CLINICAL SCIENCE OF NUTRITION

Review Article

DOI: 10.5152/ClinSciNutr.2023.221646

Methods Used in Confirmation of the Position of Nasogastric Feeding Tubes: Advantages and Limitations

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Cite this article as: Pars H. Methods used in confirmation of the position of nasogastric feeding tubes: advantages and limitations. *Clin Sci Nutr.* 2023;5(1):29-36.

ABSTRACT

Confirmation of the placement of the nasogastric tube is essential to ensure safe feeding without the risk of aspiration, pneumonia, and pneumothorax that may occur due to incorrect placement of the nasogastric tube. The risk of incorrect placement of the nasogastric tube may increase in the high-risk patient group, especially with some factors such as decreased consciousness, weak gag reflex, intubation, mechanical ventilation, and sedation. In addition to the problems that may occur during the initial placement of the nasogastric tube, displacement of the nasogastric tube may occur during the enteral feeding process. For this reason, tube placement should be checked regularly in order to minimize the complications of enteral nutrition. Although there are some advantages and limitations of the methods used to determine the location of the nasogastric tube, it is seen that there is no standard practice on this subject in clinics. The aim of this review is to summarize the commonly used methods for the initial placement of the nasogastric tube and the confirmation of the tube position during the feeding process and to summarize the advantages and limitations of these methods.

Keywords: Enteral nutrition, nasogastric tube, nursing, evidence-based practice

INTRODUCTION

Today, nasogastric (NG) tube placement in intensive care patients and clinics has become one of the most invasive procedures performed by physicians and nurses, together with the developments in technology, prolongation of life expectancy in patients, and increasing importance of nutritional support.[1-6] Nurses providing enteral nutrition (EN) support have serious difficulties in placing the NG tube correctly and verifying its placement.[7-10] Although it seems to be a simple and safe procedure, the misplacement of the NG tube is frequently reported in both pediatric and adult patients. Generally, risks for patients arise from incorrect placement of the NG tube. The incidence of NG tube placement outside the gastrointestinal system has been reported as 1.3%-2.4% in >2000 procedures.[11-14] In addition to the lack of a complete reporting system on the subject, the 2017 Pennsylvania Patient Safety Authority reported 166 cases of NG tube misplacement between 2011 and 2016. In this report, 10.2% of misplacements occurred in pediatric patients.[15] In the report of the UK national health center, misplacement of the NG tube was reported in 95 people between 2011 and 2016.[16] Incorrect placement of the NG tube can cause serious fatal complications in the patient. Important complications that may occur with the placement of the tube in the lungs are aspiration, pneumonia, pneumothorax, hemothorax, atelectasis, emphysema, and esophageal perforation.[14-17]

In a report by the US Food and Drug Administration, 51 cases of pneumothorax associated with the misplacement of the NG tube were reported between 2012 and 2017. Most cases have a history of emergency intervention such as decompression and chest tube placement, with some cases resulting in cardiopulmonary arrest and death.[17] In another study, 95 cases in which the NG tube was accidentally placed in the lungs over a 5-year period were detected and this resulted in the death of 32 patients. The risk of misplacement of the NG tube may increase in the high-risk patient group, especially with some factors such as decreased consciousness, weak gag reflex, intubation, mechanical ventilation, and sedation.[18] In addition to the problems that may occur during the

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Received: September 21, 2022 Accepted: January 30, 2023
Publication Date: March 10, 2023

initial placement of the NG tube, displacement of the NG tube may occur during the enteral feeding process.

For this reason, in order to minimize the complications associated with the placement of the tube during the EF support process, especially pulmonary aspiration secondary to the placement of the tube in the respiratory tract and gastroesophageal reflux, tube placement should be checked before each feeding in intermittent feeding, at least twice a day on continuous feeding, and more frequently if the patient has vomiting, retching, or respiratory problems such as coughing spasms.[19]

Evaluation of NG tube position is an important issue in maximizing the functionality of the NG tube, minimizing tube- and feeding-related complications, and ensuring optimal patient safety. Methods used in clinics to determine the location of the NG tube include radiological examination, pH measurement of gastric aspirate, observation of color of gastric aspirate, auscultation, enzyme tests, and measurement of the length of the NG tube.[20] In light of this information, this review aims to provide information about reliable and practical verification methods in confirming the placement of the NG tube, as well as to reduce the complications that may occur with the use of the most reliable and accurate method in clinics in our country, to present the results of studies with a high level of evidence for the use of common reliable methods, and to shed light on new studies to be done. Table 1 presents the advantages and limitations of the methods used to place the NG tube. Below are the methods used to determine the location of the NG tube and information about the studies performed with these methods.

Radiological Examination

The placement of feeding tubes should be checked regularly. Especially in patients with high risk and endotracheal tubes, it is recommended to control the tube location with the radiological method in the first placement of the NG tube.[21] The most reliable and valid evaluation method for checking the location of the NG feeding tube is properly obtained and interpreted radiography. Radiological examination is accepted as the gold standard method for distinguishing the placement of the tube in the stomach and lungs.[11,19,21-28] Guidelines published on the subject have reported that radiography is the gold standard testing method.[29]

While radiological verification is accepted as the gold standard in tube placement, this method is not a mandatory policy in institutions. It is difficult to say that it is used routinely in every hospital because it has some disadvantages such as the cost of the procedure, the difficulty of interpretation by health personnel due to radio-opacity or insufficient radio-opacity in some tubes, and poor x-ray quality, continuous exposure to radiation, and the need to constantly go to the hospital for patients who continue to be treated at home.[22,23,27,29] In children's hospitals, the radiological examination method is not used as the first choice, especially to reduce radiation exposure.[30] In addition, it is very important that the radiological examination is carried out by experts and that the result is interpreted correctly. In a report by the National Patient Safety Agency, the radiological examinations of 45 patients with NG tubes were misinterpreted, resulting in the death of 12 patients.[22,23,31]

In recent years, ultrasonography and sonography techniques are among the other radiological examination methods recommended to confirm the location of the NG tube, since it is a non-invasive and radiation-free imaging method and it is a faster application compared to x-ray. In addition, studies have reported that it is a suitable method for emergency intervention in unconscious patients.[19,32-34] In a study conducted in the pediatric intensive care unit, it was reported that confirming the location of the NG tube by a radiologist with bedside ultrasonography and sonography was 100% sensitive.[33] In a study conducted in the adult intensive care unit, the ultrasound method correctly determined the location of the NG tube in 34 of 35 patients; however, studies with larger groups were recommended due to the limited sample size in studies on this method.[35]

In a study conducted by community health nurses, the confirmation of the NG tube location of 68 adult patients was compared with ultrasound and pH measurement by nurses, and the sensitivity and specificity of ultrasound were determined as 95.45% and 100%, respectively. It was emphasized that ultrasound could be used in cases where the x-ray device could not be used.[36] A systematic review and meta-analysis examining studies on 420 patients with NG tubes reported that the diagnostic performance of ultrasound was useful for confirming

Main Points

- Nasogastric (NG) tube placement in intensive care patients and clinics is one of the most invasive procedures performed by physicians and nurses.
- Misplacement of the NG tube and/or failure to evaluate the tube position after placement may lead to serious fatal complications in the patient.
- Control of the placement/location of the NG tube should be ensured with practices with a high level of evidence supporting patient safety, and adequate training and competence of health personnel on the subject should be supported.

Table 1. Advantages and Limitations of Methods Used to Confirm Nasogastric Tube Position		
Method	**Advantages**	**Limitations**
Radiological examination	There is no need to aspirate gastric contents from the tube	It causes radiation exposure It has relatively high cost Bedside application and interpretation by every healthcare professional is difficult.
pH test	It is easy to apply It is cost-effective It can distinguish the stomach, intestine, and lung location	There is a need to aspirate stomach contents from the tube Last feeding time, continuous infusion feeding, and some medications such as proton pump inhibitors may affect gastric pH and alter the outcome. pH value is limited in detecting esophageal localization
Auscultation method	There is no need to aspirate gastric contents from the tube It is cost-effective	Regardless of whether the nasogastric tube is in the stomach, duodenum, or proximal jejunum, inflated air sounds can be heard from the upper abdominal wall.
Biochemical markers	The use of biochemical markers increases the accuracy of the pH result. pH and bilirubin levels detect gastric location highly and accurately in all respiratory tract locations	The gastric contents need to be aspirated. There are limited studies on the method There is no pepsin and trypsin test that can be done on the bedside, so it is difficult and costly to apply. Similar to the pH method, the last feeding time, continuous infusion feeding, and some drugs such as proton pump inhibitors can affect the gastric pH and change the result.
Capnography/calorimetric capnometry	There is no need to aspirate gastric contents from the tube It can detect tracheal localization with very high accuracy.	Contact of gastric reflux with capnometry may cause false-positive results. Fizzy drinks and medications containing sodium bicarbonate can potentially cause carbon dioxide in the stomach
Ultrasound	It defines the placement of the tube in the stomach and esophagus	It is difficult for intubated patients to determine that the nasogastric tube is in the trachea. Its cost can be high Additional training is required for users and evaluators

NG tube placement, but not optimal for detecting incorrect NG tube position.[37] On the other hand, the fact that radiological examination methods will be constantly performed and evaluated by a radiologist creates a limitation for nurses and other health personnel to verify the location of the bedside tube. It has also been emphasized that this may delay the start of feeding and interrupt the feeding process.[38] Tsujimoto et al.,[35] on the other hand, reported that the ultrasound method should not be applied alone to confirm the location of the NG tube, but it could help in determining the location of the NG tube in cases where the x-ray device could not be used. It is emphasized that more studies are needed with a larger sample group on the subject.[1]

pH Test

Testing gastric pH by aspirating a small amount of liquid from the tube is considered an alternative method for confirming the location of the NG tube. Measuring the acidity of stomach contents is accepted as an evidence-based method used to confirm the location of the NG tube. Studies have shown that the pH value of 5.5 and below for the aspirate obtained from the NG tube indicates that the tube is properly placed in the stomach. In the studies performed, the value with the highest sensitivity and specificity in determining the location of the NG tube was determined as pH $\leq$ 5.5.[39-41]

A working group was formed in 2012 by the American Society for Parenteral and Enteral Nutrition (ASPEN) in order to eliminate the disadvantages of radiography, which is accepted as the gold standard, and to identify a practical and applicable method with the highest level of evidence for radiography. This working group constituted of the American Association for Critical Care Nurses, Society of Pediatric Nurses, National Association of Neonatal Nurses, North American Society for Pediatric Gastroenterology, Hepatology and Nutrition, Children's Healthcare Association Patient Safety Organization, and ASPEN and it is known as the New Opportunities for Verification of Enteral Tube Location (NOVEL) project.[19] The NOVEL project's recommendation to confirm the placement of the NG tube is to measure gastric pH, especially in children. As an indication of gastric location,

gastric pH ≤ 5.5 is accepted as an indication that the tube is in place. In cases where gastric contents cannot be obtained, radiological examination is recommended. Moreover, the working group prepared a chart on how to measure pH from the NG tube (Figure 1).

As a standard practice by the UK National Patient Safety Center and the American Association of Intensive Care Nurses, pH measurement is performed to confirm the location of the NG tube, and a pH value between 1 and 5.5 is accepted as an accurate indicator for the placement of the tube in the stomach.[15] Although it is an easy, practical, and cost-effective method that can be applied at the bedside, the method has some limitations. The pH measurement is helpful in distinguishing gastric location from pleural or intestinal location (usually pH ≥ 6), but it is difficult to say that it is completely reliable in confirming the location in the esophagus. Anecdotal reports indicate that the pH measurement of fluid aspirated from tubes in the esophagus can be as low as 1 (perhaps as a result of reflux of acidic gastric juice) or as high as 7 (as a result of swallowing alkaline saliva). Therefore, it is stated that the pH value of the fluid is limited in detecting esophageal localization.[42] On the other hand, a difficulty of the application is that the patient is fed enterally with continuous infusion and the result is not reliable as some drugs may affect the pH value. For example, Histamine-2 receptor antagonists, antacids, and proton pump inhibitors can suppress stomach acid, causing measurement of high pH (pH > 5.5) values that raise concerns about tube misplacement.[11,19,42,43]

In a study, it was determined that gastric pH value was higher in patients using acid-inhibiting drugs (4.34 ± 0.14) compared to non-users (43.33 ± 0.2).[42] In the study of

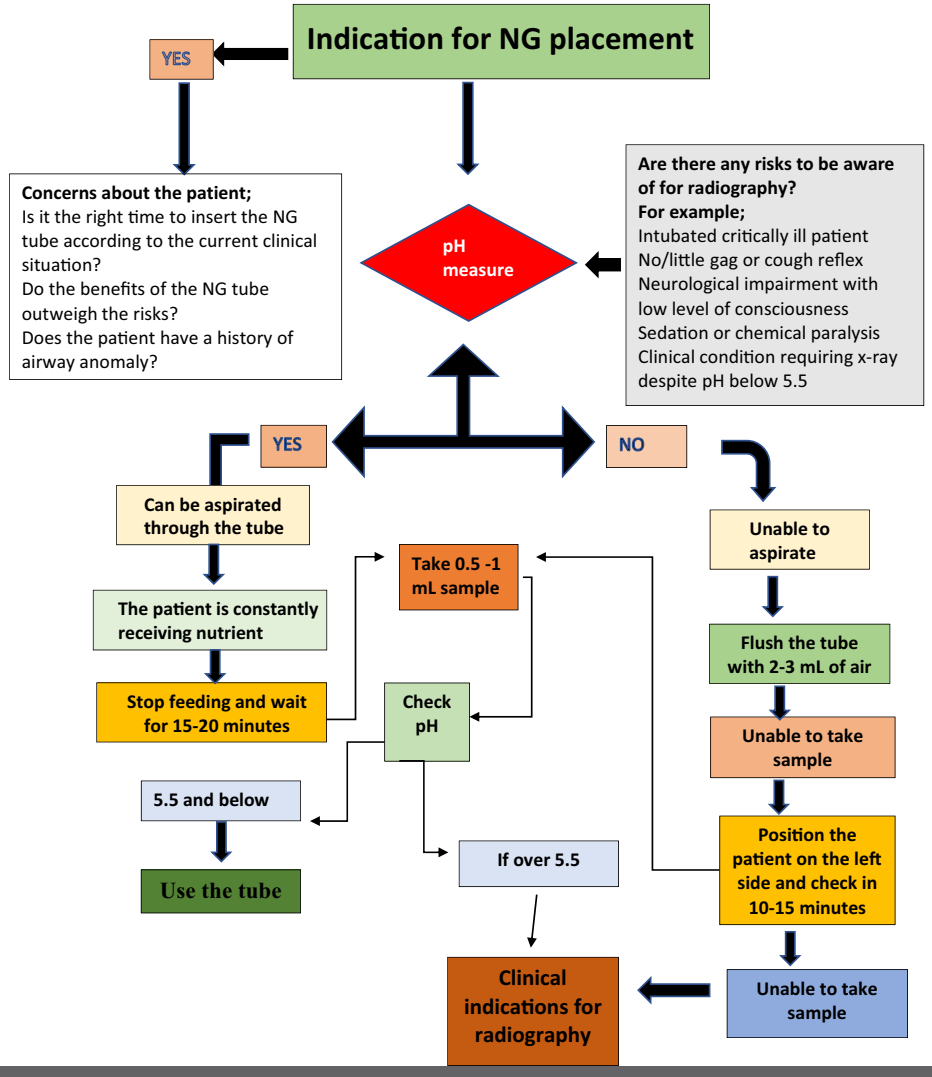

Figure 1. Placement of nasogastric feeding tube and verification of its location. mL, milliliter; NG, nasogastric. Adapted from Irving SY, et al. Pediatric nasogastric tube placement and verification: Best practice recommendations from the NOVEL Project. *Nutr Clin Prac.* 2018;33:921–927.

Boeykens et al.,[43] gastric pH_1 value was reported as 4.6 in people using H2 receptor antagonists and proton pump inhibitors and as 3.5 in non-users. Moreover, the inability to take gastric aspirate is another limitation of the application. Borsci et al[44] reported that gastric contents could not be obtained in 45% of the cases, 11% of the personnel participating in the study misinterpreted the strips, and the possibility of misreading the strips could lead to wrong decisions. In another study, gastric contents could be aspirated from only 48.6% of the patients. In the same study, in 33.5% of the cases, gastric content could be taken in line with additional measures such as providing air from the NG tube and lateral positioning. This situation caused a delay in feeding in 33.5% of the patients. The method could not be used because gastric contents could not be obtained from 18.4% of the patients. For accurate evaluation of pH measurements, pH sensors or guide wire with pH sensors in clinics and NG tube placement are recommended.[45]

Recently, some devices that can be used to evaluate the pH of the stomach contents without the need for pH strips to determine the gastric tip placement of the tube have been produced. On the other hand, with the fiberoptic sensor technology that can measure pH without the need for gastric aspirate, measurement devices that easily verify the location of the tube by turning on the green light on the device accompanied by a guide placed in the tube have been produced. In addition, some measuring devices have been produced in which CO_2 and pH measurement are made together. Although clinical studies on these devices are not yet available, they are seen as very promising technologies in determining the placement of the NG tube. In general, although the pH method has some limitations, it is accepted as an alternative to radiography, which is considered as gold standard, and as a practical application with the highest level of evidence. pH measurement is considered to be the most appropriate method to be used in clinics in terms of its ease of application, practicality, ability to give immediate results, cost-effectiveness, no exposure to radiation, and accurate results.[19,46]

Visual Evaluation of Fluid Aspirated From the Feeding Tube

This method is the visual examination of the fluid taken from the feeding tube. Gastric contents may be sedimented grass-green, brown (if blood is present and gastric acid has acted), clear and colorless (often snuff-colored with streaked grayish-white mucus or sediment), and rarely straw-colored. Since tracheobronchial fluids are actually composed of yellowish brown (snuff-colored) grayish-white mucus, the fluid in this appearance can be both respiratory fluid and gastric fluid. The pleural fluid is mostly clear and straw-colored. As a result of inadvertent insertion of the feeding tube into the pleura, the pleural fluid may appear bloody. When the infection develops, the pleural fluid may be seen as unclear. The contents of the small intestine are mostly clear and yellow to bile pigment in color. Therefore, it has been reported that the evaluation of the color of gastric contents taken with an injector is not an appropriate method without a high level of evidence to confirm the location of the feeding tube, and it has been reported that this method alone is inconvenient to use in clinics.[39]

Auscultation Method

This method involves injecting air through the tube with an injector and simultaneously listening to the "bubbling" or "gurgling-whining" sound over the epigastrium using a stethoscope. When the tube is placed in both the lung and upper gastrointestinal system (esophagus, stomach, duodenum, or proximal jejunum), the given air passes audible sounds through the epigastric region. Although this estimated sound is not an indication that the tube is directly in the stomach, it may be confused with intestinal, bronchial, or pleural sounds.[42] However, it is reported as the most frequently used method by nurses in clinics.[47]

A large-scale prospective study comparing the auscultation method and pH measurement with abdominal x-ray, which is accepted as the gold standard, examined 178 stomach contents and emphasized that the auscultation method was not a reliable method with 79% sensitivity and 61% specificity.[46] Although it is seen as an advantage that there is no need for gastric aspirate and measurement of aspirate, the reliability of the method is questionable and its use alone in clinics is not recommended.[31,43,48] In a review examining international guidelines, auscultation was reported as an unreliable method.[29]

Measurement of the Length of Tube

Once the NG feeding tube is in place, the tube is secured and marked with an indelible pen at the point where it exits the hole. In this method, the length of the tube outside the patient's body is measured and the line marked with this measurement is recorded in the patient file. These measurements are followed regularly. The majority of a previously correctly placed tube being left out is a clear indication for re-administration or replacement of the tube. However, in this method, although the tube is properly fixed, it may migrate, bend in the stomach, or extend to the first part of the duodenum. Especially in small diameter tubes, tube migration may occur more frequently. For this reason, it has been reported that it has no high level of evidence in confirming the location of the NG tube and it is inconvenient to use this method alone in clinics.[49,50]

Capnography and Calorimetric Capnometry

Capnography is an alternative method to confirm the position of the NG tube in mechanically ventilated patients. Capnography is the continuous analysis and recording of carbon dioxide (CO_2) using infrared technology. The result is expressed as the partial pressure of mercury in millimeters. In colorimetric capnometry, pH-sensitive filter paper impregnated with phenolsulfonephthalein is used and the strip color changes from purple to yellow in the presence of CO_2. The device, which is used to determine whether the placement of the tube is correct during the administration of NG tube, shows different colors according to the presence of CO_2 in the region where the tube is placed, after it is placed on the outer end of the tube. The purple color indicates the absence of CO_2 (indicating that the tube is in the stomach), and the brown or yellow color indicates the presence of CO_2 (indicating that the tube is outside the stomach). Since the lungs breathe CO_2, capnography/colorimetric capnometry is expected to detect CO_2 if the NG tube is placed in the lung rather than the stomach. The calorimetric capnography method is accepted as a valid method for confirming the placement of the NG tube for patients on mechanical ventilation.[5] On the other hand, this method confirms the accidental placement of the NG tube in the trachea, but it is not a useful method to distinguish between the placement of the tube in the esophagus or duodenum. Fizzy drinks or sodium bicarbonate may affect the result. When these methods are used in combination with radiology, they strengthen the accuracy of the tube location.[5,46]

In a systematic review examining studies comparing the placement of NG tube with capnography/calorimetric capnometry in adult patients, despite the high sensitivity and specificity of both methods, the limited sample size of the studies was reported as an important limitation and colorimetric capnometry method was reported to be more reliable than auscultation method for confirming the placement of the NG tube. Moreover, it was stated that it was compatible with the radiological method, but insufficient in distinguishing gastric or duodenal localization. It was emphasized that more studies on the subject were needed.[5] The use of these methods alone for locating the NG tube is not recommended.[1]

Biochemical Markers

In this method, bilirubin, trypsin, and pepsin levels are used together with pH measurement to confirm the location of the NG tube. Adding laboratory enzyme analyses to pH tests of fluid aspirated from feeding tubes increases the possibility of accurately distinguishing gastric, intestinal, and respiratory locations. Fluid withdrawn from the tube in the stomach contains mostly pepsin, and fluid withdrawn from the small intestine contains mostly trypsin, but little or no pepsin. Fluid drawn through misplaced tubes in the lungs usually contains little or no 2 of these gastrointestinal enzymes. Bilirubin level in the intestines is significantly higher than in the stomach. The major disadvantages are that there are not many studies on the subject, there are no simple bedside enzyme tests used in combination with pH measurements to confirm the tube position, it wastes time waiting for laboratory results, and it delays the feeding process. In addition, the necessity of removing gastric contents and the effect of factors that will influence the gastric pH result (continuous EN, some drugs, etc.) in this method are other disadvantages.[22,51]

CONCLUSION

The combined results of studies and guidelines show that x-ray is the most reliable and accurate method for distinguishing gastric and pulmonary location of the NG tube. Although it is not primarily used in all cases, it is supported to prefer the radiological method, especially for intensive care patients and critical patients with decreased consciousness levels and gag reflexes. Among the non-radiological methods, the common agreement of the guidelines and studies is the pH measurement of the gastric content. It is seen that the use of other non-radiological methods such as auscultation, examination of the color of the gastric contents, and monitoring of the length of the tube may cause distressing results in terms of patient safety and should not be used alone to confirm the location of the NG tube. Some methods alone have failed to provide an evidence base. For example, the absence of special bedside tests such as enzyme tests and the limitations of the use of CO_2 detectors in the routine clinical setting. Additional validation methods have been proposed for these applications.

In conclusion, a valid and comprehensive safety approach is required in verifying the placement of NG tubes. However, it is seen that there is no consensus on a standard method on this subject in studies and guidelines. More studies with a high level of evidence are needed to develop good practice protocols on the subject. Although the pH method is the most widely accepted method in order to increase safety and minimize radiological exposure in patients with NG tube, more studies are needed to standardize it as an application that health personnel can easily evaluate. Adequate training and competency of all healthcare personnel are extremely important in developing standards that include high-evidence practices that support patient safety and in determining the placement/location of the NG tube.

Peer-review: Externally peer-reviewed.

Declaration of Interests: The author have no conflicts of interest to declare.

Funding: The author declared that this study has received no financial support.

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