SUPPLEMENT

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Comparison of neck ultrasonography with a pH meter to confirm correct position of nasogastric tube

Abstract

Purpose: The aim of this study was to compare pH meter and neck ultrasonograph for evaluation of nasogastric tube (NGT) position.

Methods: A total of 35 adult patients who required NGT insertion were included. The NGT was inserted by an anesthetist after endotracheal intubation, and the transducer was placed transversely on the neck, just superior to the suprasternal notch. The passage of the NGT in the esophagus was evaluated by a sonographer, and the stomach was emptied by nasogastric suction. Secretion from inside the NGT was analyzed using a pH meter. The tip of the NGT was accepted as being in the stomach if the pH measured between 1 and 5. Neck ultrasonography was compared with the pH meter analysis for confirmation of NGT position.

Results: Ultrasonography was highly sensitive (100% (95% CI 89.6–100%) and specific (97.2% (95% CI 85.4–99.5%)) for evaluation of NGT position. The specificity for the pH meter was 100% (95% CI 16.6–100%), while the sensitivity was 76.5% (95% CI 58.8–89.2%).

Conclusions: This study showed that neck ultrasonography is more sensitive than the pH meter for confirmation of NGT position.

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Insertion of a nasogastric tube (NGT) following tracheal intubation is required for several gastrointestinal surgical procedures. It is often easy and straightforward and accomplished in a single attempt; the success rate at the first attempt with the patient in the neutral position, without the use of any additional maneuver, has been reported as being 66–68% [1]. However, NGT insertion can be a time-consuming and difficult procedure in patients who are anesthetized and paralyzed, as a result of their inability to swallow and the presence of the inflated cuff of the endotracheal tube [2–5]. In addition, if the tube is impacted against the pyriform sinuses or arytenoids cartilage, bending of the tube occurs at these points, thereby leading to coiling in the oropharynx [4,6,7]. The tube may be misplaced in the tracheobronchial tree, and it has been reported that this occurs in 0.3% to 15% of cases [8,9]. In addition, there are many reports of pulmonary complications and death from NGT misplacement [10]. Incidence of fatalities therefore approximates to 0.001% of intubations conducted [11].

Confirmation of correct placement of NGT can avoid these complications [8]. Several techniques for such confirmation have been described [10], and one of the most reliable of these currently available is the measurement of pH of NGT aspirates [8]. Indeed, the National Patient Safety Agency has recently recommended the use of pH-specific paper to test gastric aspirates, in order to reduce harm caused by a misplaced NGT [12]. Gastric contents may have a pH of between 1 and 5, while small bowel, esophageal, oral, and bronchial secretions may have a pH of greater than 6 [8]. Use of H₂-blockers (e.g., ranitidine) and proton-pump inhibitors (PPIs; e.g., omeprazole and lansoprazole) raises gastric pH, potentially giving a false negative result and making differentiation of position impossible [11]. In this case, pH testing is not sufficiently sensitive to distinguish between gastric and bronchial secretions [8]. A second problem with pH testing is colourimetric differentiation of pH. Although there is a strong correlation between pH meter readings and pH strips, the strips may be inaccurate, depending on the strip itself and the operator's eyesight [11]. Furthermore, the gastric contents may not be withdrawn from the NGT, and this procedure can also be time-consuming.

Abdominal ultrasound has proved successful in confirming correct placement of nasoenteric feeding tubes in critically ill adult patients [13]. However, it may not always be safe and reliable for confirming NGT position [12]; it is not an easy method, and it requires experience to view the NGT. However, passage of the NGT through the esophagus can easily be viewed with neck ultrasound. Our hypothesis is that

the neck ultrasound can be more successful than the pH meter for evaluation of NGT position, and this study compared the success of these two methods.

Methods

This prospective study was approved by the Hospital Ethics Committee and written informed consent was obtained from patients before surgery. A total of 35 adult patients who required NGT insertion, and who were scheduled for elective laparoscopic cholecystectomy and gastrectomy under general anesthesia, were included. Patients with abnormal airway anatomy, morbid obesity, full stomach, nasal deformity, history of epistaxis, gastrointestinal hemorrhage, coagulopathy and esophageal or thyroid diseases were excluded, as were those using H₂-blockers, PPIs and antacids.

Anesthetic management was standardized and no sedative premedication was given. Monitoring was established before induction and included an electrocardiograph, pulse oximeter, capnograph and non-invasive blood pressure monitor. Anesthesia was induced by intravenously administered propofol 2 mg/kg¹, fentanyl 1 µg/kg¹ and vecuronium 0.1 mg/kg¹. All patients were intubated using an endotracheal tube with a cuff, and were mechanically ventilated to maintain normocapnia. Anesthesia was maintained with 1%–2% sevoflurane in 50% nitrous oxide in oxygen.

After endotracheal intubation, the 16-G NGT was inserted by an anesthetist, via the nostril, with lubrication, until it reached the pharyngeal area. The patient's head was kept in the neutral position. The 16-G NGT was subsequently advanced gently with sonographic vision until an insertion depth of 50 cm was reached.

A sonographer, who was an anesthesiologist with superficial ultrasonography experience, determined whether the NGT was placed in the esophagus. The procedure was performed using an ultrasound machine (SonoSite, USA) capable of creating ordinary two-dimensional sector images. The linear ultrasonography transducer frequency was selected according to the physical size of the patient, and varied from 9 to 12 MHz. A linear ultrasonography probe was placed transversely on the anterior neck, just superior to the suprasternal notch before the NGT was inserted into the esophagus. When the NGT passes through the esophagus, its lumen expands, and a hyperechoic shadow or comet sign is observed deep in the esophagus (Figure 1).

The stomach was emptied by nasogastric suction. Secretion from inside the NGT was analyzed using a pH meter (pH indicator strips, MERCK, Germany). Measurement was carried out by a different anesthesiologist. The tip of the NGT

FIGURE 1. Transverse sonogram of the esophagus in a patient with an endotracheal and a nasogastric tube. Nasogastric tube (long arrow) is shown as a hyperechoic layer. T. left lobe of the thyroid; t. trachea; and, C. left common carotid artery.

FIGURE 2. Transverse sonogram of the esophagus in a patient with an endotracheal tube shows the cervical esophagus (arrows) as an oval and multiconcentric ring structure. The right wall of the cervical esophagus is covered by the acoustic shadow of the trachea. T. left lobe of the thyroid; t. trachea; and, C. left common carotid artery.

was accepted as being in the stomach if the pH measured was between 1 and 5. The periods for the assessment of ultrasonography and measurement of pH were recorded.

The tube was advanced to a sufficient depth for NGT insertion, and its presence in the stomach was confirmed by a surgeon by direct vision; therefore, successful NGT insertion was defined by the surgeon as it appeared in the stomach. The surgeon and the anesthetists were unaware of one another's assessments.

Statistics

Power analysis suggested a sample size of 34 patients in the study with $\alpha = 0.05$ and $b = 0.80$, presuming that the incidence of successful assessment would increase by 20% if the success rate of ultrasonography compared to that of the pH meter. Statistical analyses were performed using SPSS version 13.0 software for Windows (SPSS Inc., Chicago, IL). The McNemar test was used to compare the success of the pH test and ultrasonography. Sensitivity, specificity, and positive and negative predictive values, and their 95% confidence intervals (CIs), were calculated for evaluation of NGT placement. Data

were expressed as mean (SD), median (range) or % (95% CI). $P < 0.05$ was considered statistically significant.

Results

All the NGTs were smoothly inserted in the patients, without complications such as bleeding or mucosa injury. The characteristics of the 35 patients are shown in Table 1.

Correct identification of NGT position was achieved by ultrasonography in 34/35 patients. Although the NGT was observed in the esophagus of one patient, it was not in the stomach and was, therefore, evaluated as a false positive diagnosis. Ultrasonography was highly sensitive (100% (95% CI 89.6–100%)) and specific (97.2% (95% CI 85.4–99.5%)) for evaluation of NGT position. The measured pH values were 5 or <5 in 25 patients, >5 in nine patients and were not measured in one patient, due to the absence of secretion. The specificity for the pH meter was 100% (95% CI 16.6–100%), while the sensitivity was 76.5% (95% CI 58.8–89.2%). Sensitivities, specificities, and positive and negative predictive values are shown in Table 2. Statistical analysis revealed a

TABLE 1. Patients characteristics

Age (year)	47±17
Weight (kg)	76±16
Height (cm)	166±9
Sex (M/F)	14/21
Measured pH	2.5 (1-7)
The time taken for pH (min)	17.5 (1-60)
The depth of the esophagus (mm)	23±4
The time taken to place the NG (s)	60 (10-300)
The number of attempts (I/II/III)	22/7/6
Operation (n)	
Laparoscopic cholecystectomy	25
Laparoscopic Nissen	3
Gastrectomy	7

n, mean±SD or median (min-max)

TABLE 2: Sensitivities, specificities, positive and negative predictive values for ultrasonography and pH meter

	Ultrasonography	pH meter
Sensitivity	100% (89.6-100%)	100% (86.7-100%)
Specificity	97.2% (85.4-99.5%)	10% (1.7-44.5 %)
Positive predictive value	97.1% (85- 99.5 %)	73.5% (55.6-87.1 %)
Negative predictive value	100% (89.9-100%)	100% (16.6-100%)

% (95% CI)

significant difference between these two methods (McNemar test; $p=0.004$).

NGT placement is shown in Figure 1. The depth of the esophagus was 23 ± 4 mm on average. The esophagus was observed in the paratracheal space (Figure 2). We found that the esophagus was usually to the left of the trachea (32/35 patients); three cases of esophageal intubation were detected by visualization of the tube in the left paratracheal space.

Discussion

NGT may cause few, or no, symptoms when incorrectly positioned, particularly in high-risk patients, such as those who are unconscious or intubated, or who lack a gag or swallow reflex. Several methods can be used to confirm the position of the NGT, one of which, the "Whoosh test", is traditionally

used in practice. Utilizing this test, air is insufflated through the feeding tube while auscultating the epigastrium; however, the efficacy of this method is highly questionable. There have been multiple reports of its ineffectiveness leading to unintentional consequences [14-16]. There is no reliable non-radiographic method to differentiate respiratory, esophageal and gastric placement of NGT tubes. The gold standard test for confirming the location of an NGT is an X-ray, although numerous reports have described the misreading of X-rays by physicians not trained in radiology [17]. Moreover, X-ray confirmation is not an appropriate method to check NGT placement or location in every patient, and it is necessary to use the most accurate bedside methods.

One such bedside method that is available to confirm NGT placement is the measurement of pH of NGT aspirates [18,19]. There is a need to be able to differentiate between gastric contents that may have a pH of between 1 and 5, small bowel or bronchial secretions, which may have a pH of greater than 6, and esophageal secretions, which may have a pH of between 6 and 7; although esophageal pH can be acidic in the presence of acid reflux from the stomach [20,21]. It has been asserted that this technique should replace the testing of the acidity/alkalinity of aspirate using the pH meter, which is not sufficiently sensitive to distinguish between gastric, bronchial and oral secretions [8]. Taylor [11] found that use of H2-blockers and PPIs could reduce pH confirmation of NGT position to 58% at best. We measured pH values of more than 5 in nine patients, although the tip of the NGT was visually confirmed to be within the stomach. None of these patients used H2-blockers or PPIs. The reason for this elevated pH may be contamination with oral or small bowel secretions. Irrespective of the cause, we found that the sensitivity of the pH meter was low (76.5%), while the specificity of this ultrasonographic method was high (100%).

Alternative bedside testing methods have been proposed, such as the use of pH probes, capnography and measurement of aspirate bilirubin, trypsin and pepsin. Each of these methods has limitations and drawbacks. In addition, none of them can be relied upon to determine distal NGT tip position. When undertaking assessments, the strength of single indicators is increased if a greater number of other indicators are present [22].

The use of ultrasonography is also an alternative bedside testing method; Hernandez-Socorro *et al.* described placing feeding tubes into the small bowel with the abdominal sonographic method. They were successful in 84.6% of patients, compared with only 25.7% of successful placements using the blind manual method [13]; however, abdominal

ultrasonography requires experience to confirm the NGT location. In addition, it takes time to evaluate NGT position, and is not practical to use in the operating room. Alternatively, NGT may be detected in the cervical esophagus by neck ultrasonography, which is practical to use in this location.

In this study, the sensitivity and specificity, and positive and negative predictive values of neck ultrasonography, which were evaluated as a confirmation of NGT position, were fairly high. The sensitivity and specificity varied between 89.6–100% and 85.4–99.5%, respectively, and the positive and negative predictive values were between 85–99.5% and 89.9–100%, respectively. These results show that ultrasonography is superior to the pH meter for confirmation of NGT position.

We understand that neck ultrasonography is associated with some limitations. This technique shows whether or not the NGT passes through the esophagus, but it does not provide information regarding the location of the tip of the NGT. If the tip of the NGT is still within the esophagus, it gives a false positive result. Importantly, if the operator is not sufficiently trained in the use of neck ultrasonography, it is difficult to visualize the cervical esophagus, which is often right next to the trachea, usually appears as a multi-layer, and is normally closed. The cervical esophagus is not easy to view sonographically because of the presence of the trachea and vertebrae [23]. On transverse ultrasonography, although the left lobe of the thyroid can be used as an acoustic window, the right wall of the cervical esophagus is usually covered by the acoustic shadow cast by the trachea [23]. Our previous study and the present study showed that the esophagus was usually to the left of the trachea (85–94%) [24]. This technique provides an advantage in that it is possible to view the cervical esophagus. Anatomically, the esophagus is composed of four layers [25,26]: from the inside out, these are the mucosa, the submucosa, the muscularis and the adventitia. On ultrasonography, the wall of the cervical esophagus generally appears as five to seven layers [23]. A hypoechoic layer always presents between the inner hyperechoic layer (the submucosa) and there are strong echoes within the esophageal lumen. This hypoechoic layer can be determined as the mucosa of the esophagus, as confirmed in examinations of patients with an NGT placed in their esophagus [23].

The present study showed that neck ultrasonography, which has high sensitivity and specificity, had greater sensitivity than the pH meter for confirmation of NGT position. In addition, application of ultrasonography was easy, rapid and safe. A pH meter cannot provide information to support decision-making because it does not provide information regarding the location of the tip of the NGT. In

conclusion, compared to the pH meter, neck ultrasonography proved to be of great value in confirmation of NGT position.

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