Development of a Best Evidence Statement (Best) for Confirmation of Nasogastric (NGT) or Orogastric Tube (OGT) Placement

Sherri A. Sievers
Wright State University - Main Campus

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DEVELOPMENT OF A BEST EVIDENCE STATEMENT (BEST) FOR
CONFIRMATION OF NASOGASTRIC (NGT) OR OROGASTRIC TUBE (OGT)
PLACEMENT

A capstone project submitted in partial fulfillment of the
requirements of for the degree of
Doctor of Nursing Practice

By

SHERRI A. SIEVERS
M.S.N., Northern Kentucky University, 2000

2012
Wright State University-Miami Valley College of Nursing and Health
WRIGHT STATE UNIVERSITY – MIAMI VALLEY
COLLEGE OF NURSING AND HEALTH
GRADUATE SCHOOL

November 29, 2012

I HEREBY RECOMMEND THAT THE CAPSTONE PROJECT PREPARED UNDER MY SUPERVISION BY Sherri A. Sievers ENTITLED Development of a Best Evidence Statement (BEST) For Confirmation of Nasogastric (NGT) or Orogastric Tube (OGT) Placement BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Doctor of Nursing Practice

_____________________________________
Tracy L. Brewer, DNP, RNC-OB, CLC
Scholarly Project Co-chair

_____________________________________
Rosalie O. Mainous, PhD, ARNP, NNP-BC
Dean, College of Nursing and Health

Committee on
Final Examination

_____________________________________
Tracy L. Brewer, DNP, RNC-OB, CLC

_____________________________________
Donna Miles Curry, PhD, RN, CNS

_____________________________________
Kelly Phillips, PhD, RN, CNS
ABSTRACT

Sievers, Sherri A. D.N.P. College of Nursing and Health, Wright State University, 2012. Development of A Best Evidence Statement (BES) For Confirmation of Nasogastric (NGT) or Orogastric Tube (OGT) Placement.

The purpose of this scholarly project was to develop a Best Evidence Statement (BES) for the confirmation of nasogastric or orogastric tube placement in hospitalized children. The nose-ear-xiphoid (NEX) method of measurement and auscultatory method of tube verification is commonly used but is unreliable and has resulted in misplaced tubes as well as poor patient outcomes. Radiography is considered the gold standard however the risks outweigh the benefits due to excessive radiation exposure, increases in healthcare costs and delay in delivery of care. Methods which utilize bedside testing and proper tube measurement have been shown to be effective in nasogastric tube (NGT) or orogastric tube (OGT) verification. Gastric pH has been shown to be an accurate method of bedside testing with a pH of $\leq 5$ confirming placement in the stomach. In addition, age-related height-based (ARHB) methods have been shown to be an accurate method of predicting tube length. The Iowa Model of Evidence-Based Practice to Promote Quality Care was used to guide development of evidenced-based care recommendations that were published as a BES statement at Cincinnati Children’s Hospital Medical Center and through The Agency for Healthcare Research and Quality’s (AHRQ) National Guideline Clearinghouse (NGC). The BES recommendations include tube length prediction using ARHB methods and pH testing of gastric aspirate.
# TABLE OF CONTENTS

I. PROBLEM..............................................................................................................1
   Description of the Problem........................................................................1
   Significance of the Problem......................................................................3
   PICO Questions.........................................................................................7

II. EVIDENCE...........................................................................................................9
   Evidence-based Practice Framework................................................9
      The Iowa Model..................................................................................9
   Needs Assessment/Triggers...................................................................12
   Analysis for Readiness to Change/Priority of the Topic......................13
   Resources..................................................................................................16
   Literature Review and Appraisal.........................................................17
   Critical Appraisal....................................................................................18
      Radiography.........................................................................................20
      Auscultation.........................................................................................20
      Tube Management...............................................................................24
      Aspirate Testing Methods.................................................................28
      Other Methods....................................................................................34
      Expert Opinion...................................................................................41
      Patient and Family Preferences.......................................................41
   Synthesis of the Evidence.......................................................................41
Recommendation for Practice.................................................45

III. IMPLEMENTATION............................................................49
   Population of Interest......................................................49
   Practice Setting..............................................................49
   Identification of Resources..............................................49
   Ethical and Legal............................................................49
   Process of Implementation..............................................50

IV. EVALUATION........................................................................52
   Cincinnati Children’s.......................................................52
   National Guideline Clearinghouse....................................53
   Evaluation of Impact......................................................53

V. DISCUSSION.........................................................................55
   Outcomes and Future Steps..............................................55
   Facilitators and Barriers..................................................56
   Final Summary...................................................................59

REFERENCES...........................................................................61

APPENDIX A. BESt Template....................................................69
APPENDIX B. Stakeholders/team.............................................73
APPENDIX C. Databases Searched and Abstraction Table..........74
APPENDIX D. Table of Evidence.............................................75
APPENDIX E. RCT Appraisal Form.......................................76
APPENDIX F. Descriptive Appraisal Form.............................80
<table>
<thead>
<tr>
<th>Appendix</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>Cohort Appraisal Form</td>
<td>84</td>
</tr>
<tr>
<td>H</td>
<td>Grade of the Body of Evidence</td>
<td>88</td>
</tr>
<tr>
<td>I</td>
<td>Prediction Equation Table</td>
<td>89</td>
</tr>
<tr>
<td>I</td>
<td>Judging the Strength of a Recommendation</td>
<td>90</td>
</tr>
<tr>
<td>J</td>
<td>Analysis of Utility</td>
<td>91</td>
</tr>
<tr>
<td>K</td>
<td>Agency Permission Form</td>
<td>93</td>
</tr>
<tr>
<td>L</td>
<td>Permission to Reproduce the Iowa Model</td>
<td>94</td>
</tr>
<tr>
<td>L</td>
<td>Permission to Use Prediction Equation Table</td>
<td>95</td>
</tr>
<tr>
<td>M</td>
<td>Implementation Plan</td>
<td>96</td>
</tr>
<tr>
<td>N</td>
<td>BESt User checklist</td>
<td>97</td>
</tr>
<tr>
<td>O</td>
<td>Conflict of Interest</td>
<td>100</td>
</tr>
<tr>
<td>P</td>
<td>Reviewer Checklist</td>
<td>101</td>
</tr>
<tr>
<td>Q</td>
<td>Final BESt</td>
<td>102</td>
</tr>
<tr>
<td>R</td>
<td>Guideline Submission Checklist</td>
<td>111</td>
</tr>
<tr>
<td>S</td>
<td>Inclusion Criteria</td>
<td>112</td>
</tr>
<tr>
<td>T</td>
<td>Template of Guideline Attributes</td>
<td>113</td>
</tr>
<tr>
<td>U</td>
<td>NGC BESt</td>
<td>117</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The Iowa Model</td>
<td>11</td>
</tr>
<tr>
<td>2. The Iowa Model for This Project</td>
<td>51</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PICO Questions for NGT/OGT Placement</td>
<td>8</td>
</tr>
<tr>
<td>2. Studies Assessing Radiography</td>
<td>21</td>
</tr>
<tr>
<td>3. Studies Assessing Auscultation</td>
<td>25</td>
</tr>
<tr>
<td>4. Studies Assessing Tube Measurement</td>
<td>29</td>
</tr>
<tr>
<td>5. Studies Assessing Aspirate</td>
<td>35</td>
</tr>
<tr>
<td>6. Studies Assessing Other Methods</td>
<td>40</td>
</tr>
<tr>
<td>7. Comparison of Mean by pH Site</td>
<td>43</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

This project would not have been possible without the guidance and help of several individuals who in one way or another contributed and extended their valuable assistance and support throughout the duration of this program.

It is with immense gratitude that I acknowledge the help of my mentor, Barbara Giambra. Her vast knowledge of the evidence-based practice process and contribution to this project was invaluable. Her support and words of encouragement kept me going when I needed it most.

I’d like to thank my project committee members Dr. Donna Miles Curry and Dr. Kelly Phillips. Their valuable feedback was important in helping this manuscript be the best it could be. I’d especially like to thank my project co-chair Dr. Tracy Brewer. I truly believe without her enthusiasm, dedication, and unending willingness to help I would have never made it through to the end.

I’d like to thank my husband Don for his constant support and for never complaining about not having dinner on the table or the clean laundry because I was hard at work on my project. Thanks to my children Eric, Nicholas, and Mark, for their understanding and encouragement over the past four years. Finally, my parents, Roger and Barb Luken for their willingness to help with whatever I needed but mostly for encouraging me to go into nursing in the first place.
DEDICATION

This project is dedicated to my family; my husband Don, my children Eric, Nicholas and Mark Sievers and my parents Roger and Barb Luken, who have always supported and encouraged me throughout all of my endeavors.
I. Problem

Description of the Problem

Hospitalized pediatric patients often require nasogastric tube (NGT) or orogastric tube (OGT) insertion for the therapeutic purpose of administering enteral feedings and medications, or for gastric decompression. Feeding tubes are required for children who display clinical symptoms of feeding and swallowing disorders. Common symptoms include a weak or poor suck-swallow pattern, breathing disruptions, coughing or choking, poor oral, tongue, lip and jaw control, delayed swallow, recurrent pneumonia and upper respiratory infections, aspiration, failure to thrive, malnutrition, weight loss, prolonged feeding time, and unexplained refusal to eat (Skitberg & Bantz, 1999). Children who are comatose, semi-comatose, or have swallowing problems are at high risk for placement errors outside the intended location (Ellett & Beckstrand, 1999). However, every child who is receiving a tube is at risk for tube placement errors.

Determination of proper tube placement is an important part of safe nursing practice. Properly placed tubes are those which are placed orally or nasally and terminate in the stomach. However, NGT’s can be placed incorrectly into the brain, airway, pleural cavity, esophagus or peritoneum (Ellett & Beckstrand, 1999). Error rates for placement of enteral tubes in any location, other than the intended location, can be up to 43.5% in pediatric settings (Ellett & Beckstrand, 1999). A small percentage of those misplaced tubes, reported as 1%-4% in adult intensive care settings but unknown in pediatrics, are incorrectly placed within the respiratory tract with potentially serious consequences.
Prevention of medical errors should be taken seriously. The Institute of Medicine (IOM) (1999) released the report *To err is human: building a safer health system* which estimated at least 44,000 and possibly as many as 98,000 people die in hospitals each year as a result of medical errors. In a follow-up report, *Crossing the quality chasm: a new health system for the 21st century*, IOM (2001) outlined six specific aims for improvement of the American health care system. It is proposed health care should be “safe, effective, patient centered, timely, efficient and equitable” (p. 51). This report launched a major federal initiative to reduce medical errors and improve patient safety.

The IOM (2001) defines an adverse event as one that results in “unintended harm to the patient by an act of commission or omission” (p 32). The Joint Commission (n.d.), an independent, not-for-profit organization who evaluates the quality and safety of care for health care organizations, has also addressed the issue of medical errors. In 1996 the Joint Commission implemented the sentinel event policy to address the issue of safety events. A sentinel event is defined as “an unexpected death or serious physical injury, including loss of limb or function, or psychological injury, or the risk thereof” (Joint Commission, 2011, p.1). “Risk thereof” refers to incidents that may have not caused harm but a recurrence of the error would carry a significant chance of a serious adverse outcome. The sentinel event policy is designed to help institutions identify events which could cause harm and take action to prevent future recurrence. When a sentinel event occurs, an institution is expected to analyze the cause of the event, make improvements to
reduce risk, and monitor the effectiveness of the improvements (Joint Commission, 2011).

**Significance of the Problem**

Safety is a top priority for Cincinnati Children’s Hospital Medical Center (Cincinnati Children’s) who declares, “Safety is central to delivering the best-in-class outcome” (Cincinnati Children’s Hospital Medical Center, 2012a, p.1). Cincinnati Children’s is a full service, not-for-profit pediatric academic medical center serving children locally, nationally and internationally. The vision of Cincinnati Children’s is to be “the leader in improving child health” (Cincinnati Children’s Hospital Medical Center, 2012b, p.1). The mission statement expands on this idea and aims to “improve child health and transform delivery of care through fully integrated, globally recognized research, education and innovation while striving to achieve the best medical and quality-of-life outcomes, patient and family experience, and value” (Cincinnati Children’s Hospital Medical Center, 2012b, p.1). Cincinnati Children’s has 577 registered inpatient beds accounting for 30,951 admissions for fiscal year 2011 (Cincinnati Children’s Hospital Medical Center, 2012c) while providing care to patients from newborn to 21 years of age.

Insertion of NG tubes is common practice at Cincinnati Children’s in addition to other pediatric hospitals. The supply purchasing department estimates that over 10,000 tubes are placed annually at Cincinnati Children’s (G. Graham, personal communication, September, 2012). NGT/OGT’s are typically placed at the bedside by registered nurses (R.N.) or physicians. Cincinnati Children’s uses the nose-ear-xiphoid (NEX) method of measurement combined with the auscultory method for NGT or OGT placement.
verification. Radiographic verification is not routinely done but is recommended for patients at high risk for aspiration.

Prior to the start of this project, Cincinnati Children’s reported a safety event resulting from an incorrectly placed NGT using the NEX and auscultory methods. Therefore, recognition that misplaced tubes could result in an adverse or sentinel event was documented. Improper placement of NG tubes into the lungs can cause pneumothorax or pneumonia, which could lead to sentinel events (Ellett et al., 2005; Metheny et al., 1999b; Metheny et al, 1994a). In response to the resulting safety event at Cincinnati Children’s, a group was formed to examine the literature pertaining to placement of NGT/OGT’s and a guideline was developed. However, the guideline was not implemented related to issues with clarity of the statement, presentation of the data, and feasibility of the recommendations. Instead the NGT/OGT insertion policy was modified to require that all patients who had a NGT/OGT placed have an x-ray to confirm placement. However, after being in place for only two weeks, the policy was placed on hold when several problems were encountered after implementation. Initially, the radiology department could not handle the increase demand for x-rays. Secondly, patient care was delayed related to long wait times requiring transport to radiology and processing of films. Lastly, patients and families complained about the inconvenience and expense of having to obtain an x-ray. The policy was revised again requiring x-rays for patients who were obtunded, sedated, unconscious, critically ill or those that presented with a reduced gag reflux. In addition, an x-ray could be obtained on any patient for which there were concerns about the tube being properly placed. However the desire to develop a clear and feasible guideline for NGT/OGT, which is reflective of the
literature, remained despite revisions and thus became the basis for this project. Therefore, the project targeted hospitalized pediatric patients who required NGT/OGT placement for feeding, medications, or decompression at Cincinnati Children’s. A large number of hospitalized children at Cincinnati Children’s require feeding tubes and the desire was to find a safe and evidence-based method for correct NGT/OGT placement and assessment.

An evidence-based practice (EPB) approach was used to identify an accurate method of NGT/OGT placement in hospitalized pediatric patients who require NGT/OGT placement for feedings, medications, or gastric decompression. Radiography is the gold standard for documenting tube placement because of the extremely small margin of error, which is attributed to human error from misread films (Ellett & Beckstrand, 1999; Metheny & Meert, 2004). However, routine radiologic verification in pediatric and adolescent patients increases the risk of excessive radiation exposure, increases patient and healthcare costs, and slows the delivery of clinical care (Ellett & Beckstrand, 1999; Neumann, Meyer, Dutton & Smith, 1995). In addition, having to leave the hospital unit to obtain an x-ray can be inconvenient to the patient, family, and staff and portable x-rays are not always feasible. Thus, it was necessary to find a method of NGT/OGT placement that exemplifies safe clinical practice and also considers the needs and preferences of the patient and family, and staff.

Methods of NGT or OGT verification which utilize nursing assessment skills and bedside testing are an alternative to radiography. These methods include proper tube measurement, auscultation, gastric aspirate pH, enzyme tests, visual inspection of aspirate, and carbon dioxide (CO2) testing. However, not all of these methods are highly
accurate nor are they always feasible to perform at the bedside (Metheny & Stewart, 2002).

Clinical practice guidelines are often used to guide nursing practice. However guidelines related to the placement of NGT/OGT’s in pediatrics are limited. Minimal guidelines were found in the literature. The U.S. Department of Health and Human Services Agency for Health Research and Quality’s (AHRQ) holds the National Guideline Clearinghouse (NGC). AHRQ’s mission is to improve the quality, safety, efficiency, and effectiveness of health care for all Americans (U.S. Department of Health and Human Services Agency for Health Research and Quality, 2012a). The NGC’s mission is to provide physicians and other health professionals, health care providers, health plans, integrated delivery systems, purchasers, and others an accessible mechanism for obtaining objective, detailed information on clinical practice guidelines and to further their dissemination, implementation, and use (U.S. Department of Health and Human Services Agency for Health Research and Quality, 2012b). The NGC is a public resource for evidence-based clinical practice guidelines and offers clinicians the most recent information about the continuum of care and best practices for all health care recipients (U.S. Department of Health and Human Services Agency for Health Research and Quality, 2012c). However, there were no clinical practice guidelines found related to the placement of NGT/OGT’s in pediatrics within the NGC.

Best Evidence Statements (BEST’s) are similar to clinical practice guidelines and provide a format for the presentation of clinical recommendations, discussions, and methods in a user friendly way and are intended for publication (McGee & Clark, 2010). BEST’s are useful for the point-of-care clinician seeking concise evidence to guide
clinical decision-making (McGee & Clark, 2010). The scope of a BESl is smaller than a clinical practice guideline. According to Cincinnati Children's Hospital Medical Center (2012d) a BESl contains a concise summary of the EBP review and presents clinical recommendations. A BESl is based on high quality evidence related to a limited topic or single clinical question and depends more on synthesized evidence. Synthesized evidence can include published guidelines and other systematic reviews when available, rather than primary research. The BESl template is presented in Appendix A.

This paper will discuss an EBP project development and publication of a BESl for confirmation of NGT or OGT tube placement for children. After a description of the specific problem, target population, and impact of the problem, the Iowa Model of Evidence-Based Practice To Promote Quality Care (The Iowa Model) will be used as a guiding framework for BESl development.

**PICO Questions**

One method of problem identification is utilization of the PICO question format. The acronym PICO represents the following: (P) patient, population or problem, (I) intervention or independent variable, I comparison, and (O) dependent variable or outcome (Stone, 2002). Using the PICO format, the purpose of this EBP project is to examine the following two questions: 1) Among pediatric patients who require NGT/OGT placement does auscultation, pH, enzyme, visual inspection of aspirate, and CO2 testing compared to radiological verification provide an accurate confirmation of tube placement? 2) Among pediatric patients who require NGT/OGT placements are tube length predictions using age-related height-based (ARHB) methods compared to nose-ear-xiphoid (NEX) morphological measurements more accurate in predicting tube
length? The PICO questions will aid in determining the criteria for selecting studies to review and will serve as a guide for the remainder of the EPB process (Stone, 2002). The PICO questions are broken down in Table 1.

Table 1

**PICO Questions for NGT/OGT Placement**

<table>
<thead>
<tr>
<th>Format</th>
<th>Specific clinical question component</th>
<th>Rationale for selection of the specific component</th>
</tr>
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<tbody>
<tr>
<td>P</td>
<td>Among hospitalized pediatric patients who require NGT or OGT placement</td>
<td>Hospitalized pediatric patients frequently require NGT or OGT’s for enteral feedings, medication administration or gastric decompression.</td>
</tr>
<tr>
<td>I</td>
<td>does auscultation, pH, enzyme, visual inspection of aspirate, and CO₂ testing</td>
<td>Methods that are done at the bedside have been shown to be effective in accurate tube placement and have been associated with decreased costs, increased convenience.</td>
</tr>
<tr>
<td>C</td>
<td>compared to radiological verification</td>
<td>Radiologic verification is the Gold Standard</td>
</tr>
<tr>
<td>O</td>
<td>provide an accurate confirmation of tube placement?</td>
<td>Inaccurately placed tubes can result in poor patient outcomes including pneumothorax or pneumonia</td>
</tr>
<tr>
<td>P</td>
<td>Among hospitalized pediatric patients who require NGT or OGT placement</td>
<td>Hospitalized pediatric patients frequently require NGT or OGT’s for enteral feedings, medication administration or gastric decompression.</td>
</tr>
<tr>
<td>I</td>
<td>are tube length predictions using age-related height – based (ARHB) methods</td>
<td>ARHB methods have been shown to be accurate predictors of tube length.</td>
</tr>
<tr>
<td>C</td>
<td>compared to nose-ear-xiphoid (NEX) morphological measurements</td>
<td>NEX method is associated with a higher percentage of tube placement errors.</td>
</tr>
<tr>
<td>O</td>
<td>more accurate in predicting tube length?</td>
<td>Tubes which are accurately measured result in higher incidence of properly placed tubes.</td>
</tr>
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II. Evidence

Evidence-Based Practice Framework

The term EBP was introduced over ten years ago and evolved out of the concept of evidence-based medicine (EBM). The terms EBM and EBP are often interchanged. Gray (2001) offered one of the earliest descriptions of EBM claiming it is “doing the right things right” (p 37). Sackett, Richardson, Rosenberg and Haynes (1997) produced the first book on EBM, and defined it as “the conscientious, explicit and judicious use of current, best evidence in making decisions about the health care of patients” (p.18). “Best research evidence” was defined by Sackett, Straus, Richardson, Rosenberg and Haynes (2000) as “taking previously accepted diagnostic tests and treatment and replacing them with new ones that are more powerful, more accurate, more efficacious and safer” (p.1). Sackett et al. (2000) expanded the definition to include clinical expertise and patient values. Patient values should take into consideration the “unique preferences, concerns and expectations of the patient” (p.1). Clinical expertise is an important attribute of EBP. The success of the EBP guidelines that are being implemented, rely on the clinical skill and past experience of the nurse (Sackett et al., 2000). LoBiondo-Wood and Haber (2006) contend that EBP should also include case reports and expert opinion.

The Iowa model. Many models have been developed to guide the development of EBP. The Iowa Model originated in 1994, was revised in 2001 and has been used by providers as a guide to use research findings to improve patient care. The Iowa Model
(Figure 1) guides the development of EBP by taking clinicians through several steps including: (a) identification of the practice questions or “triggers”, (b) priority of the topic, (c) forming a team, (d) assembling relevant research and related literature, (e) critique and synthesis of research, (f) decision on whether or not to implement research into practice, (g) pilot testing, (h) adaptation into practice, and (i) outcome assessment (Titler et al., 2001).

In the first step, “triggers” are classified as either problem focused, or knowledge focused. Examples of problem-focused triggers may include risk management data, process improvement data, financial data, benchmarking data, or identification of a clinical problem. Knowledge focused triggers may relate to new research or other literature, national agency or organizational standards, philosophies of care, or questions from standards committees (Titler et al., 2001).

Triggers must be a priority of the organization. With a commitment to pursue a change in practice, a team is formed (Titler et al., 2001). Team members should be multidisciplinary and represent all of the stakeholders involved in the project. Teams may already exist or be newly developed.

Next, the team will assemble, critique, and synthesize relevant research. Titler and colleagues (2001) recommend one individual serve as the leader for the project, but to divide the work among the group. Once studies are critiqued a decision to retain each study is made based on the overall merit of the study, the type of subjects and similarity to the project, and the clinical relevance of the study. Summary tables can aid in summarizing information about the literature review.
Figure 1

The Iowa Model

Used/Reprinted with permission from the University of Iowa Hospitals and Clinics and Marita G. Titler, PhD, RN, FAAN. Copyright 1998. For permission to use or reproduce the model, please contact the University of Iowa Hospitals and Clinics at (319) 384-9090
A critical point in the process of the Iowa Model is determining if there is significant research to support a recommendation for a change in practice. Determination is made by analyzing several factors: (a) consistency of the findings, (b) type and quality of the studies, (c) relevance of the findings, (d) number of studies similar to the sample, (e) the feasibility of the findings, and (f) the risk benefit ratio (Titler et al., 2001). After sufficient evidence is found to support a practice change future steps would include pilot testing, adoption into practice, and outcomes evaluation.

**Needs Assessment/Triggers**

In order to identify the triggers for this clinical problem and determine if there is organizational support, it is necessary to perform a needs assessment specific to the Cincinnati Children’s culture. The population of interest was children newborn to nineteen years of age admitted to an inpatient unit (excluding the emergency department and neonatal or pediatric intensive care unit), at Cincinnati Children’s for any reason, which require a NGT/OGT for medication, feeding or decompression of the stomach. The key drivers or the triggers for this project were the history of a safety event and the potential for poor outcomes resulting from misplaced NGT/OGT’s. In addition, Cincinnati Children’s commitment to safety and quality would also be considered a key driver.

When a safety event occurs institutions are required to analyze the cause of the event and make improvements to reduce risk. When Cincinnati Children’s encounters a problem related to nursing practice a referral is sent by risk management to the Nursing Practice Council. In this case, a referral was sent related to the issue of misplaced NGT/OGT’s and after review; the Nursing Practice Council recommended a group be
formed to examine the evidence relating to NGT/OGT insertion. A group was formed and in 2008 a BESt was published. The BESt was then presented to the Nurse Practice Council for incorporation into a policy for NGT/OGT placement. In September 2008 as part of the Nursing Practice Council project I was given the task of incorporating the BESt into the new policy for NGT/OGT placement.

At that time, nursing practice for confirmation of NGT/OGT placement consisted of measurement using NEX and auscultation. The BESt described additional methods of placement verification, which included testing the pH of gastric aspirate. Prior to this proposed change in practice it was necessary to assess readiness for change and support for the policy revision.

**Analysis for Readiness to Change/Priority of the Topic**

Analysis for readiness to change can be examined from both an institutional and specific setting perspective. From an institutional perspective, the history of a safety event as well as the strong culture of safety lends support for a change in practice. Support from stakeholders is also important when instituting a new program. Stakeholders include those involved in program operations, those affected by the program, and the primary users of the program (Centers for Disease Control and Prevention (CDC), 1999, p. 5). Key stakeholders for this project included members of the Cincinnati Children’s senior nursing administrative team, the directors of the inpatient units, physicians, nursing staff, education coordinators, laboratory staff, and nurse practitioner/Doctor of Nursing Practice (DNP) student (Appendix B). In December 2008, the DNP student met with a small team of administrators, nursing leaders, and physicians to explore their commitment to the project and readiness for change. The team expressed
support for change but raised concerns about the ability to perform bedside testing of pH of gastric contents.

Bedside testing is federally regulated under the Clinical Laboratory Improvement Amendment (CLIA), which was passed in 1988 (Food and Drug Administration (FDA), 2010). These amendments established quality standards for all laboratory testing to ensure the accuracy, reliability, and timeliness of patient test results regardless of where the test was performed (FDA, 2010). However, tests may be waived from regulatory oversight if they meet certain requirements established by the statute. In the regulations, waived tests are defined as “simple laboratory examinations and procedures that are cleared by the FDA for home use; employ methodologies that are so simple and accurate as to render the likelihood of erroneous results negligible; or pose no reasonable risk of harm to the patient if the test is performed incorrectly” (FDA, 2010, p). Bedside pH testing is included as one of the waived tests by the FDA. The issue with CLIA waived tests is the tedious record keeping and documentation that is required as part of the regulation. Failure to comply with the documentation guidelines could result in fines and sanctions. Therefore, implementation of a practice guideline that utilizes a CLIA waived test was carefully considered.

In February 2009, the DNP student met with a member of laboratory administration to further investigate the issue of bedside testing of pH. The laboratory administrator confirmed that with proper training, monitoring and record keeping bedside testing of pH was possible because other bedside tests were done in the institution (L. Anderson, personal communication, February, 2009). In May 2009 the DNP student met with the director of the nursing education coordinators to discuss the implications of a
policy change. The education director supported the policy change but reported education for nurses would be necessary and could take up to six months to complete (A. Longo, personal communication, May, 2009).

Through these meetings with the stakeholders it was evident that, although the project was a priority for the institution, there were potential barriers to implementation. However, consensus was that a change in practice would be considered if patient safety was the perceived benefit.

The next step was to begin the policy revision. However, when the DNP student closely examined the BESt there were many questions about the data. The statement and recommendations were confusing. In addition the research and statistical data were not clearly understood. Therefore the DNP student submitted a request for assistance from the Nursing Research Team. In July of 2009, the DNP student met with the Assistant Vice President (AVP) of nursing research in the Center for Professional Excellence in research. After examination of the BESt the AVP concluded that the data analysis was incorrect and therefore the recommendations may not be accurate. She recommended the entire process be repeated and the BESt be recreated prior to any policy change (M. Huth, personal communication, July, 2009). At that time it became the focus of the DNP student to develop a new BESt for the confirmation of NGT/OGT placement starting from the beginning of the developmental process.

The AVP of nursing research suggested the DNP student contact the original BESt development team to inquire if there was any interest in assisting with the new project. Members were contacted by electronic mail and of the fifteen original members, ten declined involvement, four members responded positively, and one had left the
institution and could not be contacted. In addition, the AVP of nursing research suggested the DNP student invite one of the EBP mentors to be part of the team.

At Cincinnati Children’s the role of the EBP mentor is to foster the development of an evidence-based approach to clinical practice on the unit level and to guide nursing staff by educating and role modeling the use of evidence to advance best practice at the point of care (Cincinnati Children’s Hospital Medical Center, 2010b). The EBP mentor is an advanced practice nurse practitioner who has completed extended training through a week-long immersion program in EBP. The mentor’s purpose is to collaborate with an interdisciplinary unit-based team to facilitate the use of evidence in clinical decision-making (Cincinnati Children’s Hospital Medical Center, 2010b). The EBP mentor is part of Cincinnati Children’s Center for Professional Excellence (CPE) whose purpose is to support excellence in nursing. The CPE is divided into education, research, and quality. The vision of the research division is to "to establish expertise in research and evidence-based practice that improves the health and well-being of children and families" (Cincinnati Children’s Hospital Medical Center, 2010a). The mission is to “advance the process and practice of research and evidence-based practice in the care of children and families” (Cincinnati Children’s Hospital Medical Center, 2010a). Mentors are available to staff as support with projects related to evidence-based practice. In this case the DNP student was the project leader and facilitator of the overall BESt development process.

Resources

In BESt development it is helpful to assess available resources and current barriers for the project. Resources for this project included financial and administrative support from organizational stakeholders. In addition, staff support in the way of
personnel, equipment, and supplies were also available. Barriers to the success of the project were also considered. Future implementation would require training and development, equipment, and supplies, all which require financial support. Other potential barriers included staff resistance to change, lack of commitment from nurses, and the lack of time needed to learn a new process. Regulatory barriers related to the monitoring and reporting of bedside testing also posed a threat.

**Literature Review and Appraisal**

The literature review was conducted in order to uncover information, which will answer the clinical questions. Search strategies aimed to identify literature pertaining to any method of NGT insertion. The search was conducted using Ovid database including Medline, CINAHL, and Cochrane Database for Systematic Reviews. Search filters used years 1996 to present and was limited to humans, the English language, and the highest quality evidence, such as systematic reviews. Key words used were children and nasogastric tube, NG tube, gastric aspirate, auscultation and nasogastric, x-ray verification of NG tube, morphological distances, and nasoenteral measurement (Appendix C). Additional articles were identified from a hand search of the reference lists of the reviewed articles.

Multiple studies were reviewed and 24 met the inclusion criteria for the project based on the clinical questions. In addition to clinical relevance, other factors that were considered for inclusion were the overall merit of the study, and applicability of the subjects. Literature review tools served as a guide for individual study review.

A hierarchy of evidence, or level of evidence, provided guidance about the types of evidence that would provide reliable answers to the clinical questions (Melnyk & Fineout-Overholt, 2011). There are various hierarchies depending on the type of clinical
question being asked. For example for intervention questions such as the questions for this project, the hierarchy of evidence ranks a well done systematic review or meta-analysis the highest level of evidence.

**Critical Appraisal**

The levels of evidence as adopted by Cincinnati Children’s are based on the LEGEND system that stands for “Let Evidence Guide Every Decision” (Clark, Burkett, & Stanko-Lopp, 2009). The LEGEND system is a comprehensive evaluation system that was developed through a review of the literature, which examines multiple evidence evaluation systems. Evaluation systems were evaluated by criteria, which assessed if the system was systematic, functional, generalizable, user-friendly, and validated. From the evaluation criteria, the LEGEND system was created and consists of six tools; glossary, table of evidence levels, algorithm, evidence appraisal forms, grading the body of evidence, and judging the strength of a recommendation (Clark, Burkett, & Stanko-Lopp, 2009).

Following the LEGEND system, literature is assigned a quality level or grade from one to five with one being highest-level studies. Level 1 studies are systematic reviews or meta-analysis, Level 2 include randomized controlled trials, Level 3 studies are non-randomized controlled, quasi-experimental, or cohort studies. The fourth level studies are well-designed non-experimental studies that are descriptive or case studies, and Level 5 studies are expert opinion, case reports and clinical examples (Cincinnati Children’s Hospital Medical Center, 2011). Another component of leveling is the subjective classification by the reviewer of the study as either “a” or “b” based on the quality of the study. An “a” level study is one that is considered by the reviewer to be a
good quality study with appropriate methods and sufficient sample size. Whereas a “b” study in comparison would be a lesser quality study with a less adequate sample size, or lacking validity, reliability, or applicability. This quality assignment is subjective from the reviewer’s standpoint and allows for flexibility and individual judgment. For example, a study, which uses a cohort design and has a small sample size and demonstrated some applicability, might be given a grade of 3b. Appendix D shows the table of evidence levels.

Evidence appraisal forms guide the researcher through the questions of validity, reliability and applicability (Clark, Burkett, & Stanko-Lopp, 2009). Each form is specific to each type of study design. Most of the studies reviewed for this project were descriptive with a few cohort studies and only one randomized controlled trial. While cohort studies represent a stronger study design, there were very few available related to the ethical concern of having an experimental group with a misplaced tube and a control group with a correctly placed tube. The appraisal tools used for randomized controlled studies; descriptive studies and cohort studies are presented in Appendices E, F and G respectively.

The literature for the clinical questions was reviewed with two main objectives in mind. The first was to identify literature, which pertained to current practice of measurement with the NEX method and verification by auscultation. The second was to identify other methods of NGT or OGT measurement and verification. Findings were organized according to the method examined: radiography, auscultation, measurement, aspiration, and other methods.
**Radiography.** In the review of the literature, no one best method of NGT/OGT placement was identified however; radiography, or x-ray, is cited as the gold standard for verification by multiple researchers and is used as a benchmark to test other methods (Metheny et al., 1994a; Metheny & Stewart 2002; Nyquist, Sorell, & Ewald, 2005; Peter & Gill, 2008; Ellett & Beckstrand, 1999; Westhus, 2004). However, a landmark study that established radiography as the gold standard could not be identified. Still, radiography is the gold standard for tube verification because it is the only method in which the entire course of the tube can actually be visualized. In addition, there is a very small error rate associated with x-ray that is attributed to human error, related to misread films.

Even though radiography is the gold standard, it is expensive especially when the frequency of verification is considered. Furthermore, the exact risk of radiation exposure from x-rays obtained for tube verification is unknown but any radiation exposure is concerning in young children (Neuman et al., 1995). The literature summary for radiography is presented in Table 2.

**Auscultation.** Auscultation pertains to the method of using a ten or twelve milliliter syringe and instilling one to two millimeters of air into the tube while auscultating over the stomach with a stethoscope (Hockenberry & Wilson, 2007). Although widely used by pediatric nurses, the accuracy of auscultation to verify placement in the stomach has been shown to have poor reliability and is not recommended as a sole verification method (Ellett & Beckstrand, 1999; Metheny, McSweeney, Werhle, & Wiersma, 1990; Neumann et al., 1995). The high error rate with this method is related to the inability to differentiate sounds from the esophagus,
# Table 2

Studies assessing radiography

<table>
<thead>
<tr>
<th>Study Citation</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Setting</th>
<th>Sample Population</th>
<th>Independent Variable/ Intervention</th>
<th>Dependent variable/ outcome measure</th>
<th>Results/ outcomes</th>
<th>Applicability</th>
<th>Evidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellett &amp; Beckstrand, 1999</td>
<td>Descriptive</td>
<td>n=46</td>
<td>Pediatric hospital</td>
<td>Less than 19 yr. requiring enteral nutrition or decompression by NG, OG, or NJ</td>
<td>Verification of existing tube placement by submersion in water, auscultation and aspiration and pH testing compared to x-ray</td>
<td>Tube placement in intended location</td>
<td>Tube placement errors occurred in 43.5% of tubes. Children who were comatose or semi-comatose, were inactive, had swallowing problems or had argyle tubes were more likely to have errors</td>
<td>Yes</td>
<td>4b</td>
</tr>
<tr>
<td>Metheny, et al., 1994A</td>
<td>Prospective cohort</td>
<td>n=605</td>
<td>Hospital</td>
<td>18-94 yr.</td>
<td>Compared tube verification with pH, using pH paper or pH meter with x-ray. Determine mean pH of gastric and intestine</td>
<td>Impact of feedings on pH, H2 blockers or PPI on tube placement in intended location</td>
<td>pH ≥ 6 indicated gastric placement. Meter and pH paper moth effective. Medications resulted in slightly higher pH values.</td>
<td>Teens and Adults</td>
<td>3a</td>
</tr>
<tr>
<td>Study Citation</td>
<td>Study Design</td>
<td>Sample Size</td>
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<tr>
<td>Metheny &amp; Stewart, 2002</td>
<td>Prospective cohort</td>
<td>n=80</td>
<td>Hospital</td>
<td>18-87 yr. with NG tubes in place receiving continuous feedings</td>
<td>Appearance for bile stain or no bile stain, pH, pepsin, trypsin, bilirubin of aspirated</td>
<td>The extent to which appearance, pH, pepsin, trypsin and bilirubin of aspirated could differentiate between placement in the stomach and intestine during continuous feedings</td>
<td>Bile stained aspirates are more likely to be from the intestine. Aspirate of pH ≤ 6 less likely that the tube is in the stomach. Mean pepsin was higher in gastric. Mean trypsin was higher in intestinal. Bilirubin was higher in intestine</td>
<td>Teens and Adults</td>
<td>3a</td>
</tr>
<tr>
<td>Nyquist et al., 2005</td>
<td>Descriptive</td>
<td>n=60, 2970 observations</td>
<td>Hospital</td>
<td>Infants born at gestational age 24-42 weeks</td>
<td>Tested aspirate for litmus reaction.</td>
<td>To determine the use of litmus paper tests for assessment of aspirates in infants.</td>
<td>High ratio of positive litmus reactions in all ages.</td>
<td>Infants</td>
<td>4a</td>
</tr>
<tr>
<td>Peter &amp; Gill, 2008</td>
<td>Descriptive</td>
<td>n=1527</td>
<td>Hospital</td>
<td>Unknown</td>
<td>Evaluated aspirates for presence and pH following new guideline.</td>
<td>To evaluate practice changes.</td>
<td>Aspirates were obtained for 97% of all tests, pH was ≤ 5.5 for 84%</td>
<td>Yes</td>
<td>5</td>
</tr>
<tr>
<td>Study Citation</td>
<td>Study Design</td>
<td>Sample Size</td>
<td>Setting</td>
<td>Sample Population</td>
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<tr>
<td>Westhus, 2004</td>
<td>Descriptive</td>
<td>n=56</td>
<td>Hospital ICU</td>
<td>Birth-14yr. with NG, OG or NJ</td>
<td>Examined pH, appearance, pepsin and trypsin of aspirate and got x-ray</td>
<td>To what extent pH, appearance, pepsin and trypsin predict placement. Impact of acid suppression.</td>
<td>Yes</td>
<td>4b</td>
<td></td>
</tr>
</tbody>
</table>
stomach, intestine, or lungs (Metheny et al., 1990). In a descriptive study, Ellett and Beckstrand (1999) studied hospitalized children with existing enteral tubes and compared submersion method, auscultation, aspiration, and pH testing to x-ray. Auscultation of a sound over the left upper quadrant was found to have a positive predictive value of 20% (assessed to be incorrectly placed by auscultation and found to be incorrectly placed on x-ray) and a negative predictive value of 63.6% (tubes assessed to be correctly placed by auscultation and found to be correctly placed on x-ray) (Ellett & Beckstrand, 1999). Metheney et al. (1990) also observed the auscultation method. In this study nurses were asked to classify recorded sounds which were generated by air insufflations through feeding tubes. The overall average percent of correct classification was 34.4%.

Auscultation over the left upper quadrant were classified correct 41.6% of the time, F(3/111) = 2.94, p=.0362. In a prospective cohort study, Newman et al. (1995) compared auscultation to x-ray and found that sensitivity (percentage of tubes incorrectly placed on x-ray and also incorrectly placed on auscultation) was high at 98.3%, but specificity (correctly placed on x-ray and determined correctly placed on auscultation) was only 6.3% with a positive predictive value (assessed to be incorrectly placed by auscultation and found to be incorrectly placed on x-ray) of 79.5% and a negative predictive value (tubes assessed to be correctly placed by auscultation and found to be correctly placed on x-ray) of only 50% (p=0.31). These studies support the idea that auscultation alone is not an accurate method of NGT or OGT placement. A summary of the literature for auscultation is presented in Table 3.

**Tube measurement.** Proper tube measurement also plays an important role in a successful NGT/OGT placement. Several studies have examined the NEX method to
# Table 3

**Studies assessing auscultation**

<table>
<thead>
<tr>
<th>Study Citation</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Setting</th>
<th>Sample Population</th>
<th>Independent Variable/ Intervention</th>
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<td>Tube placement errors occurred in 43.5% of tubes. Children who were comatose or semi-comatose, were inactive, had swallowing problems or had argyle tubes were more likely to have errors</td>
<td>Yes</td>
<td>4b</td>
</tr>
<tr>
<td>Metheny, et al., 1990</td>
<td>Descriptive</td>
<td>n=123</td>
<td>Hospital</td>
<td>21 yr. &amp; older</td>
<td>Compared audio recorded sounds from 5 sites</td>
<td>Ability to classify sounds</td>
<td>Overall classification only 34%</td>
<td>Yes</td>
<td>4a</td>
</tr>
<tr>
<td>Newman et al., 1995</td>
<td>Cohort</td>
<td>n=28</td>
<td>Hospital</td>
<td>36-92 years old</td>
<td>Compared pH and auscultation to x-ray</td>
<td>To determine cut off for pH of gastric aspirates. Reliability of auscultation.</td>
<td>Recommended pH cut off of ≤ 4. Auscultation alone was not effective.</td>
<td>Adults</td>
<td>3b</td>
</tr>
</tbody>
</table>
estimate tube length. The NEX method is done by measuring from the tip of the nose, to the tip of the ear lobe, to the tip of the xiphoid (Gallaher, Cashwell, Hall, Lowe, & Ciszek, 1993). Although NEX is a relatively simple method its reliability has been questioned. Weibly, Adamson, Clinkscales, Curran, & Bramson (1987) compared the NEX method to a method using a point mid-way between the termination of the xiphoid and the umbilicus (NEMU) then compared both to x-ray. The NEX method had an incorrect placement rate of 55.6 percent and the NEMU method had an incorrect rate of 39.3 percent (Weibly et al., 1987). In a RCT, Klaussner, Luke and Scalzo (2002) examined the variability of the NEX method compared to a graphic method based on the patient’s height. Tubes were placed according to one of the methods and then compared to x-ray. Results showed that tubes placed with the NEX methods showed twice as much variability in placement off the center of the stomach compared to the graphic method (1.31cm [SD3.39] versus -1.12 cm [SD1.36] (Klaussner, Luke, & Scalzo, 2002). This study suggests that alternate methods of measuring may be more accurate. Gallaher and colleagues (1993) studied minimal insertion lengths of OGT’s in premature infants and compared estimated lengths with NEX to x-ray. Results showed that of 171 x-rays, eight (4.7%) revealed the OGT to be low, 57 (33.3%) revealed the OGT to be high and 106 (62%) revealed the OGT to be in adequate position (Gallaher et al., 1993).

The poor accuracy of the NEX method to determine placement prompts the need to examine other methods to determine proper tube length. Early work was done by Strobal, Byrne, Ament, and Euler (1979) who looked at correlating esophageal lengths in children with height. Esophageal length was measured manometrically and compared to
age, surface area, and height to determine if there was a correlation with any of these values. From these measurements an equation was developed for calculation of esophageal length. These measurements were then tested by comparing the calculated length to those obtained using the esophageal length. The correlation coefficients of esophageal length with age and surface area were significant \(P< 0.001\) with \(r=0.9444\) and 0.963 (oral) and \(r= 0.01\) and 0.876 (nasal). This study was important as it provided a reliable calculation of esophageal length based on the patient’s height.

Putnam and Orenstein (1991) also looked at esophageal lengths to determine whether crown rump length (CRL) and distance from the suprasternal notch to the anterior superior iliac spine are correlated with esophageal length. Additionally, they examined whether there was a mathematical reliability between distance from the nose to the mid-right atrial (NTMRA) shadow and the nose to the diaphragm (NTD). A correlation with CRL was identified. The NTD and NTMRA measurements correlated best with height NTD=0.4 (height)= 5.2, with \(r=0.96\), and SEM = 1.1; and NTMRA =0.2 (height)=4.8 with \(r=0.96\) and SEM =0.98. CRL also correlated will with NTD and NTMRA with NTD =0.47 (CRL) =0.57, \(r=0.93\) and SEM =1.4. The distance from suprasternal notch to anterior superior iliac spine correlated less well, with NTD=0.9 (SIS) =1.3, \(r=0.82\), and SEM =2.3; and NTMRA =0.7 (SIS) =1.2, \(r =0.84\), SEM=1.9.

Ellett, Beckstrand, Welch, Dye, & Games (1992) tested Stroebel et al.’s (1979) regression equations by comparing esophageal lengths by manometry to the regression equations. Results indicated that the oral reference equation predicts esophageal length in children less than four years old. The nasally-referenced equation appeared
systematically biased and performed poorly but was probably related to a small sample size (Ellett et al., 1992).

Beckstrand, Ellett, & McDaniel (2007) also considered the work of Stroebel et al. (1979), Putnam and Orenstein (1991) and others to examine how well morphological distances perform as predictors of the internal distance to the targeted position for the tube tip in the stomach. In a large sample of children aged 2 weeks to 19 years, the predicted distances were compared to endoscopic and manometric distances. The age-specific prediction equations were able to predict the internal distance to place all pores (openings at the tip) of the tube in the body of the stomach 98.8% of children aged 6 months to 100 months of age and 96.5% in children older than 100 months old. A summary of the literature for tube measurement is presented in Table 4.

**Aspirate testing methods.** In addition to auscultation and measurement, there is considerable discussion in the literature about methods, which rely on examination of gastric aspirate, which includes pH, enzymes, and visual inspection.

An early multi-site study by Metheny, Reed, Wiersma, McSweeney, Werhle & Clark (1993) evaluated the extent to which pH aspirates from feeding tubes can be used to differentiate between gastric and intestinal tube placement and gastric and respiratory tube placement. They performed pH readings with a pH meter within five minutes of obtaining an abdominal radiograph. Of the 794 pH meter readings 405 were from nasogastric tubes and 389 were from nasointestinal tubes. They reported 85% of the 405 reading were between 0 and 6.0 while over 87% of the 389 intestinal aspirates were greater than 6.0. In addition, four aspirates from feeding tubes inadvertently place in the
<table>
<thead>
<tr>
<th>Study Citation</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Setting</th>
<th>Sample Population</th>
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<th>Applicability</th>
<th>Evidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beckstrand, et al., 2007</td>
<td>Descriptive</td>
<td>n=498</td>
<td>Hospital</td>
<td>2 weeks to 19 yr. undergoing endoscopy or manometry</td>
<td>Morphological distances compared to endoscopy and/or manometry</td>
<td>Internal distance to the stomach for nasogastric and orogastric tube insertion.</td>
<td>Age specific methods predict distance to the body of the stomach in 98.8% of children. NEXU was nest best predictor.</td>
<td>Yes</td>
<td>4a</td>
</tr>
<tr>
<td>Ellett, et al., 1992</td>
<td>Descriptive</td>
<td>n=107</td>
<td>Hospital</td>
<td>1 mo – 14.4 yr. undergoing esophageal manometry</td>
<td>Compared esophageal length by manometry to Strobel’s regression equations</td>
<td>Esophageal length</td>
<td>Strobel’s oral reference equation predicts EL in children less than 4 yr.</td>
<td>Yes</td>
<td>4b</td>
</tr>
<tr>
<td>Study Citation</td>
<td>Study Design</td>
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<td>Gallaher, et al., 1993</td>
<td>Cohort</td>
<td>n=171</td>
<td>Neonatal Intensive care</td>
<td>23-31 weeks post conceptual age who had OGT and x-ray</td>
<td>Length of gavage tube insertion via NEX compared to x-ray</td>
<td>Minimal insertion length</td>
<td>Predicted length was 62% accurate</td>
<td>Neonates</td>
<td>4a</td>
</tr>
<tr>
<td>Klasner, et al., 2002</td>
<td>RCT</td>
<td>n=44</td>
<td>Hospital emergency room</td>
<td>6 mo. – 18 yr.</td>
<td>NEX to graphic method based on height</td>
<td>NEX and graphic method to determine tube in intended location</td>
<td>Graphic method resulted in tubes being placed closer to the center of the stomach.</td>
<td>Yes</td>
<td>2b</td>
</tr>
<tr>
<td>Putnam, et al., 1991</td>
<td>Descriptive</td>
<td>n=65</td>
<td>unknown</td>
<td>3 days – 10 yr.</td>
<td>Measured height, crown-rump length, and distance from the suprasternal notch to the left anterior superior iliac spine</td>
<td>Correlation of crown-rump length with esophageal length</td>
<td>Crown-rump lengths correlated will with esophageal length</td>
<td>yes</td>
<td>4a</td>
</tr>
<tr>
<td>Study Citation</td>
<td>Study Design</td>
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<tr>
<td>Strobel, et al., 1979</td>
<td>Descriptive</td>
<td>n=119</td>
<td>unknown</td>
<td>3 weeks – 235 months</td>
<td>Measured esophageal length, and correlated with age, height and surface area. Generated equation of esophageal length</td>
<td>Correlation of esophageal lengths with height</td>
<td>Age, surface area and height were all significantly correlated. For children less than 120 months there was less variability. Esophageal length best correlates with height</td>
<td>Yes</td>
<td>4b</td>
</tr>
<tr>
<td>Weibley, et al., 1987</td>
<td>Descriptive</td>
<td>n=30</td>
<td>unknown</td>
<td>28 to 36 weeks gestational age at birth</td>
<td>Placed NG tube NEX, or nose, ear &amp; point mid-way between the termination of the xiphoid and the umbilicus confirmed with x-ray</td>
<td>Compare two methods of placement NEX compared to x-ray showed 55.6 % incorrect placement. Nose ear and mid-way showed 39.3 % placements</td>
<td>Premature infants</td>
<td>4a</td>
<td></td>
</tr>
</tbody>
</table>
respiratory tract had pH values greater than 6.5. They concluded that gastric placement was distinguished from intestinal placement (p < .0001), and from respiratory placement.

In the same study by Ellett and Beckstrand (1999) that looked at auscultation, pH testing was also compared to x-ray. Using a pH cut off of ≤ 4 the positive predictive value was 0% (assessed to be incorrectly placed by pH and found to be incorrectly placed on x-ray) and a negative predictive value of 85% (tubes assessed to be correctly placed by pH and found to be correctly placed on x-ray). In an attempt to compare gastric and intestinal aspirates, Metheny et al, (1999b) described pH, visual appearance, as well as the enzymes pepsin, trypsin and bilirubin. pH samples were obtained from feeding tubes of infants and sent to a research laboratory for testing. Although mean gastric and intestinal aspirates could not be compared because of the low number of intestinal aspirates that were obtained, findings from this study were important because it suggested that gastric pH was not significantly higher with feedings, 4.66 versus 3.92; p=.07. The study reported a mean gastric pH of 4.32.

Metheny, Stewart, Smith, Diebold & Clouse (1999a), also examined pH and bilirubin as predictors of placement. They compared mean pH and bilirubin of aspirates from intestine, stomach, and lungs from newly inserted small-bore feeding tubes. pH was measured with a pH meter and bilirubin content was measured spectrophotometrically. Results of the testing were compared with tube location determined by radiography. Mean pH levels in the lung (7.73) and intestine (7.35) were significantly higher than the mean pH level in the stomach (3.90; p<.001). In addition, bilirubin levels in the stomach and lung were significantly higher than the intestine. This study suggested that a low pH of ≤ 5 is a strong indicator of gastric placement. Findings were similar in a 2002 study
by Meteny & Stewart who reported the mean pH was 5.7 for gastric and 6.6 for intestinal making a pH of $\leq 6$ a statistically significant indicator of gastric placement. In addition the mean pepsin concentration was higher in gastric aspirate (188ug/ml) than intestinal aspirate (38.5ug/ml) ($t=7.98$, $p<.001$). For bilirubin, the mean concentration was higher in intestinal aspirates (7.9 mg/dl) than in gastric (0.4 mg/dl) ($t=-11.26$, $p<.001$). Gharpure, Meert, Sarnaik, and Metheny (2000) confirmed the findings of Metheny & Stewart (2002) and found that a pH of $> 6$ has high negative predictive value for intestinal position and a bilirubin of $> 5$ has high positive predictive value. Westhaus (2004) also looked at pH as predictor of tube location. This study confirmed that mean gastric pH was significantly lower (4.1) than mean intestinal pH7.5 ($t=-4.0$, $p<.001$).

One study examined the ability to classify aspirates by visual inspection. Metheny, Reed, Burglund and Werhle (1994b) used photographs of aspirates from the stomach or intestine to test clinician’s ability to classify aspirates. The subjects were able to identify 81% of the gastric aspirates correctly but only 64 percent of the intestinal aspirates were correctly identified.

At least one study compared pH testing using pH paper versus a pH meter. Metheny et al. (1994a) reported that pH paper was a reliable method of pH testing. In addition it was reported that a pH of $\leq 6$ indicated gastric placement.

Ellett et al. (2005) also observed pH and bilirubin levels and compared the methods to x-ray. Aspirates were collected and measured with a pH meter. This study was important for several reasons. First, they reported that pH of $\leq 5$ had a positive predictive value (tubes assessed to be incorrectly placed outside the stomach) of 25%, and a negative predictive value (tubes shown to be correctly placed in the stomach) of
85% in confirming gastric placement. Like previous studies, they reported that mean pH levels were not significantly different for patients receiving feedings. This study also found that acid-inhibiting medication did not significantly affect pH. The summary of the literature for aspirate methods is presented in Table 5.

**Other methods.** In addition to x-ray, auscultation, aspiration, other methods of placement confirmation are described in the literature. Carbon dioxide (CO₂) measurement is another method of testing for NG/OG tube placement. Typically a capnograph monitor is used to measure the concentration of the partial pressure of CO₂. A low level of CO₂ would indicate placement outside the respiratory tract (Ellett et al., 2005). In the same study by Ellett and colleagues (2005) the method of CO₂ measurement was compared to x-ray. CO₂ measurement was done by attaching the open end of a gastric tube to a capnograph monitor and two repeated measurements were taken. The values in all 72 cases were well below the established cut off of ≤ 15 for adults suggesting CO₂ measurement is reliable in children. However, equipment can be costly and may not be practical for bedside use.

Recently, use of a magnet tracking system to determine NG tube placement has been described in the literature (Bercik et al., 2005). Bercik and colleagues (2005) compared tubes placed with a magnet system to those placed by x ray. A small magnet was attached to the end of an NG tube and the position was monitored using an external sensor. The study reported the accuracy of the magnet tracking system to be 100% compared with fluoroscopy. A summary for the literature for other methods is presented in Table 6.
Table 5

*Studies assessing aspirate*

<p>| Study Citation       | Study Design | Sample Size | Setting                  | Sample Population       | Independent Variable/ Intervention | Dependent variable/ outcome measure | Results/ outcomes | Applicability   | Evidence level |
|----------------------|--------------|-------------|--------------------------|-------------------------|-------------------------------------|-------------------------------------|------------------|----------------|----------------|----------------|
| Metheny et al., 1993 | Cohort       | n=794       | Multi-site hospital      | 18 to 94 years          | Measured pH of aspirates at time of placement compared to x-ray | The extent to which pH can determine tube placement | Gastric placement distinguished from intestinal and respiratory placement. Mean gastric pH 3.52 | Yes, Teens and Adults | 3a             |
| Ellett &amp; Beckstrand, 1999 | Descriptive | n=46        | Pediatric hospital       | &lt; Than 19 yr. requiring enteral nutrition or decompression by NG, OG or NJ | Verification of existing tube placement by submersion in water, auscultation and aspiration and pH testing compared to x-ray | Tube placement in intended location | Tube placement errors 43.5% of tubes. Children comatose or semi comatose, inactive, had swallowing problems or had argyle tubes were more likely to have errors. | Yes, children | 4b             |</p>
<table>
<thead>
<tr>
<th>Study Citation</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Setting</th>
<th>Sample Population</th>
<th>Independent Variable/ Intervention</th>
<th>Dependent variable/ outcome measure</th>
<th>Results/ outcomes</th>
<th>Applicability</th>
<th>Evidence level</th>
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<tbody>
<tr>
<td>Metheny, et al., 1999B</td>
<td>Descriptive</td>
<td>n=90</td>
<td>Neonatal intensive care</td>
<td>4 days –182 days old</td>
<td>Compared pH, pepsin, trypsin, bilirubin and visual appearance determine mean pH of gastric an intestinal aspirates in fed and unfed</td>
<td>pH, pepsin, trypsin and bile levels to compare gastric and intestinal tube aspirates</td>
<td>Mean gastric and intestinal aspirates could not be compared due to low number of intestinal aspirates.. Gastric pH was higher with feedings. Mean gastric pH 4.3</td>
<td>Neonates</td>
<td>4a</td>
</tr>
<tr>
<td>Metheny, et al., 1999A</td>
<td>Descriptive</td>
<td>n=587</td>
<td>Unknown</td>
<td>14 – 93 yr. with newly placed feeding tubes verified by xray</td>
<td>Compared mean pH and bilirubin of aspirates from intestine, stomach and lungs</td>
<td>The extent to which pH and bilirubin can determine tube placement</td>
<td>Mean bilirubin of &lt; 5 confirmed gastric placement. pH cut off of 5 confirmed gastric placement</td>
<td>Yes, Teens and Adults</td>
<td>4a</td>
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<tr>
<td>Study Citation</td>
<td>Study Design</td>
<td>Sample Size</td>
<td>Setting</td>
<td>Sample Population</td>
<td>Independent Variable/ Intervention</td>
<td>Dependent variable/ outcome measure</td>
<td>Results/ outcomes</td>
<td>Applicability</td>
<td>Evidence level</td>
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<tr>
<td>Garpure, et al., 2000</td>
<td>Descriptive</td>
<td>n=96</td>
<td>Pediatric ICU</td>
<td>8 days – 19 yr.</td>
<td>Color, pH, bilirubin, pepsin, and trypsin compared to x-ray</td>
<td>Color, pH, bilirubin, pepsin, and trypsin to verify tube placement in intended location</td>
<td>pH of ≥6 had high negative predictive value. Overall efficiency best for clear yellow, pepsin ≤ 20 94%, trypsin ≥ 50 94%. No difference for H2 blockers or PPI</td>
<td>Yes, children</td>
<td>4a</td>
</tr>
<tr>
<td>Metheny &amp; Stewart, 2002</td>
<td>Prospective cohort</td>
<td>n=80</td>
<td>Hospital</td>
<td>18-87 yr. with NG tubes in place receiving continuous feedings</td>
<td>Appearance for bile stain or no bile stain, pH, pepsin, &amp; trypsin</td>
<td>The extent to which appearance, pH, pepsin, trypsin and bilirubin of aspirated could differentiate between placement in the stomach and intestine during continuous feedings</td>
<td>Bile stained aspirates are more likely to be from the intestine. Aspirate of pH ≤ 6 less likely tube in the stomach. Mean pepsin higher in gastric. Mean trypsin &amp; bilirubin higher intestine.</td>
<td>Yes, Teens and Adults</td>
<td>3a</td>
</tr>
<tr>
<td>Study Citation</td>
<td>Study Design</td>
<td>Sample Size</td>
<td>Setting</td>
<td>Sample Population</td>
<td>Independent Variable/ Intervention</td>
<td>Dependent variable/ outcome measure</td>
<td>Results/ outcomes</td>
<td>Applicability</td>
<td>Evidence level</td>
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<tr>
<td>Westhus, 2004</td>
<td>Descriptive</td>
<td>n=56</td>
<td>Hospital intensive care</td>
<td>Birth to 14 yr. with NG, OG or NJ</td>
<td>Examined pH, appearance, pepsin and trypsin of aspirate and got x-ray</td>
<td>To what extent pH, appearance, pepsin &amp; trypsin predict placement. Impact of acid suppression.</td>
<td>Yes, children</td>
<td>4b</td>
<td></td>
</tr>
<tr>
<td>Westhus, 2004</td>
<td>Descriptive</td>
<td>n=56</td>
<td>Hospital intensive care</td>
<td>Birth to 14 yr. with NG, OG or NJ</td>
<td>Examined pH, appearance, pepsin and trypsin of aspirate and got x-ray</td>
<td>To what extent pH, appearance, pepsin &amp; trypsin predict placement. Impact of acid suppression.</td>
<td>Yes, children</td>
<td>4b</td>
<td></td>
</tr>
<tr>
<td>Metheny, et al., 1994B</td>
<td>Descriptive</td>
<td>n=880</td>
<td>Hospital</td>
<td>Not given</td>
<td>Classified photographs of aspirated from stomach or intestine</td>
<td>Ability to classify aspirates</td>
<td>Able to identify 81% of gastric aspirated and 64 percent of intestinal aspirates</td>
<td>Yes</td>
<td>4a</td>
</tr>
<tr>
<td>Study Citation</td>
<td>Study Design</td>
<td>Sample Size</td>
<td>Setting</td>
<td>Sample Population</td>
<td>Independent Variable/ Intervention</td>
<td>Dependent variable/ outcome measure</td>
<td>Results/ outcomes</td>
<td>Applicability</td>
<td>Evidence level</td>
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<tr>
<td>Metheny, et al., 1994A</td>
<td>Prospective cohort</td>
<td>n=605</td>
<td>Hospital</td>
<td>18-94 yr.</td>
<td>Compared tube verification with pH, using pH paper or pH meter with x-ray. Determine mean pH of gastric and intestine</td>
<td>Impact of feedings on pH, H2 blockers or PPI on tube placement in intended location</td>
<td>pH &gt; 6 indicated gastric placement. Meter and pH paper moth effective. Medications resulted in slightly higher pH values.</td>
<td>Yes, Teens and Adults</td>
<td>3a</td>
</tr>
<tr>
<td>Ellet, et al., 2005</td>
<td>Cohort</td>
<td>n=72</td>
<td>Hospital</td>
<td>3 days-7 yr. with gastric tube in place</td>
<td>Verification of tube placement by CO2 and aspirating contents and measuring pH and bilirubin compared to x-ray</td>
<td>pH and CO2 of aspirate of correctly placed tubes</td>
<td>pH of 5 correctly predicted tubes in the stomach 85%, bilirubin failed to indentify the two misplaced tubes</td>
<td>Yes, children</td>
<td>3a</td>
</tr>
</tbody>
</table>
### Table 6

**Other confirmation methods**

<table>
<thead>
<tr>
<th>Study Citation</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Setting</th>
<th>Sample Population</th>
<th>Independent Variable/ Intervention</th>
<th>Dependent variable/ outcome measure</th>
<th>Results/ outcomes</th>
<th>Applicability</th>
<th>Evidence level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bercik, et al., 2005</td>
<td>Descriptive</td>
<td>n=22</td>
<td>Healthy subjects</td>
<td>26-42 yr.</td>
<td>Used magnet tracking system to determine NG tube tip and compared to manometry</td>
<td>Accuracy of NG tube placement with magnet-tracking system</td>
<td>Magnet tracking system was accurate in NG tube tip localization</td>
<td>No</td>
<td>4b</td>
</tr>
<tr>
<td>Ellet, et al., 2005</td>
<td>Cohort</td>
<td>n=72</td>
<td>Hospital</td>
<td>3 days-7 yr. with gastric tube in place</td>
<td>Verification of tube placement by CO₂ and aspirating contents and measuring pH and bilirubin compared to x-ray</td>
<td>pH and CO₂ of aspirate of correctly placed tubes</td>
<td>pH of 5 correctly predicted tubes in the stomach 85%, bilirubin failed to identify the two misplaced tubes</td>
<td>Yes</td>
<td>3a</td>
</tr>
</tbody>
</table>
**Expert opinion.** Throughout the development of the guideline experts in the field were consulted. One expert, Dr. Philip Putnam, Director of Endoscopy Services at Cincinnati Children’s was consulted regarding his opinion related to a reasonable cut off for pH which would determine gastric placement. Dr. Putnam has been a board certified pediatrician for 24 years and a board certified pediatric gastroenterologist for 17 years. He specializes in the area of gastro esophageal reflux in children. In the literature, recommended pH cut off varied from 4 to 6.5. Lack of consensus in the literature made Dr. Putnam’s opinion a valued part of this project. Based on his experience he felt a cut off pH of 5 would be valid (P. Putnam, personal communication, June, 2011)

**Patient and family preferences.** Patient values are an important part of EBP (Sackett et al, 2000). When dealing with children the needs of the family must also be considered therefore the opinions of parents whose children need NG or OG tubes were explored.

During the two week period in November 2008 when NGT/OGT insertion required radiographic verification, the Gastrointestinal Unit director received negative feedback from several families (A. Longo, personal communication, November, 2008). Comments mostly pertained to the inconvenience of having to leave the hospital unit to obtain an x-ray and the wait times. The cost of repeated x-rays was also mentioned as a concern by a few of the parents.

**Synthesis of the Evidence**

Having performed the review of the literature (ROL) as well as leveling and grading of each piece of evidence, it is important to grade the entire body of evidence as it pertains to the clinical question. The method utilized at Cincinnati Children’s is
presented in Appendix I. The body of evidence for NGT or OGT tube insertion was evaluated and determined to have a grade of “moderate”. This was supported by the number of studies, the corresponding quality of the studies, and the consistency of the results. The evidence would not be considered “high” level evidence because of the low number of available RCT’s.

Following the Iowa Model for EBP development, the next step was to synthesize the research. From the ROL for NGT/OGT placement several key ideas were summarized. First, radiologic verification of NGT/OGT is the gold standard. However, non-radiologic verification methods provide an accurate alternative in patients who are not considered at high risk for aspiration. Patients who are at high risk include those who have neurologic impairment and other conditions such as those patients who are obtunded, sedated, unconscious, critically ill, have a reduced gag reflux, or have static encephalopathy (Ellett & Beckstrand, 1999; Metheny et al., 1994a; Phang, Marsh, Barlows, & Schwartz, 2004).

Second, bedside pH testing of gastric aspirate can be used to confirm placement (Ellett et al., 2005; Metheny et al., 1993; Metheny et al., 1999a; Metheny et al., 1999b; Metheny & Stewart, 2002). The mean pH levels were summarized in Table 7. The mean pH of gastric aspirate is statistically lower (higher acidity) compared to intestinal aspirate mean pH (Metheny et al., 1999a). Mean pH of respiratory aspirate from the tracheobronchial tree or plural space is statistically higher than gastric aspirate pH (Metheny et al., 1999a). In addition, pH testing can be accurately done with either pH paper or pH meter (Ellet et al., 2005; Metheny et al., 1994a; Westhus, 2004). Mean
Table 7

*Comparison of mean pH by site*

<table>
<thead>
<tr>
<th>Summary of findings for Gastric, Intestinal and Respiratory pH Study</th>
<th>Sample</th>
<th>Gastric Aspirate pH mean (SD)</th>
<th>Intestinal Aspirate pH mean (SD)</th>
<th>Respiratory Aspirate pH mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellett, 2005</td>
<td>3 days -7 years n=72</td>
<td>4.5 (1.4)</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>Metheny, 1999b</td>
<td>Neonates n=90</td>
<td>4.32 (0.20)</td>
<td>7.80</td>
<td>No data</td>
</tr>
<tr>
<td>Metheny, 2002</td>
<td>18 years-87 years n=80</td>
<td>5.7 (0.1) *</td>
<td>6.6 (0.1)*</td>
<td>No data</td>
</tr>
<tr>
<td>Metheny, 1999a</td>
<td>14yrs-adult n=587</td>
<td>3.90 (0.15)</td>
<td>7.35 (0.06)</td>
<td>7.73 (0.04) (tracheobronchial tree)</td>
</tr>
<tr>
<td>Metheny, 1993</td>
<td>18yrs-94 yrs n=794</td>
<td>3.52 (2.02)</td>
<td>7.05 (1.26)</td>
<td>No data</td>
</tr>
<tr>
<td>Phang, 2004</td>
<td>25yrs-92yrs n=181</td>
<td>4.8 (2.3) Acid 43up 5.0 (2.3) No acid 4.0 (2.5)</td>
<td>7.1 (1.0) Acid 43up 7.2±1.0 No acid 6.7±1.1</td>
<td>No data</td>
</tr>
<tr>
<td>Metheny, 1994a</td>
<td>n=800</td>
<td>3.52 (2.02) Acid 3.84 (2.06) No acid 3.12 (1.90)</td>
<td>7.05 (1.26)</td>
<td>7.38 (0.59) (plural space)</td>
</tr>
<tr>
<td>Westhus, 2004</td>
<td>Birth-14yrs n=56</td>
<td>4.1 (0.32)</td>
<td>7.5 (0.33)</td>
<td>No data</td>
</tr>
<tr>
<td>Garpure, 2000</td>
<td>8 days -19yrs n=96</td>
<td>4.1 Fed 5.0 Not fed 4.0</td>
<td>6.8 Fed 6.6 Not fed7.0</td>
<td>No data</td>
</tr>
</tbody>
</table>
values for gastric aspirate are not significantly different when patients are fed or fasting (Metheny & Stewart, 2002; Metheny, 1999a) nor are mean values for aspirates significantly different when patients are on or off acid suppression medications (Ellett et al., 2005; Metheny et al., 1994a).

Other bedside testing methods are available but have limitations. For example, auscultation has been shown to have poor reliability and is not recommended as a sole verification method (Ellett & Beckstrand, 1999; Metheny & Stewart, 2002, Metheny et al., 1990; Neumann et al., 1995). In addition, visual inspection of aspirate has not been shown to be a reliable sole method of verification; however, it may have some use when done in conjunction with pH testing (Gharpure et al., 2000; Metheny & Stewart, 2002; Metheny et al., 1999b, Metheny et al., 1994a; Metheny et al., 1994b; Phang et al., 2004; Westhaus, 2004). Aspirate testing of enzyme levels for bilirubin, pepsin, and trypsin also provide an alternate method of verification, but it is limited to laboratory assessment (Ellett et al., 2005; Gharpure et al., 2000; Metheny & Stewart, 2002; Metheny et al., 1999a; Westhaus, 2004). While CO₂ monitoring provides an alternate method of verification, it requires a capnograph monitor to determine incorrect tube placement (Ellett et al., 2005). Magnet tracking systems have also been shown to be accurate but the clinical feasibility of their use needs further investigation (Bercik et al., 2005). Finally, there is moderate evidence that improving the accuracy of NGT or OGT length prior to insertion will enhance the precision of successful tube placement (Beckstrand et al., 2007; Ellett et al., 1992; Gallaher et al., 1993; Klaussner et al, 2002; Putnam & Orenstein, 1991; Stroebel et al., 1979). While morphological measurement using NEX or NEMU can be used, prediction equation tables are more accurate in predicting tube
length (Beckstrand et al., 2007, Elle et al., 1992; Klaussner et al. 2002; Putnam & Orenstein, 1991; Stroebel et al., 1979) (Appendix I)

**Recommendations for Practice**

Following a thorough review and critique of the literature, recommendations for practice were developed with input from the EBP mentor and the original BESt team members. Furthermore, in order to determine the strength of each recommendation the evaluation tool *Judging the Strength of a Recommendation* was used. The judgment of the recommendation is made based on a process, which considers the critically appraised evidence, clinical experience and other dimensions (Cincinnati Children’s Hospital Medical Center, 2011). Dimensions include grade of the body of evidence, safety, health benefit, burden of adherence, cost effectiveness, and directness of evidence as it relates to the recommendation (Appendix J). Based on the evidence evaluated for the insertion of NGT/OGT’s several practice change recommendations can be made:

1. It is recommended that radiologic verification be used to determine NGT/OGT placement in pediatric patients who are determined by clinical judgment to be at high risk of aspiration or when non-radiologic methods are not feasible (aspirate cannot be obtained), or results of non-radiologic methods are unclear. Pediatric patients at risk for incorrect tube placement include those who have neurologic impairment and other conditions which may increase the difficulty of safe, effective tube placement and include patients who are obtunded, sedated, unconscious, critically ill and those with reduced gag reflex or static encephalopathy (Metheny et al., 1994a; Phang et al., 2004; Ellett & Beckstrand, 1999). An order from a provider with prescriptive authority is required for radiological verification.
2. It is recommended that non-radiological verification methods be used to confirm placement of NGT/OGT in pediatric patients who are not considered at high risk for aspiration using the following method: Aspirate pH testing using pH paper or pH meter with aspirate pH cut off of ≤5 to confirm gastric placement (Ellett et al., 2005; Metheny et al., 1999b; Metheny & Stewart, 2002; Metheny et al, 1999a; Metheny et al, 1993). An order from a provider with prescriptive authority is required for tube placement and for pH testing.

3. It is recommended that NGT/OGT length be predicted as follows:
For children >2 weeks, age-related height-based (ARHB) methods are more accurate than other morphological measures such as nose-ear-xiphoid (NEX) or nose-ear-mid-xiphoid-umbilicus (NEMU) in predicting tube length and should be calculated using prediction equation tables (Appendix J) (Beckstrand et al., 2007; Ellett et al. 1992; Klaussner et al., 2002; Putnam & Orenstein, 1991; Stroebel et al., 1979). Calculations will be computed automatically by the electronic medical record system.

For neonates less than 2 weeks of age, patients with short stature, or if unable to obtain an accurate height, use morphological measurements such as NEX or NEMU (Beckstrand et al, 2007). Short stature is defined as a standing height more than 2 standard deviations (SDs) below the mean (or below the 2.5 percentile) for sex (Cohen, Rogol, Deal et al., 2008).

Measurement using the NEMU method for tube length prediction versus the NEX method is slightly more reliable for tube length prediction (Beckstrand et al., 2007; Gallaher et al, 1993; Weibly et al., 1987). Tube length should be marked at the nare for NGT, or corner of the mouth for OGT with indelible permanent marker and document...
amount of tube remaining (external visible length) (EVL) outside the patient in the patient record (Weibly et al, 1987).

The next step was to present the recommendations for NGT/OGT insertion utilizing the BESt format. However in order to examine the applicability of the project, it is helpful to first perform a SWOT analysis. A SWOT analysis pertains to the identification of potential or actual Strengths, Weaknesses, Opportunities and Threats to a new program or guideline (Berkowitz, 2006). Each area was explored as it pertained to the development and future implementation of a BESt for NGT/OGT insertion.

**Strengths.** The strengths of a project consider what benefits the proposed change might have. For this project, the biggest strength was the opportunity to change practice to reflect current literature. In addition, the project provided nursing staff with the satisfaction of knowing practice is current and supports safety standards.

**Weaknesses.** The weaknesses of the project addressed potential barriers that were encountered. One barrier related to the regulations for bedside testing. Currently routine bedside testing of gastric pH was not being done at Cincinnati Children’s and its implementation could be problematic related to government regulations regarding bedside testing and stringent monitoring and record keeping. Failure to maintain proper documentation could result in sanctions from governing agencies.

**Opportunities.** Opportunities for a project identify what benefits the implementation of change has to offer. In this case, development and implementation of a guideline for NGT/OGT insertion resulted in safer outcomes and improved quality care for patients and contributed to cost savings as well as improved patient and staff satisfaction.
**Threats.** Threats to a project or program addresses what obstacles might be faced or what difficulties might be encountered. For this project, potential threats included difficulties related to future implementation of the recommendations including staff resistance to change, lack of commitment from nurses, and the lack of time it takes to learn a new process.

**Analysis of utility.** Prior to development of a BESt for NGT/OGT insertion an analysis of utility should be performed. An analysis of utility serves to examine the findings from the literature and determine applicable to the project, feasibility of development, benefits, resources, and potential costs as it relates to the population of interest. The analysis of utility for this project is outlined in Appendix K.
III. Implementation

Population of Interest

The population of interest was patients admitted to Cincinnati Children’s who required a NGT/OGT. The population was limited to patients aged 2-weeks to adult. This population was chosen because it is representative of the population found in the literature review.

Practice Setting

Project implementation took place at Cincinnati Children’s. This setting was chosen because of the culture of safety and the desire to find an evidence-based method of NGT/OGT placement. In addition, institutional support and the availability of resources made Cincinnati Children’s an appropriate choice for the location of the project.

Identification of Resources

When implementing a change in practice it is vital to identify resources which will be important for success of the project. Key personnel for this project included: the EBP mentor, the Evidence-Based Decision Making (EBDM) Program Administrator and the BESt review team who are part of the Anderson Center for Health Systems Excellence.

Ethical and Legal

While the project did not require institutional review board approval, there were necessary permissions that were obtained. In order to use Cincinnati Children’s name in the final paper, agency permission was obtained from the Vice President of Patient Services at Cincinnati Children’s (Appendix L). Written permission to use the Iowa
Model was also obtained via electronic mail from the University of Iowa Hospitals and Clinics (Appendix M). In addition, written permission to use Beckstrand’s (2007) tube length prediction equation tables was obtained via electronic mail (Appendix N).

**Process for Implementation**

Implementation of this project consisted of publication of the BESt and involved two separate processes. First, recommendations were published August 22, 2011 according to the BESt development process at Cincinnati Children’s and posted on the James M. Anderson Center for Health Systems Excellence website. Publication of the BESt allowed Cincinnati Children’s, as well as, any provider to acquire the updated guideline. Subsequently, the BESt was submitted to the National Guideline Clearinghouse and published online March 28, 2012.

The project was implemented following the steps of the Iowa Model. The steps of the Iowa Model were used to guide the specific activities of the project and are presented in figure 2. The objectives, correlating activities, accountability of team members, and completion dates are presented in an implementation plan (Appendix O).

Following development of the recommendations the next step was to arrange the information from each step of the Iowa Model into the BESt format according to the BESt User Checklist (Appendix P). The BESt template was also used as a guide and provided a systematic arrangement in which the information was summarized and organized. In May 2011 the process was completed and the document was ready for review.
Figure 2

*Iowa Model for this project*
IV. Project Evaluation

For the purpose of this project, evaluation pertains to the process of BESt review for publication. Two separate processes were utilized and will be described separately; the process of BESt publication internally and externally on the Cincinnati Children’s James M. Anderson Center for Health Systems Excellence website, and the process of publication on the National Guideline Clearinghouse (NGC) website.

Cincinnati Children’s Hospital Medical Center Publication

Following preparation of the BESt according to the BESt template a conflict of interest form was submitted (Appendix Q). The purpose of this form was to disclose any financial or intellectual conflicts of interests. There were no conflicts related to this project. The BESt was then submitted electronically to the Evidence-based Decision Making (EBDM) Program Administrator. The role of the EBDM Program Administrator is to serve as a facilitator of the review and publication process of BESt’s. The Program Administrator then forwarded the document to two independent reviewers, who are trained in EBDM, who evaluated the BESt against a defined set of quality criteria (Appendix R). In June 2011 the BESt was returned to the DNP student for editing and revisions. After editing, the document was resubmitted in July 2011 and passed the final review. On August 22, 2011 the BESt for Confirmation of NGT/OGT Placement was published internally on Cincinnati Children’s intranet and externally on the Cincinnati Children’s James M. Anderson Center for Health Systems Excellence web page. The final Cincinnati Children’s BESt is presented in Appendix S.
National Guideline Clearinghouse Publication

Upon approval and publication both internally and externally at Cincinnati Children’s the process for publication on the National Guideline Clearinghouse (NGC) was initiated. The NGC has a well-defined process of approving submitted guidelines for publication, which is outlined on the NGC web site. A guideline submission checklist provided step-by-step instructions for submission (Appendix T). Criteria for inclusion was a document which provided an explanation as to what type of guideline documents are accepted by the NGC (Appendix U). The BESt was eligible for consideration under the second criterion which states that the “guideline was produced under the auspices of a health care organization” (U.S. Department of Health and Human Services Agency for Health Research and Quality, 2012e). The BESt was prepared for submission following the required guideline attributes (Appendix V). In August, 2011, with the assistance of Cincinnati Children’s EBDM Program administrator, the BESt was submitted to the NCG electronically in a word document in the BESt format. The following day, submission verification was received from NGC via electronic mail. Approximately two weeks later, notification was received via electronic mail stating the submission met the inclusion criteria and that the document would be abstracted into the NGC format according to the guideline attributes. Communication from the NGC also stated that there was a backlog of about 250 documents and it was possible it would take four to six months before abstraction of the BESt was complete. In March of 2012 notification was received via electronic mail from NGC that abstraction of the BESt was complete and the guideline was published on the agency’s web page March 28, 2012 (Appendix W).

Evaluation of Impact
One way health care organizations can work to improve safety and patient outcomes is through development of clinical practice guidelines (CPG’s). According to Peter and Gill (2008) CPG’s “are designed to improve the quality of health care, reduce practice variation, and reduce unnecessary, harmful, or ineffective interventions, at an acceptable cost”. CPG’s can be developed using an EBP model (Gray, 2001) and BESt’s are one way to organize the findings. Clinical practice guidelines are designed “to improve the quality of health care, reduce practice variation and reduce unnecessary harmful or ineffective interventions at an acceptable cost” (Peter and Gill, 2008). NGC employs the definition of clinical practice guideline developed by the IOM that “clinical practice guidelines are systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances”(U.S. Department of Health and Human Services Agency for Health Research and Quality, 2012d).

Publication of the BESt within the Cincinnati Children’s institution provided the groundwork for future policy revision and subsequent practice change. Through publication on the NGC, the BESt is a nationally published resource for others who care for children needing NGT/OGT insertion.
V. Discussion

Outcomes and Future Steps

The desired outcomes for this clinical project were met and are evidenced by the publication of the BESt statement both internally and externally by Cincinnati Children’s, and by the NGC. Notification of publication of the BESt on Cincinnati Children’s web site was sent to the key team members via electronic mail.

Although goals for this project were met through publication of the BESt and a considerable amount of time has lapsed since the start of the project, more work is still needed. This project is clinically significant because it will become the framework for which a pilot or test of change will be designed and implemented, and will guide policy revision and widespread incorporation into practice.

According to the Iowa Model, if there is significant evidence to support a change in practice the change should be piloted. Piloting is the next step in the EBP process and serves to identify the feasibility and effectiveness of a guideline (Titler et al., 2001). The steps of the pilot process involves (a) selecting outcomes, (b) collecting baseline data, (c) developing a written guideline, (d) testing the guideline in a small setting, (e) evaluating the process and outcome of the trial, and (f) modifying the guideline based on process and outcome data. A pilot could be conducted on one unit of a multiunit institution.

Based on the results of the pilot and determination of feasibility, a decision should be made whether or not to adopt the change into practice. If a change is implemented on a large scale it will be important to monitor and analyze structure, process, and outcome data. This information will include insight from staff, patients and families, as well as
environmental and cost factors. Finally, following the Iowa Model, the results of the EBP project should be disseminated.

Facilitators and Barriers

The most important reason for implementing EBP is that it leads to the highest quality care and high quality care is synonymous with safety. The Institute of Medicine (IOM) defines safety as “the prevention of harm to patients” (Institute of Medicine, 2004, p 5) and considers patient safety “indistinguishable from the delivery of quality health care” (Institute of Medicine (IOM), 2004, p 5). Therefore, it is important to build a delivery system that prevents errors, learns from the errors that do occur; and is built on a culture of safety (Institute of Medicine, 2004). A culture of safety can be defined as an “integrated pattern of individual and organizational behavior, based upon shared beliefs and values, that continuously seeks to minimize patient harm that may result from the processes of care delivery” (IOM, 2004, p 174). Misplaced NGT/OGT’s are errors from which there are lessons to be learned and should become the focus of future quality improvement projects. Organizations such as Cincinnati Children’s that strongly support a culture of safety use EBP to improve outcomes. Bartelt et al (2011) reported that the support of administrators, clinical leaders, expert clinicians and practice decision makers is necessary for effective EBP. Other concepts, which support implementation of EBP, are leadership, EBP teams, methods of group supervision, and modeling and mentoring (Bartelt et al, 2011). Cincinnati Children’s organizational commitment to safety and quality improvement contributed to success of this project.

Although the organization supported a culture of safety and utilization of quality measures, barriers still existed throughout the project. Barriers to using research
evidence in nursing practice has been described in the literature and categorized as individual or organizational (Brady & Lewin, 2007; McCleary & Brown, 2003).

Individual barriers include lack of time for EBP activities, difficulty understanding findings, lack of authority to implement findings, being unaware of research and being blocked in implementing findings by nurses or physicians. Organizational barriers include lack of access to technology, time demands for clinical work, lack of peer or administrative support, and an organizational culture that does not value EBP activities.

In several studies where nurses were surveyed regarding the perceived barriers to using research in practice, organizational support was found to be the most important factor, specifically, insufficient time (Retsas, 2000; Van Patter Gale & Schaffer, 2009; McCleary & Brown, 2003). Barriers for this project were consistent with those reported in the literature.

Organizational barriers presented the biggest challenge for this project specifically the lack of dedicated project time and level of priority for the project. While stakeholders verbalized support of the project, little support in the way of dedicated project time was given to team members. Team members verbalized time constraints and were not always able to give the project priority. Because of these time constraints, there were difficulties in scheduling meetings in a timely fashion. Although administrators supported the project there was a lack of urgency for its completion. This lack of urgency resulted in a considerable time lag from start to finish of the project.

One way to aid in implementation of evidence is to apply a model to support clinical change. Application of Rogers (2003) Diffusion of Innovations theory can be applied to aid in implementation and adoption of EBP. Rogers defines diffusion as “the
process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, 2003, p11). While most of his work was concerned with the diffusion of innovations to individuals, Rogers recognized that many innovations are adopted also by organizations. Often an individual cannot adopt a new idea until an organization has adopted the change. The innovation process for organizations consists of five stages: agenda setting, matching, redefining or restructuring, clarifying and routinizing (Rogers, 2003). Agenda setting occurs when an organizational problem is defined. Matching is the stage which a problem from the organization agenda is fit with an innovation and this match is planned and designed. Redefining/restructuring occurs when the innovation is re-invented to accommodate the organizations needs and structure more closely and when the organizations structure is modified to fit with the innovation. Clarifying occurs when the innovation is put into more widespread use and finally, routinization occurs when the innovation has become incorporated into the regular activities of the organization.

The barriers encountered in this project can be addressed by considering Rogers stage of matching. During this stage in the innovation process is when “conceptual matching occurs to see how well they fit” with the goals of an organization (Rogers, 2003, p 423). One explanation for the time lag and lack of dedicated time for the project is the possibility that the innovation is mismatched with the problem. The situation surrounding NGT/OGT tube placement may no longer be a problem or a priority for the organization, or the problem has low importance in the context of organization. Therefore prior to proceeding with the remaining three stages of Rogers’s theory which relate to implementation, it may be necessary to revisit the level of priority the project
holds with the stakeholders and reconsider whether the change is an appropriate match
with the organization.

**Final Summary**

EBP is key to the delivery of the highest quality healthcare and for ensuring best
patient outcomes (Melynk & Fineout-Overholt, 2011). An EBP model such as The Iowa
Model can be used to guide the Doctorate of Nursing Practice (DNP) through
implementation of an EBP change project. The Iowa Model was used to guide the
development of a Best Evidence statement (BESt) for confirmation of NGT/OGT
placement, which was published both at an institutional level as well as on a public
guideline database.

In 2006 the American Association of Colleges in Nursing published The
Essentials of Doctoral Education for the Advanced Practice Nurse. These eight essentials
outline the elements of doctoral education. One of the foundational outcome essentials
pertains to clinical scholarship and analytical methods for evidence-based practice
(American Association of Colleges of Nursing, 2006). The DNP is prepared to use
advance nursing knowledge to create EBP guidelines, such as BESt’s, through translation
of new science, application, and evaluation.

Rogers (2003) emphasized the value of a *champion* and the role a champion can
play in innovation of new idea in an organization. The advanced practice nurse
practitioner that provides direct patient care is in a unique position to evaluate current
practice and use EBP to directly improve patient care outcomes. Advanced practice
nurses’ who have earned a DNP degree are considered key facilitators’, or champions’, of
EBP. As a champion of EBP, the DNP serves as a role model, coach, and mentor of EBP
with others. In conclusion, the DNP is integral in closing the evidence to practice gap by being a champion for EBP and therefore contributing to improved high quality, safe outcomes at the systems and organizational level.
References


Cincinnati Children’s Hospital Medical Center, (Cincinnati Children’s) (2010a), Center for professional excellence, research: Mission and vision. Retrieved from Cincinnati Children’s intranet.

Cincinnati Children’s Hospital Medical Center, (Cincinnati Children’s) (2010b), Center for professional excellence, research: EBP mentor job description. Retrieved from Cincinnati Children’s intranet.


Http://www.jointcommission.org/PatientSafety/facts_patient_safety.htm#2


http://www.jointcommission.org/Sentinel_Event_Policy_and_Procedures/


Appendix A

Best Template

Date

Title

Clinical Question  
(Please include PICO format)

P  (Population/Problem)
I  (Intervention)
C  (Comparison)
O  (Outcome)

Definitions for terms marked with * may be found in the Supporting Information section.

Target Population for the Recommendation  
(Inclusion / Exclusion Criteria for the recommendation)

Recommendation(s)  
(See Dimensions for Judging the Strength of the Recommendation)

Notes:  
(Optional)

Discussion / Synthesis of Evidence related to the recommendation(s)

Reference List  
(Evidence Level in [ ]; See Table of Evidence Levels)
IMPLEMENTATION

Applicability Issues

Relevant CCHMC Tools for Implementation

Policies, Procedures, Knowing Notes, or Health Topics

Outcome or Process Measures

SUPPORTING INFORMATION

Background / Purpose of BEST Development

Definitions

Search Strategy

Databases
Search Terms
Limits, Filters, Search Dates
Date Search Done

Relevant CCHMC Evidence-Based Documents
List evidence-based guidelines and best evidence statements

Group / Team Members (Name, Credentials, Specialty/Area of Expertise)

Team Leader/Author
Team Members/Co-Authors
Support/Consultant
Ad Hoc/Content Reviewers
Patient/Family/Parent or Other Parent Organization

Conflicts of Interest were declared for each team member and:

☐ No financial or intellectual conflicts of interest were found.
☐ No external funding was received for development of this BEST.
☐ The following conflicts of interest were disclosed:
**Table of Evidence Levels (see note above):**

<table>
<thead>
<tr>
<th>Quality level</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a or 1b</td>
<td>Systematic review, meta-analysis, or meta-synthesis of multiple studies</td>
</tr>
<tr>
<td>2a or 2b</td>
<td>Best study design for domain</td>
</tr>
<tr>
<td>3a or 3b</td>
<td>Fair study design for domain</td>
</tr>
<tr>
<td>4a or 4b</td>
<td>Weak study design for domain</td>
</tr>
<tr>
<td>5a or 5b</td>
<td>General review, expert opinion, case report, consensus report, or guideline</td>
</tr>
<tr>
<td>5</td>
<td>Local Consensus</td>
</tr>
</tbody>
</table>

*<sup>a</sup> = good quality study, *<sup>b</sup> = lesser quality study

**Table of Language and Definitions for Recommendation Strength (see note above):**

<table>
<thead>
<tr>
<th>Language for Strengths</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Minimal</td>
<td>Moderate</td>
</tr>
<tr>
<td>Serious</td>
<td>Moderate</td>
</tr>
<tr>
<td>Significant</td>
<td>Minimal</td>
</tr>
<tr>
<td>Indirectly relates</td>
<td>Directly relates</td>
</tr>
<tr>
<td>Directly relates</td>
<td>Indirectly relates</td>
</tr>
<tr>
<td>Cost-effective</td>
<td>Not cost-effective</td>
</tr>
<tr>
<td>Inconclusive</td>
<td>Cost-effective</td>
</tr>
<tr>
<td>Unable to determine</td>
<td>Inconclusive</td>
</tr>
<tr>
<td>Low</td>
<td>Unable to determine</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Medium</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Rationale for judgment and selection of each dimension:**

1. Grade of the Body of Evidence
2. Safety / Harm (Side Effects and Risks)
3. Health benefit to patient
4. Burden on patient to adhere to recommendation
5. Cost-effectiveness to healthcare system
6. Directness of the evidence for this target population
7. Impact on morbidity/mortality or quality of life

Given the dimensions below and that more answers to the left of the scale indicate support for a stronger recommendation, the recommendation statement above reflects the strengths of the recommendation as judged by the developer group.

*Note that for negative recommendations, the left/high logic may be reversed for one or more dimensions.*
Copies of this Best Evidence Statement (BEST) and related tools (if applicable, e.g., screening tools, algorithms, etc.) are available online and may be distributed by any organization for the global purpose of improving child health outcomes.

Website address: http://www.cincinnatichildrens.org/service/James-M.-Anderson-Center/evidence-based-care/bests/

Examples of approved uses of the BEST include the following:

- Copies may be provided to anyone involved in the organization’s process for developing and implementing evidence based care;
- Hyperlinks to the CCHMC website may be placed on the organization’s website;
- The BEST may be adopted or adapted for use within the organization, provided that CCHMC receives appropriate attribution on all written or electronic documents; and
- Copies may be provided to patients and the clinicians who manage their care.

Notification of CCHMC at EBDMinfo@chmc.org for any BEST adopted, adapted, implemented, or hyperlinked by the organization is appreciated.

Please cite as: Cincinnati Children’s Hospital Medical Center: Best Evidence Statement Title, http://www.cincinnatichildrens.org/svc/alpha/b/health-policy/best.htm, BEST number, pages 1-number, Date.

This Best Evidence Statement has been reviewed against quality criteria by two independent reviewers from the CCHMC Evidence Collaboration. Conflict of interest declaration forms are filed with the CCHMC EBDM group.

Once the BEST has been in place for five years, the development team reconvenes to explore the continued validity of the guideline. This phase can be initiated at any point that evidence indicates a critical change is needed. CCHMC EBDM staff perform a quarterly search for new evidence in an horizon scanning process. If new evidence arises related to this BEST, authors are contacted to evaluate and revise, if necessary.

For more information about CCHMC Best Evidence Statements and the development process, contact the Evidence Collaboration at EBDMinfo@chmc.org.

Note

This Best Evidence Statement addresses only key points of care for the target population; it is not intended to be a comprehensive practice guideline. These recommendations result from review of literature and practices current at the time of their formulation. This Best Evidence Statement does not preclude using care modalities proven efficacious in studies published subsequent to the current revision of this document. This document is not intended to impose standards of care preventing selective variances from the recommendations to meet the specific and unique requirements of individual patients. Adherence to this Statement is voluntary. The clinician in light of the individual circumstances presented by the patient must make the ultimate judgment regarding the priority of any specific procedure.
## Appendix B

Stakeholders/Team Members

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cincinnati Children’s senior nursing administrative team</td>
<td>Upper level administrative support</td>
</tr>
<tr>
<td>Unit Director</td>
<td>Support/leadership</td>
</tr>
<tr>
<td>EBP mentor</td>
<td>Key team player/leader/partner</td>
</tr>
<tr>
<td>Nursing staff</td>
<td>Key team player/leader/partner</td>
</tr>
<tr>
<td>Education coordinator</td>
<td>Key team player/leader/partner</td>
</tr>
<tr>
<td>Best review team</td>
<td>Advisory</td>
</tr>
<tr>
<td>Medical staff</td>
<td>Support/leadership</td>
</tr>
<tr>
<td>Nurse Practice council</td>
<td>Advisory</td>
</tr>
<tr>
<td>Radiology administration</td>
<td>Advisory</td>
</tr>
<tr>
<td>Lab administrator</td>
<td>Advisory</td>
</tr>
<tr>
<td>Nurse Practitioner/DNP student</td>
<td>Leader/Partner</td>
</tr>
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### Appendix C

**Databases Searched and Data Abstraction Table**

<table>
<thead>
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<th>Keyword Used</th>
<th>Database/Source Used</th>
<th># of Hits</th>
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<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Listed</td>
<td>Reviewed</td>
<td>Used</td>
</tr>
<tr>
<td>Children, and nasogastric tube,</td>
<td>CINAHL, Cochrane Database</td>
<td>65</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>NG tube,</td>
<td>CINAHL</td>
<td>59</td>
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<td>13</td>
</tr>
<tr>
<td>Gastric aspirate,</td>
<td>CINAHL</td>
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<tr>
<td>Auscultation and nasogastric</td>
<td>CINAHL</td>
<td>13</td>
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<tr>
<td>X-ray verification of NG tube,</td>
<td>CINAHL</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Morphological distances,</td>
<td>CINAHL</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Nasoenteral and measurement,</td>
<td>CINAHL</td>
<td>22</td>
<td>10</td>
<td>8</td>
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</tbody>
</table>
## Appendix D

### Summary of Evidence Levels

<table>
<thead>
<tr>
<th>TABLE OF EVIDENCE LEVELS: Levels of Individual Studies by Domain, Study Design, &amp; Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPE OF STUDY / STUDY DESIGN</strong></td>
</tr>
<tr>
<td><strong>DOMAIN OF CLINICAL QUESTION</strong></td>
</tr>
<tr>
<td>Intervention</td>
</tr>
<tr>
<td>Treatment, Therapy, Prevention, Harm, Quality Improvement</td>
</tr>
<tr>
<td>Diagnosis / Assessment</td>
</tr>
<tr>
<td>Prognosis</td>
</tr>
<tr>
<td>Etiology / Risk Factors</td>
</tr>
<tr>
<td>Incidence</td>
</tr>
<tr>
<td>Prevalence</td>
</tr>
<tr>
<td>Meaning / KAB*</td>
</tr>
<tr>
<td>Economic Analysis</td>
</tr>
<tr>
<td>Decision Analysis</td>
</tr>
</tbody>
</table>

* a = good-quality study  
* b = lower-quality study  

LEGEND  
Let Evidence Guide Every New Decision  
Table of Evidence Levels

Shaded boxes indicate study design may not be appropriate or commonly used for the domain of the clinical question.

Development for this table is based on:  
Appendix E

RCT Appraisal Form
LEGEND: Evidence Appraisal of a Single Study Intervention
Randomized Controlled Trial (RCT) or Controlled Clinical Trial (CCT)

5. Were all patients who entered the trial accounted for at its conclusion? □ Yes □ No □ Unknown
   • Was there a low rate of attrition?
     Note: If greater than 20% lost to follow up, bias may be of greater concern.
     Comments:

6. Were patients accounted for (and analyzed) in the groups to which they were randomized (i.e., intention-to-treat analysis)? □ Yes □ No □ Unknown
   Comments:

7. Was the study process long enough to fully study effects of the intervention? □ Yes □ No □ Unknown
   Comments:

8. Were instruments used to measure the outcomes valid and reliable? □ Yes □ No □ Unknown
   Comments:

9. Was there freedom from conflict of interest? □ Yes □ No □ Unknown
   • Sponsor/Funding Agency or Investigators
   Comments:

RELIABILITY: ARE THESE VALID STUDY RESULTS IMPORTANT?

10. Did the study have a sufficiently large sample size? □ Yes □ No □ Unknown
     • Was there a power analysis?
     • Did the sample size achieve or exceed that resulting from the power analysis?
     • Did each subgroup also have sufficient sample size (e.g., at least 6 to 12 participants)?
     Comments:

11. What were the main results of the RCT or CCT? (e.g., see data: Page #, Table #, Figures, Graphs)
     • What was the effect size? (How large was the treatment effect?)

     • What were the measures of statistical uncertainty (e.g., precision)?
       (Were the results presented with Confidence Intervals or Standard Deviations?)

12. Were the results statistically significant? □ Yes □ No □ Unknown
    Comments:
LEGEND: Evidence Appraisal of a Single Study Intervention
Randomized Controlled Trial (RCT) or Controlled Clinical Trial (CCT)

13. Were the results clinically significant?  □ Yes □ No □ Unknown
   • If potential confounders were identified, were they discussed in relationship
     to the results?
   Comments:

14. Were adverse events assessed?  □ Yes □ No □ Unknown
   Comments:

APPLICABILITY:  CAN I APPLY THESE VALID, IMPORTANT STUDY RESULTS TO TREATING MY PATIENTS?

15. Can the results be applied to my population of interest?  □ Yes □ No □ Unknown
   • Is the treatment feasible in my care setting?
   • Do the patient outcomes apply to my population or question of interest?
   • Are the likely benefits worth the potential harm and costs?
   • Were the patients in this study similar to my population of interest?
   Comments:

16. Are my patient’s and family’s values and preferences satisfied by the treatment
    and its consequences?  □ Yes □ No □ Unknown
   Comments:

17. Would you include this study/article in development of a care recommendation?  □ Yes □ No □ Unknown
   Comments:

ADDITIONAL COMMENTS OR CONCLUSIONS ("TAKE-HOME POINTS"): ________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________

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James M. Anderson Center for Health Systems Excellence | Center for Professional Excellence | Edward L. Frist Research Library
Evidence-Based Decision Making – http://groups.org/ehc/HEC/EDC/EvidenceBased.htm
**Quality Levels / Evidence Level**

- Consider each "No" answer and the degree to which this limitation is a threat to the validity of the results, then choose the appropriate box to assign the level of quality for this study/online.
- Consider an "Unknown" answer to one or more questions as a similar limitation to answering "No." if the information is not available in the article.

**The Evidence Levels:**

- Good Quality RCT (2x)
- Lesser Quality RCT (2x)
- Good Quality CCT (3x)
- Lesser Quality CCT (2x)
- Not Valid, Reliable, or Applicable

---

**Table of Evidence Levels**

<table>
<thead>
<tr>
<th>Domain of Clinical Practice</th>
<th>Systematic Review</th>
<th>Meta-Analysis</th>
<th>RCT</th>
<th>Cohort - Prospective</th>
<th>Cohort - Retrospective</th>
<th>Case Control</th>
<th>Longitudinal Study (Intervention, Time Series)</th>
<th>Cross-Sectional Study</th>
<th>Ecological Research Study</th>
<th>Case Series</th>
<th>Randomized Controlled Trial</th>
<th>Controlled Clinical Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td></td>
<td></td>
<td>1a</td>
<td>2a</td>
<td>2b</td>
<td>4a</td>
<td>4a</td>
<td>4a</td>
<td>4a</td>
<td>5a</td>
<td>2b</td>
<td>3x</td>
</tr>
</tbody>
</table>

**Table Notes:**

- RCT = Randomized Controlled Trial
- CCT = Controlled Clinical Trial

---

**References:**

Appendix F

Descriptive Appraisal Form
5. Were all participants accounted for at the conclusion of the study? [ ] Yes [ ] No [ ] Unknown
   - Were withdrawals from the study explained?
   - Was the rate of attrition acceptable?
   Comments:

6. Was there freedom from conflict of interest? [ ] Yes [ ] No [ ] Unknown
   - Sponsor/Funding Agency or Investigators
   Comments:

## RELIABILITY: ARE THESE VALID STUDY RESULTS IMPORTANT?

7. Were the statistical analysis methods clearly described and appropriate? [ ] Yes [ ] No [ ] Unknown
   Comments:

8. Did the study have a sufficiently large sample size? [ ] Yes [ ] No [ ] Unknown
   - Was there a sufficient response rate?
   - Was a power analysis described?
   - Did the sample size achieve or exceed that resulting from the power analysis?
   - Did each subgroup also have sufficient sample size (e.g., at least 6 to 12 participants)?
   Comments:

9. What are the main results of the study?
   - What were the measures of statistical uncertainty (e.g., precision)?
     (Were the results presented with Confidence Intervals or Standard Deviations?)

10. Were the results statistically significant? [ ] Yes [ ] No [ ] Unknown
    Comments:

11. Were the results clinically significant? [ ] Yes [ ] No [ ] Unknown
    Comments:

12. Were any adverse events, safety concerns, or risks/benefits appropriately described? [ ] Yes [ ] No [ ] Unknown
    Comments:
### Applicability: Can I apply these valid, important study results to treating my patients?

13. Can the results be applied to my population of interest?  
- [ ] Yes  
- [ ] No  
- [ ] Unknown  
- Do the patient outcomes apply to my population or question of interest?  
- Are the likely benefits worth the potential harm and costs?  
- Were the patients in this study similar to my population of interest?  
  Comments: 

14. Are my patient's and family's values and preferences satisfied by the knowledge gained from this study (such as outcomes considered)?  
- [ ] Yes  
- [ ] No  
- [ ] Unknown  
  Comments: 

15. Would you include this study/article in development of a care recommendation?  
- [ ] Yes  
- [ ] No  
- [ ] Unknown  
  Comments: 

### Additional Comments or Conclusions (“Take-Home Points”):
Appendix G
Cohort Appraisal Form

LEGEND: Evidence Appraisal of a Single Study
Intervention
Cohort Study (Prospective / Retrospective)

Project/Topic of your Clinical Question:
Reviewer: ___________________________ Today’s Date: _________________ Final Evidence Level: ___________________________
Article Title: ________________________ First Author: __________________ Journal: ____________________________
Year: ________________________________

Do the study aim/purpose/objectives and inclusion/exclusion criteria assist in answering your clinical question? □ Yes □ No □ Unknown
  • Study Aim/Purpose/Objectives:
  • Inclusion Criteria:
  • Exclusion Criteria:

Is a cohort study congruent with the author’s study aim/purpose/objectives above? □ Yes □ No □ Unknown

Comments:

When reading the bolded questions, consider the bulleted questions to help answer the main question.
If you are uncertain of your skills in evidence evaluation, please consult a local evidence expert for assistance:
CCHMC Evidence Experts: http://groups.ce/NewEBC/EBCMHelp.htm
Unfamiliar terms can be found in the LEGEND Glossary: http://groups.ce/NewEBC/EBCFiles/GLOSSARY-EBDM.pdf

VALIDITY: ARE THE RESULTS OF THE COHORT STUDY VALID OR CREDIBLE?

1. Were the study methods appropriate for the question? □ Yes □ No □ Unknown
   • Were the study methods clearly described (e.g., setting, sample population)?
   • Were the interventions clearly described?

Comments:

2. Were the participants recruited prospectively with a comparison group? □ Yes □ No □ Unknown
   Note: If no comparison group was studied, consider using the Longitudinal Appraisal Form.
   Comments:

3. Were instruments used to measure the outcomes valid and reliable? □ Yes □ No □ Unknown
   • Were the instruments tested to be valid and reliable?

Comments:

4. Were all appropriate variables (e.g., potential confounders, exposures, predictors) and interventions clearly described? □ Yes □ No □ Unknown
   Comments:
<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Were all appropriate outcomes clearly described?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Was the follow-up process described and complete?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Was the follow-up long enough to fully study the effects of the intervention?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Was there a low rate of attrition?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: If greater than 20% lost to follow up, bias may be of greater concern.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Was there freedom from conflict of interest?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Sponsor/Funding Agency or Investigators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**RELIABILITY: ARE THESE VALID STUDY RESULTS IMPORTANT?**

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Were the statistical analysis methods appropriate?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Were the statistical analysis methods clearly described?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Did the study have a sufficiently large sample size?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Was a power analysis described?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Did the sample size achieve or exceed that resulting from the power analysis?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Did each subgroup also have sufficient sample size (e.g., at least 6-12 participants)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. What are the main results of the study? (e.g., Helpul data: Page #, Table #, Figures, Graphs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• What is the effect size? (How large was the treatment effect?)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• What were the measures of statistical uncertainty (e.g., precision)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Were the results presented with Confidence Intervals or Standard Deviations?)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Were the results statistically significant?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
12. Were the results clinically significant? [ ] Yes  [ ] No  [ ] Unknown
   - If potential confounders were identified, were they discussed in relationship to the results?
   Comments:

13. Were adverse events assessed?  [ ] Yes  [ ] No  [ ] Unknown
   Comments:

### APPLICABILITY: CAN I APPLY THESE VALID, IMPORTANT STUDY RESULTS TO TREATING MY PATIENTS?

14. Can the results be applied to my population of interest?  [ ] Yes  [ ] No  [ ] Unknown
   - Is the treatment feasible in my care setting?
   - Do the patient outcomes apply to my population or question of interest?
   - Are the likely benefits worth the potential harm and costs?
   - Were the patients in this study similar to my population of interest?
   Comments:

15. Are my patient's and family's values and preferences satisfied by the treatment and its consequences?  [ ] Yes  [ ] No  [ ] Unknown
   Comments:

16. Would you include this study/article in development of a care recommendation?  [ ] Yes  [ ] No  [ ] Unknown
   Comments:

### ADDITIONAL COMMENTS OR CONCLUSIONS (“TAKE-HOME POINTS”):

---

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Evidence-Based Decision Making – [http://groups.cchmc.org/EBDM/EBDAppForms.htm](http://groups.cchmc.org/EBDM/EBDAppForms.htm)
QUALITY LEVEL / EVIDENCE LEVEL

- Consider each "No" answer and the degree to which this limitation is a threat to the validity of the results, then check the appropriate box to assign the level of quality for this study/article.
- Consider an "Unknown" answer to one or more questions as a similar limitation to answering "No," if the information is not available in the article.

THE EVIDENCE LEVEL IS:

- Good Quality Prospective Cohort Study
  - (3a)
- Lesser Quality Prospective Cohort Study
  - (3b)
- Good Quality Retrospective Cohort Study
  - (4a)
- Lesser Quality Retrospective Cohort Study
  - (4b)
- Not Valid, Reliable, or Applicable

<table>
<thead>
<tr>
<th>TYPE OF STUDY / STUDY DESIGN</th>
<th>Systematic Review</th>
<th>RCT</th>
<th>CCT * Cohort – Prospective</th>
<th>Cohort – Retrospective</th>
<th>Case – Control</th>
<th>Longitudinal (Before/After, Time Series)</th>
<th>Cross – Sectional</th>
<th>Epidemiology Descriptive Case Series</th>
<th>Expert Opinion Case Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment, Therapy, Prevention, Harm, Quality Improvement</td>
<td>1a</td>
<td>2a</td>
<td>3a</td>
<td>4a</td>
<td>4a</td>
<td>4a</td>
<td>4a</td>
<td>4a</td>
<td>5a</td>
</tr>
</tbody>
</table>

\* RCT = Randomized Controlled Trial; CCT = Controlled Clinical Trial

Development for this appraisal form is based on:

**Appendix H**

**Grading of the Body of Evidence**

![Legend](image)

### High

<table>
<thead>
<tr>
<th>Step 1 (see worksheet to summarize the body of evidence)</th>
<th>Sufficient number of high quality studies with consistent* results.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of studies</td>
<td>Quality of studies*</td>
</tr>
<tr>
<td>1</td>
<td>1a or 2a</td>
</tr>
<tr>
<td>2+</td>
<td>1a or 2a</td>
</tr>
<tr>
<td>3+</td>
<td>1a, 2a, or 3a</td>
</tr>
</tbody>
</table>

**Step 2** (if the studies didn’t fit neatly into a box in step 1)

- multiple studies, unless large effect and very clinically important
- strong designs for answering the question addressed
- clinically important and consistent results with minor exceptions at most
- free of any significant doubts about validity (generalizability, bias, design flaws)
- adequate statistical power (including studies showing no difference)

**Confirmation Step**

Further research is unlikely to change our confidence in the answer to the clinical question.

### Moderate

<table>
<thead>
<tr>
<th>Step 1 (see worksheet to summarize the body of evidence)</th>
<th>Multiple studies of lesser quality or with inconsistent results, or a single well-done study.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of studies</td>
<td>Quality of studies*</td>
</tr>
<tr>
<td>1</td>
<td>2a</td>
</tr>
<tr>
<td>3+</td>
<td>1, 2, 3, a or b</td>
</tr>
<tr>
<td>5+</td>
<td>1, 2, 3, 4, a or b</td>
</tr>
</tbody>
</table>

**Step 2** (if the studies didn’t fit neatly into a box in step 1)

- multiple studies
- strong designs for answering the question addressed
- some uncertainty due to either validity threats (generalizability, bias, design flaws or adequacy of statistical power), or inconsistency

Or

- multiple studies
- weaker designs for answering the question addressed
- consistent results with minor exceptions at most

**Confirmation Step**

Further research is likely to have an important impact on our confidence in the precision of the answer to the clinical question, and may even change the answer itself.

### Low

<table>
<thead>
<tr>
<th>Step 1 (see worksheet to summarize the body of evidence)</th>
<th>Local opinion, case reports, case studies, and general reviews.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of studies</td>
<td>Quality of studies</td>
</tr>
<tr>
<td>1+ or local opinion</td>
<td>Clear local consensus</td>
</tr>
</tbody>
</table>

**Step 2** (if the studies didn’t fit neatly into a box in step 1)

- local consensus is clear
- health care professional opinion is the only relevant published information

**Confirmation Step**

There is local and/or published consensus, but no research, to answer the clinical question. Further research is very likely to have an important impact on the answer.

### Grade Not Assignable

<table>
<thead>
<tr>
<th>Step 1 (see worksheet to summarize the body of evidence)</th>
<th>Insufficient design or execution, too few studies, and inconsistent results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of studies</td>
<td>Quality of studies*</td>
</tr>
<tr>
<td>0</td>
<td>3b, 4b</td>
</tr>
</tbody>
</table>

**Step 2** (if the studies didn’t fit neatly into a box in step 1)

- studies have not been done, or
- published studies are seriously flawed and/or
- published studies give inconsistent results

**Confirmation Step**

There is insufficient evidence and lack of consensus to answer the clinical question.

---

*Note: When there is both high and low quality evidence and the results are inconsistent:
- Disregard lower quality evidence if the lower quality evidence is inconsistent with all higher quality evidence.
- Avoid disregarding lower quality evidence when inconsistency is at multiple quality levels, because bias could be introduced when determining which evidence to disregard.


---

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evidence-based decision making LEGEND Resources - [http://www.cincinnatichildrens.org/wc/alpha/h/health-policy/resources.htm](http://www.cincinnatichildrens.org/wc/alpha/h/health-policy/resources.htm)
# Appendix I

## Prediction Equation Table

<table>
<thead>
<tr>
<th>Route</th>
<th>Age Group (months)</th>
<th>Predicted internal distance to the body of the stomach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral</td>
<td>Age &lt; 28</td>
<td>9.1 cm + 0.183 (height cm) + 6 cm = 15.6 cm = 16.6 cm + 0.183 (height cm)</td>
</tr>
<tr>
<td></td>
<td>28 &lt; age &lt; 100</td>
<td>9.1 cm + 0.183 (height cm) + 8 cm = 17.1 cm = 20.1 cm + 0.183 (height cm)</td>
</tr>
<tr>
<td></td>
<td>100 &lt; age &lt; 121</td>
<td>4.5 cm + 0.218 (height cm) + 7.5 cm = 10.1 cm = 17 cm + 0.218 (height cm)</td>
</tr>
<tr>
<td></td>
<td>Age &gt; 121</td>
<td>4.5 cm + 0.218 (height cm) + 9 cm = 13.5 cm = 18.5 cm + 0.218 (height cm)</td>
</tr>
<tr>
<td>Nasal</td>
<td>Age &lt; 28</td>
<td>10.1 cm + 0.197 (height cm) + 6 cm = 16.6 cm = 17.6 cm + 0.197 (height cm)</td>
</tr>
<tr>
<td></td>
<td>28 &lt; age &lt; 100</td>
<td>10.1 cm + 0.197 (height cm) + 8 cm = 18.1 cm = 21.1 cm + 0.197 (height cm)</td>
</tr>
<tr>
<td></td>
<td>100 &lt; age &lt; 121</td>
<td>4.5 cm + (2.7) + 0.218 (height cm) + 6.5 cm = 10.2 cm = 18.7 cm + 0.218 (height cm)</td>
</tr>
<tr>
<td></td>
<td>Age &gt; 121</td>
<td>4.5 cm + (2.7) + 0.218 (height cm) + 9 cm = 13.2 cm = 21.2 cm + 0.218 (height cm)</td>
</tr>
</tbody>
</table>

*Note: the distance measured is to the bottom of the distal pore on the tube*

Appendix J
Judging the Strength of a Recommendation

In determining the strength of a recommendation, the development group makes a considered judgment. The judgment is made explicit in a consensus process which considers critically appraised evidence, clinical experience, and other dimensions. The development group will consider what the relative weight each dimension listed below contributes when determining the strength of a recommendation.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>High grade evidence</th>
<th>Moderate grade evidence</th>
<th>Low grade evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Grade of the Body of Evidence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Safety / Harm</td>
<td>Has minimal adverse effects</td>
<td>Has moderate adverse effects</td>
<td>Has serious adverse effects</td>
</tr>
<tr>
<td>3. Health benefit to patient (direct benefit)</td>
<td>Has significant health benefit</td>
<td>Has moderate health benefit</td>
<td>Has minimal health benefit</td>
</tr>
<tr>
<td>4. Burden on patient to adhere to recommendation (cost, hassle, discomfort, pain, motivation, ability to adhere, time)</td>
<td>Low burden of adherence</td>
<td>Unable to determine burden of adherence</td>
<td>High burden of adherence</td>
</tr>
<tr>
<td>5. Cost-effectiveness to healthcare system (balance of cost / savings of resources, staff time, and supplies based on published studies or onsite analysis)</td>
<td>Cost-effective to healthcare system</td>
<td>Inconclusive economic effects</td>
<td>Not cost-effective to healthcare system</td>
</tr>
<tr>
<td>6. Directness (the extent to which the body of evidence directly answers the clinical question [population/problem, intervention, comparison, outcome])</td>
<td>Evidence directly relates to recommendation for this target population.</td>
<td>There is some concern about the directness of evidence as it relates to the recommendation for this target population.</td>
<td>Evidence only indirectly relates to recommendation for this target population.</td>
</tr>
<tr>
<td>7. Impact on morbidity/mortality or quality of life</td>
<td>High impact on morbidity/mortality or quality of life</td>
<td>Medium impact on morbidity/mortality or quality of life</td>
<td>Low impact on morbidity/mortality or quality of life</td>
</tr>
</tbody>
</table>

Some of the concepts for this development based on:


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Evidence-Based Decision Making LEGEND Resources – http://www.cincinnatichildrens.org/cvc/dha/health-policy/resources.htm
### Appendix K

**Analysis of Utility**

<table>
<thead>
<tr>
<th>Finding(s)</th>
<th>Intervention</th>
<th>Fit with Setting</th>
<th>Fit with Sample</th>
<th>Feasibility of Implementation</th>
<th>Benefits</th>
<th>Risks</th>
<th>Resources Needed</th>
<th>Potential Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metheny et al., 1994a; Phang et al., 2004; Ellett &amp; Beckstrand, 1999</td>
<td>X-ray</td>
<td>Good fit</td>
<td>Similar population</td>
<td>Very feasible.</td>
<td>Safest way to determine practice in high risk patients</td>
<td>None</td>
<td>Staff support, administrative support</td>
<td>None</td>
</tr>
<tr>
<td>Ellett et al., 2005; Metheny et al., 1999b; Metheny &amp; Stewart, 2002; Metheny et al, 1999a ; Metheny et al, 1993</td>
<td>pH testing</td>
<td>Good fit</td>
<td>Similar population</td>
<td>Somewhat feasible. Will require education and change in practice.</td>
<td>More accurate determination of placement in patients not considered high risk.</td>
<td>May be difficult to maintain compliance with required regulations</td>
<td>Financial, staff support, administrative support, Equipment, education</td>
<td>Equipment, training,</td>
</tr>
<tr>
<td>Finding(s)</td>
<td>Intervention</td>
<td>Fit with Setting</td>
<td>Fit with Sample</td>
<td>Feasibility of Implementation</td>
<td>Benefits</td>
<td>Risks</td>
<td>Resources Needed</td>
<td>Potential Costs</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------------------------------</td>
<td>------------------</td>
<td>-----------------------</td>
<td>------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>-------------</td>
<td>-------------------------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Beckstrand et al., 2007; Ellett et al., 1992; Klausner et al., 2002;</td>
<td>Measurement using ARHB methods</td>
<td>Good fit</td>
<td>Similar population</td>
<td>Very feasible. Will require modifications to documentation system and staff education.</td>
<td>Will provide a more accurate length prediction.</td>
<td>System error</td>
<td>Information services, education, staff support, administrative support</td>
<td>TBD</td>
</tr>
<tr>
<td>Putnam &amp; Orenstein, 1991; Strobel et al., 1979</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix E

Wright State University-Miami Valley College of Nursing and Health

AGENCY PERMISSION FOR CONDUCTING STUDY

THE CINCINNATI BLOOMFIELD HOSPITAL MEDICAL CENTER GRANTS TO

[Name], a student enrolled in the joint Doctor of Nursing Practice Program at Wright State University—University of Toledo, the privilege of using its facilities in order to conduct the following project:

The conditions mutually agreed upon are as follows:

1. The agency (may) (may not) be identified in the final report.
2. The names of consultative or administrative personnel in the agency (may) (may not) be identified in the final report.
3. The agency (wants) (does not want) a conference with the student when the report is completed.
4. Other:

[Signature]
Date

[Signature of Agency Personnel/Title]

Student Signature

[Signature]
Project Chair Signature
Appendix M

Permission to Reproduce the Iowa Model

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norply@gomailserver.com

to deliver to

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If you have questions, please contact Kimberly Jordan at 319-384-9098 or kimberly-jordan@uiowa.ed
Appendix N

Permission to use Prediction Equation Table

RE: permission to use one of your tables

Barbara Giambra

Actions
To:
Jan Beckstrand [jan@lamasfrombolivia.com]
Cc:
Sherri Sievers
Thank you so much!!!
Barbie

>>> Jan Beckstrand <jan@lamasfrombolivia.com> 4/11/2011 12:14 PM <<<
Barbara you can certainly use them. Note that the distance is to the
bottom of the distal pore on the tube. J

Jan Beckstrand, Ph.D., M.S., R.N., F.A.A.N.
Associate Professor of Nursing
Indiana University
1111 Middle Dr. Rm 402
Indianapolis, IN 46202-2895
Tel: 317-274-4120 or 765-956-4176
jbeckstr@iupui.edu

On 4/11/2011 9:01 AM, Barbara Giambra wrote:
> Dear Dr. Beckstrand;
> I'm not sure you'll remember me - I was in your theory class as a first year PhD student in 2009 during the
summer intensive. I am still working on my degree, but also work at Cincinnati Children's as an Evidence-Based
Practice Mentor. I am working with a colleague on a revision of our B.E.S.T. statement for NG placement and we
came across your work. We would like your permission to use your table:
>
> Prediction equations for the internal distance to the body of the stomach for use in clinical practice, by route of
insertion and age in children.
>
> This comes from your publication: Beckstrand, J., Ellet, M. L. C. and McDaniel, A. (2007). Predicting internal
distance to the stomach for positioning nasogastric and orogastric feeding tubes in children. Journal of Advanced
Nursing, 59(3), 274-289.
>
> It is our hope to incorporate your prediction equations into our electronic medical record system to enable the
system to calculate the proper length of NG or OG tube for a child based on their age and height. This has the
potential to improve the safety of tube placement for our children.
>
> The revised B.E.S.T. statement will be posted on the Cincinnati Children's Evidence-Based Decision Making website
and available to both employees and the public.
>
> We look forward to your reply.
> Sincerely,
>
> Barbie Giambra
### Appendix O

#### Implementation Plan

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Activities</th>
<th>Person(s) Accountable</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identification of the practice questions or “triggers”</td>
<td>Prioritization of topics: brainstorming about current problem and overall goals of project.</td>
<td>Sherri Sievers</td>
<td>9/2008</td>
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<tr>
<td></td>
<td>Elicit input of stakeholders</td>
<td>Sherri Sievers</td>
<td>12/2008</td>
</tr>
<tr>
<td></td>
<td>Set focus and limits of project</td>
<td>Sherri Sievers, Barbara Giambra</td>
<td>7/2009</td>
</tr>
<tr>
<td>3. Forming a team</td>
<td>Identify potential members</td>
<td>Sherri Sievers, Barbara Giambra</td>
<td>7/2009</td>
</tr>
<tr>
<td></td>
<td>Invite identified members</td>
<td>Sherri Sievers</td>
<td>8/2009</td>
</tr>
<tr>
<td></td>
<td>Select team leader</td>
<td>Sherri Sievers</td>
<td>8/2009</td>
</tr>
<tr>
<td>5. Critique and synthesis of research</td>
<td>Complete scientific merit review</td>
<td>Sherri Sievers, Barbara Giambra</td>
<td>10/2009</td>
</tr>
<tr>
<td></td>
<td>Synthesize best evidence and develop recommendations</td>
<td>Sherri Sievers, Barbara Giambra</td>
<td>1/2010</td>
</tr>
<tr>
<td>6. Determine if there is significant research to guide practice</td>
<td>Development of BESt statement.</td>
<td>Sherri Sievers, Barbara Giambra</td>
<td>1/2010-5/2011</td>
</tr>
<tr>
<td></td>
<td>Publish BESt on Cincinnati Children’s website</td>
<td></td>
<td>8/2011</td>
</tr>
<tr>
<td></td>
<td>Publish BESt on AHRQ/Guidelines.gov</td>
<td></td>
<td>5/2012</td>
</tr>
</tbody>
</table>
Appendix P

BESt User Checklist

BES Title: _____

Check each box once item has been completed on the BES Template.

☐ Title: Include topic or title for BES. The title succinctly describes the topic and clinical question. This will be used for posting of the BES.

☐ Clinical question is complete and presented in PICO format. [BEST Manual: Step 1]
  ☐ P (population/problem)
  ☐ I (intervention)
  ☐ C (comparison)
  ☐ O (outcome)

☐ Target Population is complete, including Inclusion & Exclusion Criteria. [BEST Manual: Step 1]
  • The population (e.g., patients, public) to whom the recommendation is meant to apply are specifically described.

☐ Recommendation(s) is/are adequately specific and unambiguous. [BEST Manual: Step 5]
  • To be specific and unambiguous, the recommendation will state:
    ○ Who (which patients and which caregivers are being addressed)
    ○ What (which specific treatment, test, or prognostic marker is being recommended)
    ○ When
    ○ Where (in the course of disease and in location - home, clinic, ED, hospital bed, ICU)

☐ Citations are included with the recommendation(s)
  • One effective way to present citations is to order them by (1) evidence-quality level, (2) year of publication, and (3) alphabetical by first author. This order presents cited evidence of the highest quality level first, then in order of year and author. If quality levels are low or equal, citations are in order of year and author.

☐ Include any Notes related to the recommendation(s)
  • Recommendation(s) is/are easily identifiable and begin(s) with the appropriate recommendation phrase to signify the strength of the recommendation. [BEST Manual: Step 5]
    ○ To be easily identifiable, the recommendation will begin with one of the following phrases:
      • It is recommended that... or It is strongly recommended that...
      • It is recommended that... not... or It is strongly recommended that... not...
      • There is insufficient evidence and a lack of consensus to make a recommendation on...


☐ References/Citations are present and explicitly associated with the recommendation(s).
  • User may use a reference manager, such as RefWorks or EndNote.

☐ All citations have been assigned a quality level, and level legend is present. [BEST Manual: Step 3]
  • See Table of Evidence Levels on BEST Template for definition of level or grade of evidence.

☐ Dimensions for judging the strength of a recommendation have been appropriately considered, including Body of Evidence, health benefits, side-effects, risks, and others. [BEST Manual: Step 5]
  • See Table of Recommendation Strengths: Dimensions for Judging the Strength of a Recommendation on BEST Template.
  • Include a rationale for each selection of the dimensions and citations, if applicable.
Appendix 2
User Checklist for development and posting of a BEST

Implementation

☐ Applicability Issues
  - Consider the following items for inclusion in this section:
    □ The BEST provides implementation tools on how the recommendation(s) can be put into practice.
    □ The BEST describes facilitators and barriers to its application.
    □ The potential resource implications of applying the recommendation(s) have been considered.
  - If the recommendation statement includes “insufficient evidence,” then this section may not apply.

☐ Relevant CCHMC Tools for Implementation (if any)
  - List relevant CCHMC policies/procedures, if appropriate
  - List relevant CCHMC Knowledge Notes or Health Topics, if appropriate
  - If no documents were found, specify “None were found.”

☐ Outcome or Process Measures
  - The BEST presents monitoring and/or auditing criteria.
  - If no recommendation is made (e.g., insufficient evidence), then measures for outcomes or processes will not apply.

Supporting Information

☐ Background / Purpose of BEST Development (optional)
  - Why was this BEST developed?
  - What needs or issues encouraged pursuing a recommendation for your topic?
  - Who is the target user? For whom are you writing the BEST?
  - Delete section header, if not completed.

☐ Definitions (optional)
  - Mark any terms included in this section with an asterisk (*) where first used in the BEST document.
  - Delete section header, if not completed.

☐ Systematic search strategy is defined.
  - Databases: include all that apply
    □ Medline (PubMed, Ovid)
    □ CINAHL
    □ PsychInfo
    □ Scopus
    □ The Cochrane Library (Cochrane Database of Systematic Reviews, etc.)
    □ Other: Specify is strategy
  - Search Terms (and Boolean combinations, if any)
  - Limits and Filters: include all that apply
    □ English
    □ Humans
    □ Specify Age Range (e.g., pediatric or ages 0–2 years)
    □ Search Date: Specify date range (e.g., 2000–2010)
    □ Specify Date when last literature search was completed
    □ Specify Date when last literature search was completed
    □ Clinical Queries or other Clinical Filters
    □ Other filters or limits

☐ Relevant CCHMC Evidence-Based Documents (if any)
  - List relevant CCHMC guidelines or other BESTs, if appropriate
  - If no documents were found, specify “None were found.”

☐ Team member(s), including credentials, specialty and/or area of expertise is present.

☐ Conflicts of Interest: Indicate all conflicts of interest. [See Col in BEST Manual: Implementation & Conclusion, Appendix]
  - Once all team members have completed and signed Col forms, the statements for this item are either:
    □ “No financial or intellectual conflicts of interest were found.”
    □ “No external funding was received for development of this BEST.”
    □ “The following conflicts of interest were disclosed.” (List all that apply)
  - Scanned forms are submitted with the final BEST and archived electronically.

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April 25, 2012
CCHMC Evidence Collaboration: James M. Anderson Center for Health Systems Excellence | Center for Professional Excellence |
Edward L. Pratt Research Library | Occupational Therapy & Physical Therapy | Hospital Medicine www.cincinnatichildrens.org/quality
Format and style is consistent and professional throughout the BEST.

- This is including, but not limited to:
  - Conducting spell check on the document text
  - Defining acronyms the first time used in text
  - Numbering tables, figures, and appendices in the order of appearance in text
  - Assuring that journal names are consistently used in the citations
    (e.g., always use the full name or the abbreviation not both)
  - Choose a consistent reference style for all citations in the text and all references in the reference list.
    (e.g., APA formatted citation or EBDM format [i.e., Author, Last Name, Year] PLUS Evidence Level [i.e., [Aa/Bb]])
    (See also BEST Manual Step 5: Recommendation Development)

Submit completed BEST and checklist to EBMInfo@chmc.org for quality review/posting by Evidence Collaboration.
Appendix Q

Conflict of Interest

Evidence-Based Care Guideline or Best Evidence Statement
Conflict of Interest Disclosure

(CoI)

In accordance with IOM (Institute of Medicine) and AGREE (Appraisal of Guidelines for Research and Evaluation) criteria, Development Team Members and key professional support staff must declare whether they have any conflict of interest. Any situation that would or would be perceived as capable of influencing the decision for any recommendation within the evidence work is considered a conflict.

<table>
<thead>
<tr>
<th>Name:</th>
<th>Credentials (e.g. RN, MD):</th>
</tr>
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<tbody>
<tr>
<td>Division:</td>
<td></td>
</tr>
<tr>
<td>Title or Topic of Guideline or Best Evidence Statement:</td>
<td></td>
</tr>
<tr>
<td>Role on Proposal:</td>
<td>Team Member</td>
</tr>
<tr>
<td></td>
<td>Key Professional Support Staff (e.g. members of Evidence Collaboration)</td>
</tr>
</tbody>
</table>

Please check all that apply:

A. [ ] No significant financial interests* exist related to this Evidence-Based Care Guideline (EBCG) or Best Evidence Statement (BESI) development or revision which would require a disclosure.

B. [ ] No significant intellectual interests exist related to this Evidence-Based Care Guideline (EBCG) or Best Evidence Statement (BESI)

C. [ ] A disclosure is required. I hereby disclose the following significant interest(s): (Check all that apply)

- Salary or other payment for services (e.g., consulting fees or honoraria, royalties)
- Equity interests (e.g., stocks, stock options, or other ownership interests)
- Other significant financial interests that could possibly affect or be perceived to affect the specific EBCG or BESI development, implementation or reporting activities
- Intellectual interests (e.g., patents, copyrights, authorship of article or research involvement that bears directly on recommendations, influence of expertise)
- Other interests pertinent to the potential scope of these activities (e.g., non-commercial, institutional, and patient/public activities)

If C is checked, you must attach a signed, written statement (in an envelope marked “Confidential”) identifying the business entity involved, the nature/type of the interest, and the amount of the interest that is related to the specific EBCG or BESI development, implementation or reporting activities.

[ ] I attest that I have listed all relevant financial, intellectual, professional, and personal conflicts that have occurred within the previous 12 months and that I will immediately update this information if changes occur.

By checking this box, I agree to the terms of this electronic disclosure.

Signature (please type your signed name): ______
Date: ______

Send completed form via e-mail to EBDMinfo@cchmc.org.

* Financial Interest does not include:
1. Salary, royalties, or other remuneration received directly from CCHMC.
2. Equity interests that, when aggregated for the Covered Individual and his/her family, do not exceed $5,000 in fair market value and do not represent a five (5) percent or greater ownership interest in a single entity.
3. Salary, royalties, or other payments that, when aggregated for the Covered Individual and his/her Family are not expected to exceed $5,000 in the prior or next twelve (12) months.
4. Interests arising solely by reason of investment by mutual, pension, or other institutional investment funds over which the Covered Individual does not exercise control.
5. Royalties for publishing scholarly works or other writings.
Appendix R
Reviewer Checklist

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<td>Clinical question is complete and presented in PICO format.</td>
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<tr>
<td>Discussion/Synthesis of Evidence relates to the recommendation(s).</td>
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<td>Comment:</td>
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<tr>
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<td>Comment:</td>
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<tr>
<td>Applicability Issues are defined.</td>
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<tr>
<td>Relevant CCHMC Evidence-Based Documents are listed. If no documents, then &quot;None were found.&quot;</td>
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<tr>
<td>Comment:</td>
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<tr>
<td>Team member(s), including credentials, discipline and/or specialty is present.</td>
<td></td>
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<tr>
<td>Comment:</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Known Conflicts of Interest are declared by each team member.</td>
<td></td>
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</tr>
<tr>
<td>Comment:</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I, the reviewer, was not involved with the development of this BESt.</td>
<td></td>
<td></td>
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<tr>
<td>Comment:</td>
<td>☐</td>
<td>☐</td>
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</tbody>
</table>

☐ Meets all criteria (may be posted)
☐ Does not meet all criteria (return to EBDInfo@cchmc.org for required changes)

BESt is attached with tracked changes: ☐ Yes ☐ No, not attached

Additional Comments / Suggestions: ☐

<table>
<thead>
<tr>
<th>Reviewers’ Names</th>
<th>Date Reviewed</th>
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</thead>
<tbody>
<tr>
<td></td>
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CCHMC Evidence Collaboration: James M. Anderson Center for Health Systems Excellence | Center for Professional Excellence | Edward L. Pratt Research Library
Evidence-Based Decision Making (EBDM) LEGEND Resources – http://www.cincinnatichildrens.org/evidence
Appendix S

Final BESt

Date: August 22, 2011

Confirmation of Nasogastric/Orogastric Tube (NGT/OGT) Placement

Clinical Question

P (population/problem) Among pediatric patients who require NGT/OGT placement
I (intervention) does auscultation, pH, enzyme, visual inspection of aspirate, and CO2 testing
C (comparison) compared to radiological verification
O (outcome) provide an accurate confirmation of tube placement?

P (population/problem) Among pediatric patients who require NGT/OGT placement
I (intervention) are tube length predictions using age-related height – based (ARHB) methods
C (comparison) compared to nose-ear-xiphoid (NEX) morphological measurements
O (outcome) more accurate in predicting tube length?

Target Population Pediatric patients who require NGT/OGT placement for feeding or gastric decompression.

Recommendations (See Table of Recommendation Strength following references)

1. It is recommended that radiologic verification be used to determine NGT/OGT placement in pediatric patients who are at high risk of aspiration or when non-radiologic methods are not feasible, or results are unclear.

   Note: Pediatric patients at risk for incorrect tube placement include those who have neurologic impairment and other conditions which may increase the difficulty of safe, effective tube placement and include patients who are obtunded, sedated, unconscious, critically ill and those with reduced gag reflex or static encephalopathy (Metheny, 1994a [3a], Phang, 2004 [3b], Ellett 1999 [4b]).

   Note: Radiologic verification is considered the gold standard but may contribute to higher costs, decreased convenience, and increased radiation exposure (Metheny 1994a [3a], Metheny2002 [3a], Nyqvist 2005 [4a], Peter 2008 [4a], Ellett 1999 [4b], Weshus 2004 [4b]).

2. It is recommended that non-radiologic verification methods be used to confirm placement of NGT/OGT in pediatric patients who are not considered at high risk for aspiration as outlined above, using the following method:

   Aspirate pH testing: Use aspirate pH ≤5 to confirm gastric placement (Ellett, 2005 [3a], Metheny, 1999b [4a], Metheny, 2002 [3a], Metheny, 1999a [4a], Metheny, 1993 [3a]). (See Table 1).

   Note: Gastric aspirate pH mean is statistically lower (higher acidity) compared to intestinal aspirate mean pH (Metheny, 1999a [4a]).

   Note: Mean pH of respiratory aspirate from the tracheobronchial tree or plural space is statistically higher than gastric aspirate pH (Metheny, 1999a [4a]).
Note: pH testing can be accurately done with pH paper or pH meter (Ellett, 2005 [3a], Metheny, 1994a [3a], Westhus, 2004[4b]).

Note: Mean values for gastric aspirate are not significantly different when patients are fed or fasting (Metheny, 2002[3a], Metheny, 1999a [4a]).

Note: Mean values for aspirate are not significantly different when patients are on or off acid suppression medications (Ellett, 2005[3a], Metheny, 1994a [3a]).

Note: Auscultation has been shown to have poor reliability and is not recommended as a sole verification method. (Ellett, 1999[4b], Metheny, 2002 [3a], Metheny, 1990 [4a], Neumann, 1995 [3b]).

Note: Visual inspection of aspirate has not been shown to be a reliable sole method of verification; however, it may have some use when done in conjunction with pH testing (Garpure, 2000[4a], Metheny, 2002 [3a], Metheny, 1999b [4a], Metheny, 1994a [3a], Metheny, 1994b [4a], Phang, 2004 [3b], Westhaus 2004 [4b]).

Note: Aspirate testing of enzyme levels for bilirubin, pepsin, and trypsin also provide an alternate method of verification, but it is limited to laboratory assessment (Ellett 2005 [3a], Gharpure, 2000 [4a], Metheny, 2002 [3a], Metheny, 1999 a [4a], Westhaus, 2004 [4b]).

Note: While CO2 monitoring provides an alternate method of verification, it requires a capnograph monitor to determine incorrect tube placement (Ellett, 2005 [3a]).

3. It is recommended that NGT/OGT length be predicted as follows:

For children >2 weeks, age-related height-based (ARHB) methods are more accurate than other morphological measures such as nose-ear-xiphoid (NEX) or nose-ear-mid-xiphoid-umbilicus (NEMU) in predicting tube length and can be calculated using prediction equation tables (see Table 2) (Beckstrand, 2007 [4a], Ellett, 1992 [4b], Klausner, 2002 [2b], Putnam, 1991[4a], Strobel, 1979 [4b]).

For neonates less than 2 weeks of age, patients with short stature, or if unable to obtain an accurate height, use morphological measurements such as NEX or NEMU (Beckstrand, 2007 [4a]).

Note: Measurement using the NEMU method for tube length prediction versus the NEX method is slightly more reliable for tube length prediction (Beckstrand, 2007[4a], Gallaher, 1993 [3a] Weibley, 1987[4a]).

Note: Short stature is defined as a standing height more than 2 standard deviations (SDs) below the mean (or below the 2.5 percentile) for sex (Cohen, 2008, [5])).

Note: Mark tube length at the nare for NGT, or corner of the mouth for OGT with indelible permanent marker and document amount of tube remaining (external visible length) (EVL) outside the patient in the patient record (Weibley, 1987 [4a]).

See Figure 1 for Algorithm: Confirmation of NGT/OGT Placement

Grade for the Body of Evidence is moderate.

Relevant CCHMC policies/procedures:

I-229 Confirmation of Proper Position of NG/NJ Tubes
Discussion/summary of evidence

Radiologic verification of NGT/OGT is considered the gold standard. However, non-radiologic verification methods provide an accurate alternative in patients who are not considered at high risk for aspiration. Bedside pH testing of gastric aspirate can be used to confirm placement (Ellett, 2005 [3a], Metheny, 1999b [4a], Metheny, 2002 [3a], Metheny, 1999a [4a], Metheny, 1993 [3a]). Although widely used, the auscultatory method of tube verification has been shown to have poor reliability and is not recommended as a sole verification method (Ellett, 1999[4b], Metheny, 2002 [3a], Metheny, 1990 [4a], Neumann, 1995 [3b]). In addition, visual inspection of aspirate has not been shown to be a reliable sole method of verification; however, it may have some use when done in conjunction with pH testing (Garpure, 2000[4a], Metheny, 2002 [3a], Metheny, 1999b [4a], Metheny, 1994a [3a], Metheny, 1994b [4a], Phang, 2004 [3b], Westhaus 2004 [4b]). Aspirate testing of enzyme levels for bilirubin, pepsin, and trypsin also provide an alternate method of verification, but are limited to laboratory assessment (Ellett, 2005 [3a], Garpure, 2000 [4a], Metheny, 2002 [3a], Metheny, 1999a[4a], Westhaus, 2004 [4b]). While CO2 monitoring provides an alternate method of verification, it requires a capnograph monitor to determine incorrect tube placement (Ellett, 2005 [3a]). There is moderate evidence that improving the accuracy of NGT/OGT length prior to insertion will enhance the precision of successful tube placement (Beckstrand, 2007 [4a], Ellett, 1992 [4b], Gallagher, 1993) [3a], Klaassen, 2002 [2b], Patnam, 1991 [4a], Strobel, 1979 [4b]). Magnit tracking systems have been shown to be accurate but the clinical feasibility of their use needs further investigation (Bercik, 2005).

Health Benefits, Side Effects and Risks

Non-radiological NGT/OGT placement methods contribute to decreased radiation exposure for pediatric patients (Metheny, 2002 [3a], Peter, 2008 [4a], Westhus, 2004 [4b], Nyqvist, 2005 [4a], Metheny, 1994a [3a], Ellett, 1999 [4b]). Side effects include improperly placed tube due to measurement or placement error. Risks of improperly placed tubes include aspiration, feeding into the wrong place, and irritation.

References/citations (evidence grade in [ ]: see Table of Evidence Levels following references)


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Note: Full tables of evidence grading system available in separate document:
- Table of Evidence Levels of Individual Studies by Domain, Study Design, & Quality (abbreviated table below)
- Grading a Body of Evidence to Answer a Clinical Question
- Judging the Strength of a Recommendation (abbreviated table below)

Table of Evidence Levels (see note above)

<table>
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<th>Quality level</th>
<th>Definition</th>
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<td>1a or 1b</td>
<td>Systematic review, meta-analysis, or meta-synthesis of multiple studies</td>
</tr>
<tr>
<td>2a or 2b</td>
<td>Best study design for domain</td>
</tr>
<tr>
<td>3a or 3b</td>
<td>Fair study design for domain</td>
</tr>
<tr>
<td>4a or 4b</td>
<td>Weak study design for domain</td>
</tr>
<tr>
<td>5</td>
<td>Other: General review, expert opinion, case report, consensus report, or guideline</td>
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*a = good quality study;  b = lesser quality study

Table of Recommendation Strength (see note above)

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<th>Strength</th>
<th>Definition</th>
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<td>&quot;Strongly recommended&quot;</td>
<td>There is consensus that benefits clearly outweigh risks and burdens (or visa-versa for negative recommendations).</td>
</tr>
<tr>
<td>&quot;Recommended&quot;</td>
<td>There is consensus that benefits are closely balanced with risks and burdens.</td>
</tr>
<tr>
<td>No recommendation made</td>
<td>There is lack of consensus to direct development of a recommendation.</td>
</tr>
</tbody>
</table>

Dimensions: In determining the strength of a recommendation, the development group makes a considered judgment in a consensus process that incorporates critically appraised evidence, clinical experience, and other dimensions as listed below:

1. Grade of the Body of Evidence (see note above)
2. Safety / Harm
3. Health benefit to patient (direct benefit)
4. Burden to patient of adherence to recommendation (cost, hassle, discomfort, pain, motivation, ability to adhere, time)
5. Cost-effectiveness to healthcare system (balance of cost / savings of resources, staff time, and supplies based on published studies or onsite analysis)
6. Directness (the extent to which the body of evidence directly answers the clinical question [population/problem, intervention, comparison, outcome])
7. Impact on morbidity/mortality or quality of life

Supporting information

Introductory/background information

Error rates for placement of enteral tubes in any location, other than the intended location, can be up to 43.5% in pediatric settings (Ellett, 1999). A small percentage of enteral tubes, reported as 1%-4% in adult intensive care settings but unknown in pediatrics, are incorrectly placed within the respiratory tract with potentially serious consequences (Ellett, 2005, Metheny, 1999b, Metheny, 1994a). Children who are comatose, semi-comatose, or have swallowing problems have higher placement errors outside the intended location (Ellett, 1999) and ought to be considered at higher risk for incorrect placement. Radiography is considered the gold standard for documenting tube placement (Ellett, 1999, Metheny, 2004). However, routine radiologic tube verification in pediatric and adolescent patients increases the risk of excessive radiation exposure, increases patient and healthcare costs, and slows the delivery of clinical care (Ellett, 1999, Neumann, 1995). Due to these patient and healthcare risks, the evidence for the best methods to accurately verify NG/OG placement was reviewed.

Group/team members

*Revision Group/Team Leader: Sherri Sievers, MSN, RN, CNP, Department of Anesthesia*
Support personnel: Barbara K. Giambra, MS, RN, CPNP, Center for Professional Excellence, Research and Evidence-Based Practice

Ad hoc team members:

Development Group
Kim Klotz, BSN, RN, Vascular Access Team, Chair
Lois Siegle, BSN, RN, Home Care Services
Anne Longo, MBA, BSN, RN-BC, Center for Professional Excellence, Education
Karen Burkett, MS, CNP, RN, Center for Professional Excellence, Research & Evidence-Based Practice

Search strategy
OVID Databases
Medline, CINAHL, PubMed and the Cochrane Database for Systematic Reviews (CDSR)
OVID Filters
Publication Date: 1996 to present
Limits: Humans and English Language
Study Type: Highest quality evidence
Search Terms and MeSH Terms
Children, nasogastric tube, NG tube, aspirate, auscultation, radiology, morphological, age-related height based, accuracy, prediction, length.
Additional articles identified from reference lists and clinicians

Applicability issues
Can be applied to pediatric and adolescent patients in a hospital setting.

Methods which can be performed at the bedside allow greater convenience for the patients, families and staff, and may contribute to decreased costs.

Required equipment is minimal and includes pH strips which are sensitive enough to make a determination of \( \leq 5 \). A pH meter was not found to be more accurate than pH strips for measuring gastric pH. (Westhaus, 2004) [4b].

Copies of this Best Evidence Statement (BEST) are available online and may be distributed by any organization for the global purpose of improving child health outcomes. Website address: http://www.cincinnatichildrens.org/svc/alpha/health-policy/re-based/default.htm

Examples of approved uses of the BEST include the following:

- copies may be provided to anyone involved in the organization’s process for developing and implementing evidence based care;
- hyperlinks to the CCHMC website may be placed on the organization’s website;
- the BEST may be adopted or adapted for use within the organization, provided that CCHMC receives appropriate attribution on all written or electronic documents, and
- copies may be provided to patients and the clinicians who manage their care.

Notification of CCHMC at HPCEInfo@cchmc.org for any BEST adopted, adapted, implemented or hyperlinked by the organization is appreciated.

For more information about CCHMC Best Evidence Statements and the development process, contact Center for Professional Excellence/Research and Evidence-based Practice office at CPE-EBP-Group@cchmc.org

Note
This Best Evidence Statement addresses only key points of care for the target population; it is not intended to be a comprehensive practice guideline. These recommendations result from review of literature and practices current at the time of their formulation. This Best Evidence Statement does not preclude using care modalities proven efficacious in studies published subsequent to the current revision of this document. This document is not intended to impose standards of care preventing selective variances from the recommendations to meet the specific and unique requirements of individual patients. Adherence to this Statement is voluntary. The
clinician in light of the individual circumstances presented by the patient must make the ultimate judgment regarding the priority of any specific procedure.

Reviewed against quality criteria by two independent reviewers
Table 1: Summary of findings for Gastric, Intestinal and Respiratory pH

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Gastric Aspirate pH mean (SD)</th>
<th>Intestinal Aspirate pH mean (SD)</th>
<th>Respiratory Aspirate pH mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellett, 2005[3a]</td>
<td>3days -7 years n=72</td>
<td>4.5 (1.4)</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>Metheny, 1999b[4a]</td>
<td>Neonates n=90</td>
<td>4.32 (0.20)</td>
<td>7.80</td>
<td>No data</td>
</tr>
<tr>
<td>Metheny, 2002[3a]</td>
<td>18 years-87 years n=80</td>
<td>5.7 (0.1)</td>
<td>6.6 (0.1)*</td>
<td>No data</td>
</tr>
<tr>
<td>Metheny, 1999a[4a]</td>
<td>14yrs-adult n=587</td>
<td>3.90 (0.15)</td>
<td>7.35 (0.06)</td>
<td>7.73 (0.04) (tracheobronchial tree)</td>
</tr>
<tr>
<td>Metheny, 1993[3a]</td>
<td>18yrs-94 yrs n=794</td>
<td>3.52 (2.02)</td>
<td>7.05 (1.26)</td>
<td>No data</td>
</tr>
<tr>
<td>Phang, 2004[3b]</td>
<td>25yrs-92yrs n=181</td>
<td>4.8 (2.3)</td>
<td>Acid sup 5.0 (2.3) No acid 4.0 (2.5)</td>
<td>7.1 (1.0)</td>
</tr>
<tr>
<td>Metheny, 1994a[3a]</td>
<td>n=800</td>
<td>3.52 (2.02)</td>
<td>Acid 3.84 (2.06) No acid 3.12 (1.90)</td>
<td>7.05 (1.26)</td>
</tr>
<tr>
<td>Westhus, 2004[4b]</td>
<td>Birth-14yrs n=56</td>
<td>4.1 (0.32)</td>
<td>7.5 (0.33)</td>
<td>No data</td>
</tr>
<tr>
<td>Garpure, 2000[4a]</td>
<td>8 days -19yrs n=96</td>
<td>4.1 Fed 5.0 Not fed 4.0</td>
<td>6.8 Fed 6.6 Not fed7.0</td>
<td>No data</td>
</tr>
</tbody>
</table>

*standard error of the mean rather than SD

Table 2: Age-related height-based (ARHB) prediction equations for the internal distance to the body of the stomach for use in clinical practice, by route of insertion and age in children.

<table>
<thead>
<tr>
<th>Route</th>
<th>Age Group (months)</th>
<th>Predicted internal distance to the body of the stomach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral</td>
<td>Age ≤ 28</td>
<td>9.1cm + 0.183 (height cm) + 6 cm + 1.5 cm = 16.6 + 0.183 (height cm)</td>
</tr>
<tr>
<td></td>
<td>28 &lt; age ≤ 100</td>
<td>9.1cm + 0.183 (height cm) + 8 cm + 3 cm = 20.1 + 0.183 (height cm)</td>
</tr>
<tr>
<td></td>
<td>100 &lt; age ≤ 121</td>
<td>4.5cm + 0.218 (height cm) + 7.5 cm + 5 cm = 17 + 0.218 (height cm)</td>
</tr>
<tr>
<td></td>
<td>Age &gt; 121</td>
<td>4.5cm + 0.218 (height cm) + 9 cm + 5 cm = 18.5 + 0.218 (height cm)</td>
</tr>
<tr>
<td>Nasal</td>
<td>Age ≤ 28</td>
<td>10.1cm + 0.197 (height cm) + 6 cm + 1.5 cm = 17.6 + 0.197 (height cm)</td>
</tr>
<tr>
<td></td>
<td>28 &lt; age ≤ 100</td>
<td>10.1cm + 0.197 (height cm) + 8 cm + 3 cm = 21.1 + 0.197 (height cm)</td>
</tr>
<tr>
<td></td>
<td>100 &lt; age ≤ 121</td>
<td>4.5cm + (2.7) + 0.218 (height cm) + 6.5 cm + 5 cm = 18.7 + 0.218 (height cm)</td>
</tr>
<tr>
<td></td>
<td>Age &gt; 121</td>
<td>4.5cm + (2.7) + 0.218 (height cm) + 9 cm + 5 cm = 21.2 + 0.218 (height cm)</td>
</tr>
</tbody>
</table>

Note: the distance measured is to the bottom of the distal pore on the tube

Beckstrand, (2007) [4a] Used with permission

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Figure 1: Confirmation of Nasogastric or Orogastric (NG/OG) Tube Placement

1. Begin by gathering needed supplies and idea
2. Does patient already have a NG/OG?
   - Yes: Is the external visible length at the previously recorded measurement?
     - No: Use age-related height based method to determine tube length
     - Yes: Mark external visible length on the tube at the level of the nare with a permanent marker
3. Measure then record the external visible length in the patient record
4. Insert tube to marked length and document
5. Is the child in respiratory distress?
   - No: Is the child at high risk for aspiration?
     - No: Can you aspirate gastric contents?
       - Yes: Obtain x-ray to confirm placement
       - No: Reattempt with smaller syringes, if still no aspirate, obtain x-ray
     - Yes: Remove tube and reattempt placement or obtain x-ray
6. Check pH of aspirate
7. Is aspirate pH?
   - No: Gastric placement confirmed, document
   - Yes: Reattempt with smaller syringes, if still no aspirate, obtain x-ray
Appendix T

Guideline Submission Checklist

Guideline Submission Checklist

This document is a checklist for developers to use as a guide for gathering the information required for submission of guidelines to NGC. All submissions must include the following information:

- Developing/Submitting Organization(s) Identifying Information
  - Developer organization name
  - Contact name(s)
  - Contact title(s)
  - Full address(es)
  - Telephone number(s)
  - Fax number(s)
  - E-mail address(es)

- A listing of the titles being submitted for consideration.

- Print and/or electronic copies for each guideline submitted. Electronic copies, or the URL(s) where access can be obtained, are preferred.

- Completed NGC Copyright Agreement Form (if applicable). Note: For guidelines in the public domain, no copyright permission is required.

All of the criteria below must be met for a clinical practice guideline to be included in NGC:

- Criteria for Inclusion of Clinical Practice Guidelines in NGC (See the NGC Guideline Submission Kit for a detailed description of the Inclusion Criteria).

  You should be able to demonstrate the following:
  - The clinical practice guideline contains systematically developed statements that include recommendations, strategies, or information that assists physicians and/or other health care practitioners and patients in making decisions about appropriate health care for specific clinical circumstances.
  - The clinical practice guideline was produced under the auspices of medical specialty associations; relevant professional societies, public or private organizations, government agencies at the Federal, State, or local level; or health care organizations or plans.
  - A systematic literature search and review of existing scientific evidence published in peer reviewed journals was performed during the guideline development.
  - The full text guideline is available upon request in print or electronic format (for free or for a fee), in the English language.
  - The guideline is current and the most recent version produced.
  - The guideline was developed, reviewed, or revised within the last five years.

  For guidelines more than five (5) years old or nearly five years old, we need to know how the guideline has been reviewed for currency since its original publication.

  You should be able to demonstrate that the guideline is current using one or more of the following:
  - A NEW systematic literature search (including searches of electronic databases such as MEDLINE/PubMed, CINAHL, Colid, Embase, Cochrane databases, etc.) was performed since the original publication of the guideline, and a description of the search is provided.
  - An expert committee was convened to review the currency of the guideline(s) since the original publication of the guideline, and a description of the process is provided.
  - If an expert committee was convened, the committee reviewed current literature available since the publication of the original guideline, and a description of the process is provided.
Appendix U

Inclusion Criteria

Inclusion Criteria

Note: NGC is currently re-evaluating the definition and inclusion criteria described below. This work will be informed by a number of efforts, such as review of the literature, guidance from the NGC/NQMC Editorial Board, previous and ongoing studies of the Institute of Medicine, and your input. We invite you to send your comments on this matter to info@guideline.gov.

Definition of Clinical Practice Guideline

NGC employs the definition of clinical practice guideline developed by the Institute of Medicine (IOM).


Criteria for Inclusion of Clinical Practice Guidelines in NGC

All of the criteria below must be met for a clinical practice guideline to be included in NGC.

1. The clinical practice guideline contains systematically developed statements that include recommendations, strategies, or information that assists physicians and/or other health care practitioners and patients to make decisions about appropriate health care for specific clinical circumstances.
2. The clinical practice guideline was produced under the auspices of medical specialty associations; relevant professional societies, public or private organizations, government agencies at the Federal, State, or local level; or health care organizations or plans. A clinical practice guideline developed and issued by an individual not officially sponsored or supported by one of the above types of organizations does not meet the inclusion criteria for NGC.
3. Corroborating documentation can be produced and verified that a systematic literature search and review of existing scientific evidence published in peer reviewed journals was performed during the guideline development. A guideline is not excluded from NGC if corroborating documentation can be produced and verified detailing specific gaps in scientific evidence for some of the guideline’s recommendations.
4. The full text guideline is available upon request in print or electronic format (for free or for a fee), in the English language. The guideline is current and the most recent version produced. Documented evidence can be produced or verified that the guideline was developed, reviewed, or revised within the last five years.
## Appendix V

### Template of Guideline Attributes

The Template of Guideline Attributes is the primary tool used to develop NGC guideline summaries. This template lists each guideline attribute, its description, and controlled vocabulary values where applicable.

<table>
<thead>
<tr>
<th>Guideline Title</th>
<th>Identifies the complete title of the guideline.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bibliographic Source(s)</td>
<td>Identifies the complete bibliographic source(s) for the published guideline as disseminated by the guideline developer(s). The number of references cited is included for each source. Links are provided to PubMed where applicable.</td>
</tr>
<tr>
<td>Guideline Status</td>
<td>Identifies whether the guideline is a revised or updated version of a previously issued document as well as whether an update is currently in progress.</td>
</tr>
</tbody>
</table>

### Regulatory Alert

| FDA Warning/Regulatory Alert | Identifies important warnings and/or revised regulatory information released by the U.S. Food and Drug Administration (FDA) or other official regulatory body for a drug and/or device for which recommendations are provided in the original guideline document. |

### Scope

<table>
<thead>
<tr>
<th>Disease/Condition(s)</th>
<th>Identifies the major areas of clinical medicine or health care addressed in the guideline. Values are expressed using the natural language expressions found in the text of the guideline.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guideline Category</td>
<td>Classifies the major focus of the guideline. Values are selected from the appropriate concepts in the Classification Scheme.</td>
</tr>
<tr>
<td>Clinical Specialty</td>
<td>Classifies the clinical specialties that might use the guideline professionally. Values are selected from the appropriate concepts in the Classification Scheme.</td>
</tr>
<tr>
<td>Intended Users</td>
<td>Classifies the groups intended to use the guideline. Values are selected from the appropriate concepts in the Classification Scheme.</td>
</tr>
<tr>
<td>Guideline Objective(s)</td>
<td>Describes the objectives of the guideline, as specified in the guideline text by the developers.</td>
</tr>
</tbody>
</table>

### Methodology

<table>
<thead>
<tr>
<th>Target Population</th>
<th>Describes the target population(s) addressed in the guideline.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interventions and Practices Considered</td>
<td>Identifies the specific clinical interventions and practices considered in the guideline. Values are expressed using natural language expressions found in the text of the guideline.</td>
</tr>
<tr>
<td>Major Outcomes Considered</td>
<td>Describes the most important specific outcomes or performance measures considered in the guideline. Includes patient outcomes described in treatment guidelines and diagnostic test performance characteristics described in diagnosis or screening guidelines.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Methods Used to Collect/Select the Evidence</th>
<th>Classifies the methods used to collect and select the evidence that was evaluated. Values are chosen from the appropriate concepts in the Classification Scheme.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of Methods Used to Collect/Select the Evidence</td>
<td>Describes/summarizes the specific methods used to collect and select the evidence, as identified in the text of the guideline or by the guideline developer. Can include detailed search strategies, lists of journals scanned, keywords, database sources, inclusion and exclusion criteria, etc.</td>
</tr>
<tr>
<td><strong>Indexing Attribute</strong></td>
<td><strong>Template of Guideline Attributes</strong></td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Population</td>
<td>NGC Status</td>
</tr>
<tr>
<td>Copyright Statement</td>
<td>Patient Resources</td>
</tr>
<tr>
<td>Date Released</td>
<td>Guidelines Availability</td>
</tr>
<tr>
<td>Source(s) of Funding</td>
<td>Implementation Tools</td>
</tr>
<tr>
<td>Methods Used to Formulate the Recommendations</td>
<td>Description of the Methods used to Analyze the Evidence</td>
</tr>
<tr>
<td>Description of Method of Guideline Validation</td>
<td>Number of Source Documents</td>
</tr>
<tr>
<td>Methods Used to Assess the Quality and Strength of the Evidence</td>
<td>Rating Scheme for the Strength of the Evidence</td>
</tr>
</tbody>
</table>
| Description of Methods Used to Analyze the Evidence | Describes specific strategies, aims, performance measures, or plans for implementing the guideline.
| Methods Used to Analyze the Evidence | Identifies the complete bibliographic source(s) for the published guideline as disseminated by the guideline developer(s).
| Description of Methods Used to Analyze the Evidence | Identifies the instances (e.g., co-authors, contributing organizations) of the guideline developer(s).
| Methods Used to Formulate the Recommendations | Lists the method(s) used to validate the recommendations of the guideline. Validation is defined as “the process of determining the quality and strength of the evidence they obtained. Values are chosen from the appropriate concepts in the Classification Scheme.”
| Description of the Methods used to Formulate the Recommendations | Describes the methods used to validate the evidence into statements that will assist practitioners and patients make decisions about appropriate health care for specific clinical circumstances. Values are chosen from the appropriate concepts in the Classification Scheme.
| Rating Scheme for the Strength of the Recommendations | Captures the details of the methods used to translate evidence into recommendation statements, if so provided in the guideline documents. Issues, such as cost, patient preference, and values, considered by the guideline developers during recommendation formulation are also captured.
<p>| Cost Analysis | Identifies the major recommendations, copied verbatim from the guideline, or supplied separately by the guideline developer. |
| Method of Guideline Validation | Identifies which of the recommendations are expressed in the form of clinical algorithm(s) and where the algorithm(s) are provided. |
| Description of Method of Guideline Validation | Lists the references of evidence supporting the recommendations when explicit recommendations are offered and when the references are supplied with those explicit recommendations. This field opens in a new window. Links are provided to PubMed where applicable. |
| Recommendations | Describes the type of evidence supporting the recommendations. |
| Major Recommendations | Describes the anticipated benefits associated with implementing the guideline’s recommendations, as stated in the guideline text, to target populations or intended users. Where applicable, the field also includes information on the major subgroup(s) of patients within the target population most likely to benefit from the guideline recommendations, as identified by the guideline developer. |</p>
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Harms</td>
<td>Description of the anticipated harms, potential risks or adverse consequences associated with the guideline's recommendations, as stated in the guideline text, to target populations or intended users. Where identified by the original guideline document, the major subgroup(s) of patients within the target population most likely to suffer harm/adverse consequences associated with the guideline recommendations will also be described.</td>
</tr>
<tr>
<td>Contraindications</td>
<td>Identifies the instances (e.g., co-morbidities), as provided by the guideline developers, which might render the use of medications or procedures improper, undesirable, or inadvisable.</td>
</tr>
<tr>
<td>Qualifying Statements</td>
<td>Presents qualifying statements or important caveats pertaining to the major recommendations of the guideline emphasized by the guideline developer. Identifies the area of uncertainty and presents a brief description of how the guideline developer addressed this uncertainty in developing the major recommendations of the guideline. Only caveats pertaining to the major recommendations are included. This attribute may also present information regarding uncertainty or controversies in the field identified by the guideline developer that prevents formulation of specific recommendations regarding important aspects within the guideline. Disclaimer-type statements are also captured in this field.</td>
</tr>
<tr>
<td>Description of Implementation Strategy</td>
<td>Describes specific strategies, aims, performance measures, or plans for implementing the guideline recommendations, if presented in the guideline or supplied by the guideline developer.</td>
</tr>
<tr>
<td>Implementation Tools</td>
<td>Classifies the types of implementation tools provided by the guideline developer to facilitate the implementation of their guideline. Values are selected from the appropriate concepts in the Classification Scheme.</td>
</tr>
<tr>
<td>Related NQMC Measures</td>
<td>Identifies link(s) to related quality measures or measure sets in the National Quality Measures Clearinghouse™ (NQMC).</td>
</tr>
</tbody>
</table>

**Institute of Medicine (IOM) National Healthcare Quality Report Categories**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOM Care Need</td>
<td>Classifies the guideline into one of four Institute of Medicine (IOM) care need classifications: End of life care; Getting better; Living with illness; Staying healthy.</td>
</tr>
<tr>
<td>IOM Domain</td>
<td>Classifies the guideline into one or more of the four Institute of Medicine (IOM) care domains: Effectiveness; Patient-centeredness; Safety; Timeliness.</td>
</tr>
</tbody>
</table>

**Identifying Information and Availability**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bibliographic Source(s)</td>
<td>Identifies the complete bibliographic source(s) for the published guideline as disseminated by the guideline developer(s). The number of references cited is included for each source. Links are provided to PubMed where applicable.</td>
</tr>
<tr>
<td>Adaptation</td>
<td>Identifies that the guideline has been adapted from another guideline and identifies the source document.</td>
</tr>
<tr>
<td>Date Released</td>
<td>Identifies the date the guideline was released to the public.</td>
</tr>
<tr>
<td>Guideline Developer(s)</td>
<td>Identifies the organization(s) responsible for the development of the guideline. Each organization is classified by the major designation or function (derived from the Organization Type attribute), such as &quot;Medical Specialty Society&quot; or &quot;Professional Association.&quot;</td>
</tr>
<tr>
<td>Guideline Developer Comment</td>
<td>If the guideline developer is a consortium or represents a group of organizations, this attribute identifies the individual organizations by name.</td>
</tr>
<tr>
<td>Source(s) of Funding</td>
<td>Identifies source(s) of financial support for guideline development, as identified in the guideline text or by the guideline developer. Lists any grant numbers associated with funding, as identified in the guideline text or by the guideline developer.</td>
</tr>
<tr>
<td><strong>Guideline Committee</strong></td>
<td>Identifies formal name, if any, of committee/subcommittee within the guideline developer organization(s) responsible for developing the guideline.</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Composition of Group That Authored the Guideline</strong></td>
<td>Describes the composition of the group/committee that authored the guideline, including professional degree and affiliations, and lists the names of individual committee members, where given.</td>
</tr>
<tr>
<td><strong>Financial Disclosure/Conflicts of Interest</strong></td>
<td>Captures relationships between individuals of the guideline development committee/group and for-profit and not-for-profit companies or organizations that could potentially influence that individual's contribution to the guideline's development.</td>
</tr>
<tr>
<td><strong>Endorseer(s)</strong></td>
<td>Identifies organization(s) that have endorsed the guideline, as identified in the text of the guideline document or explicitly by the guideline developer. Each organization is classified by the major designation or function (derived from the Organization Type attribute), such as “Medical Specialty Society” or “Professional Association.”</td>
</tr>
<tr>
<td><strong>Guideline Status</strong></td>
<td>Identifies whether the guideline is a revised or updated version of a previously issued document as well as whether an update is currently in progress.</td>
</tr>
<tr>
<td><strong>Guideline Availability</strong></td>
<td>Identifies information about the availability of the guideline. Provides, where possible, information regarding electronic (including hypertext links to the full-text copies) copies and ordering information for print copies.</td>
</tr>
<tr>
<td><strong>Availability of Companion Documents</strong></td>
<td>Identifies the companion documents produced by the guideline developer that are considered relevant to the guideline. These companion documents are not necessarily available within NGC. For example, Quick Reference Guides and Technical Reports, all of which would be listed here, accompany guidelines produced by the Agency for Healthcare Research and Quality (AHRQ) (formerly the Agency for Health Care Policy and Research [AHCPR]).</td>
</tr>
<tr>
<td><strong>Patient Resources</strong></td>
<td>Identifies patient resources that are directly related (i.e., derived and/or prepared from the guideline by the guideline developer) to the guideline included in NGC. The patient information is not reviewed by NGC to establish whether or not it accurately reflects the original guideline’s content.</td>
</tr>
<tr>
<td><strong>NGC Status</strong></td>
<td>Identifies when the guideline was completed or revised by ECRI Institute, and verified by the submitting organization(s).</td>
</tr>
<tr>
<td><strong>Copyright Statement</strong></td>
<td>Provides the copyright statement of the organization that submitted the guideline.</td>
</tr>
</tbody>
</table>

**Disclaimer**

Provides disclaimer information about the relationship between NGC (including its appraiser, the Agency for Healthcare Research and Quality [AHRQ], and its contractor, ECRI Institute) and the guidelines and guideline developers represented on the Website.

**Indexing Attributes**

Guideline Summaries are also indexed for the following attributes to support Advanced Search and By Topic features of the database.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of the Target Population</td>
<td>Describes the age group(s) represented by the target population, enabling users to restrict their searches to a particular age group(s).</td>
</tr>
<tr>
<td>Sex of the Target Population</td>
<td>Describes the sex(s) represented by the target population, enabling users to restrict their searches to a particular gender.</td>
</tr>
<tr>
<td>Disease/Condition(s)</td>
<td>NGC Uses Medical Subject Headings (MeSH) produced by the U.S. National Library of Medicine (NLM)™, along with other controlled vocabularies, such as the International Classification of Diseases (ICD), incorporated into NLM’s Unified Medical Language System (UMLS)™ to classify disease concepts related to NGC guidelines.</td>
</tr>
<tr>
<td>Treatment/Intervention</td>
<td>NGC Uses Medical Subject Headings (MeSH) produced by the U.S. National Library of Medicine (NLM)™, along with other controlled vocabularies, such as the U.S. Health Care Financing Administration’s (HCFA) Common Procedure Coding System and ECRI Institute’s Universal Medical Device Nomenclature System (UMDNS), incorporated into NLM’s Unified Medical Language System (UMLS)™ to classify treatment/intervention concepts related to NGC guidelines.</td>
</tr>
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</table>
Appendix W

BESSt on NGC

Guideline Summary NGC-8840

Guideline Title
Best evidence statement (BESt). Confirmation of nasogastric/orogastric tube (NGT/OGT) placement.

Bibliographic Source(s)
Cincinnati Children’s Hospital Medical Center. Best evidence statement (BEST). Confirmation of nasogastric/orogastric tube (NGT/OGT) placement. Cincinnati (OH): Cincinnati Children’s Hospital Medical Center; 2011 Aug 22. 9 p. [25 references]

Guideline Status
This is the current release of the guideline.
This guideline updates a previous version: Cincinnati Children’s Hospital Medical Center. Best evidence statement (BEST). Confirmation of nasogastric tube placement in pediatric patients. Cincinnati (OH): Cincinnati Children’s Hospital Medical Center; 2009 Apr 27. 11 p. [20 references]

Scope

Disease/Condition(s)
Conditions in pediatric and adolescent patients that require a nasogastric/orogastric tube (NGT/OGT)

Guideline Category
Assessment of Therapeutic Effectiveness
Evaluation

Clinical Specialty
Critical Care
Pediatrics
Radiology

Intended Users
Advanced Practice Nurses
Nurses
Physician Assistants
Physicians

Guideline Objective(s)
- To evaluate, among pediatric patients who require nasogastric/orogastric tube (NGT/OGT) placement, if auscultation, acidity (pH), enzyme, visual inspection of aspirate, and carbon dioxide (CO₂) testing compared to radiological verification provides an accurate confirmation of tube placement.
- To evaluate, among pediatric patients who require NGT/OGT placement, if tube length predictions using age-related height-based (ARHB) methods compared to nose-ear-xiphoid (NEX) morphological measurements are more accurate in predicting tube length.

Target Population
Pediatric patients who require nasogastric/orogastric tube (NGT/OGT) placement for feeding or gastric decompression

Interventions and Practices Considered
1. Verification methods
   - Radiological verification
   - Aspirate pH
• Gastric auscultation (not recommended as the sole verification method)
• Visual Inspection of aspirate in conjunction with aspirate pH
• Aspirate testing of enzyme levels for bilirubin, pepsin, and trypsin
• Carbon dioxide (CO₂) monitoring

2. Nasogastric tube length prediction:
• Age-related height-based methods
• Morphological measurements, including nose-ear-xiphoid (NEX) and nose-ear-mid-xiphoid-umbilicus (NEMU)

**Major Outcomes Considered**
- Incidence of misplaced nasogastric/orogastric tube (NGT/OGT) tubes
- Reliability of NGT/OGT placement verification methods
- Effect of feeding and medications on gastric aspirate testing
- Predictive success of methods to calculate NGT/OGT tube length
- Reduction in exposure of pediatric patients to x-rays
- Time to delivery of clinical care via NGT/OGT
- Patient/family satisfaction

**Methodology**

**Methods Used to Collect/Select the Evidence**
- Hand-searches of Published Literature (Primary Sources)
- Hand-searches of Published Literature (Secondary Sources)
- Searches of Electronic Databases

**Description of Methods Used to Collect/Select the Evidence**

**OVID Databases**
- Medline, CINAHL, PubMed and the Cochrane Database for Systematic Reviews (CDSR)

**OVID Filters**
- Publication Date: 1996 to present
- Limits: Humans and English language
- Study Type: Highest quality evidence

**Search Terms and MeSH Terms**
- Children, nasogastric tube, NG tube, aspirate, auscultation, radiology, morphological, age-related height based, accuracy, prediction, length.

Additional articles identified from reference lists and clinicians.

**Number of Source Documents**
Not stated

**Methods Used to Assess the Quality and Strength of the Evidence**
- Weighting According to a Rating Scheme (Scheme Given)

**Rating Scheme for the Strength of the Evidence**

**Table of Evidence Levels**

<table>
<thead>
<tr>
<th>Quality Level</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a or 3b</td>
<td>Systematic review, meta-analysis, or meta-synthesis of multiple studies</td>
</tr>
<tr>
<td>3a or 2b</td>
<td>Best study design for domain</td>
</tr>
<tr>
<td>3a or 3b</td>
<td>Fair study design for domain</td>
</tr>
<tr>
<td>4a or 4b</td>
<td>Weak study design for domain</td>
</tr>
<tr>
<td>5</td>
<td>Other: general review, expert opinion, case report, consensus report, or guideline</td>
</tr>
</tbody>
</table>

\( ^a \) good quality study; \( b \) = lesser quality study

**Methods Used to Analyze the Evidence**
- Systematic Review with Evidence Tables

**Description of the Methods Used to Analyze the Evidence**
Methods Used to Formulate the Recommendations

Expert Consensus

Description of Methods Used to Formulate the Recommendations

Not stated

Rating Scheme for the Strength of the Recommendations

Table of Recommendation Strength

<table>
<thead>
<tr>
<th>Strength</th>
<th>Definition</th>
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<tbody>
<tr>
<td>&quot;Strongly recommended&quot;</td>
<td>There is consensus that benefits clearly outweigh risks and burdens (or vice versa for negative recommendations).</td>
</tr>
<tr>
<td>&quot;Recommended&quot;</td>
<td>There is consensus that benefits are closely balanced with risks and burdens.</td>
</tr>
</tbody>
</table>

No recommendation made: There is a lack of consensus to direct development of a recommendation.

Dimensions: In determining the strength of a recommendation, the development group makes a considered judgment in a consensus process that incorporates critically appraised evidence, clinical experience, and other dimensions as listed below.

1. Grade of the body of evidence
2. Safety/harm
3. Health benefit to the patients (direct benefit)
4. Burden to patient of adherence to recommendation (cost, hassle, discomfort, pain, motivation, ability to adhere, time)
5. Cost-effectiveness to healthcare system (balance of cost/savings of resources, staff time, and supplies based on published studies or onsite analysis)
6. Directness (the extent to which the body of evidence directly answers the clinical question [population/problem, intervention, comparison, outcome])
7. Impact on morbidity/mortality or quality of life

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Peer Review

Description of Method of Guideline Validation

Reviewed against quality criteria by two independent reviewers.

Recommendations

Major Recommendations

The strength of the recommendation (strongly recommended, recommended, or no recommendation) and the quality of the evidence (1a–5) are defined at the end of the "Major Recommendations" field.

1. It is recommended that radiologic verification be used to determine nasogastric/orogastric tube (NGT/OGT) placement in pediatric patients who are at high risk of aspiration or when non-radiologic methods are not feasible, or results are unclear.

   Note: Pediatric patients at risk for incorrect tube placement include those who have neurologic impairment and other conditions which may increase the difficulty of safe, effective tube placement and include patients who are obtunded, sedated, unconscious, critically ill and those with reduced gag reflex or static encephalopathy (Metheny et al., "Techniques," 1994 [3a]; Phang et al., 2004 [3b]; Ellett & Beckstrand, 1999 [4b]).

   Note: Radiologic verification is considered the gold standard but may contribute to higher costs, decreased convenience, and increased radiation exposure (Metheny et al., "Techniques," 1994 [3a]; Metheny & Stewart, 2002 [3a]; Nystvist, Sorell, & Ewald, 2005 [4a]; Peter & Gill, 2009 [4a]; Ellett & Beckstrand, 1999 [4b]; Westhus, 2004 [4b]).

2. It is recommended that non-radiological verification methods be used to confirm placement of NGT/OGT in pediatric patients who are not considered at high risk for aspiration as outlined above, using the following method:

   Aspirate acidity (pH) testing: Use aspirate pH ≤ 5 to confirm gastric placement (Ellett et al., 2005 [3a]; Metheny et al., "Indicators," 1999 [4a]; Metheny & Stewart, 2002 [3a]; Metheny et al., "pH," 1999 [4a]; Metheny et al., 1993 [3a]) (see Table 1 in the original guideline document).

   Note: Gastric aspirate pH mean is statistically lower (higher acidity) compared to intestinal aspirate mean pH (Metheny et al., "pH," 1999 [4a]).

   Note: Mean pH of respiratory aspirate from the tracheobronchial tree or plural space is statistically higher than gastric aspirate pH (Metheny et al., "pH," 1999 [4a]).

   Note: pH testing can be accurately done with pH paper or pH meter (Ellet et al., 2005 [3a]; Metheny et al., "pH," 1994 [3a]; Westhus, 2004 [4b]).
Predicted Internal Distance to the Body of the Stomach

\[ 10.1 \text{ cm} + 0.197 (\text{height cm}) + 8 \text{ cm} + 3 \text{ cm} = 21.1 + 0.197 (\text{height cm}) \]

Note: Mean values for aspirate are not significantly different when patients are fed or fasting (Metheny & Stewart, 2002 [3a]; Metheny et al., "pH and concentration," 1999 [4a]).

\[ 9.1 \text{ cm} + 0.183 (\text{height cm}) + 6 \text{ cm} + 1.5 \text{ cm} = 16.6 + 0.183 (\text{height cm}) \]

Note: Mean values for aspirate are not significantly different when patients are on or off acid suppression medications (Ellett et al., 2005 [3a]; Metheny et al., "pH," 1994 [3a]).

Note: Auscultation has been shown to have poor reliability and is not recommended as a sole verification method. (Ellett & Beckstrand, 1999 [4b]; Metheny & Stewart, 2002 [3a]; Metheny et al., 1990 [4a]; Neumann et al., 1995 [3b]).

Note: Visual inspection of aspirate has not been shown to be a reliable sole method of verification; however, it may have some use when done in conjunction with pH testing (Gharpure et al., 2000 [4a]; Metheny & Stewart, 2002 [3a]; Metheny et al., "Indicators," 1999 [4a]; Metheny et al., "Techniques," 1994 [3a]; Metheny et al., "Visual," 1994 [4a]; Phang et al., 2004 [3b]; Westhus, 2004 [4b]).

Note: Aspirate testing of enzyme levels for bilirubin, pepsin, and trypsin also provide an alternate method of verification, but it is limited to laboratory assessment (Ellett et al., 2005 [3a]; Gharpure et al., 2000 [4a]; Metheny & Stewart, 2002 [3a]; Metheny et al., 1999 [4a]; Metheny et al., "pH and concentration," 1999 [4a]; Westhus, 2004 [4b]).

Note: While carbon dioxide \((CO_2)\) monitoring provides an alternate method of verification, it requires a capnograph monitor to determine incorrect tube placement (Ellett et al., 2005 [3a]).

3. It is recommended that NGT/OGT length be predicted as follows:

For children >2 weeks, age-related height-based (ARHB) methods are more accurate than other morphological measures such as nose-ear-xiphoid (NEX) or nose-ear-mid-xiphoid-umbilicus (NEMU) in predicting tube length and can be calculated using prediction equation tables (see Table below: Age-related height-based equations for nasogastric tube [NGT] length predictions) (Beckstrand, Ellett, & McDaniel, 2007 [4a]; Ellett et al., 1992 [4b]; Klasner, Lüké, & Scalzo, 2002 [2b]; Putnam & Orenstein, 1991 [4a]; Strobel et al., 1979 [4b]).

For neonates less than 2 weeks of age, patients with short stature, or if unable to obtain an accurate height, use morphological measurements such as NEX or NEMU (Beckstrand, Ellett, & McDaniel, 2007 [4a]).

Note: Measurement using the NEMU method for tube length prediction versus the NEX method is slightly more reliable for tube length prediction (Beckstrand, Ellett, & McDaniel, 2007 [4a]; Gallaher et al., 1993 [3a]; Weibley et al., 1987 [4a]).

Note: Short stature is defined as a standing height more than 2 standard deviations (SDs) below the mean (or below the 2.5 percentile) for sex (Cohen et al., 2008 [5]).

Note: Mark tube length at the nare for NGT, or corner of the mouth for OGT with indelible permanent marker and document amount of tube remaining (external visible length) (EVL) outside the patient in the patient record (Weibley et al., 1987 [4a]).

### Table: Age-related Height-based (ARHB) Prediction Equations for the Internal Distance to the Body of the Stomach for Use in Clinical Practice, by Route of Insertion and Age in Children

<table>
<thead>
<tr>
<th>Route</th>
<th>Age Group (months)</th>
<th>Predicted Internal Distance to the Body of the Stomach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral</td>
<td>age &gt; 28</td>
<td>9.1 cm + 0.183 (height cm) + 6 cm + 1.5 cm = 16.6 + 0.183 (height cm)</td>
</tr>
<tr>
<td></td>
<td>28 &lt; age ≤ 100</td>
<td>9.1 cm + 0.183 (height cm) + 8 cm + 3 cm = 20.1 + 0.183 (height cm)</td>
</tr>
<tr>
<td></td>
<td>100 &lt; age ≤ 121</td>
<td>4.5 cm + 0.218 (height cm) + 7.5 cm + 5 cm = 17 + 0.218 (height cm)</td>
</tr>
<tr>
<td></td>
<td>age &gt; 121</td>
<td>4.5 cm + 0.218 (height cm) + 9 cm + 5 cm = 18.5 + 0.218 (height cm)</td>
</tr>
<tr>
<td>Nasal</td>
<td>age ≤ 28</td>
<td>6.0 cm + 0.197 (height cm) + 6 cm + 1.5 cm = 17.6 + 0.197 (height cm)</td>
</tr>
<tr>
<td></td>
<td>28 &lt; age &lt; 100</td>
<td>6.0 cm + 0.197 (height cm) + 8 cm + 3 cm = 21.1 + 0.197 (height cm)</td>
</tr>
<tr>
<td></td>
<td>100 &lt; age ≤ 121</td>
<td>4.5 cm + 2.7 + 0.218 (height cm) + 6.5 cm + 5 cm = 18.7 + 0.218 (height cm)</td>
</tr>
<tr>
<td></td>
<td>age &gt; 121</td>
<td>4.5 cm + 2.7 + 0.218 (height cm) + 9 cm + 5 cm = 21.2 + 0.218 (height cm)</td>
</tr>
</tbody>
</table>

Note: the distance measured is to the bottom of the distal pore on the tube Beckstrand, (2007) [4a] Used with permission.

See Figure 1 in the original guideline document for Algorithm: Confirmation of NGT/OGT Placement.

### Definitions:

- **Table of Evidence Levels**

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</tbody>
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### Dimensions:

In determining the strength of a recommendation, the development group makes a considered judgment in a consensus process that incorporates critically appraised evidence, clinical experience, and other dimensions as listed below.

1. Grade of the body of evidence
2. Safety/harm
3. Health benefit to the patients (direct benefit)
Clinical Algorithm(s)

A clinical algorithm for the confirmation of nasogastric or orogastric tube (NG/OG) placement is provided in the original guideline document.

Evidence Supporting the Recommendations

References Supporting the Recommendations


Phang JS, Marsh WA, Barlow TG, 3rd, Schwartz HL. Determining feeding tube location by gastric and intestinal pH values.
Type of Evidence Supporting the Recommendations:

The type of supporting evidence is identified and graded for each recommendation (see the "Major Recommendations" field).

Benefit/Harms of Implementing the Guideline Recommendations

Potential Benefits
- Appropriate placement of a nasogastric/orogastric tube (NGJOGST) iniatrically or using radiological or non-radiological methods
- Non-radiological NGJOGST placement methods contribute to decreased radiation exposure for pediatric patients.
- Methods which can be performed at the bedside allow greater convenience for the patient, families, and staff, and may contribute to decreased costs.

Potential Harms
- Side effects include improper tube placement due to misidentification or placement error.
- Risks of improper placement include aspiration, feeding into the wrong place, etc., irritation.

Qualifying Statements

Qualifying Statements

This Best Evidence Statement addresses only key points of care for the target population; it is not intended to be a comprehensive practice guideline. These recommendations are based on a review of literature and practices current at the time of their formulation. The Best Evidence Statement does not include data from studies published subsequent to the current version of this document. The document is not intended to impose standards of care preventing selective variance from the recommendations to meet the specific and unique requirements of individual patients. Reference to the Statement is voluntary. The clinician in light of the individual circumstances presented by the patient must make the ultimate judgment regarding the priority of any specific procedure.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Implementation Tools
- Clinical Algorithm
  - For information about availability, see the Availability of Companion Documents and Patient Resources fields below.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Bere
- Staying Healthy

IOM Domain
- Effectiveness
- Safety

Identifying Information and Availability

Bibliographic Source(s)
- Cincinnati Children's Hospital Medical Center. Best evidence statement (BES). Confirmation of nasogastric/orogastric...
Guideline

Not applicable: The guideline was not adapted from another source.

Date Released

2009 Apr 27 (revised 1011 Aug 22)

Guideline Developer(s)

Cincinnati Children’s Hospital Medical Center - Hospital/Medical Center

Source(s) of Funding

Cincinnati Children’s Hospital Medical Center

Guideline Committee

Guideline Development Group

Composition of Group That Authored the Guideline

Revision Group/Team Leader: Shari Sewers, MSN, RN, CNP, Department of Anesthesia
Support Personnel: Barbara K. Giambra, MS, RN, CPNP, Center for Professional Excellence, Research and Evidence-Based Practice
Ad Hoc Team Members, Development Group: Kim Klooz, BSN, RN, Vascular Access Team (Chair); Louis Sigle, BSN, RN, Home Care Services; Anne Longo, MBA, BSN, RN-BC, Center for Professional Excellence, Education; Karen Burkett, MS, CNP, RN, Center for Professional Excellence, Research and Evidence-Based Practice

Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

The guideline updates a previous version: Cincinnati Children’s Hospital Medical Center. Rec. evidence statement (RES): Confirmation of nasogastric tube placement in pediatric patients. Cincinnati (OH): Cincinnati Children’s Hospital Medical Center; 2009 Apr 27. 11 p. [20 references]

Guideline Availability

Electronic copies: Available from the Cincinnati Children’s Hospital Medical Center Website.
Print copies: For information regarding the full-text guideline, print copies, or evidence-based practice support services contact the Children’s Hospital Medical Center Health Policy and Clinical Effectiveness Department at HRCInfo@cchmc.org.

Availability of Companion Documents

The following are available:
- A draft of the strength of recommendation: Cincinnati (OH): Cincinnati Children’s Hospital Medical Center; 2008. 1 p. Available from the Cincinnati Children’s Hospital Medical Center Website.
- Grading a body of evidence to answer a clinical question. Cincinnati (OH): Cincinnati Children’s Hospital Medical Center; 1 p. Available from the Cincinnati Children’s Hospital Medical Center Website.
- Table of evidence levels. Cincinnati (OH): Cincinnati Children’s Hospital Medical Center; 2018 Feb 29. 1 p. Available from the Cincinnati Children’s Hospital Medical Center Website.

Print copies: For information regarding the full-text guideline, print copies, or evidence-based practice support services contact the Children’s Hospital Medical Center Health Policy and Clinical Effectiveness Department at HRCInfo@cchmc.org.

Patient Resources

None available

HG C Status

This NGC summary was completed by ECRI Institute on October 2, 2009. This NGC summary was updated by ECRI Institute on March 28, 2012.

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- The BEST may be adapted or altered for use within the organization, provided that CCHMC receives appropriate attribution on all written or electronic documents
- Copies may be provided to patients and the clinicians who manage their care

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