Anaesth Intensive Care 2005; **33:** 229-234

A Novel Technique for Post-pyloric Feeding Tube Placement in Critically Ill Patients: A Pilot Study

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SUMMARY

Delivery of enteral nutrition in critically ill patients is often hampered by gastric stasis necessitating direct feeding into the small intestine. Current techniques for placement of post-pyloric feeding catheters are complex, time consuming or both, and improvements in feeding tube placement techniques are required. The Cathlocator™ is a novel device that permits real time localisation of the end of feeding tubes via detection of a magnetic field generated by a small electric current in a coil incorporated in the tip of the tube. We performed a pilot study evaluating the feasibility of the Cathlocator™ system to guide and evaluate the placement of (1) nasoduodenal feeding tubes, and (2) nasogastric drainage tubes in critically ill patients with feed intolerance due to slow gastric emptying. A prospective study of eight critically ill patients was undertaken in the intensive care unit of a tertiary hospital. The Cathlocator™ was used to (1) guide the positioning of the tubes post-pylorically and (2) determine whether nasogastric and nasoduodenal tubes were placed correctly. Tube tip position was compared with data obtained by radiology. Data are expressed as median (range). Duodenal tube placement was successful in 7 of 8 patients (insertion time 12.6 min (5.3-34.4)). All nasogastric tube placements were successful (insertion time 3.4 min (0.6-10.0)). The Cathlocator™ accurately determined the position of both tubes without complication in all cases. The Cathlocator™ allows placement and location of an enteral feeding tube in real time in critically ill patients with slow gastric emptying. These findings warrant further studies into the application of this technique for placement of post-pyloric feeding tubes.

Key Words: CRITICAL CARE: enteral feeding, nasoduodenal tube placement

Effective, early delivery of nutritional requirements is an important component in the management of critically ill patients[1]. Enteral feeding is the optimal mode of nutrient delivery, with advantages over parenteral nutrition being demonstrated in numerous prospective, randomized studies[2,3,4]. A major limiting factor in the provision of enteral nutrition in critically ill patients is the high incidence of slow gastric emptying[5]. Small bowel motility, on the other hand, is usually preserved[6,7]. Delayed gastric emptying may be thus overcome by post-pyloric tube placement enabling enteral feeding in most critically ill patients.

A number of approaches to positioning small intestinal feeding tubes have been described. These include placement at surgery, under fluoroscopic or ultrasound-guidance, at endoscopy[8,9] and blind introduction at the bedside with[10] or without prokinetic administration[11]. An ideal placement technique would be noninvasive, require no special training, achieve a high success rate and be performed at the bedside without expensive equipment. None of the currently available approaches fulfills all of these requirements.

The Cathlocator™ (Micronix Pty Ltd, Adelaide, Australia) is a novel device that generates a low energy electromagnetic field from a coil incorporated in the tip of a modified enteral feeding tube connected by wires to a proximal interface (see below). A small receiving plate positioned on the patient's abdomen, enabling the position and direction of the

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Accepted for publication on December 20, 2004.

feeding tube to be determined and displayed, is used to detect the electromagnetic field. A previous study showed that this device accurately determined the position of the tip of a nasogastric tube in healthy volunteers[12]. This pilot study was conducted to assess the feasibility of using the Cathlocator(tm) device to guide bedside placement of small intestinal feeding tubes and confirm placement of nasogastric tubes in critically ill patients requiring post-pyloric feeding.

MATERIALS AND METHODS

Patients

Nasoduodenal and nasogastric tube insertions were attempted in eight adult critically ill, mechanically-ventilated patients in whom enteral nutrition was indicated. All patients had failed nasogastric feeding with high gastric aspirates (>250 ml/6 hours). Patients with oesophageal obstruction or previous gastrectomy were excluded. The patient demographics and APACHE II scores are shown in Table 1. The study was approved by the Research Ethics Committee of the Royal Adelaide Hospital. Written informed consent was obtained from the patients' next of kin prior to inclusion in the trial.

The Cathlocator™ System

The Cathlocator™ system comprises a modified feeding tube, an electronic interface module, a receiver and a graphic computer display (Figure 1). The nasoduodenal feeding tubes were modified 110 cm, 10F polyvinyl chloride, non-weighted feeding tubes with removable stylets (Corpak Medsystems, Wheeling, Il, U.S.A.). The nasogastric drainage tubes were modified 100 cm, 14F polyvinyl chloride, non-weighted feeding tubes without stylets (Maersk Indoplas Pty Ltd, Sydney, N.S.W., Australia). One hundred and twenty coils of 0.125 mm diameter polyester-insulated copper wire were wound around the tips of the tubes, i.e. the wire remained outside the tube and was coated by a polyester sheath such that no occlusion of the internal feeding lumen occurred. Two wires from the coil were passed along the inside of the feeding tube to a connector at the proximal end that was connected to the electronic interface module. The coil and wires were securely bonded to the tip of the feeding tube using cyanoacrylate glue. The conducting wires and coil were coated with a biocompatible silicon sealant that completely embedded the added components into a resin matrix. Electrical continuity is thus maintained throughout the duration of the tubes placement enabling serial measurements to be performed (Figure 2).

The electronic interface module generated a source signal for the coil in the tip of the feeding tube. The power output of the signal generator was 0.25 mW at a frequency of 40 kHz resulting in energy emitted at the tip of the feeding tube of less than 0.25 mW. This is well below the limit of exposure for humans recommended by the United States Food and Drugs Administration[12]. The source signal was synchronized with the signal detected by the receiver (see below) to remove background noise.

During the study, the passive receiver was placed on the midline of the patient's abdomen, with the xiphoid process as a reference point (Figure 1). The receiver contained three sets of three coils to detect the source signal generated by the coil in the tip of the feeding tube. Each set of coils was arranged on the apices of an equilateral triangle and the three coils within each set arranged at right angles to each other. This geometric arrangement enabled a measurement of the precise distance and direction of the signal source on the feeding tube tip to each set of coils using the inverse square law, which governs the relationship between the intensity of an electromagnetic signal and the distance from its source. These measurements were used to determine the relationship of the signal source in three dimensions,

TABLE 1

Patient demographics, outcome of post-pyloric tube placement using the Cathlocator(tm) device and relevant past medical and surgical history. The figures in bold are a mean of the data

Patient#	Age (y)	Sex	APACHE II	Height (cm)	Weight (kg)	BMI (kg/m^2)	Post-pyloric placement?	Admission diagnosis
1	47	M	17	178	90	28.4	Yes	Organophosphate poisoning
2	62	M	36	185	95	27.7	Yes	Major burns
3	62	F	20	160	115	44.9	Yes	Multiple trauma
4	62	F	30	145	130	61.8	Yes	Necrotising fasciitis
5	34	M	20	177	105	33.5	Yes	Urosepsis
6	28	M	22	178	80	25.2	Yes	Multiple trauma
7	68	F	34	165	85	31.2	No	Lobectomy for lung cancer
8	77	M	22	161	90	34.7	Yes	Laparotomy for bowel obstruction
Mean	51	5M:3F	25	169	99	36		

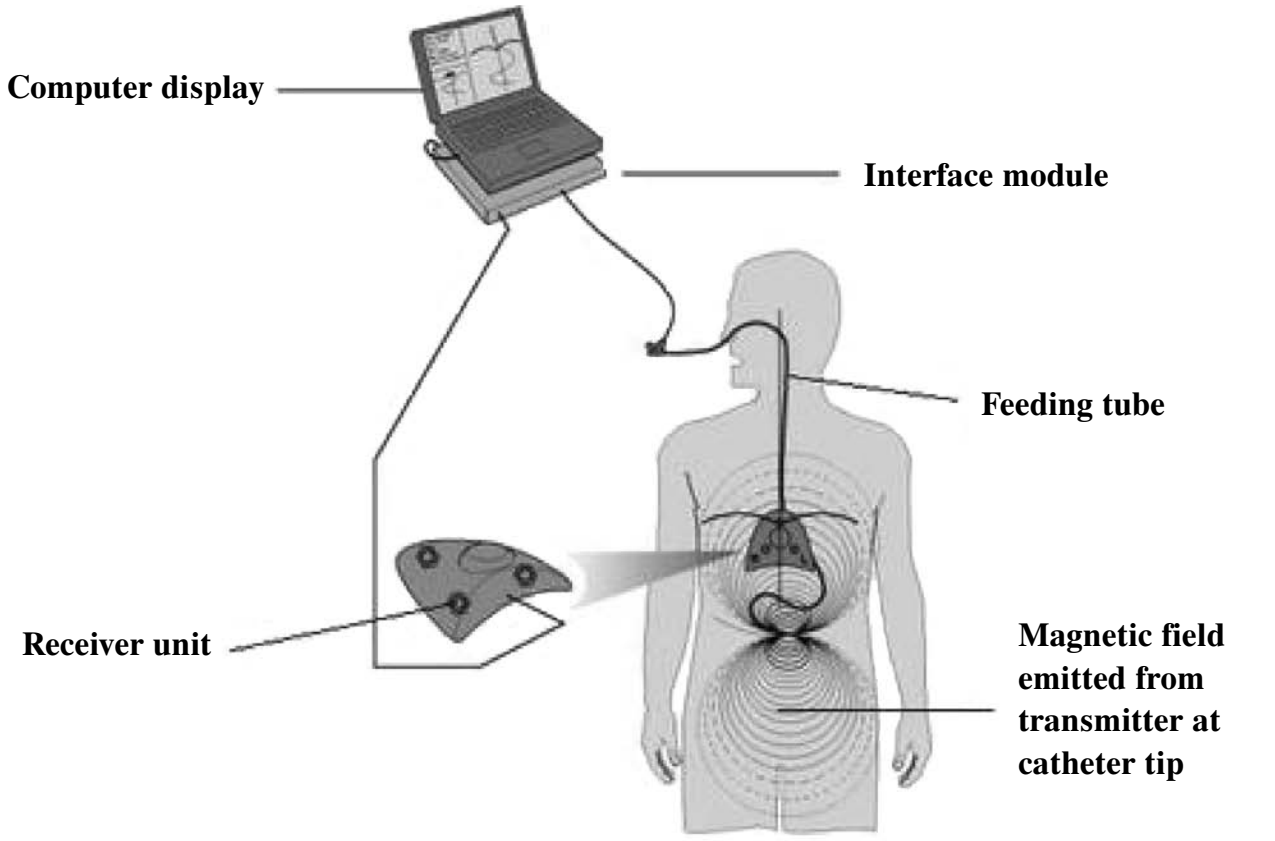

FIGURE 1: Components of the Cathlocator™ system. The receiver unit is placed on the xiphisternum to track the passage of the transmitter located on assembly tip as it is moved along the upper gastrointestinal tract. The position is displayed on the computer screen to assist the operator in manoeuvring the tip of the nasoenteric assembly through the stomach and beyond the pylorus.

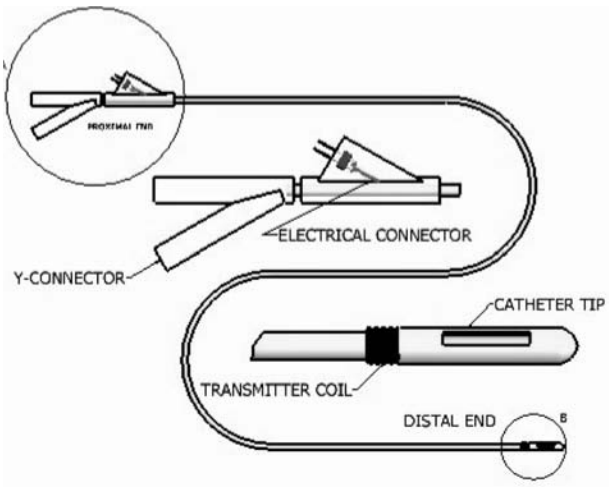

FIGURE 2: Diagram of the Cathlocator™ catheter.

to a set reference point in the device and hence display the distance and direction of the tip of the tube. Using the xiphoid process as a fixed reference point, together with the surface anatomy of the stomach, the position of the tube tip within the gastrointestinal tract was determined. These data were then processed by the computer, which converts the received data into a graphical display (Figure 3). The electronic interface module, receiver and computer were powered by low voltage battery packs providing Class II electrical protection.

Protocol for Tube Placement

Prior to introduction of the assembly, each patient was placed supine and the Cathlocator™ receiver was positioned immediately caudal to the xiphoid process on the anterior abdominal wall. The nasoduodenal tube was passed through the nose into the proximal stomach by the same investigators (RY or MC) and its position confirmed by the Cathlocator™ (Figure 3), aspiration of acidic gastric contents and auscultation over the left upper quadrant during insufflation of 50 ml of air. Air (500 ml) was insufflated into the stomach through the tube, which was then advanced. Using the graphic display of the Cathlocator™ for guidance the tip was viewed as it manoeuvred to pass

beyond the pylorus. The tip was considered to have passed the pylorus when the tip advanced >2 cm to the right of the midline and its track followed the surface markings of the duodenum (i.e. posteriorly[14]).

Following placement of the nasoduodenal tube, a nasogastric tube was then passed to ensure continuous drainage of gastric contents during duodenal feeding. The tube's position was confirmed by the Cathlocator™, aspiration of acidic gastric contents and/or auscultation over the left upper quadrant of 50 ml of insufflated air.

When both tubes had been placed or if duodenal placement could not be achieved, the position of the tubes was checked by plain abdominal X-ray as per standard clinical practice prior to initiation of feeding. Subjects were monitored until approximately 48 hours following removal of the enteric feeding tube for adverse events.

RESULTS

TABLE 2
Time taken to reach the fundus and the duodenum using the Cathlocator™ in critically ill patients

Patient Number	Tube type	Time to Fundus (min:s)	Time Duodenum (min:s)
1	NG	5:00	
	ND		17:00
2	NG	1:28	
	ND		12:00
3	NG	0:51	
	ND		34:25
4	NG	10:00	
	ND		14:52
5	NG	0:45	
	ND		11:18
6	NG	0:39	
	ND		12:37
7	NG	1:17	
	ND		5:16
8	NG	6:01	
	ND		>21:19

There were no adverse events. Post-pyloric placement of the nasoduodenal tube was successful in seven of the eight patients. In the remaining patient the tube could not be advanced through the pylorus and the procedure was abandoned after 21 minutes. The median time for successful insertion was 12.6 minutes (5.3-34.4 min). All nasogastric tube placements were successful with median insertion time 3.4 minutes from opening the packet to verification of tube position (0.6-10.0 min). The Cathlocator(tm) accurately determined the position of both tubes in all cases, when compared with plain abdominal X-ray.

Successful feeding of the patients (90% of desired energy requirements for two consecutive days) was achieved in six of the eight patients.

DISCUSSION

In the current study the Cathlocator™ guided rapid placement of post-pyloric intubation of feeding tubes in seven of eight critically ill patients with slow gastric emptying allowing successful feeding (90% of the ideal energy requirement for two consecutive days[15]) in six of the patients. In addition, the Cathlocator™ correctly determined the placement of the nasogastric and nasoduodenal feeding tubes in all patients compared with plain abdominal X-ray.

Early enteral nutrition is believed to optimise gut function in critically ill patients[15]. However slow gastric emptying frequently hampers feeding[5,6] and post-pyloric intubation is required to ensure adequate nutrient delivery. The main barrier to post-pyloric feeding has been the technical difficulty in placing a tube beyond the pylorus. In the current study a new system (the Cathlocator™) was evaluated and found to guide the rapid placement of post-pyloric enteral feeding tubes. The median time taken for transpyloric insertion using the Cathlocator™ was 13 minutes. These findings compare favourably with both the blind intubation technique described by Zaloga (the "corkscrew" technique)[11] and an approach utilizing gastric insufflation of air[16]. These three techniques have the advantage of being minimally invasive, and can be performed at the bedside without expensive equipment. Although the gastric insufflation with air technique took only two to four minutes to perform[16] it was less successful (60% success rate). The corkscrew technique has been reported to allow successful placement in up to 92% of patients but is considerably more time-consuming (mean 40 minutes)[11]. Furthermore, not all operators are able to achieve the same high rate of success. Thus the Cathlocator™ appears to have the advantage of increased efficiency and reduced time of insertion. With greater familiarity with the Cathlocator™ equipment it is highly likely that the insertion time could be further reduced. A further advantage to the technique is that it allows immediate verification of tube location. We have previously shown the device discriminates between the positions of a feeding tube above and below the lower oesophageal sphincter[12], and that tube depth and deviation from the midline measurements also provide an accurate indication of malposition within the trachea[12].

Other approaches currently used for placement of post-pyloric feeding tubes (surgical, fluoroscopic, ultrasound-guided, and endoscopic)[8,9,17] have significant limitations. Surgical jejunostomy is highly invasive, and is not feasible or practical in many critically ill patients. Radiological placement utilizes

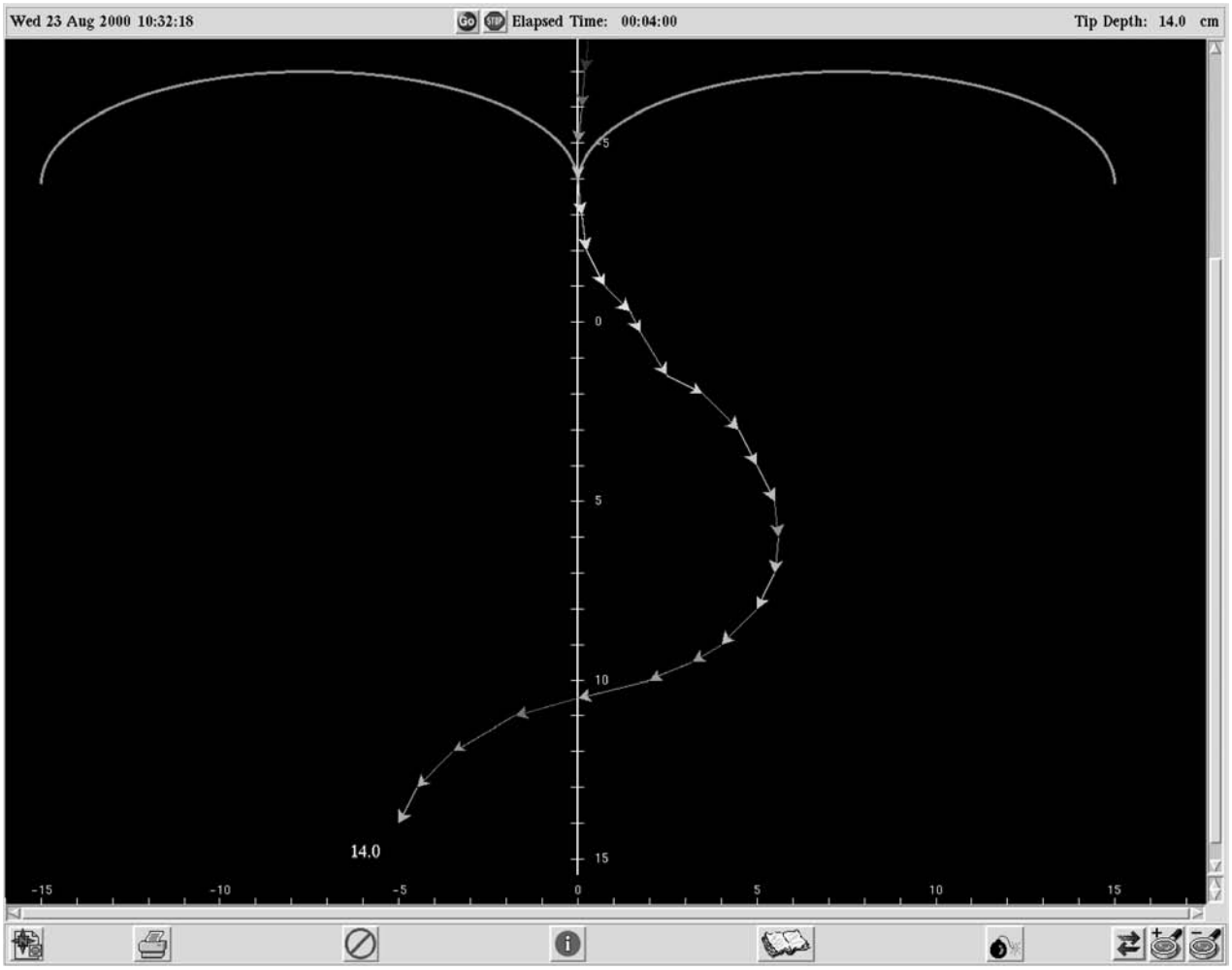

FIGURE 3: Computer screen display, showing tracking of the feeding tube relative to the diaphragm and midline. Position identified at 10 second intervals, represented by arrows.

expensive equipment and is not generally available at the bedside; additionally fluoroscopy requires patient and technician exposure to ionising radiation. Endoscopic and ultrasound-guided nasoenteric tube placement are as effective as fluoroscopy with success rates of 90-95%[8,18]. They can be performed at the bedside with mean insertion times comparable to those reported in this study (15-16 min). However they require expensive equipment and specialised training, and the logistics associated with finding appropriately trained medical staff frequently delays initiation of feeding. The simplicity of the Cathlocator™ has the potential for its use by other clinicians such as nursing and allied health staff. Additional studies are required to ascertain the ease and accuracy with which the Cathlocator™ can be used to place post-pyloric feeding tubes by non-medical staff.

There were no adverse events seen during the use of the technique. Modifications to the feeding catheter can potentially increase the risk of problems with feeding such as catheter blockages or even intestinal perforation. However, the fine electrode does not encroach on the feeding tube and is not likely to increase the risk of damage or blockage. In addition, once bonded, the ends of the catheter are smooth. Bench testing showed that the wiring and bonding become an intrinsic part of the assembly and do not vary the flexibility or stiffness of the assembly. Given the minimal invasiveness, low power output of the equipment and the extremely low intensity of the magnetic field generated, it is also unlikely that significant physiological effects or interference with medical equipment will occur.

Whilst this pilot study was performed in a small number of patients, the medical and surgical diagnoses of the patients who participated was varied,

suggesting that the Cathlocator™ provides a feasible alternative for placing post-pyloric feeding tubes in a range of critically ill patients with slow gastric emptying. The Cathlocator™ system for post-pyloric tube placement also has the potential to eliminate the need for abdominal X-ray, facilitating an earlier start to feeding. Further studies are required to establish this capability.

In conclusion, it appears feasible to use the Cathlocator™ system to guide duodenal feeding tube placement at the bedside in critically ill patients. The technique is simple, safe and allows rapid initiation of enteral nutrition. Further studies are required to determine its utility and cost effectiveness compared with blind techniques of post-pyloric feeding tube placement.

Data from this paper has been presented in abstract form at the International Symposium on Intensive Care and Emergency Medicine, Brussels.

ACKNOWLEDGEMENT

This study was funded in part by a grant from Micronix Pty Ltd, Parkside, South Australia.

REFERENCES

1. Marshall A, West S. Nutritional intake in the critically ill: Improving practice through research, Aust Crit Care 2004; 17;6-8.
2. Adams S, Dellinger E, Wertz MJ et al. Enteral versus parenteral nutritional support following laparotomy for trauma: a randomized prospective trial. J Trauma 1986; 26:882-890.
3. Moore F, Feliciano D, Andrassy R et al. Early enteral feeding, compared with parenteral, reduces postoperative septic complications. The results of a meta-analysis. Ann Surg 1992; 216:172-183.
4. Moore F, Moore E, Jones T, McCroskey B, Peterson V. TEN versus TPN following major abdominal trauma—reduced septic morbidity. J Trauma 1989; 29:916-922.
5. Ritz M, Fraser R, Edwards N et al. Delayed gastric emptying in ventilated critically ill patients: measurements by 13C-octanoic acid breath test. Crit Care Med 1994; 29:1744-1749.
6. Dive A, Moulart M, Jonard P, Jamart J, Mahieu P. Gastroduodenal motility in mechanically ventilated critically ill patients: a manometric study. Crit Care Med 1994; 22:441-447.
7. Tournadre J-P, Barclay M, Fraser R et al. Small Intestinal motor patterns in critically ill patients following major abdominal surgery. Am J Gastroenterol 2001; 96:2418-2427.
8. Hernandez-Socorro C, Marin J, Ruiz-Santana S, Santana L, Manzano JL. Bedside sonographic-guided versus blind nasoenteric feeding tube placement in critically ill patients. Crit Care Med 1996; 24:1690-1694.
9. O'Keefe SJ, Foody W, Gill S. Transnasal endoscopic placement of feeding tubes in the intensive care unit. J Parenter Enteral Nutr 2003; 27:349-354.
10. Di Lorenzo C, Lachman R, Hyman P. Intravenous erythromycin for post-pyloric intubation. J Paed Gastroenterol Nutr 1990; 11:45-47.
11. Zaloga G, Roberts PR. Bedside placement of enteral feeding tubes in the intensive care unit. Crit Care Med 1998; 26:987-988.
12. Williams AJK, Fraser R, Chorley DP, Dent J. The Cathlocator: a novel non-radiological method for localization of enteral tubes. J Gastroenterol Hepatol 1996; 11:500-505.
13. Leigh J. FDA safety guidelines for MR devices. Resonance 1990; 20:9.
14. Basmajian J, Slonecker CE. Grant's Method of Anatomy. 11th ed. Baltimore: Williams and Wilkins 1989.
15. Heyland D, Cook D, Guyatt G. Enteral nutrition in the critically ill patient: a critical review of the evidence. Intensive Care Med 1993; 19:435-442.
16. Salasidis R, Fleiszer T, Johnson R. Air insufflation technique of enteral tube insertion: a randomized controlled trial. Crit Care Med 1993; 26:1036-1039.
17. Berger MM, Bollmann MD, Revelly JP et al. Progression rate of self-propelled feeding tubes in critically ill patients. Intensive Care Med 2002; 28:1768-1774.
18. Foote JA, Kemmeter PR, Prichard PA et al. A randomized trial of endoscopic and fluoroscopic placement of postpyloric feeding tubes in critically ill patients. J Parenter Enteral Nutr 2004; 28:154-157.