pH Testing as the Primary Method for Nasogastric Tube Placement Verification

Kira Olson*

Abstract

The placement of a nasogastric tube is a standard intervention completed by nurses in the clinical setting. Correct placement of a nasogastric tube is critical for treatment and successful patient outcomes. There are many reasons for nasogastric tube insertion and many methods of placement verification, but the two most common ways of assessing nasogastric tube placement are auscultation and pH testing. There are advantages and disadvantages to both the auscultation and the pH testing methods. Evidence from ten studies on nasogastric tube placement in adults was gathered and evaluated to compare and contrast both approaches. The auscultation method is currently the most commonly used in practice. However, the overall research analysis suggests that the pH testing method is the most accurate and is accompanied by positive patient outcomes. There is still need for further research on this topic as a limited number of studies were analyzed. Study limitations included small sample sizes and were often located outside of Canada, but all studies presented similar evidence in regards to auscultation versus pH testing. Finally, based on the analysis of the evidence, recommendations are made and barriers to implementation are outlined for practice regarding the application of the pH method.

Keywords: nasogastric, tube, placement, auscultation, pH testing, nursing, recommendations

Background

Critical thinking skills and knowledge of how to adequately care for patients in a high acuity setting is integral for nursing. Patients in acute care settings usually require a variety of different types of interventions that are focused on symptom management, which is "alleviating symptoms so that the client is able to function at the highest level" (Ackley & Ladwig, 2014, p.10). Being able to alleviate symptoms requires that nurses be able to accurately assess patients, make clinical decisions, and implement a broad range of skills in the care they provide. This paper will discuss the skill and intervention of nasogastric tubes (NG tube) in the clinical setting, analyze ten articles on this topic to determine which method of placement verification is most reliable for NG tubes (auscultation or pH testing), and make recommendations for practice regarding NG tube placement verification.

A common intervention for patients in a high acuity setting is the use of an NG tube. There are a variety of reasons why NG tubes are used, including: decompression of the stomach, removal of stomach contents to prevent aspiration, diminishing nausea and vomiting, and in some

*College of Nursing, University of Saskatchewan, Saskatoon, SK, Canada
Correspondence: **km0103@mail.usask.ca**

cases, administering liquids (feed) or medications (Proehl et al., 2011). An important nursing responsibility in caring for and assessing patients with NG tubes is verifying tube placement to prevent the occurrence of life-threatening complications (Proehl et al., 2011; Simons & Abdallah, 2012). NG tube placement needs to be verified after initial insertion as well as before any feeding or administration of medications because NG tubes can easily become misplaced through "vomiting, coughing, retching, or suctioning [which] can cause the distal tip to migrate upward into the esophagus or downward into the duodenum" (Simons & Abdallah, 2012, p.40). NG tube misplacement can cause complications such as pneumonia, perforation, aspiration, pneumothorax, and sepsis (Bougault & Halm, 2009; Simons & Abdallah, 2012). These complications and changes in illness lead to a delay in discharge and longer hospitalizations for patients, which can cause a reduction in patient outcomes and satisfaction (Kozier, et al., 2014).

There are a variety of methods for checking NG tube placement. These include placing the end of the tube in water and assessing for the absence of bubbling, assessing the appearance of the aspirated gastric contents, and measuring the feeding tube length from the client's nose to the end of the tube and comparing this measurement to the initial insertion length (Bourgault & Halm, 2009; Simons & Abdallah, 2012). However, the most commonly used methods in the clinical setting are the auscultation method and pH method (Preetha, 2009; Simons & Abdallah, 2012).

The following evidence-based clinical inquiry will analyze and critique the available evidence that examines adults requiring NG tubes, and determine whether injecting air and auscultating over the stomach or aspirating and checking the pH of the gastric contents is more effective in determining the placement of the NG tube.

Table 1: Definitions and explanation of procedures.

Nasogastric tube- a small tube that is inserted through the nose, down the throat, and goes down into the gastric lumen (Kozier et al., 2014).
Auscultation- listening to sounds within the body through the use of a stethoscope (Jarvis, 2013).
Procedure for the auscultation method- "place a stethoscope over the patient's epigastrium [stomach], and [using a 30mL syringe] inject 10 mL to 30 mL of air into the tube while listening for a whooshing sound" (Kozier et al., 2014, p.1246).
pH- "hydrogen ion concentration of the solution [gastric juice]: The higher the hydrogen ion concentration, the lower is the pH; the lower the hydrogen ion concentration, the higher is the pH" (Kozier et al., 2014, p.1418).
Procedure for the pH method- attaching a 30mL syringe to the end of the nasogastric tube and "aspirating the stomach contents and checking the pH, which should be acidic… gastric contents are commonly pH 1 to 5" (Kozier et al., 2014, p.1246).

Methodology

There is limited research available on the topic of NG tube placement verification. Most sources included systematic reviews of previous articles as well as a collection of outcome data on individuals in hospitals with a nasogastric tube already in place. Studies varied in location, and age and gender often were not specified. Therefore, there is a need for further studies to examine specific populations or age groups (for example, women compared to men or younger ages compared to older). A literature review was conducted using Cumulative Index to Nursing and Allied Health (CINAHL) and Medline with key phrases and terms such as "adult," "nasogastric," "tube," "gastric," verification," "placement," "methods," "pH," and "auscultation." The analysis of articles included those that discussed nasogastric or gastric tube (which would include nasogastric tubes) placement through the use of pH testing or auscultation in adults. Articles that left a recommendation as to which method (pH testing or auscultation) was best practice were preferred. Articles which discussed interventions other than nasogastric tubes such as feeding ostomies- gastrostomy or jejunostomy, placement verification through x-ray, or discussed studies

involving children only were not included in the analysis. Articles were chosen based on the above criteria and were then individually reviewed and analyzed. The articles were broken down based on their level of evidence, purpose/problem, setting, sample/population, pH testing, comparison (auscultation), findings, and limitations. A table was made from the data that had been analyzed and divided into the above categories for easier comparison purposes (see Appendix A). After each article was individually analyzed, all articles were compared to one another to see which method (pH testing or auscultation) was more reliable in verifying nasogastric tube placement in adults. The present study included data from 1950 to 2012.

Results

Ten studies were identified as being clinically relevant to the topic of nasogastric tube placement. These studies were then analyzed and presented in Appendix A. The level of evidence (presented in Table 2) was used to assess the strength of each study (Howick, 2009). Note that looking at the outcome of pH testing versus auscultation helps to determine the reliability of each method.

Table 2: Levels of Evidence for Medical Therapies (Howick, 2009).

Level	Type of Evidence
1a	Systematic review of random control trials (RCTs)
1b	Individual RCT (with narrow confidence intervals)
1c	All or none studies (e.g., all patients died before a therapy/intervention was available but now some survive with the therapy/intervention or when some patients died before the therapy/intervention was made available and now with the therapy/intervention all patients survive)
2a	Systematic review (with homogeneity) of cohort studies
2b	Individual cohort study (includes low quality RCT)
2c	Outcomes research and Ecological studies
3a	Systematic review (with homogeneity) of case-control studies
3b	Individual case-control study
4	Case series and poor quality cohort and case-control studies
5	Expert opinion without explicit critical appraisal, or based on physiological bench research or "first principles"

Discussion of Results

The two most commonly used methods for verifying NG tube placement are the auscultation and pH methods. It is important to determine which method is better because that ensures that best evidence-based practice is being implemented by nurses in the clinical setting and also maintains patient safety. One of the most widely and commonly used methods for verifying NG tube placement is the auscultation method (Preetha, 2009). The auscultation method is viewed as being favorable in verifying NG tube placement because it is easy, time efficient, cost effective, and can be quickly performed by the nurse at the bedside (Preetha, 2009). The auscultation method does not require a variety of supplies as compared to the pH testing method (i.e., pH indicator paper or pH meters) which can save the health care system unnecessary expenditures. However, a major downfall to this method is that it has been shown to be inaccurate and unreliable at identifying correct NG tube placement in a variety of studies (Bourgault & Halm, 2009; Proehl et al., 2011; Simons & Abdallah, 2012; Taylor & Clemente, 2005). Often, the "whooshing sound" heard with the auscultation method can be heard with correct and incorrect placement (Simons & Abdallah, 2012). These results indicate a strong correlation with a higher risk for complications such as aspiration and perforation and were associated with a number of recorded deaths attributed to misplaced NG tubes (Simons & Abdallah, 2012; Taylor & Clemente, 2005). Due to these key downfalls, there were no studies in the review of the literature that supported the use of the auscultation method for NG tube placement verification. In many of the studies examined there was a reoccurring argument that this method should be discouraged and

discontinued (Boeykens et al., 2014; Bourgault and Halm, 2009; Simons & Abdallah, 2012; Taylor & Clemente, 2005). The discontinuation of the auscultation method would lead to correct verification of NG tube placement, decreased patient complications, and increased patient outcomes. Therefore, auscultation, the current method of NG tube verification, should be improved and reassessed as to whether this method is the safest for patients and the most evidence-based method for the acute care setting.

The other commonly used method in NG tube verification is the pH method (Simons & Abdallah, 2012). A major strength of this method is that it has a higher sensitivity and specificity for accurately determining correct NG placement than auscultation (Boeykens et al., 2014; Preetha, 2009; Simons 2012; Turgay & Khorshid, 2010). This method is more reliable in its ability to accurately distinguish between gastric, intestinal, or respiratory placement (Simons & Abdallah, 2012). Therefore, the pH method is more accurate at identifying the placement of NG tubes (Boeykens et al., 2014; Bourgault & Halm, 2009; Ellet, 2004; Metheny & Meert, 2004; Proehl et al., 2011; Simons & Abdallah, 2012; Taylor & Clemente, 2005). When testing the gastric pH using the pH method, it is important to have a 30mL syringe to aspirate the gastric contents. There is a range of recommended values for pH that detects where the NG tube is placed. A pH less than or equal to 5.5 indicates the NG tube is placed in the stomach (Boeykens et al., 2014; Fernandez et al., 2010; Kozier et al., 2014). A pH of 6 or higher usually indicates NG placement in the respiratory tract, pleural space, or intestinal tract (Boeykens et al., 2014; Kozier et al., 2014). Simons and Abdallah (2012) stated that this method is accurate, simple, and efficient for nurses in the clinical setting and for distinguishing between correct and incorrect NG tube placements.

However, there are significant disadvantages associated with the pH method. Accuracy of NG tube placement can be altered through the use of medications such as proton pump inhibitors and H2-receptor blockers because these medications can alter the pH of the stomach and lead to higher pH levels (Simons & Abdallah, 2012; Fernandez, Chau, Thompson, Griffiths, & Lo, 2010; Bourgault & Halm, 2009; Ellet, 2004; Boeykens et al., 2014; Taylor & Clemente, 2005; Turgay & Khorshid, 2010). Another downfall to this method is when patients are on continuous feeds through the NG tubes because NG feedings can alter the pH of the stomach and cause inaccurate pH readings leading to difficulties determining correct NG tube placement (Boeykens et al., 2014; Simons & Abdallah, 2012). The pH method is also seen as being costly when compared to the auscultation method because of the cost of pH indicator paper and pH meters (Preetha, 2009). These weaknesses are minor compared to the vast number of complications that can occur from the incorrect placement by using the auscultation method (e.g., pneumonia, perforation, aspiration, pneumothorax, and sepsis which can lead to longer hospitalizations (Bougault & Halm, 2009; Simons & Abdallah, 2012)). In reviewing the literature, studies were consistent with one another in coming to the conclusion that the pH method is accurate and reliable in determining correct NG tube placement. This is especially true when being compared to the auscultation method; therefore, the pH method is very well supported by all of the studies analyzed (Boeykens et al., 2014; Bourgault & Halm, 2009; Ellet, 2004; Fernandez et al., 2010; Metheny & Meert, 2004; Preetha, 2009; Proehl et al., 2011; Simons & Abdallah, 2012; Taylor & Clemente, 2005; Turgay & Khorshid, 2010). Further research on this topic is needed, such as additional research looking at the different NG tube placement verification methods, research on specific pH values and what placement is associated with those values, and research on interventions such as feeds or medications like proton pump inhibitors and H2-receptor blockers and what pH value can be associated with correct placement when a patient is receiving these interventions. However, the preliminary evidence in the articles analyzed suggests that pH testing for NG tube placement verification is the more accurate and reliable method (Boeykens et al., 2014; Bourgault & Halm, 2009; Ellet, 2004; Metheny & Meert, 2004; Proehl et al., 2011; Simons & Abdallah, 2012; Taylor & Clemente, 2005). See Appendix 1.

Limitations

There is limited research that specifically discusses nasogastric tube placement verification using pH testing and auscultation. In the present study, there were a small number of studies analyzed and varied in regards to time frames, locations, and sample sizes. Making it difficult to perform a homogeneous analysis of the articles. Other limitations indicate the reliability of the pH testing method include whether feeding infusions are continuous or bolus and whether acid inhibitor medications are being used by the patient (Fernandez et al., 2010). Since NG tube insertion is unpleasant, uncomfortable, and can cause distress (Kozier et al., 2014), it is difficult and unethical to have a control group; therefore, there were no articles available that included randomized control trials (the strongest level of evidence). Small sample sizes were a common limitation in the reviewed studies, and often consisted of opportunity population of individuals who had already had an NG tube in place (Preetha, 2009; Taylor & Clemente, 2005; Turgay & Khorshid, 2010). Finally, many of the articles assessed were based out of the United States or other countries and not based in Canada.

Summary and Recommendations for Practice

Based on the review of the literature, the auscultation method for verification of NG tube placement is not well supported; however, it is still a commonly used method in clinical practice (Proehl et al., 2011; Saskatoon Health Region, 2013; Simons & Abdallah, 2012). Therefore, a recommendation for practice would include using the pH method instead of the auscultation method for verification of NG tube placement to ensure accuracy and reliability and help reduce complications and improve patient outcomes. This method can help to ensure safe practice and correct feeding and medication administration (Fernandez et al., 2010). Implementation of the pH method in Saskatoon would require an analysis of current policies and procedures regarding NG tubes in the Saskatoon Health Region's policies. These policies would need to be analyzed to ensure that they are up-to-date and follow best practice of using the pH method instead of auscultation. The implementation of the pH method may also require close monitoring of nursing practice to ensure that NG tube placements are being confirmed with the use of the most accurate evidence-based practice, and that adverse effects from inaccurate NG tube placement confirmation are reported (Bourgault & Halm, 2009). The implementation process would also require accurate resources and supplies such as pH indicator paper and pH meters to be available on the unit so that nurses have immediate access to these supplies. Implementation can also be enhanced through educational programs and by providing information that is focused on the pH method and its levels of accuracy and reliability to enhance nursing knowledge and attitudes towards this method (Gesme & Wiseman, 2010). Other important aspects in program implementation would include demonstrations for staff, effective leadership, communication, a shared vision for evidence-based change, and collaboration among team members (Gesme & Wiseman, 2010). This can help nurses feel supported and encouraged. However, there are barriers to the implementation of new skills, such as negative attitudes, unwillingness to change, and the challenge of breaking old habits (Gesme & Wiseman, 2010; Simons & Abdallah, 2012). The implementation of the pH method for verification of NG tube placement may be costly, as this technique requires the use of pH indicator paper for verification (Preetha, 2009) which may act as a barrier to the implementation of this method. Short term goals for the implementation of the pH method include educating nurses as to why auscultation is not an effective method for determining NG tube placement, and the risks associated with it, and encouraging communication and collaboration between nurses. A long-term goal could include the revision of hospital policies to reflect evidence-based practice through the removal of the auscultation method and the implementation of the pH method to enhance patient outcomes and decrease patient complications from inaccurate NG tube placement (Bourgault & Halm, 2009). Overall, through the analysis of these articles, there was strong evidence to support the use of the pH method for determining NG tube placement and little support for the use of the auscultation method.

References

Ackley, B. J., & Ladwig, G. B. (2014). *Nursing diagnosis handbook: An evidence-based guide to planning care* (10th ed.). St. Louis, MO: Mosby Elsevier.

Boeykens, K., Steeman, E., & Duysburgh, I. (2014). Reliability of pH measurement and the auscultatory method to confirm the position of a nasogastric tube. *International Journal of Nursing Studies, 51*, 1427-1433. doi:10.1016/j.ijnurstu.2014.03.004

Bourgault, A., & Halm, M. (2009). Feeding tube placement in adults: Safe verification method for blindly inserted tubes. *American Journal Of Critical Care, 18*(1), 73-76. doi:10.4037/ajcc2009911

Ellett, M. (2004). What is known about methods of correctly placing gastric tubes in adults and children. *Gastroenterology Nursing, 27*(6), 253-261. doi: 10.1097/00001610-200411000-00002

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. *International Journal Of Nursing Studies, 47*(8), 1037-1046. doi:10.1016/j.ijnurstu.2010.03.015

Gesme, G., & Wiseman, M. (2010). How to implement change in practice. *Journal of Oncology Practice, 6*(5), 257-259. doi: 10.1200/JOP.000089

Howick, J. (2009). *Oxford Center for Evidence-based Medicine- Levels of Evidence*. Retrieved from http://www.cebm.net/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/

Jarvis, C. (2013). *Physical examination & health assessment* (2nd ed.). Toronto, ON: Saunders Elsevier.

Kozier, B., Erb, G., Berman, A., Snyder, S. J., Buck, M., Yiu, L., & Stampler, L. L. (2014). *Fundamentals of Canadian*

nursing: Concepts, process, and practice. Toronto, ON: Pearson Education.

Metheny, N., & Meert, K. (2004). Monitoring feeding tube placement. *Nutrition In Clinical Practice*, *19*(5), 487-495. doi: 10.1177/0115426504019005487

Preetha, K. (2009). Effectiveness of auscultation and testing pH for assessing the placement of feeding tube. *Nursing Journal Of India*, *100*(5), 112-114. Retrieved from http://crawl.prod.proquest.com.s3.amazonaws.com/fpcache/50b8acba0076ed270bfc6e8c960e6577.pdf?AWSAccessKeyId=AKIAJF7V7KNV2KKY2NUQ&Expires=1476999773&Signature=ObbPhpY56u48sJG5rKJJIobvZiM%3D

Proehl, J. A., Heaton, K., Naccarato, M. K., Crowley, M. A., Storer, A., Moretz, J. D., & Li, S. (2011). Emergency nursing resource: Gastric tube placement verification. *JEN: Journal Of Emergency Nursing*, *37*(4), 357-362. doi:10.1016/j.jen.2011.04.011

Saskatoon Health Region. (2013). *Policy and procedure manual: Nasogastric/Orogastric tube: Insertion, care of, and removal- 1040*. Retrieved from https://www.saskatoonhealthregion.ca/about/NursingManual/1040.pdf

Simons, S. R., & Abdallah, L. M. (2012). Bedside assessment of enteral tube placement: Aligning practice with evidence. *American Journal Of Nursing*, *112*(2), 40-48. doi: 10.1097/01.NAJ.0000411178.07179.68

Taylor, S., & Clemente, R. (2005). Confirmation of nasogastric tube position by pH testing. *Journal Of Human Nutrition & Dietetics*, *18*(5), 371-375. doi: 10.1111/j.1365-277X.2005.00635.x

Turgay, A., & Khorshid, L. (2010). Effectiveness of the auscultatory and pH methods in predicting feeding tube placement. *Journal Of Clinical Nursing*, *19*(11-12), 1553-1559. doi:10.1111/j.1365-2702.2010.03191.x

Appendix A
Analysis of Sources with the Level of Evidence

Table A1: Boeykens et al., 2014.

Level of Evidence	3b
Research Design	-Large prospective observational study - 270 used pH measurement -301 had the auscultation method done after X-ray confirmation from a total of 331 tubes.
Problem/Purpose	-Evaluate the auscultatory method and pH method with a measurement cut off of 5.5 after tube insertion and to compare this with the gold standard: an abdominal X-ray.
Setting	-General hospitals in Belgium from September 2009 to December 2012
Sample/Population	-331 tubes inserted into 314 patients -Average age of 69 years old and mostly male
pH Testing	-Without the use of antacids the pH was 3.5 in the stomach. -With the use of antacids the average gastric pH was 4.6. -In 270 pH measurements (241 could be compared to x-ray) there was a pH of less than or equal to 5.5 and this method was accurate 98.9% of the time in determining NG tube location in the stomach. -Overall, the pH was able to show that the NG tube was correctly placed in the stomach 78.4% of the time and the pH method was able to tell that the NG tube was not placed in the stomach 84.6% of the time.
Comparison	-The auscultation method was used in 301 individuals after x-ray confirmation and was able to tell the NG tube was correctly placed in the stomach 79% of the time and that the NG tube was not in the stomach 61% of the time.
Findings	-The auscultatory method may identify tube placement but it is not an accurate way to detect if the NG tube is outside of the stomach. -The whooshing sounds in the auscultatory method can have different interpretations and lead to wrong judgments of NG tube placement, therefore this method is discouraged. The pH method using a pH cut off of less than or equal to 5.5 is a reliable method to identify NG tube placement in the stomach compared to other methods.
Limitations	-Based out of Belgium

Table A2: Bourgault & Halm, 2009.

Level of Evidence	2a
Research Design	-Systematic review of 12 studies published between 1988 and 2007
Problem/Purpose	-Determine the accuracy of methods to verify initial feeding tube placement after blind insertion
Setting	-Acute/intermediate care and intensive care settings
Sample/Population	-Adults with feeding tubes -Sample sizes ranged from 51-880
pH Testing	-pH less than 5.0 indicates NG placement in the stomach -This may not be helpful in detecting esophageal placement because of gastric reflux -This method may be difficult to use when assessing NG placement in people receiving H2 blockers or continuous feeding

Comparison	-For auscultation, many studies had audible air entry over the epigastrium even when the tube was malpositioned therefore this method is not reliable
Findings	-Auscultation to check tube placement should be discontinued because of its lack of efficacy and increased risk for harm to the patient -Best way to identify insertion is through radiography -pH method can be used for ongoing assessment at the bedside
Limitations	-Based on initial insertion of feeding tubes only -Article is based out of the United States -Size of the systematic review was small (only 12 studies) and specific setting (country/city) was not given -This article is more than 5 years old

Table A3: Ellet, 2004.

Level of Evidence	2a
Research Design	-Literature review of an unknown number of studies
Problem/Purpose	-To find information about the different types of gastric tube placement methods and determine which method is best at determining GT placement in adults and children
Setting	-not stated in article
Sample/Population	-Adults and children that had gastric tubes placed for short term feeding
pH Testing	-pH method is better at detecting over auscultation because of the different pH in different tissues. -pH testing alone is seen to be an inadequate indicator of GT placement because of factors such as overlap pH between sites and difficulties with aspiration. -The use of acid-inhibiting medications can limit the usefulness of this method.
Comparison	-The auscultation method should not be used because it is not reliable at detecting mispositioning in the respiratory system.
Findings	-Overall, pH is a promising method for determination tube position. -pH of less than or equal to 5 is able to differentiate between gastric and esophageal and intestinal placements but a pH greater then 5 cannot differentiate between intestinal, esophageal, and gastric placements and may need a second method (abdominal radiograph) to determine tube location.
Limitations	-The article is from 2004, therefore articles cited are old. -Narrowed to small-bore nasogastric and orogastric tubes under the umbrella term of gastric tubes (GT). -A setting was not given in this study. -Sample size/range from the studies analyzed was not made specific.

Table A4: Fernandez et al., 2010.

Level of Evidence	2a
Research Design	-Systematic review of 10 studies from 1950-2008 from online databases
Problem/Purpose	-Investigate the diagnostic performance of biochemical tests used to determine placement of NG tubes after insertion in adults
Setting	-Acute care facilities in the USA

Sample/Population	-NG tube placements in adults -Sample sizes in the 10 studies ranged from 36-890.
pH Testing	-pH value of less than or equal to 5.5 has a greater ability to determine gastric placement of the NG tube. -pH can be varied because of antacid medications.
Comparison	-not stated in article
Findings	-This study has insufficient evidence to be able to determine the optimal cut-off pH value to differentiate between gastric and intestinal placements. -Use of a pH of less than or equal to 5.5 has led to higher detection of tubes in the gastric and/or intestinal areas. -This method is more reliable than auscultation in determining NG placements.
Limitations	-This study is based out of the United States. -This study did not examine the effectiveness and reliability of auscultation for NG tube placement and only focused on pH. -Studies analyzed in the systematic review were very similar. -This study does not include NG misplacement in the respiratory tract.

Table A5: Metheny & Meert, 2004.

Level of Evidence	5
Research Design	-Literature review on an unknown number of studies leading to a mix of research based and opinion based discussion
Problem/Purpose	-To describe currently available bedside methods to determine feeding tube placement after initial insertion and once tube feedings have been started -Review information about clinically available bedside methods to predict feeding tube location
Setting	-not stated in article
Sample/Population	-Individuals with feeding tubes
pH Testing	-pH testing is helpful in differentiating between gastric, intestinal, and respiratory placement when gastric pH is low. -pH of 0-4 indicates gastric placement. -Respiratory secretions do not have a pH less than 6, while intestinal secretions have a pH greater or equal to 7, allowing a pH of 0-4 in the stomach to be an effective predictor of gastric placement. -When gastric pH is 6 or greater this method is not useful because it is too difficult to differentiate from gastric and respiratory placement. -A change in pH is a useful indicator of tube movement.
Comparison	-The auscultation method has been used for many years but is questioned for accuracy and reliability. -No evidence available that states this method can rule out respiratory placement. -The efficacy of this method in determining between gastric and intestinal placement has not been done under controlled conditions therefore, it has little evidence to support its reliability.
Findings	-Auscultation is not effective (on its own or combined) in determining tube placement. -The pH method can be useful in combination with other methods for checking tube placement.
Limitations	-The article is from 2004, therefore articles referenced are old. -Setting and specific sample sizes were not given.

Table A6: Preetha, 2009.

Level of Evidence	3b
Research Design	-A comparative and evaluative search approach
Problem/Purpose	-Determine the effectiveness of auscultation and testing pH for assessing the placement of feeding tubes.
Setting	-P. S. Medical Centre in Kanya-kumari district of India over a one month period
Sample/Population	-50 adult subjects with feedings tubes -Ages ranged from 30-70 years old -56% were males and 44% were females
pH Testing	-All 50 subjects had aspirate checked. -pH < 5 is considered gastric placement and a pH of >6 was considered an intestinal placement. -This method stated that 90% of the NG tubes had gastric placement and 10% of the NG tubes were misplaced, which was proven to be correct when compared to the X-ray.
Comparison	-All 50 subjects had auscultation checked. -Whooshing sound heard over the epigastric area was considered a gastric placement. -With this method it stated that 96% of subjects had gastric placement and 4% had intestinal placement, when this was compared to X-ray it was stated that 90% of the tubes were placed in the stomach and 10% of the tubes were misplaced.
Findings	-pH testing is more reliable and accurate compared to the auscultation method when assessing NG tube placement.
Limitations	-Study is out of India -Small sample size -This article is more than 5 years old

Table A7: Proehl et al., 2011.

Level of Evidence	2a
Research Design	-Systematic review of an unknown number of studies between 1994 to October 2010
Problem/Purpose	-Evaluation of various bedside gastric tube placement verification methods as an alternate to radiography
Setting	-A variety of English language articles from a variety of settings
Sample/Population	-Patients with gastric tubes inserted
pH Testing	-pH value less than 3.9 to 7 to differentiate placement in the stomach versus the pulmonary system. -pH can be influenced by feedings and acid suppressing medications. -Reliability of this method ranges from 84% to 97%.
Comparison	- Instillation of air into the tube while listening over the epigastric region with a stethoscope for a whooshing sound -Unreliable as a single verification method -Most common method used by nurses
Findings	-GT placement verification methods are more accurate when combined. -Auscultation cannot be a verification method for placement on its own because it is unreliable. -The pH method can be used as a component of a multiple method verification approach.
Limitations	-Examines nasogastric and orogastric tubes under the umbrella term gastric tubes (GT). -A specific sample size/range was not given.

	-Setting was not specific to a certain area (city/country) or facility.

Table A8: Simons & Abdallah, 2012.

Level of Evidence	2a
Research Design	-Systematic review of nursing literature published between 1980-2010 from a variety of databases (20 research articles), including 20 nursing textbooks published between 2002-2010 and 28 hospital policies
Problem/Purpose	- Assess and evaluate the various methods for assessing enteral feeding tube placement and make an evidence-based practice recommendation based on the reliability of each method
Setting	-not stated in article
Sample/Population	-Online review of nursing literature -Convenience sample of hospital and skilled nursing facility policies from Massachusetts and New Hampshire for assessing enteral feeding tube placement (28 in total)
pH Testing	-pH of 1-4 indicates the NG tube is in the stomach. -Easy method that can distinguish between gastric and intestinal placement. -Many studies support this method but it is not always reliable.
Comparison	-Auscultation is a commonly used method that has been proven to be ineffective in determining NG tube placement and can cause significant harm to patients. - This method is seen as highly unreliable because a whooshing sound can still be heard even if the tube is incorrectly placed in the lung.
Findings	-Methods should be used in combination for checking NG placement (e.g., visually assessing aspirate and checking pH). -If an X-ray has confirmed initial tube placements, bedside methods for assessing NG placement could include a variety of options including aspirating and checking pH, but not including auscultation and listening for air over the epigastrium, since this method is ineffective. -pH can be altered by the use of medications such as PPIs and H2 receptor blockers and feeding tube preparations can be more alkaline.
Limitations	-Study based out of the United States -A specific sample or sample range from the studies analyzed were not given.

Table A9: Taylor & Clemente, 2005.

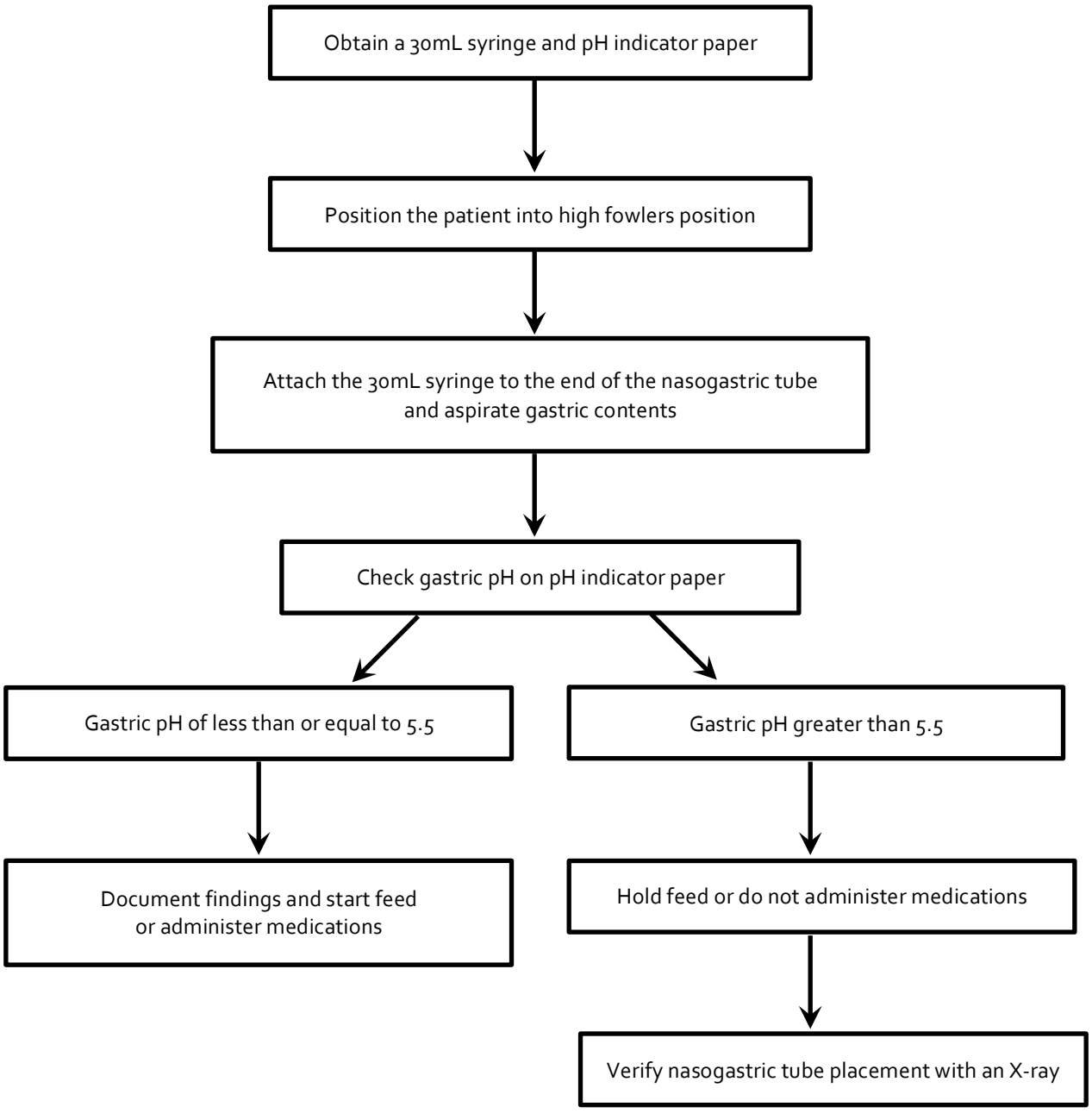
Level of Evidence	3b
Research Design	-One day cross-sectional survey of all patients requiring NG tube placement checks, followed by an observational study to assess the accuracy of pH strip testing for NG tube placement
Problem/Purpose	-To assess currently used NG tube placement methods and assess their safety and efficacy for confirming tube placement -Determining NG tube placement accuracy and methods in relation to the use of H2-receptor blockers and PPIs
Setting	-Hospitals
Sample/Population	-52 patients required NG and nasointestinal (NI) feedings -It was not stated what number of patients were tested with pH vs. auscultation. Nurses were asked which method was used or charts were checked as to which method was used.
pH Testing	-pH testing is the first line confirmation technique for NG placement.

Comparison	-Auscultation method is unlikely to warn of improper tube placement. -This method should be discontinued
Findings	-Large surveys and trials on the efficacy and accuracy of pH testing are still required. -Many factors can alter pH (PPIs, H2 blockers). -pH testing is a more safe and reliable method than other methods such as auscultation. -Use of pH in determining confirmation of NG tube positioning is imperative. -X-ray is still the gold standard.
Limitations	-The article is from 2005, therefore articles referenced are old. -Small sample size -Setting is not specific as to where (city/country) the study took place

Table A10: Turgay & Khorshid, 2010.

Level of Evidence	3b
Research Design	-A prospective observational study
Problem/Purpose	-To determine the effectiveness of the auscultatory and pH methods in predicting feeding tube location in critically ill patients
Setting	ICU in Turkey
Sample/Population	-44 newly inserted feeding tubes in 32 critically ill adult patients ranging in age from 38-87 years
pH Testing	-Before checking pH, 30mL of air was insufflated into the tube to ensure that no formula or medications were in the tube so that a more accurate pH could be obtained. - 88.6% of the gastric aspirates had a pH value <6. -39 of the 44 tubes were able to be predicted as the correct placement via the pH method, whereas the other 5 were able to be determined as incorrect by the pH method. -pH method was most accurate with the radiological readings.
Comparison	-40 of the 44 tubes inserted were said to be correct with the auscultation method, and 4 tubes were said to be incorrect, which does not agree with the radiological readings of 39 and 5.
Findings	-The mean pH readings were found to be 4.2. -Several factors can affect gastric pH such as H2 receptor agonists and PPIs. -The auscultatory method should not be used as the only method to determine NG tube placement and rule out respiratory positioning of inserted NG tubes. -Overall, the pH method is most effective in determining the feeding tube position.
Limitations	-Small sample size -Setting in Turkey

Appendix B
Decision Making Aid in the Clinical Setting



Original diagram created using information from Boeykens et al., (2014), Kozier et al., (2014), and Turgay and Khorshid (2010).