Enteral feeding is a common and necessary practice in critical care. Clinical practice for verification of small- and large-bore feeding tubes is variable. Although radiographic confirmation is the reference standard for blindly inserted small-bore tubes, it is not consistently performed to verify large-bore tubes before administration of formula or medication.

These practices raise concerns; both small- and large-bore tube placement in the tracheobronchial tree have been reported. Malpositioning has also involved the intracranial cavity. In a review of more than 2000 insertions of small-bore tubes, 50 pulmonary placements (3%) were detected. In another study, the incidence of inadvertent pulmonary placement did not differ between small- and large-bore tubes. Of note, endotracheal or tracheostomy tube cuffs do not prevent pulmonary malposition.

Unfortunately, pulmonary malposition may occur silently, without coughing, dyspnea, or oxygen desaturation. Adding confusion, aspirated fluids that resemble gastric fluids have been obtained from tubes placed in the lungs. Malpositioned tubes may cause pneumonia, pneumothorax, perforations, empyema, and bronchopleural fistula—events that can lead to death in rare cases. The Joint Commission identified pulmonary malposition of nasogastric tubes as one of the most frequent procedural complications that result in postoperative sentinel events. Expert recommendation included checking tube placement with an abdominal radiograph. Also, failure to report malpositioned tubes and complications due to insertion continues to be a problem.

In addition to pulmonary malposition, aspiration risk is high when tubes are placed in the esophagus or gastroesophageal junction. Patients at highest risk are those who are sedated, confused, or uncooperative during insertion, and those who have artificial airways, decreased cough-gag reflexes, a decreased level of consciousness, or craniofacial trauma. Given the risk for tube malposition and aspiration in critically ill patients, this clinical review synthesizes current evidence on the accuracy of methods to verify initial placement of blindly inserted feeding tubes.

**Methods**

The search strategy included MEDLINE and CINAHL, as well as hand-searching bibliographies. Key words included enteral feeding/nutrition, nasogastric/feeding tubes, and placement/verification/confirmation. All types of evidence (nonexperimental/experimental, systematic reviews) were included, but only if the evidence related to verification of initial feeding tube placement in adults.

**Results**

Twelve pertinent studies were published between 1988 and 2007 (Table 1). A variety of methods were used to evaluate tube placement: 7 studies evaluated pH, 3 used capnography/capnometry, 3 used auscultation, 2 measured bilirubin levels, 1 measured enzyme levels, and 1 used visual inspection. Five of the 12 studies used multiple methods. Populations included adults from acute/intermediate care and intensive care unit settings. Sample sizes, often measured as number of feeding tubes or specimens, ranged from 51 to 880.

**pH Testing**

Although a pH less than 5.0 may indicate gastric placement of a feeding tube, this method is not helpful for detecting esophageal placement, because...
### Table 1
Evidence summary for verification of feeding tube placement in adults

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Design/ population</th>
<th>Accuracy, %</th>
<th>Usual values</th>
<th>Level of evidence, class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>Metheny et al¹²³</td>
<td>75</td>
<td>Descriptive Acute care/ICUs Small/large bore</td>
<td>Gastric and intestinal: 94%</td>
<td>Gastric ≤4.0: 81% Intestinal ≥6.0: 87% Pulmonary &gt;7.5 (n = 1)</td>
<td>III</td>
</tr>
<tr>
<td>Metheny et al¹²³</td>
<td>181</td>
<td>Descriptive Acute care Small bore</td>
<td>Gastric ≤4.0: 64% Intestinal &gt;6.0: 87% Pulmonary &gt;6.5 (n = 4)</td>
<td>Indeterminate</td>
<td></td>
</tr>
<tr>
<td>Metheny et al¹²³</td>
<td>794</td>
<td>Descriptive Acute care Small bore</td>
<td>Gastric &lt;4.0: 64% Intestinal &gt;6.0: 87% Pulmonary &gt;6.5 (n = 4)</td>
<td>Indeterminate</td>
<td></td>
</tr>
<tr>
<td>Metheny et al¹²³</td>
<td>880</td>
<td>Comparative ICU</td>
<td>Gastric: 48% Intestinal: 64% Pulmonary: 57%</td>
<td>Gastric ≤4.0: 100%; &gt;4.0: 86%</td>
<td>III</td>
</tr>
<tr>
<td>Neumann et al⁴</td>
<td>78</td>
<td>Comparative Acute care Small bore</td>
<td>Gastric: 81%</td>
<td>Gastric ≤4.0: 100%; &gt;4.0: 86%</td>
<td>Auscultation: III; pH: indeterminate</td>
</tr>
<tr>
<td>Metheny et al¹²³</td>
<td>888 (742 GI,146 pulmonary)</td>
<td>Comparative Acute care/ICU Small bore</td>
<td>Gastric: 4.06 Intestinal: 7.40 Pulmonary: 7.89</td>
<td>Gastric: ↑Pepsin (349.1); ↑Trypsin (19.3) Intestinal: ↑Pepsin (24.2); ↑Trypsin (143) Pulmonary: ↑Pepsin (3.2) ↑Trypsin (1.4)</td>
<td>pH: IIb; enzymes: indeterminate</td>
</tr>
<tr>
<td>Metheny et al¹²³</td>
<td>587 (437 GI,150 pulmonary)</td>
<td>Descriptive Acute care/ICU Small bore</td>
<td>Gastric: 99% pH ≤5, bilirubin &lt;5 Intestinal: 93% pH &gt;5, bilirubin ≥5 Pulmonary: 100% pH &gt;5, bilirubin &lt;5</td>
<td>Gastric &lt;4.0: 0%; ≤5.9: 36%; ≥6.0: 64% Intestinal ≤5.9: 21%; &gt;6.0: 79%</td>
<td>pH: IIb; bilirubin: indeterminate</td>
</tr>
<tr>
<td>Metheny et al¹²³</td>
<td>856 (631 GI, 225 pulmonary)</td>
<td>Comparative Acute care Small bore</td>
<td>Gastric (pH ≤5, bilirubin &lt;5) and intestinal (pH &gt;5, bilirubin ≥5): 86% sensitivity, 99% specificity Pulmonary (pH &gt;5, bilirubin &lt;5): 100% sensitivity, 87% specificity</td>
<td>Gastric: 99% pH ≤5, bilirubin &lt;5 Intestinal: 93% pH &gt;5, bilirubin ≥5 Pulmonary: 100% pH &gt;5, bilirubin &lt;5</td>
<td>pH: IIb; bilirubin: indeterminate</td>
</tr>
<tr>
<td>Araujo-Preza et al¹²³</td>
<td>53</td>
<td>Descriptive ICU Small bore</td>
<td>Gastric: 100% Pulmonary: 100%</td>
<td>Gastric: 100% Pulmonary: 100%</td>
<td>IIb</td>
</tr>
<tr>
<td>Conner et al¹²³</td>
<td>51</td>
<td>Descriptive ICU Small bore</td>
<td>Gastric &lt;4.0: 0%; ≤5.9: 36%; ≥6.0: 64% Intestinal ≤5.9: 21%; &gt;6.0: 79%</td>
<td>Gastric &lt;4.0: 0%; ≤5.9: 36%; ≥6.0: 64% Intestinal ≤5.9: 21%; &gt;6.0: 79%</td>
<td>III</td>
</tr>
<tr>
<td>Burns et al¹²³</td>
<td>195</td>
<td>Comparative ICU Small/large bore</td>
<td>Gastric: 100% Pulmonary: 100%</td>
<td>Gastric: 100% Pulmonary: 100%</td>
<td>IIb</td>
</tr>
<tr>
<td>Elperti et al¹²³</td>
<td>91</td>
<td>Descriptive ICU/ intermediate care Large bore</td>
<td>Gastric: 95%</td>
<td>Gastric: 95%</td>
<td>Auscultation: III; capnometry: indeterminate</td>
</tr>
</tbody>
</table>

Abbreviations: GI, gastrointestinal; ICU, intensive care unit.

¹ Units for bilirubin, mg/dL (multiply by 17.104 to convert to micromoles per liter); units for pepsin and trypsin, micrograms per milliliter.
Aspirate could be gastric reflux. Other limitations include inability to determine placement when pH exceeds 6.0, difficulty obtaining aspirates, and possible inaccuracy related to use/timing of acid-lowering medications such as H₂ blockers, and recent ingestion of enteral formula or food.

Capnography/Capnometry
Carbon dioxide detection using capnography/capnometry has yielded variable results. With this method, color change indicates detection of carbon dioxide and, therefore, pulmonary placement. Although pulmonary vs gastric placement was differentiated in 2 studies, the exact location within the gastrointestinal tract was unknown. Pulmonary placement was suspected because carbon dioxide was detected in 27% of tubes, although such placement was not confirmed radiographically. A third study indicated 15 false-positive results, suggesting pulmonary placement, although disconfirmed by radiography. Furthermore, capnometry relies on tube patency and avoidance of reflux for accuracy.

Auscultation/Water Bubbling
Numerous studies identified audible air entry over the epigastrum even when tubes were malpositioned in the esophagus, pulmonary system, and brain. No research was located on the water bubbling method, which involves placing the proximal end of the tube into water to observe for bubbling. A case report confirmed that this method lacks accuracy; no bubbling was observed in a tube with known pulmonary placement, possibly because the ports were occluded.

Bilirubin/Enzyme Testing
Pulmonary fluid has little or no trypsin or pepsin, whereas intestinal fluid has high levels of trypsin and gastric fluid has high levels of pepsin. On their own, bilirubin results can be misleading, because levels less than 5 mg/dL could indicate gastric/pulmonary placement; however, a combination of a pH greater than 5 and a bilirubin level less than 5 mg/dL could indicate gastric/pulmonary placement. A study indicated 15 false-positive results, suggesting pulmonary placement, although disconfirmed by radiography. Furthermore, capnometry relies on tube patency and avoidance of reflux for accuracy.

Differentiate gastrointestinal from pulmonary placement of tubes, but are not helpful for determining whether tubes are placed in the esophagus or at the gastroesophageal junction.

Visual Inspection
Inspection of aspirated fluid had 48% to 90% accuracy for tube location in the stomach or intestines. However, visual inspection had only 57% accuracy for proper identification of the fluid source for tubes with pulmonary placement.

Recommendations
Levels of evidence for feeding tube verification vary by methods, ranging from indeterminate to class III (Table 2). Although pH, enzyme, bilirubin, and carbon dioxide testing have been used to distinguish respiratory from gastrointestinal placement of feeding tubes, none of these methods has enabled detection of tube placement in the esophagus or gastroesophageal junction. Additionally, although bilirubin/enzyme testing shows promising results, these methods are not available for use at the bedside.

Three practices that have been used for tube verification—auscultation, aspirate inspection, and placing tubes underwater to assess for “bubbling”—should be discontinued because of their lack of established efficacy and potential risk for harm. Of concern, an audible “air pop” over the epigastrum falsely leads clinicians to assume correct gastric placement of a tube.
feeding tube. Hospital policies should be revised to reflect evidence-based practices.

Although clinicians may have concerns about financial and time constraints that make radiographic confirmation of all tube placements impractical, radiography remains the only reliable method to verify initial placement of blindly inserted small- or large-bore feeding tubes. In addition, according to research and expert opinion, secondary confirmation (via pH or carbon dioxide testing, visualization of tube at exit site) must be performed regularly to ensure ongoing assessment of tube location. Judgment must be used to assess for tube dislocation after the patient vomits or retches, or when tubes are improperly secured or pulled. Practice changes should include evaluation of outcomes and reporting of adverse events, including malpositioned tubes and the aspiration of formula or medications. Until verification methods consistently enable pulmonary and esophageal placement of feeding tubes to be detected, radiographic confirmation remains the method of choice for initial verification of blindly inserted feeding tubes.

REFERENCES


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Annette M. Bourgault and Margo A. Halm

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