

# A Review of Location Methods of Nasogastric Tube in Critically Ill Patients

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## Abstract

Nasogastric tube is widely used in intensive care units. The complications of misplacement are rare but very dangerous for critically ill patients. Accurate localization of the position of the tip of nasogastric tube can effectively decrease complications and ensure the safety of critically ill patients. There are various methods that can be used to verify the location of the nasogastric tube such as radiography, PH measurement, electromagnetic navigator and ultrasound. However, there is a lack of general consensus regarding a standard method. In this review, we found that the accuracy of nasogastric tube placement can be greatly improved by visual technology such as X-ray, sonography and electromagnetic navigator. However, visual technology has not been widely used to locate the tip of nasogastric tube in critically ill patients. Best practice guidelines based on the available knowledge and evidence of current methods are necessary to increase the accuracy placement of nasogastric tube. It is envisioned that development of visual technologies will determine a new standard of care for verification of placement of nasogastric tube.

## Keywords

Critically Ill, Nasogastric Tube, Placement, Visualization

## 1. Introduction

Nasogastric (NG) tube is widely used in intensive care units [1] [2] [3] [4]. The use of the NG tube has become used for several reasons, not only for the administration of enteral nutrition and medications, but also for gastric decompression.

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sion. The annual application of NG tube reached 1.2 million in the United States [5]. However, NG tube misplacement has been reported in quite different frequencies: 1.9% - 89.5% in adults and 20.9% - 43.5% in children [6]. The complications of misplacement are very dangerous for patients [7]. The serious complications correlated with the maneuver derive from the possibility of misplacement in the tracheobronchial tree, pneumothorax, pneumomediastinum, subcutaneous emphysema, pneumonia, pulmonary hemorrhage, empyema, hemothorax, bronchopleural fistula, perforation of the esophagus or even death [8]-[13]. Therefore, accurate positioning of the tip of NG tube can effectively ensure the safety of critically ill patients. There are various methods that can be used to verify the location of the NG tube such as radiography, PH measurement, electromagnetic navigator and ultrasound [14]. However, there is a lack of general consensus regarding a standard method. The purpose of this review is to conduct a review of location methods of nasogastric tube in critically ill patients.

## 2. Non-Visualization Technology

### 2.1. Length Measurement

Insertion length of NG tube determined by the distance from the tip of the nose to the ear lobe and from the ear lobe to the xiphoid process of the sternum or the distance from the hairline of the forehead to the xiphoid process of the sternum [15]. Some scholars proposed that insertion length of NG tube should be extended 10 - 15 cm in adults [16] [17] [18]. A Meta analysis shows that extended insertion length of NG tube 10 cm can reduce the incidence of reflux, choking coughs, aspiration, pneumonia [18] [19]. Other scholars improved the measurement methods for premature infants, neonates and catheterization [20] [21] [22]. However, these studies did not compare with X-ray and report the location of NG tube. Furthermore, this measuring method is affected by age, height, anatomical structure, body position and other factors [23] [24] [25]. Therefore, this method is limited to evaluate the placement of NG tube.

### 2.2. PH Measurement

The PH of gastric juice was 3.9, the PH of pulmonary bronchial secretion was 7.73, and the PH of intestinal juice was 7.35, which is used to distinguish the variety of liquid [26].  $\text{PH} \leq 5.5$  is contributed to ensure placement of nasogastric tube [27] [28]. The sensitivity of a  $\text{pH} \leq 5.5$  to correctly identify gastric samples was 68% and the specificity was 79% [29]. The accuracy of this method was 94% in children [26]. The alert recommended testing with PH indicator paper as the first line check [30]. However, Borsci [31] found that in 45.7% of cases aspiration could not be achieved only using this method, and the likelihood of misreading the strips that may lead to errors of decision making with an adverse impact on a patient is 11.15%. The determination of PH value, considering a value lower than 5 as the cut-off for the correct placement, is not indicated in patients who take some medications, such as  $\text{H}_2$  blockers, and doesn't distin-

guish between intestinal and tracheal placement [32]. Due to its uncertainty of this method, a cross-sectional survey in 383 intensive care units from 20 European countries reported that only 3.5% of ICUs used this method to confirm the location of nasogastric tube [4].

### 2.3. Auscultation of Injected Air

Hearing bubbling sound over epigastric region while air injected via tube perceived as evidence of NG tube placement. This method is widely used, and 51.93% - 84.7% of nurses used this method to confirm the location of NG tube [4] [33]. The uncertainty of this method was documented by American group Metheny in 1990 following a study. In the study, the average percentage of correct classifications was 34.4%, three subjects with feeding tubes inadvertently positioned in the respiratory tract, air insufflations were clearly audible in 2 of the 3 cases [34]. The accuracy of this method was 67% in children [26]. The effect of auscultation will be lower when nurses wear disposable caps, protective clothing and other personal protective equipment. Therefore, auscultation of injected air to predict NG tube location is unreliable and it should not be used alone [12] [30].

## 3. Visualization Technology

### 3.1. X-Ray

X-ray is the gold standard for NG tube placement [24] [32] [35] [36] [37] [38] [39]. This method can timely detect gastric tube heterotopia and prevent complications [35] [40]. This method was usually used to confirm the position of NG tube [37] [41]. However, due to the uncertainty of ray frequency and radiation exposure, it is not a first-line solution for the tip location of NG tube [4] [30] [42].

### 3.2. Sonography

Sonography was firstly used to confirm the tip of a naso-enteric tube feeding during the passing of pylorus in 1996 [43]. Bedside sonography is a sensitive method for confirming the position of NG tubes and performs in a shorter time than X-ray. Compared with X-ray, the sensitivity of sonography could reach 92.2% - 100%, and average time-consuming of this method was 42 - 140 s. [7] [37] [41] [44] [45] [46] [47]. The sensitivity of subxiphoid sonography and neck sonography and air-water mixture combined could be greatly increased [48]. The main difficulties were found in the visualization of the esophagogastric junction and the antrum in the transabdominal longitudinal scan in obese patients because of the interposition of gas. Left lateral decubitus and the injection of 50 ml of normal saline could facilitate the sonographic exam [7]. However, this location method is not widely used in intensive care unit [4]. Further research should be conducted on the feasibility of nurses using sonography to verify the location of NG tube.

### 3.3. Endoscopy

Laryngoscope and gastroscope were used to NG tube placement [49] [50] [51] [52]. Laryngoscope can direct the NG tube into the esophagus. However, laryngoscope and gastroscopy are invasive procedures, and complications such as hypopharyngeal and esophageal perforation may occur [53]. Video-guided laryngoscope reduces nasogastric intubation time compared to manual and direct laryngoscope intubation [54]. However, endoscopic procedures may produce droplets which could increase the risk of respiratory infections among medical staffs. Due to the risk of respiratory and invasive injury, endoscopy was used for these mechanical ventilated patients who have difficult nasopharyngeal anatomy. There is no study to compare the effect of this method with X-ray. More researches are needed to explore the effect of endoscopy on location of NG tube.

### 3.4. Electromagnetic Navigator

Electromagnetic navigator was used to confirm the tip of a NG tube by Williams in 1996 [55]. Electromagnetic navigator is composed to electromagnetic transmitter, receiving device and display device. Electromagnetic transmitter is at the tip of the guide wire inside the nasogastric tube to monitor the position of the tip. Receiving device receives signal from electromagnetic transmitter and the placement of nasogastric tube could be visible through display device. The placement of an enteral feeding tube is also visible in critically ill patients with slow gastric emptying [56]. The sensitivity of electromagnetic navigator was 98%, compared with chest X-ray [39]. This method is mainly applied to locate the nasojejunal tube [55] [56] [57] [58] [59]. It is needed to explore the effect of electromagnetic navigator on location of the tip of the NG tube.

## 4. Conclusions

NG tube is a common procedure in critically ill patients for feeding or drainage. The mistake placement would be leading to serious complications or fatal incidents. Therefore, it is necessary to confirm the location of the NG tube correctly. There are various methods that can be used to verify the location of the NG tube such as radiography, PH measurement, electromagnetic navigator and ultrasound. However, there is a lack of general consensus regarding a standard method.

In this review, we found that the accuracy of NG tube placement can be greatly improved by using visual technology such as X-ray, sonography and electromagnetic navigator. However, the visual technology has not been widely used to locate the tip of NG tube in critically ill patients. Visual technology to improve the accuracy and efficiency of placement and ongoing location verification is necessary. More researches are needed to verify NG tube location, develop potential solutions and actualize their use.

It may be that development of best practice guidelines for NG tube placement and ongoing location verification by a multiprofessional, collaborative team is

warranted. Best practice guidelines based on the available knowledge and evidence of current methods are necessary to increase the accuracy placement of NG tube. It is envisioned that development of visual technologies will determine a new standard of care for verification of placement of NG tube. The goal is to minimize radiologic exposure and to improve safety for all patients who insert NG tube.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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