further investigation via the gold standard methodology of radiographic examination is warranted.	I	VI
Kearns, P. & Donna, C. (2001). A controlled comparison of traditional feeding tube verification methods to a bedside, electromagnetic technique. <i>J Parenter Enteral Nutr</i> , 25: 210-215.	Compare diagnostic test characteristics of four GT confirmation methods: auscultation, pH, visual inspection of aspirate, or electromagnetic technique.	Prospective, blinded multisite trial-including ward and ICU patients from four acute care hospitals. Total of 113 patients ages 18 and older completed entire protocol. Total of 134 GT (small bore) placements in study. IRB-approved	Appropriate statistical analyses	Agreement with xray confirmation of placement (mean % of observations): Auscultation: 84; Aspiration: 50; pH: 56; Electromagnetic: 76 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.	I	II
Metheny, N., Williams, P., Wiersema, L., Wehrle, M. A., Eisenberg, P., & McSweeney, M. (1989). Effectiveness of pH measurements in predicting feeding tube placement. <i>Nursing Research</i> , 38(5), 280-5.	<u>Hypothesis 1:</u> Gastric and intestinal placement of feeding tubes can be differentiated by testing pH of aspirates <u>Hypothesis 2:</u> Gastric and respiratory placement of newly inserted feeding tubes can be differentiated by testing pH of aspirate	188 patients ages 21-97y/o from 4 acute care hospitals (94 with small bore nasogastric feeding tubes; 87 with nasointestinal tubes). 8Fr Dobhoff or 10Fr Entri-flex tubes pH paper and meter Xray confirmed placement. 75% of feeding tubes placed at the bedside; 25% placed underfluoroscopy.	Gastric pH w/o H2 antagonists 1.0 thru 4.0. Gastric pH w H2 antagonists 1.0 thru 5.5. Intestinal pH 6.0 or greater. Respiratory pH 7.0 or greater.	Correlation between pH paper and pH meter = 0.984 gastric ($t=-4.05$ $p<.001$); 0.963 intestinal ($t=-4.64$ $p<.001$). Gastric pH ranges w and w/o H2 antagonists confirmed, thus Hypothesis 1: upheld. Hypothesis 2: not adequately tested (only 1 case of respiratory placed tube able to be tested).	I	IV

CLINICAL PRACTICE GUIDELINE:

Gastric Tube Placement Verification

Appendix I: Evidence Table

Reference	Purpose/Hypothesis	Design/Sample Setting	Variables/Measures Analysis	Findings/Implications	Quality of Evidence	Level of Evidence
Metheny, N., Reed, L., Berglund, B., & Wehrle, M. A. (1994). Visual characteristics of aspirates from feeding tubes as a method for predicting tube location. <i>Nursing Research</i> , 43(5), 282-7.	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.	<u>Design</u> : Descriptive <u>Sample</u> : Convenience N = 880 aspirates-444 from stomach; 448 from intestine; conducted by 30 acute care nurses in urban hospital setting.	1. Characteristics of aspirates from GI and respiratory tract-aspirates photographed 2. Nurses' identification of likely location based on visual characteristics-observation of photographs. Appropriate analyses were conducted, using descriptive statistics and t-tests.	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%, $p < 0.0001$, 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.	I	VI
Metheny, N. A., Stewart, B. J., Smith, L., Yan, H., Diebold, M., Clouse, R.E. (1997). pH and concentration of bilirubin in feeding tube aspirates as predictors of tube placement. <i>J of Parenteral and Enteral Nutrition</i> , 21(5), 279-285.	Describe the usual concentration of bilirubin 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: -Bili will be higher in intestinal contents than gastric -Bili will be absent from tracheobronchial and pleural aspirate -High bili + high pH will indicate intestinal placement -No bili + high pH will indicate resp placement -Either no or low bili + low pH will indicate gastric placement	Samples tested for pH and bili concurrently and within 5min of radiograph taken to confirm tube placement. Excluded pts who received oral or tube antacids within 4hr, other oral or tube admin meds within 1hr, oral or tube feeding within 4hr, previous gastric surg or trauma, grossly bloody samples. Sample: N=587 samples over 3 yrs Nasogastric=209 Nasointestinal=228 Tracheobronchial=126 (from suctioning) Pleural=24 (during thoracentesis) Population: Adult (14 – 93 yo), acutely ill with newly inserted small bore feeding tube Setting: 5 acute care hospitals, urban, various inpt units	Tests: pH,Bilirubin Sites: Lung, gastric, intestinal Analysis: ANOVA, Chi-square	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 > 5 + bili < 5 correctly identified all resp placements pH > 5 + bili > 5 correctly identified 75% of intestinal placements pH < 5 + bili < 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 bili	I	VI

CLINICAL PRACTICE GUIDELINE:

Gastric Tube Placement Verification

Appendix I: Evidence Table

Reference	Purpose/Hypothesis	Design/Sample Setting	Variables/Measures Analysis	Findings/Implications	Quality of Evidence	Level of Evidence
Metheny, N. A., Smith, L., & 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</i> , 49(6), 302-9.	<p><u>Purpose of Study:</u> Test efficacy of bili test-strip compared to colorimetric scale and lab measure. Also, to determine effectiveness of pH and bili test-strips in predicting FT locations and determine rater agreement between nurses using the two techniques.</p> <p><u>Hypotheses:</u></p> <ol style="list-style-type: none"> 1. Bili teststrip and VBili scale will agree with lab bili. 2. Agreement between nurses using Vbili and teststrip will be adequate 3. High bili associated with NI vs. NG tubes 4. Negligible or neg bili from tracheobronch or pleural area 5. High bili/high pH = placement intestine 6. High pH/low bili= resp. placement. 7. Low pH/low bili= gastric placement. 	<p><u>Design:</u> Non-experimental correlational.</p> <p><u>Sample:</u> Nonrandomized sample. N = 631 acutely ill adults in urban acute care hospital setting.</p>	<p><u>Variables:</u> pH, bili via teststrip, visual scale, and lab, inter-nurse scoring of teststrip and vbili scale. Radiograph obtained within 5 minutes of specimen retrieval.</p> <p><u>Analysis:</u> Appropriate for level of variables. Analysis was conducted using Pearson's r correlation, ANOVA, and Crosstabs.</p>	<p><u>Findings:</u></p> <ol style="list-style-type: none"> 1. Strong correlation between teststrip, visual scale, and lab bili. 2. 91% agreement on dichotomous bili level less than 5 or 5 or more. 3. pH and bili combinations highly sensitive and specific for tube locations (GT, IT, lung) <p><u>Limitations:</u> Findings not applicable to pts. receiving feeds. Further testing of both the test strips and visual scale warranted before widely used.</p> <p><u>Feasibility:</u> Highly feasible if bili test strips become commercially available.</p>	I	VI
Phang, J., Marsh, W., Barlows, T. and Schwartz, H. (2004). Determining gastric tube location by gastric and intestinal pH values. <i>Nutrition in Clinical Practice</i> , 19: 640-4.	<p><u>Purpose of Study:</u> Evaluate pH values of aspirates from feeding tubes to differentiate between gastric and intestinal tube placement.</p>	<p><u>Design:</u> Descriptive</p> <p><u>Randomization:</u> Yes (no control group)</p> <p><u>Sample:</u> N = 82 ventilator-supported pts.</p> <p><u>Setting:</u> Acute care hospital IRB: Yes</p>	<p><u>Statistical Analysis is Appropriate:</u> Yes (chi-square, t-tests, descriptive statistics)</p> <p><u>Instruments:</u> 8 fr feeding tube Hand-held pH meter fluoroscopy</p>	<p><u>Findings:</u> 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>	I	VI

CLINICAL PRACTICE GUIDELINE:

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Appendix I: Evidence Table

Reference	Purpose/Hypothesis	Design/Sample Setting	Variables/Measures Analysis	Findings/Implications	Quality of Evidence	Level of Evidence
Rulli, F., Galata, G. Villa, M., Maura, A., Ridolfi, C., Grand, M., & Farinon, A. M. (2007). A simple indicator of correct nasogastric suction tube placement in children and adults. <i>Endoscopy</i> , 39, E237-8. (Study Abstract)	<p><u>Purpose of Study:</u> Determine the validity of flexible fiberoptic cable inserted into NGT to assess correct GT placement in children and adults</p> <p><u>Research Questions:</u> Not stated</p> <p><u>Hypothesis/Theoretical Framework:</u> Not stated</p>	<p><u>Design:</u> Flexible fiberoptic cable inserted into gastric tube, transillumination of abd used to indicate correct placement.</p> <p>Variables</p> <p>Independent Variable NA</p> <p>Dependent Variable NA</p> <p>Validity N = 16</p> <p>Randomization N Convenience Sample Y Population: 16 patients undergoing surgical procedures Setting: Urban Acute Care Hospital</p> <p>IRB Approval: N</p>	<p><u>Statistical Analysis is Appropriate:</u> NA (e.g. Relative Risk Ratios, p value, confidence interval)</p> <p><u>Instrument:</u> 1.3 mm diameter fiberoptic cable connected to a cold light source</p>	<p><u>Findings:</u> Epigastric areas of all patients were transilluminated and liquid aspirant was obtained from all patients' tubes. Intraoperative confirmation was achieved in all patients.</p> <p><u>Limitations:</u> Sample size, and distribution 8 children and 8 adults-all scheduled for similar operative procedures No mention of patient size</p> <p><u>Generalizability:</u> Not generalizable</p> <p><u>Relevance to Practice:</u> Highly relevant</p> <p><u>Feasibility:</u> 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>	III	VI
Stock, A., Gilbertson, H., & Babl, F. E. (2008). Confirming nasogastric tube position in the emergency department: pH testing is reliable. <i>Pediatric Emergency Care</i> , 24(12), 805-809.	<p><u>Purpose of Study:</u> Determine if pH is accurate method of confirmation of NGT placement in pediatric ED pts. with gastroenteritis</p> <p><u>Research Questions:</u> No explicitly stated-purpose</p> <p>Investigate if gastric aspirates can routinely be obtained after NGT placement; and if pH is a reliable tool in NGT placement confirmation.</p>	<p>Prospective, observational study N=404</p> <p>Non-randomized convenience sample of children with or without gastroenteritis in an urban ED</p> <p>IRB-approved</p>	<p><u>Variables-not manipulated</u></p> <p><u>Outcomes of interest:</u> Presence of aspirate and pH; Vomiting within 24 hours of admission; Number of NGT attempts; Complications; NGT position in pts. who received radiographs; use of sedation for NGT placement; comorbid conditions. Statistical analyses: relative risk ratios, p value, confidence interval. Chart and radiograph review using case record form.</p>	<p>Aspirate present in most pt (>97%). Most pts. had gastroenteritis. No difference in pH gastroenteritis vs. non-gastroenteritis. Tube placement confirmed by pH alone in >84%. pH > 4 was associated with incorrect placement; however, all pt. did not receive radiograph for confirmation. Just over 5% required > 1 insertion attempt; and there were just over 3% with minor adverse events associated with NGT placement. No major adverse effects were observed. 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 NGT. Highly relevant to practice; pH testing at bedside is feasible and well within the scope of nurses' practice.</p>	III	VI

CLINICAL PRACTICE GUIDELINE:

Gastric Tube Placement Verification

Appendix I: Evidence Table

Reference	Purpose/Hypothesis	Design/Sample Setting	Variables/Measures Analysis	Findings/Implications	Quality of Evidence	Level of Evidence
Taylor, S. J., & Clemente, R. (2005). Confirmation of nasogastric tube position by pH testing. <i>Journal of Human Nutrition and Dietetics</i> , 18(5), 371-375.	1. What is the appropriate hospital population for pH testing method of NG tube placement? Number of pts. on H2 blockers/PPI and methods of GT confirmation. 2. How does pH testing compare with different pH strips	Two phase observational study N=Phase 1: 52 patients (1-day survey of all pts requiring NG and NI feeding within a geographic area); Phase 2: 6 types of pH strips, number of testers unknown Randomization: No Convenience: Yes Population: ICU and Ward pts. Ages not stated Acute Care Hospital Urban, Bristol, UK	IV= Phase one: PPI and H-2 blocker usage; IV= Phase two: pH color and numeric test strips DV= NG tube placement verification	pH strips more reliable than Lithmus paper; pH strip testing unreliable in 29% of patients with NG tubes receiving PPI or H-2 blocker <u>Limitations:</u> feeding tube placement; observational study, unknown tester sample <u>Comments:</u> Limitations of pH test strips for pts. Receiving PPI or H-2 blocker. If patients could swallow they had them swallow acidic drinks and then tested the pH; this increased the population in which pH testing was possible from 58% to 71%.	II	VI
Tobin, R. W., Gonzales, A. J., Golden, R. N., Brown, M. C., & Silverstein, F. E. (2000). Magnetic detection to position human nasogastric tubes. <i>Biomedical Instrumentation Technology</i> , 34(6), 432-436.	To evaluate a prototype magnetic system to determine proper tube location as compared to fluoroscopy.	Commercial feeding tubes modified to substitute magnets for the tungsten weights. 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. Sample: N=88 tube placements in 22 volunteer subjects 18-75yo Setting: Research laboratory	Descriptive data with no statistical analysis	All placements were determined to be below the diaphragm by magnetic localization and confirmed by fluoroscopy. Limitation: No respiratory placements were evaluated. Currently not feasible in the clinical setting as commercial product does not exist.	I	VI

CLINICAL PRACTICE GUIDELINE:

Gastric Tube Placement Verification

Appendix II: Other Resources Table

Reference	Research Purpose	Conclusions
Christensen, M. (2001). Bedside methods of determining nasogastric tube placement: a literature review. <i>Nursing in Critical Care</i> , 6(4), 192-199.	Review of literature of three methods of gastric tube placement confirmation: pH testing, visual examination of aspirate, and auscultation.	pH testing is the most reliable method of gastric tube placement confirmation.
Ellett, M. A. C. (2004). What is known about methods of correctly placing gastric tubes in adults and children. <i>Gastroenterology Nursing</i> , 27(6), 253-259.	Review of literature regarding gastric tube placements in adults and children, specifically, tube placement error and prevention of error via confirmation techniques: pH, radiography, bilirubin, and fluid aspiration.	Confirmation techniques should include aspiration of gastric fluid and pH testing.
Eveleigh, M. et al (2011). Nasogastric feeding tube placement: changing the culture. <i>Nursing Times</i> , 107(41), 14-16.	Performance improvement article. Nasogastric tube care plan document example provided.	Offers five key points: 1) first-line testing for correct placement of an NGT is pH testing, 2) x-rays are performed when pH testing cannot confirm placement, and should be read by clinicians trained in x-ray interpretation, 3) NG feeding carries a risk and should not be started out of hours where possible, 4) insertion of a tube and confirmation of position should be documented accurately, 5) ongoing tube care should be supported by a care plan to ensure correct position every time a tube is used for feeding.
Fernandez, R. Chau, J. Thompson, D. Griffiths, R., & Lo, H. (2010). Accuracy of biochemical markers for predicting nasogastric tube placement in adults—A systematic review of diagnostic studies. <i>International Journal of Nursing Studies</i> , 47, 1037-46.	Systematic review of studies of biomarkers for detecting NG tube placement (n = 10). Biomarkers included in the studies were pH, bilirubin, pepsin, and trypsin; and various combinations of pH and one or more of the other biomarkers.	All studies used x-ray as the reference standard. Pooled results demonstrated that a pH of 4 or less had the ability to predict 63% of the tubes located in the stomach. A pH value of 5.5 demonstrated a sensitivity for predicting gastric placement of 89% and a specificity of 87%. Bilirubin combined with pH had a specificity of 99%-which demonstrated the ability of the test to identify misplaced tubes in intestine. However, the ability of the test to identify gastric placement of feeding tubes was relatively low. Significant limitations were acknowledged; including the number and variability of studies; use of acid suppression therapy, and tube feeds in participants.
Jones, L., & Elliott, M. (2003). Confirming the position of nasogastric tube--what does the literature say? <i>Australasian Journal of Neuroscience</i> , 16(1), 5-8.	Review of literature regarding methods of gastric tube placement confirmation: pH, auscultation, visualization of aspirate. Primarily included work from Metheny's team.	pH measurement and visualization of aspirate are useful, but limited. Auscultation is unreliable. If in doubt, radiography should be obtained to confirm placement.
Kunis, K., & Metheny, N. (2007). Confirmation of nasogastric tube placement..."Verification of feeding tube placement"; Preventing respiratory complications of tube feedings; evidence-based practice. <i>American Journal of Critical Care</i> , 16(1), 19.	This is a letter to the editor from Kunis asking about recommendations for large vs. small bore gastric tube. Her question is answered by Norma Metheny, who has conducted the lion's share of research in the field. Metheny replies that she feels large bore verification should be no different than small bore verification.	pH and visualization of aspirate are useful; but a radiograph should be obtained for confirmation on any blindly-placed gastric tube.
Metheny, N. A., & Titler, M. G. (2001). Assessing placement of feeding tubes. <i>American Journal of Nursing</i> , 101(5), 36-45.	Includes basic concepts of gastric tube placement, guidelines and algorithms for tube placement confirmation in large and small bore gastric tubes.	Large bore tubes: insert to 25 cm; listen for air exchange and if none, advance to stomach; aspirate; check pH; if pH less than 5, most likely in the stomach. Small bore tubes: insert to 25 cm; listen for air exchange; and if none, advance to stomach; and obtain x-ray. Auscultation is not recommended as a "stand-alone" procedure; but is included in the procedure with aspiration and pH check.
Richardson, D. S., Branowicki, P. A., Zeidman-Rogers, L., Mahoney, J., & MacPhee, M. (2006). Clinical practice column. An evidence-based approach to nasogastric tube management: special considerations. <i>Journal of Pediatric Nursing</i> , 21(5), 388-393.	Describes the process of developing an evidence-based practice guideline for gastric tube placement confirmation. Includes procedure statements for placement confirmation and indications for obtaining a radiograph.	Guidelines presented for initial placement confirmation, confirmation prior to medication administration, and special considerations in pediatric feeding tube placement confirmation. pH technique is appropriate. "Whoosh" test is eliminated. In pH less than 5.5, feedings may be initiated. Stepwise approach is recommended using algorithm if aspirate is not obtained.

CLINICAL PRACTICE GUIDELINE:

Gastric Tube Placement Verification

Appendix II: Other Resources Table

Reference	Research Purpose	Conclusions
Peter, S., & Gill, F. (2009). Development of a clinical practice guideline for testing nasogastric tube placement. <i>Journal for Specialists in Pediatric Nursing</i> , 14(1), 3-11.	Describes the process of developing an evidence-based practice guideline for gastric tube placement confirmation. Includes an algorithm describing the procedures adopted in the facility for feeding tube placement in infants and children.	pH technique is appropriate. "Whoosh" test is eliminated. In pH less than 5.5, feedings may be initiated. Stepwise approach is recommended using algorithm if aspirate is not obtained.
Tho, P. C., Mordiffi, S., Ang, E., & Chen, H. (2011). Implementation of the evidence review on best practice for confirming the correct placement of nasogastric tube in patients in an acute care hospital. <i>Int J Evid Based Healthc</i> , 9, 51-60.	Performance improvement article. Article provides algorithm for confirming correct placement of nasogastric tube.	pH less than 5 confirms gastric placement. Radiographic studies should be performed when unsure as it remains the gold standard for confirming NG/OGT placement.
Wilkes-Holmes, C. (2006). Safe placement of nasogastric tubes in children. <i>Paediatric Nursing</i> , 18(9), 14-17.	Reviews the assumptions of gastric tube placement in children; and the development and implementation of an algorithm guiding gastric tube placement confirmation in a facility.	pH less than 5 confirms gastric placement per the adopted algorithm. However, pH 6-6.5 is inconclusive. Interval x-ray is not helpful because of risk of displacement. In this type of care, an interdisciplinary risk assessment should be conducted to guide decision-making processes.