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Verification of Blindly Inserted Nasogastric Feeding Tubes: A Review of Different Test Methods

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Abstract

Placement of nasogastric feeding tubes is common practice in ICU's and hospital wards. Although the technique seems simple there is certainly a risk for morbidity and mortality due to misplacement. Confirmation of correct tip position seems mandatory but whatever test method used, it doesn't guarantee complete safety. More, some of them should be abounded. This article reviews and comments on currently used test methods for nasogastric tip position confirmation.

Keywords: Nasogastric intubation; Tube feeding; Enteral feeding

Introduction

Nasogastric feeding tubes are frequently used and usually placed by nursing staff in critically ill patients. International guidelines recommend the use of (early) enteral feeding [1,2]. Although the technique is common practice and seems simple, numerous reports or studies described harm, going from misplacement in the esophagus, throat or lungs, sometimes leading to serious morbidity (eg pneumonia, pneumothorax) or even mortality. Serious harm was demonstrated in a UK report where during a 5 years period, 21 people died because of misplaced nasogastric tubes mainly due to X-ray misinterpretation [3]. In a review of 9931 narrow-bore naso-enteric tubes, 187 ended up in the tracheobronchial tree, resulting in 35 pneumothoraxes with at least 5 of them caused patient death [4]. All blindly nasogastric feeding tubes should be properly checked before initial use and subsequently following episodes of vomiting, retching or coughing spasms, after oropharyngeal suction or when there is any indication of tube displacement [5]. For assessing correct tip position various methods (or combination of methods) have been described in the literature.

Methods for tube placement verification

Radiographic confirmation

Is still the gold standard but should be preferably interpreted by a radiologist or expertised physician to avoid misinterpretations. In the report of the NPSA, 12 out of 21 patients died because of X-ray misinterpretation [3]. The entire course of the tube must be visualized and immediately after placement the tube's exit site should be marked from the nose or mouth. Although it might be the reference standard, repeated radiographic confirmation is not practical, exposes patients to (excess) radiation, induces extra costs, time investment and delays feeding.

Signs of respiratory distress

When a patient starts to cough or has signs of dyspnea, the tube has to be removed. Note that these signs can be absent especially in patients with an impaired level of consciousness. So the lack of these signs is not a proof that the tube is in the correct position.

Visual characteristics of aspirates

Gastric aspirates are most frequently cloudy and green, tan or off-white, or bloody or brown. Intestinal fluids are primarily clear and yellow to bile-colored while pleural fluid is usually pale yellow and serous, and tracheobronchial secretions usually tan or off-white mucus. After reading first basic criteria about aspirates, nurses can improve their ability to predict gastric or intestinal aspirates but not respiratory [6].

Colorimetric Capnometry/Capnography

With capnography the concentration of carbon dioxide (CO_2) in the respiratory gases is monitored when a nasogastric tube is partially inserted (usually 35 cm to pre-empt lung trauma). Colorimetric capnometers are semiquantitative devices based on a chemical reaction between exhaled CO_2 and a chemical detector impregnated in a strip of paper. These devices are used to identify the presence or absence of a sufficient quantity of CO_2 to produce a color change (eg. from purple to yellow) at a point in time [7]. There is evidence to support the use for this devices although this method cannot determine where the tip of the tube ends in the gastrointestinal tract (esophagus, stomach, or small bowel) [8,5].

Whoosh test or auscultation

The whoosh test consists of rapidly injecting air down a nasogastric tube while auscultating (listening for a 'whooshing sound') over the epigastrium. Many case-reports, studies and alerts indicate that this method is unreliable [5, 9-11]. There is mainly a problem with the specificity of this test (the probability that the test correctly indicates when the NG tube is placed outside the stomach). In our study, 7 tubes were placed outside the stomach with hearing some degree of a whooshing sound [11].

In an overview of 20 nursing textbooks, the majority is still mentioning this method and four books consider it as the only one to be used [12]. So it is not surprisingly that in a huge European survey (383 ICU's) it was pointed out that 84.7% used this method compared to X-ray (32.7%) and pH-measurement (3.5%) [13].

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In a more recent large national survey in the US, data were collected from members of the American Association of Critical-Care Nurses. It seemed that before radiographic confirmation, auscultation was still the most popular bedside method (93%) followed by observing for respiratory distress (68.4%) and the appearance of tube aspirate (65.6%). Of the 926 respondents to the question: 'Which method you use in the absence of radiography?'; 161 reported that they use a single method to test placement. Among these: 136 used auscultation; 11 observed the appearance of tube aspirate; 7 performed pH measurement; 4 looked for respiratory distress and 3 used capnography [14]. Despite the inaccuracy of the auscultatory method, also in another trial only 12% of nurses avoided this practice all of the time [15].

The inability to instill air, however, may identify a kinked tube. Esophageal placement may be suspect if the air is "burped" back by the patient, but again: hearing the air bubble by auscultation does not determine esophageal, gastric, small-bowel, or broncho-pulmonary placement [16].

Biochemical markers

pH and bilirubin

Two studies used a combination of pH >5 and a bilirubin <5 mg/dL to differentiate between respiratory and gastrointestinal placement. The pooled results demonstrated a high predictive ability to correctly identify tubes in the respiratory tract [17,18]. But commercial strips are currently not available.

pH, pepsin and trypsin

Pepsin and trypsin are both enzymes. The first is produced in the stomach and the other one in the small intestine. One study used a combination with pH measurement (pH >6, pepsin ≥ 100 µg/mL, trypsin ≤ 30 µg/mL) to identify respiratory placement [19]. The study demonstrated a sensitivity of 1 (so all tubes in the respiratory tract were correctly identified) and a specificity of 0.93 (which means there were only a few false positives). Again, there is yet no commercial test available.

pH

Most studies have been conducted with pH-measurement alone which seems currently the most practical and feasible bedside method. In differentiating between gastric and respiratory placement different pH cut-off point have been used: ≤ 4, ≤ 5.5, ≤ 5.9, ≤ 6.5, ≤ 7 and ≤ 7.9 [20].

The problem with low cut-off points (eg ≤ 4) is a low sensitivity (more false negative results, so more X-rays) but a high specificity and with a high cut-off point this is the opposite (eg. ≤ 7.9). In our own study with CE marked test strips (Merck® pH indicator strip/pH 2.0–9.0, with a color 0.5 pH units scale), in 98.9% (n=178) of aspirate samples with a pH ≤ 5.5, the tube was located in the stomach. In two aspirates with a pH of 5.5 (two measurements in one patient with a hiatal hernia), the tube was located in the distal esophagus. If an aspirate could be obtained, the results of pH measurements showed a sensitivity of 78.4% and a specificity of 85.7%. ICU patients frequently receive proton pump inhibitors. Acid inhibition produces more false negatives pH tests (so more need for additional X-rays) but the average pH with antacids was only 1 point higher compared to no antacid use (4.6 *vs* 3.5) [11].

In the UK the National Patient Safety Agency UK recommends pH testing to use as first line test method, with pH between 1 and 5.5 as a safe range. As mentioned before, the use pH as a first line method can here be explained because the number of reported deaths was the highest (12 out of 21) due to X-ray misinterpretation [3]. The American Association of Critical Care Nurses (AACN) recommend an X-ray of any blindly inserted tube before initial use. They don't mention a specific cut-off for pH measurement but specify that a fasting gastric pH is usually 5 or less, even in patients receiving gastric-acid inhibitors and that gastric fluid occasionally has a high pH so you can't rule out the need for an X-ray [5]. We also could demonstrate that with pH-measurement, although it completely ruled out respiratory placement, two measurements in a same patient could not detect a feeding tube place in a hiatal hernia [11]. Fluid withdrawn from the esophagus can be swallowed alkaline saliva or refluxed acidic gastric juice. Although a pH cut-off of 5.5 seems safe, there is still some debate. Misinterpretation of the color of pH strips has been reported, particularly differentiating between values 4 and 6 on the pH-paper [21]. In a report for the NHS patient safety research portfolio it was highlighted that despite a pH between 4 and 5.5 was reported, six tubes were located in the lung but the specific circumstances were unclear [22].

In a study with pediatric patients (0.3-5.2 years) a total of 4330 gastric aspirate samples (96% nasogastric) were obtained. The mean pH of the gastric samples was 3.6 with a pH>4 in 30.9% of patients. There was one misplaced tube with a pH of 5.5 so the authors concluded that a pH ≤ 5 would be a safe cut-off. Simultaneously 65 endotracheal aspirate samples were collected from 19 ICU patients: the mean pH was 8.4 [23].

So after reviewing the literature, I currently would recommend a pH cut-off of 5 in all patients.

To avoid misinterpretations with pH reading companies are working on pH sensors (a guide wire with a pH sensor in the nasogastric tube) or pH test strip readers [24].

Ultrasonography

Ultrasound (US) can be used to visualize the tube *via* both the neck and abdomen and can be performed at the bedside. Visualisation of the tube in the stomach is interpreted as correct positioning. Injecting air or saline during visualisation can help to detect the tip position in the stomach.

There are two recent systematic reviews about this topic. Pooled results of the first one (5 studies in adults) showed a sensitivity of 0.93 and a specificity of 0.97. The authors concluded that US is useful to confirm nasogastric tube placement but not optimal to detect incorrect position [25].

In the second systematic review (10 studies), for all settings the sensitivity of the individual studies ranged from 0.5 to 1 and the specificity from 0.17 to 1. The authors concluded that US does not have sufficient accuracy as a single test to confirm correct tube placement [26]. Both reviews reported heterogeneity. To perform US you need a well-trained (but the training period seems short) physician who has to be available on request but in conclusion, certainly on ICU, if seems to be a practical, safe and easy alternative to decrease the number of x-rays.

Real-time image guided technology

This is a new technique where a camera is incorporated in the feeding tube (Kangaroo Feeding tube with IRIS technology) which allows anatomic landmark visualisation during insertion. In a case series a X-ray confirmed correct placement in all patients. There is the potential advantage to identify or check gastric or even postpyloric

position after placement but visualisation could be impaired after a few days. Also the cost-benefits have to be questioned [27].

Avoiding tube misplacement in the distal esophagus

Independently from all above described testing methods, it is crucial that the tip of the nasogastric tube is placed in the stomach. The Nose–Earlobe–Xiphoid (NEX) method is widely used to determine the insertion length of a nasogastric tube. However, the reliability of the NEX method in both adults and pediatric populations has been questioned several times [28]. Our group recently published the first RCT, comparing the NEX with an in the literature proposed alternative method (Hanson Formula). With both methods, in >20% of patients, the tip of the nasogastric tube was located in the esophageal danger zone (near the low esophageal sphincter) [29].

So there is an urge for a safe, simple and practical method to predict correct internal length of a nasogastric tube. Our group is currently investigating this and we hope to publish a new, feasible and safe method in the very near future [30].

Conclusion

Radiologic confirmation of blindly inserted nasogastric feeding tubes remains the golden standard although it has some drawbacks such as possible misinterpretation, (extra) exposure to X-ray (with additional costs) and feeding delay. Numerous bedside methods are available but some of them are unsafe and should not be used, certainly not as a stand-alone test: the whoosh test, observing visual characteristics of aspirates (without pH-measurement) and looking for respiratory distress during tube placement. pH-measurement (with a pH cut-off of 5) seems currently the most feasible bedside method although a combination with other biochemical makers (bilirubin, pepsin) would be preferable (but yet not commercially available). New methods such as pH sensors and pH-meters can prevent misinterpretation during pH reading. Capnometry seems a suitable alternative at least to prevent pulmonary placement although the further course of the tube cannot be determined (eg a tube curled in the distal esophagus). Finally ultrasound and direct imaging can be easy and safe alternative techniques to decrease the number of X-rays.

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