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Original Article

Assessment of a New Method to Verify Feeding Tube Placement by Syringe Aspiration in a Porcine Model☆

Hung-Jung Lin [1,2], Ning-Ping Foo [3], How-Ran Guo [4], Chih-Chan Lin [5], Chun-Chang Lin [6], Kuo-Tai Chen [1,7]*

[1] Emergency Department, Chi-Mei Medical Center, [2] Department of Biotechnology, Southern Tainan University of Technology, [3] Department of Emergency Medicine, Chi-Mei Medical Center, Liouying, [4] Department of Environmental and Occupational Health and Department of Environmental and Occupational Medicine, Medical College, National Cheng Kung University, [5] Department of Medical Research, Chi-Mei Medical Center, [6] Department of Nursing, Chi-Mei Medical Center, [7] Department of Emergency Medicine, Taipei Medical University, Taipei, Taiwan

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SUMMARY

Background: Malpositioned feeding tubes carry the risk of serious complications. However, common bedside methods of differentiating tracheal from gastric feeding tube placement are neither accurate nor practical. Therefore, we conducted an animal study to verify feeding tube placement by syringe aspiration test.
Methods: A total of 26 pigs were anesthetized and intubated with tracheal tubes in the trachea and the esophagus. The animals were divided into two groups. The animals in the mechanical ventilation group were paralysed and received mechanical ventilation. The animals in the spontaneous breathing group maintained spontaneous breathing. The feeding tubes were then inserted through the tracheal tubes, into the trachea and esophagus, so that the anterior openings of the feeding tubes were located in the trachea and esophagus. A feeding syringe was then attached and 30 ml of air was aspirated into the syringe. The ability to aspirate air without resistance was defined as a positive syringe aspiration test. If there was resistance as air was aspirated, it was defined as a negative syringe aspiration test. In the next step, 20 esophageal ventilations were given to create a distended stomach in the experimental animals, and the syringe aspiration test was repeated in the same manner described above.
Results: The syringe aspiration test was positive for feeding tubes placed in the trachea and was negative for feeding tubes located in the esophagus in both the mechanical ventilation group and the spontaneous breathing group.
Conclusion: The syringe aspiration test is an effective method of differentiating tracheal from esophageal feeding tube placement.

1. Introduction

Many methods of evaluating the position of a feeding tube have been studied. Auscultation of air over the epigastrium is the most common method but it has been proven unreliable[1,2]. Combining tests of the gastric contents for pH, bilirubin, pepsin, and trypsin has high accuracy[3,4], but no bedside tests are currently available for measuring pepsin and trypsin. More importantly, sometimes gastric aspiration does not obtain enough gastric fluid for testing[5]. Endoscopy and direct visualization were proposed but these techniques are labor intensive and cause extra discomfort for the patient[6]. Currently, a two-step radiographic technique provides the most effective evaluation of the position of a feeding tube[7]. Nevertheless, this method is expensive and time consuming; thus, it is rarely used as a standard confirmatory method in clinical practice. Measuring the expired carbon dioxide level from the feeding tube is another potential method for determining feeding tube placement[8,9]. Regardless of this method's satisfying performance, capnography is needed for its application, and capnography is not accessible at home, in nursing homes, and in many general hospitals. Disposable capnometry is easier to acquire and use but the results might be influenced by air and secretions in the gastrointestinal tract[10]. For geriatric population, tube feeding is a regular procedure and is imperative to a significant proportion of patients. A feeding tube might be inserted into the patient at home, in the field, in a nursing home, or in a hospital. Healthcare workers desire an easier, cheaper and more accessible method to determine the position of the feeding tube.

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* Correspondence to: Dr Kuo-Tai Chen, Chief of Emergency Department, 901 Chung-Hwa Road, Yung Kang, Tainan 710, Taiwan.
E-mail address: 890502@mail.chimei.org.tw (K.-T. Chen).

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The esophagus is a collapsed fibromuscular tube, whereas the trachea is a rigid cartilaginous tube that maintains its patency. If a feeding tube is located in the esophagus, it is difficult to aspirate air using a feeding syringe. On the other hand, air can be easily aspirated from a feeding tube placed in the trachea. The principle of the syringe aspiration test is similar to the design of the oesophageal detector device[11,12]. Enlightened from the application of oesophageal detector device, we conducted an animal study to verify feeding tube placement by a syringe aspiration test.

2. Materials and methods

2.1. Animal preparation

This project was approved by the animal investigation committee at Chi-Mei Medical Centre Tainan, Taiwan (ROC), and the animals were cared for in accordance with national and institutional guidelines. The study was performed on 26 healthy, Yorkshire pigs, weighing 22.0 kg (16.7–27.5 kg) on average. Before the experiment, the pigs fasted overnight but had free access to water. They were then premedicated with atropine (0.02 mg/kg) and Zoletil (2.5 mg/kg) intramuscularly. Next, 5 mg/kg of propofol was injected into an ear vein for anaesthesia. The pigs were placed in the dorsal recumbent position and both the trachea and the esophagus were intubated with standard tracheal tubes (internal diameter: 6 mm). The positions of the tracheal tubes in the trachea and the esophagus were confirmed by fibrobronchoscopy, and the depth of the tracheal tubes were fixed at 20 cm. Afterward, a standard lead II electrocardiograph was attached to monitor cardiac rhythm, and the animals received a continuous infusion of normal saline solution at 10 ml/hour.

The animals were divided into two groups. Each group contained 13 animals, and both groups participated in a two-step experiments. Muscle paralysis for the first group of 13 pigs was achieved by injecting 2 mg of pancuronium bromide. This group was called the mechanical ventilation group (MV group). The animals in the MV group were ventilated with a volume-controlled ventilator with 21% oxygen at a rate of 20 breaths per minute, and the tidal volume was set at 12 ml/kg. The second group maintained spontaneous breathing without the assistance of mechanical ventilation, and they were labelled the spontaneous breathing group (SB group). Standard Polyvinylchloride feeding tubes (Pacific Hospital supply Co. LTD) and plastic feeding syringes (Green Cross Medical Product Co. LTD) were used in this experiment.

2.2. Step I

First, the ventilators were discontinued in the animals in the MV group. Then, we inserted feeding tubes into the tracheal tubes placed in the trachea and the esophagus to a depth of 42 cm (the length of the tracheal tube was 32 cm). Thus, the feeding tubes protruded 10 cm out of the tracheal tubes and the anterior opening and the side holes of each feeding tube were located in the trachea and the esophagus. The feeding syringe was then attached and 30 ml of air was aspirated with the syringe. The ability to aspirate air into the syringe without resistance was defined as a positive syringe aspiration test. If there was resistance as the syringe was aspirated it was defined as a negative syringe aspiration test. Finally, the feeding tubes were withdrawn, and the animals were connected to ventilators. The procedure is illustrated in Fig. 1.

2.3. Step II

A total of 20 manual ventilations were delivered via a resuscitation bag connected to the tracheal tube located in the esophagus. This maneuver caused an extremely distended abdomen among these animals that simulates the condition of gaseous distended gastrointestinal tract among patients. The feeding tubes were then reinserted and the syringe aspiration tests were conducted again as described above.

The two-step experiment was repeated in the thirteen pigs of the SB group.

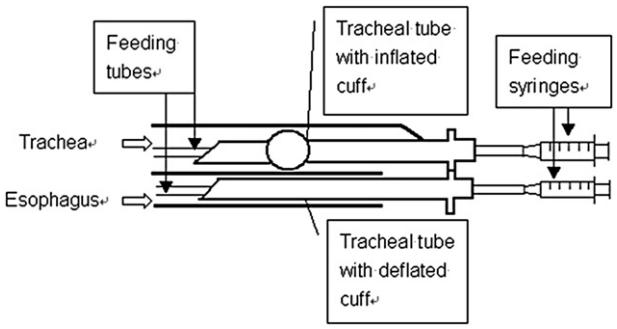

Fig. 1. Experimental setup.

2.4. Data analysis

We used the sign test to compare the results of the syringe test between the feeding tubes placed in the trachea and in the esophagus. The statistical tests were performed with a two-tailed significance level of 0.05.

3. Results

In the MV group, feeding tubes placed in the tracheas of all thirteen animals demonstrated a positive syringe aspiration test, while every feeding tube located in the esophagus had a negative syringe aspiration test. In the step II experiment, large amounts of gastric secretions were drained from two feeding tubes inserted into the esophagus after manual oesophageal ventilations. Despite the presence of gastric secretions, feeding tubes in the trachea had positive syringe aspiration tests, while feeding tubes placed in the esophagus still had negative syringe aspiration tests. The difference in the results of syringe aspiration tests between the tracheal and oesophageal feeding tubes was significant ($p < 0.01$). These results are shown in Table 1.

The results of the SB were the same as the MV group. After Ambu bagging, in the SB group, the seventh and eighth pigs had

Table 1
Results of syringe aspiration test in animals of the MV group.

MV group					
Syringe aspiration test			Syringe aspiration test (after manual ventilations to the esophagus)		
Trachea	Esophagus		Trachea	Esophagus	
+	−	$p < 0.01$	+	−	$p < 0.01$
+	−		+[a]	−[a]	
+	−		+	−	
+	−		+	−	
+	−		+	−	
+	−		+	−	
+	−		+	−	
+	−		+[a]	−[a]	
+	−		+	−	
+	−		+	−	
+	−		+	−	
+	−		+	−	
+	−		+	−	

MV = mechanical ventilation.
[a] Gastric secretions drained out of the feeding tube.

gastric secretion leakage from their feeding tubes. However, the presence or absence of gastric contents did not alter the results. The syringe aspiration tests were positive in tracheal-placed feeding tubes and were negative in feeding tubes inserted in the esophagus. The difference in the results of syringe aspiration tests between the tracheal and oesophageal feeding tubes was significant ($p<0.01$). This is shown in Table 2.

4. Discussion

Many geriatric patients require feeding tubes for enteral feeding and gastrointestinal tract decompression. A large portion of these patients have focal neurologic or anatomic defects that make them vulnerable to malpositioning of feeding tubes[13,14]. In addition, inadvertent tracheal feeding tube placement may not be discovered by healthcare workers, the patients' kin, or the patients themselves. This may be because patients lack a gag reflex, have depressed consciousness, or have anatomic abnormalities[15]. Furthermore placement of a feeding tube may be conducted by inexperienced personnel at home or in a nursing home. Other than auscultation of the abdomen after inserting a feeding tube, other methods of determining feeding tube placement (such as radiographic imaging, capnography, testing gastric contents, or endoscopy) are impractical in places other than hospitals. However, the auscultatory method is notoriously inaccurate in differentiating between tracheobronchial and gastrointestinal placement of a feeding tube. Therefore, a better method is needed to determine the position of a feeding tube.

Malpositions of feeding tubes are not usually encountered in mechanically ventilated patients. However, inadvertent feeding tube placement happens occasionally[14]. We try to simulate all situations that might meet in clinical scenario; therefore, we designed the MV group to study the effectiveness of the syringe aspiration test in mechanically ventilated patients.

On the design of the experiment, it is difficult to determine the volume of syringe aspiration. Small amount of air aspiration might increase the possibility of falsely positive test and decrease the accuracy of the syringe aspiration test. Besides, most of the time the insertion of feeding tube was conducted by a healthcare worker. Aspiration of 30 ml air could be performed easily by one hand for a single healthcare worker, and he/she could fix the feeding tube using another hand. For inexperienced personnel, moreover, it is easy to remember that the syringe aspiration test requires aspiration half of the volume of the feeding syringe (the volume of the feeding syringe is 60 ml).

Table 2
Results of syringe aspiration test in animals of the SB group.

SB group					
Syringe aspiration test			Syringe aspiration test (after manual ventilations to the esophagus)		
Trachea	Esophagus		Trachea	Esophagus	
+	−	$p<0.01$	+	−	$p<0.01$
+	−		+	−	
+	−		+	−	
+	−		+	−	
+	−		+	−	
+	−		+	−	
+	−		+[a]	−[a]	
+	−		+[a]	−[a]	
+	−		+	−	
+	−		+	−	
+	−		+	−	
+	−		+	−	
+	−		+	−	

SB = spontaneous breathing.
[a] Gastric secretions drained out of the feeding tube.

The effectiveness of the syringe aspiration test was shown in this study. It could be used in patients who maintain spontaneous breathing as well as in patients who are paralysed and dependent on mechanical ventilation. Healthcare workers should insert the feeding tube halfway (up to 30 cm, so that the tip of the feeding tube is placed in the esophagus or the main bronchus) and conduct the syringe aspiration test. The feeding tube should be withdrawn if there is a positive syringe aspiration (the tip of the feeding tube is assumed to be in the main bronchus). On the other hand, the feeding tube should be advanced further to the desired depth if there is a negative syringe aspiration test (the tip of the feeding tube is assumed to be in the esophagus). This is a simple, time-saving, easy to learn test that requires no additional equipment and carries minimal risk of mechanical damage to the broncho-alveolar system. Even when the patient has a distended stomach, which is frequently encountered in conditions of intestinal obstruction or after esophageal ventilation by a bag-valve-mask, the syringe aspiration test still functions well.

There are some potential flaws that might affect the accuracy of the syringe aspiration test for the confirmation of feeding tube position. Vomitus or aspirated foreign bodies in the trachea may occlude the feeding tube and a tracheal placed feeding tube may give a falsely negative syringe aspiration test. The operator may have placed the feeding tube so that it curls in the mouth or pharynx and, in this case, the syringe aspiration test may also be falsely negative. The test might also be unreliable in the presence of pharyngeal or oesophageal perforation. In addition, the syringe aspiration test actually verifies the position of a feeding tube in the halfway of placement instead of determining the final position of the feeding tube. In some cases, such as when the feeding tube is displaced upwards into the esophagus or the precise position of feeding tube is required, a plain film to confirm the correct location of the feeding tube is indicated.

McWey and others[16] reported that the prevalence of feeding tube placement errors in adults is 1.3%. This means that inadvertent misplacement of a feeding tube in clinical practice is relatively uncommon. Thus, for this preliminary animal study, we intentionally placed feeding tubes in the tracheobronchial tract. The real performance of the syringe aspiration test as compared with other methods in a large population of humans is still unknown. Besides, the sizes of trachea and esophagus of pigs and human were varied and were influenced by the age and weight of the subjects. Accordingly, it is difficult to know the size differences between the porcine model and the human. Further human studies are required to test the effectiveness of this new test.

5. Conclusion

We conducted an animal study to verify feeding tube placement by the syringe aspiration test and found it to be an effective method of differentiating tracheal from oesophageal feeding tube placement. This test does not require extra equipment, and the results of the test are consistent in varied conditions such as in patients with distended abdomens or mechanically ventilated patients. Therefore, syringe aspiration test is most useful in facilities that provide long-term care. We recommend the widespread use of the syringe aspiration test for verifying the placement of feeding tubes.

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