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Placement of Transpyloric Feeding Tubes in Critically Ill Children Using Electromagnetic Device Assistance with and Without Promotility Aid

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Abstract

Objective: To describe success rates of Transpyloric feeding tube (TP) placement using non-invasive Electromagnetic Device (EMD) assistance in a cohort of critically ill children, both with and without a promotility agent.

Patients and Methods: A retrospective review of children admitted to a medical/surgical intensive care unit during a one-year study period who received a TP feeding tube was performed. T-test, Fishers Exact, Mann-Whitney and multiple logistic regression were performed.

Results: A total of 182 TP placement attempts were studied. Mean age and weight of the study group was 5 yr and 21.5 kg, respectively. The overall success rate of proper TP placement was 85%. A promotility agent was used in 25 (14%) of attempts while 157 (86%) placements were not aided by a promotility agent. Initial success rates were similar between groups; 76% in the promotility group and 87% in the non-promotility group. No significant association between promotility use and success, after controlling for relevant covariates; p=0.21 was found. Enteral feedings were generally initiated at 24 hours (Range: 0.5, 124) after PICU admission and 2 hours (Range: 0, 98) following tube placement in the cohort. One adverse event occurred with malposition of the feeding tube in the lung.

Conclusion: Proper TP tube placement with EMD guidance is high. Promotility use is now uncommon and does not appear to influence placement success rates or the time to feeding initiation. While EMD guidance may drastically reduce the need for routine promotility agents, radiographic confirmation of placement is still advised.

Keywords: Electromagnetic Device; Promotility Aid; Transpyloric Feeding Tubes

Introduction

Achievement of adequate nutrition is paramount to the recovery of critically ill children. Many children admitted to the Pediatric Intensive Care Unit (PICU), however, are not able to eat by mouth and must therefore rely on intravenous feedings or specialized enteral nutrition. Enteral Nutrition (EN) is the preferred route of nutrient delivery in critically ill children with a functional gastrointestinal tract because of its lower complication rate, lower cost, and beneficial effects on the GI mucosa [1-5]. Additionally,

early EN (started within 48 hours of admission to the ICU), can improve protein intake (which is desirable during the acute phase of illness) and may have a survival benefit [6-10].

Because critically ill children often have acute and/or chronic conditions that delay gastric emptying, they are at risk for reflux, feeding aspiration and pneumonia when a feeding tube is placed into the stomach. Risk for theses adverse events is further complicated by stomach-distending therapies such as non-invasive positive pressure [11]. Therefore, many clinicians (including those at our institution) favor placing a feeding tube past the pylorus and into the small intestine. While recent guidelines for the provision and assessment of nutrition support therapy in the pediatric critically ill patient favor the gastric route for EN delivery, they do recognize that the postpyloric or small intestinal site is advisable for children unable to tolerate gastric feeding or those at high risk for aspiration [1]. This placement may allow for a greater amount of nutrition to be successfully and safely delivered [11,12].

Placement of Transpyloric (TP) tubes in children, however, can be a challenge. Consequently, bedside placement has been aided by promotility agents, patient positioning and non-invasive devices. Prior to 2014, our PICU routinely used either metoclopramide or erythromycin to aid in correct TP tube positioning. Recently, our PICU purchased an Electromagnetic Device (EMD) to aid in TP tube placement and it appears that co-administration of promotility agents has declined substantially. Reports describing the use of EMD in critically ill children have been published, [13-17] but these reports focus on feasibility, safety, efficiency and radiation exposure to determine placement. The use of promotility agents was not considered in these previous reports. Therefore, the primary aim of this study is to describe the success rate of EMD assistance for TP feeding tube placement in a cohort of critically ill children with a secondary aim focused on the use of promotility agents to augment successful placement.

Methods

Study Design and Setting

This was a retrospective review of patients admitted to a 32-bed medical/surgical PICU in a large free-standing tertiary care pediatric hospital during a one-year study period (January 1, 2014-January 1, 2015). This study protocol was reviewed and approved by the Colorado Multiple Institutional Review Board with a waiver of informed parent/subject consent. We included all patients who had placement of an 8Fr (or larger) feeding tube with the assistance of the CORTRAK® EMD (Cardinal Health, Dublin Ohio). Feeding tubes were placed by a core group of PICU nurses, who underwent special training to use the device. Promotility use was defined as the administration of metoclopramide and/or erythromycin, either before placement of the feeding tube or after placement to propel the tip of the tube into the duodenum.

The following data were collected and reviewed: (i) Patient information: sex, age, weight, Pediatric Risk of Mortality Score (PRISM III), mode of respiratory support and diagnostic category (respiratory failure, trauma/surgical and other). (ii) Feeding tube placement: promotility medication exposure (name of promotility medication, dose, route and timing of administration in relation to tube placement), method used to validate proper tube placement, number of placement deviations and size of feeding tube placed; (iii) Outcomes: success rates of achieving proper feeding tube placement, number of radiographs required and time to initiate EN (from admission to PICU and from placement of TP tube). Successful placement of EN feeding tube was the primary outcome variable and was defined as the tip of the feeding tube in the first part of the duodenum or beyond, per an abdominal radiograph obtained after placement and interpreted by a pediatric radiologist. Secondary outcomes included use of promotility agents and time to initiate enteral feeds.

Primary Data Abstraction and Analysis

Outcome measures and patient variables were extracted from the Electronic Medical Record (EMR) by three investigators using a standardized data collection form developed by the investigative group. To improve accuracy and minimize inconsistencies, all records underwent a second data abstraction by a different investigator. Discrepancies in coding were resolved after agreement by all investigators. Demographic and clinical characteristics of the cohort were described and compared between the two groups. Results are presented as mean ± Standard Deviation (SD) and range, median (IQR) or percentage, as indicated. Two-sample t-tests, Fishers Exact Tests, and Mann-Whitney U tests were used to detect differences between patient groups, for continuous, non-normally distributed continuous and categorical variables. Logistic regression was used to test the association between promotility use and successful feeding tube placement, after adjusting for relevant demographic and clinical characteristics. Statistical analysis was performed using Excel 2016 Software and R version 3.4.1. Significance was set at an alpha of 0.05.

Results

A total of 223 TP tubes were placed during the 1-year study period. Thirty-seven attempts were in infants with feeding tubes that were too small for EMD guidance (16.6%) and 5 attempts were in patients with incomplete EMR data, leaving a total of 182 placements eligible for review. The most common feeding tube size was 8Fr (72%), followed by 10Fr (27%). The mean age and weight of the cohort was 5 yrs and 21.5 kg, respectively. The overall success rate of proper TP feeding tube placement was 85% for the entire cohort. Initial confirmation of tube placement was performed by radiographic examination in 96% of cases and pH paper (with secondary confirmation by radiographic examination) in 4% of cases.

A promotility agent was used in 25 (14%) attempts compared to 157 (86%) initial attempts without. A comparison between patients exposed to a promotility agent and those who were not is illustrated in Table 1 and does not identify major differences. Figure 1 demonstrates the success rates between groups. Initial success rate was 76% (Promotility Group) and 88% (Non-Promotility Group). There was not a significant association between use of a promotility agent and initial success of tube placement after adjusting for age, weight, PRISM III score, use of positive pressure ventilation at time of tube placement and diagnosis; p=0.21.

	Promotility Group	No Promotility Group	p
	(n=25)	(n= 157)	
Age, mean ± SD (years)	6 ± 5.8	4.9 ±5.5	0.36
Weight, mean ± SD (kg)	25.9 ± 29	20.8 ± 20	0.41
PRISM III, median (IQR)	3 (0, 4)	3 (0, 7)	0.44
Positive pressure ventilation at time tube placement, n (%)	23 (92%)	128 (82%)	0.26
Diagnosis, n (%)			
Respiratory	17 (68%)	102 (65%)	0.38
Trauma/Surgery	4 (16%)	15 (9.6%)	
Other	4 (16%)	40 (25.4%)	

Table 1: Characteristics of 182 children requiring placement of a transpyloric feeding tube, with and without exposure to a promotility agent.

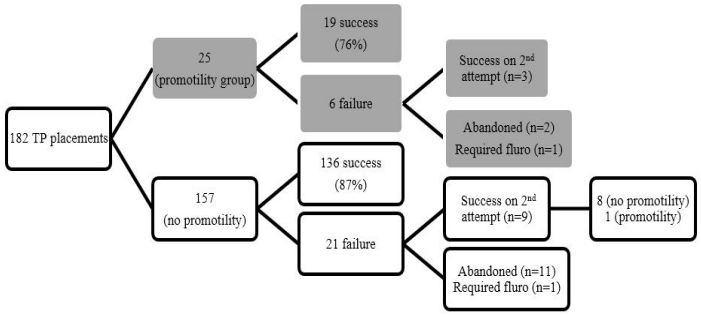

Figure 1: Description of Initial Transpyloric (TP) feeding tube placements using electromagnetic device guidance in 182 patients with (n=25) or without (n=157) the assistance of a promotility agent.

The choice of promotility agent was weighted heavily towards metoclopramide. Eighteen (of 25) patients (72%) received intravenous metoclopramide (0.1 mg/kg) and five patients (20%) received oral metoclopramide. One patient received oral erythromycin (3 mg/kg) and one patient received both oral erythromycin and intravenous metoclopramide. The median time of promotility administration was 45 minutes prior to TP placement. There was, however, a fair amount of variability, with one patient receiving therapy 150 minutes before TP insertion and six receiving therapy after placement in an effort to propel the mispositioned tube (viewed on EMD computer screen or initial radiograph).

Failed attempts (n=27) were converted to successful placements in 3 of 6 patients in the promotility group (50%) and 9 of 21 in the non-promotility group (43%). Two patients (1 in each group) required tube placement in interventional radiology under fluoroscopy. One patient in the non-promotility group had a mispositioned tube that extended down the left main stem bronchus, perforated the lung and coiled within the pleural space, ultimately requiring a chest tube. The proportion of patients who required 1 radiograph, vs. 2 or 3, was 20 (80%) (Promotility Group) and 140 (89%) (Non-Promotility Group); p=0.19.

Time to initiate enteral feeding since admission to the PICU was similar between the promotility and non-promotility groups (median and IQR: 28 (20, 42) vs 24 (16, 41) hours, p= 0.25). In addition, there was no difference in the time to begin enteral feedings following placement of TP tube between groups (median and IQR: 3 (1, 6) vs 2 (1, 4) hours, p= 0.22).

Discussion

This retrospective evaluation of critically ill children described the success rate of proper TP feeding tube placement in the era of EMD guidance, both with and without the aid of a promotility agent. Overall success rate was high (at 85%) and although promotility use was uncommon, it did not appear to influence the rates of accurate placement. In addition, the number of radiographs and the time to initiate enteral feedings (from admission to the PICU and from placement of the TP tube) were not different between groups of patients.

Swift and accurate placement of a feeding tube is necessary when promoting the strategy of early enteral nutrition. This feeding strategy has been advocated to improve nitrogen balance, reduce inflammation, enhance innate immune function and augment GI tract integrity [7-10]. Although both gastric and small bowel feedings can deliver appropriate caloric and protein intake, small bowel feedings are often preferred in children at risk for gastroparesis and aspiration. Additional advantages of post pyloric feedings include faster advancement and achievement of goal nutrition (due to fewer interruptions) and improved tolerance in patients requiring positive pressure ventilation [18]. Our critical care unit favors TP feedings in children on both non-invasive and invasive positive pressure ventilation, as evidenced by the high percentage of ventilated patients observed in this study. Many techniques have been developed for proper positioning of post pyloric feeding tubes. Historically, the highest success rates have been documented with radiographic visualization using fluoroscopy

[13,14]. This technique, however, has limitations including risk of radiation exposure, requirement of patient transport and high cost. Therefore, bedside techniques have become increasingly popular. "Blind placement" (using external anatomic landmarks for measurements, air and/or gastric insufflation to propel tube and auscultation for placement confirmation) can be performed by skilled clinicians at the bedside. Although this technique is economical and effective when experienced clinicians and radiographic confirmation are used, there is wide variability in success noted in the literature [15-17,19]. In addition, serious complications secondary to malposition have been reported. These complications prompted a patient safety action alert by the Children's Hospital Association that warned against using the blind technique in children without radiographic confirmation [20].

Promotility agents (Metoclopramide and Erythromycin) have been studied in children with mixed results. Prior to the introduction of an EMD into our practice, we routinely administered a promotility agent 30-45 minutes before TP tube placement. Successful bedside TP feeding tube placement with the aid of metoclopramide has been reported [10]. Ninety children (age: 1week-15 yrs) with non-weighted silicone rubber 6Fr or 8Fr tubes were able to achieve 93% success with metoclopramide, air insufflation and positioning [10]. However, since there was no comparison group, the influence of metoclopramide alone could not be determined. In another report, 74 children were randomly assigned to receive erythromycin or placebo 60 minutes prior to TP placement [21]. This study failed to demonstrate any advantage of promotility use on proper TP positioning or enhancement of duodenal tubes further into the small bowel. A third trial, performed in 75 critically ill children, found no influence of placement technique on the success rates of TP position using standard positioning technique, standard technique plus gastric insufflation or standard technique with preinserting erythromycin [22]. These mixed results are also described within the adult literature, with two 2 meta-analyses failing to demonstrate benefit from metoclopramide [23-31].

Reports of EMD assistance in children have also been published [32-36]. These devices can track and display the position of a feeding tube on a computer screen and allow the user to see the path of the feeding tube as it proceeds down the esophagus, through the stomach and into the small intestine. The previous work published in children is very promising, yet either uniformly used promotility agents [33] did not separate results based on the co-administration of promotility agents [32,36] or did not mention the use of promotility agents [34,35]. October et al evaluated 50 children using EMD assistance and reported an overall success rate of 82%. Twenty percent of children (n=10), however, received a prokinetic agent and results were not categorized based on this exposure. 18 Kline reported the use of EMD guidance (n= 22) compared to standard blind technique (n=27) for placement of TP feeding tubes in children [33]. Successful placements with EMD was 100% versus 92% in the blind technique group (p=0.49) – yet all patients received pre-placement metoclopramide. Finally, a recent report comparing the success rates and extent of radiation exposure between two groups of children requiring a TP feeding tube with (n=43) and without (n=30) the aid of EMD was published [32]. Children in the EMD group experienced higher rates of successful transpyloric tube placement (p=0.009) with significantly lower radiation exposure (p= 0.006). The use of promotility agents was low in the EMD group (at 7%) but was not further analyzed. The current evaluation is the largest study to date that describes postpyloric tube placement in children using EMD (both with and without promotility agents) and attempts to discern the prevalence of promotility use and the influence of promotility exposure on success. Since the establishment of EMD into our unit, the overall use of promotility agents has declined and is now quite low.

Although adverse events related to tube malposition are less likely when using an EMD guidance system, they are still reports of misdirected tubes and subsequent patient harm [37-38]. The current report had one mispositioned tube in the lung that resulted in the requirement of a chest tube. According to the Food and Drug Administration's Manufacture and User Facility Device Experience (MAUDE) database, the lung is the most common location of misplaced feeding tubes reported with CORTRAK EMD guidance system [37]. Some of these misdirected tubes resulted in pneumothorax, bleeding, and even death. This underscores the importance of a skilled user for tube placement and confirmation of anatomic position by a radiograph.

There are limitations to this work that must be acknowledged. First, the study design did not allow for control of factors that may have impacted outcomes. In particular, the decision to use a promotility agent was completely at the discretion of the prescribing provider and the resulting study groups were unequal. It is possible that circumstances not readily obvious with a retrospective study design could have influenced the decision to use a promotility agent. We attempted to control for this limitation by performing a multiple logistic regression but were limited to inclusion of variables previously measured. In addition, this study reflects the experience of a single center with a group of trained PICU nurses for TP placement.

In conclusion, this report describes the high success rates achieved for proper TP feeding tube placement using EMD guidance in a cohort of critically ill children. This report further highlights the decline in concomitant promotility use as a method to augment proper placement and suggests that promotility administration does not appear to influence the rate of successful positioning, number of radiographs required nor time to initiation of enteral feeding. It seems plausible that the high success rates achieved with EMD guidance and expert bedside nursing placement may eliminate the need for routine promotility agents. However, a de-

finitive answer to the utility of promotility agents in the placement of TP tubes cannot be fully understood without a prospective, randomized trial.

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- All authors were responsible for conceptualizing and designing the study; creating the data collection form and reviewing data collection
- Pamela Reiter was responsible for drafting the initial article, requesting and retrieving the data and initial analysis
- Claire Palmer was responsible for final data analysis validation and interpretation
- All authors were responsible for reviewing, revising and approving the final article and take responsibility for the paper as a whole

References

1. Mehta NM, Skillman HE, Irving SY, Coss-Bu JA, Vermilyea S, et al. (2017) Guidelines for the provision and assessment of nutrition support therapy in the pediatric critically ill patient: Society of Critical Care Medicine and American Society for Parenteral and Enteral Nutrition Pediatr Crit Care Med 18: 675-715
2. Lipman TO (1998) Grains or veins: Is enteral nutrition really better than parenteral nutrition? A look at the evidence. JPEN J Parenter Enteral Nutr 22: 167-182.
3. Kudsk KA, Croce MA, Fabian TC, Minard G, Tolley EA, et al. (1992) Enteral versus parenteral feeding: effects on septic morbidity after blunt and penetrating abdominal trauma. Ann Surg 215: 503-511.
4. Saito H, Trocki O, Alexander JW, Kopcha R, Heyd T, et al. (1987) The effect of route of nutrient administration on the nutritional state, catabolic hormone secretion, and gut mucosal integrity after burn injury. JPEN J Parenter Enteral Nutr 11: 1-7.
5. Herndon DN, Barrow RE, Stein M, et al. (1989) Increased mortality with intravenous supplemented feeding in severely burned patients. J Burn Care Rehabil. 10: 309-313.
6. Mikhailov TA, Kuhn EM, Manzi J, Christensen M, Collins M, et al. (2014) Early enteral nutrition is associated with lower mortality in critically ill children. JPEN J Parenter Enteral Nutr; 38:459-466.
7. Braga M, Gianotti L, Cesart A, et al. (1996) Gut function and immune and inflammatory response in patients perioperatively fed with supplemental enteral formulas. Arch Surg 131:1257-1264.
8. Sanchez C, Lopez-Herce J, Carrillo A, Santiago Mencía, Dolores Vigil, et al. (2007) Early transpyloric enteral nutrition in critically ill children. Nutrition 23: 16-22.
9. Briassoulis G, Tsorva A, Zavras N, T Hatzis (2002) Influence of an aggressive early enteral nutrition protocol on nitrogen balance in critically ill children. J Nutr Biochem 13: 560-569.
10. Chellis MJ, Sanders SV, Webster H, Dean JM, Jackson D (1996) Early enteral feeding in the pediatric intensive care unit. JPEN J Parenter Enteral Nutr 20: 71-73.
11. Meert KL, Daphtary KM, Metheny NA (2004) Gastric vs small-bowel feeding in critically ill children receiving mechanical ventilation. A randomized controlled trial. Chest 126: 872-878.
12. Stone JS, Pickett JD, Jesurum JT (2000) Bedside placement of postpyloric feeding tubes. AACN Clin Issues 11: 517-530.
13. Foote JA, Kemmeter PR, Prichard PA, et al. (2004) A randomized trial of endoscopic and fluoroscopic placement of postpyloric feeding tubes in critically ill patients. JPEN J Parenter Enteral Nutr 28: 154-157.
14. Prager R, Laboy V, Venus B, Mathru M (1986) Value of fluoroscopic assistance during transpyloric intubation. Crit Care Med 14: 151-152.
15. Spaulding HK, Sullivan KJ, Soremi O, Gonzalez F, Goodwin SR (2000) Bedside placement of transpyloric feeding tubes in the pediatric intensive care unit using gastric insufflation. Crit Care Med 28: 2041-2044.
16. Harrison AM, Clay B, Grant MJ, S V Sanders, H F Webster, et al. (1997) Nonradiographic assessment of enteral feeding tube position. Crit Care Med 25: 2055-2059.
17. Joffe AR, Grant M, Wong B, Gresiuk Cet (2000) Validation of a blind transpyloric feeding tube placement technique in pediatric intensive care: rapid, simple, and highly successful. Pediatr Crit Care Med 1:151-155.
18. Montecalvo MA, Steger KA, Farber HW, Smith BF, Dennis RC, et al. (1992) Nutritional outcome and pneumonia in critical care patients randomized to gastric versus jejunal tube feedings. Crit Care Med 20: 1377-1387.
19. Da Silva PS, Paulo CS, de Oliveira Iglesias SB, de Carvalho WB, Santana e Meneses F (2002) Bedside transpyloric tube placement in the pediatric intensive care unit: a modified insufflation air technique. Intensive Care Med 28: 943-946.
20. Child Health Patient Safety Organization: patient safety action alert. Blind pediatric NG tube placements - continue to cause harm. Children's Hospital Association.
21. Gharpure V, Meert KL, Sarnaik AP (2001) Efficacy of erythromycin for postpyloric placement of feeding tubes in critically ill children: a randomized, double-blind, placebo controlled study. JPEN J Parenter Enteral Nutr 25: 160-165.
22. Phipps LM, Weber MD, Ginder BR, Hulse MA, Thomas NJ (2005) A randomized controlled trial comparing three different techniques of nasojejunal feeding tube placement in critically ill children. JPEN J Parenter Enteral Nutr 29: 420-424.
23. Silva CCRD, Bennet C, Saconato H, Atallah ÁN (2015) Metoclopramide for post-pyloric placement of naso-enteral feeding tubes Cochrane Database Syst Rev 1: CD003353.
24. Silva CC, Saconato H, Atallah AN (2002) Metoclopramide for migration of naso-enteral tube. Cochrane Database Syst Rev CD003353.
25. Komenaka IK, Giffard K, Miller J, Schein M (2000) Erythromycin and position facilitated placement of postpyloric feeding tubes in burned patients. Dig Surg 17: 578-580.

26. Levy H, Hayes J, Boivin M, Tomba T (2004) Transpyloric feeding tube placement in critically ill patients using electromyogram and erythromycin infusion. Chest 125: 587-591.

27. Stern MA and Wolf DC (1994) Erythromycin as a prokinetic agent: a prospective, randomized, controlled study of efficacy in nasoenteric tube placement. Am J Gastroenterol 89: 2011-2013.

28. Paz HL, Weinar M, Sherman MS (1996) Motility agents for the placement of weighted and unweighted feeding tubes in critically ill patients. Intensive Care Med 22: 301-304.

29. Heisslman DE, Hofner T, Vidovich RR (1995) Enteral feeding tube placement success with intravenous metoclopramide administration in ICU patients. Chest 107: 1686-1688.

30. Kalliafas S, Choban PS, Ziegler D, et al. (1996) Erythromycin facilitates post pyloric placement of nasoduodenal feeding tubes in intensive care unit patients: randomized, double blinded, placebo-controlled trial. JPEN J Parenter Enteral Nutr 20: 385-388.

31. Kittinger JW, Sandler RS, Heizer WD (1987) Efficacy of metoclopramide as an adjunct duodenal placement of small-bore feeding tubes: a randomized, placebo-controlled, double-blind study. JPEN J Parenter Enteral Nutr 11: 33-37.

32. Brown AM, Perebzak C, Handwork C, Gothard D, Nagy K (2017) Use of electromagnetic debice to insert postpyloric feeding tubes in a pediatric intensive care unit. Am J Crit Care 26: 248-254.

33. Kline AM, Sorce L, Sullivan C, Weishaar J, Steinhorn DM, et al. (2011) Use of a noninvasive electromagnetic device to place transpyloric feeding tubes in critically ill children. Am J Crit Care 20: 453-459.

34. Koot B, Westerhout R, Benninga MA, Duflou A, Singels L, et al. (2011) Electromagnetic-guided postpyloric tube placement in children: Pilot study of its use as a rescue therapy. Eur J Clin Nutr Metabol 6: e74-e76.

35. Goggans M, Pickard S, West AN, Shah S, Kimura D (2017) Transpyloric feeding tube placement using electromagnetic placement device in children. Nutr Clin Pract 32: 233-37.

36. October TW and Hardart GE (2009) Successful placement of postpyloric enteral tubes using electromagnetic guidance in critically ill children. Pediatr Crit Care Med 10: 196-200.

37. Bourgault AM, Aguirre L, Ibrahim J (2017) Cortrack-assisted feeding tube insertion: a comprehensive review of adverse events in the MAUDE database. Am J Crit Care 26: 149-156.

38. Metheny NA and Meert K (2017) Update on effectiveness of an electromagnetic feeding tube-placement device in detecting respiratory placements. Am J Crit Care 26: 157-1561.