Carol Rees Parrish, R.D., M.S., Series Editor

Blind Bedside Placement of Feeding Tubes: Treatment or Threat?

Joe Krenitsky

Enteral nutrition is the preferred route for the provision of nutrition support in patients with a functional gastrointestinal tract. Soft, small bore feeding tubes are easily placed at the bedside, and have become the preferred method for providing temporary enteral nutrition access for acutely ill patients. It is estimated that more than 1.2 million small bore feeding tubes are used each year in the United States alone. Evidence accumulated over more than 25 years documents that between 1–2 percent of small bore feeding tubes that are placed blindly at the bedside enter the airway undetected, and a proportion of these misplacements result in pulmonary injury that is not preventable even by a single confirmatory radiograph. Although the overall percentage of injury and death from blind feeding tube placement is relatively low, the large number of feeding tube placements results in unacceptable numbers of unnecessary harm to patients. Fortunately, morbidity and mortality from enteral access is largely preventable because placement techniques and technology to guide insertion of feeding tubes at bedside are now available. However, an under appreciation of the frequency of injuries and death from blind feeding tube placement, and lack of education regarding placement techniques and technology contribute to the failure to adopt safety measures for bedside placement of enteral access at many institutions. Assessment of feeding tube position after it has been placed to approximately 30 cm allows repositioning of misplaced tubes and can prevent pulmonary injury. All available evidence suggests that blind placement of small bore feeding tubes is an unnecessary risk and should be abolished to enhance patient safety.

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INTRODUCTION

The provision of enteral nutrients through a nasogastric or orogastric route has been described since at least the the 16th century, and a case report of successful orogastric feeding was documented by Hunter in 1790 (1). Nevertheless, nasogastric feeding was used to a limited extent until the development of small bore tubes in the mid 1970's designed specifically for feeding. Dobbie and Hoffmeister's success with continuous enteral nutrition (EN) via a small bore, weighted dobhoff tube in 1976 heralded a new era of enteral feeding (2). In 1980 Brooks and Dixon introduced the use of an inner guidewire to facilitate insertion of the small bore soft feeding tubes (3). The introduction of several commercial silastic "dobhoff-type" feeding tubes and a proliferation of commercial enteral feeding formulas, pumps and other equipment quickly followed. The popularity of EN was further enhanced by reports regarding the metabolic, economic and safety advantages of EN compared to parenteral nutrition (PN) (4,5). The new generation of softer small bore feeding tubes with removable stylette appeared to decrease the risk of nasal and gastrointestinal ischemia and necrosis compared to the older polyvinal tubes (6). Additionally, the smaller diameter, softer tubes improved patient comfort and acceptance of EN. Recent estimates suggest that more than 1.2 million SBFT's are placed each year in the United States alone (7).

However, soon after the use of small bore enteral access was popularized a number of case reports were published describing bronchopleural intubation and injury during tube placement (8–18). In less than 10 years after the introduction of small bore feeding tubes, the number of published case reports of bronchopulmonary complications prompted several reviews (6,19–21). Bohnker et al in 1987 noted that although reviews of gastrointestinal intubation published prior to the development of small bore feeding tubes (SBFT's) had noted deviation of some tubes into the bronchi, none of these earlier reports documented progression of tubes into the pulmonary space or pulmonary injury (21–23). Compared to the older polyvinyl tubes, the smaller diameter of the "dobhoff-type" feeding tubes allowed passage of the SBFT through the smaller bronchioles, and the stylette provided sufficient rigidity to penetrate lung tissue and cause pneumothorax (21,24). An editorial in 1987 documented several relatively unsuccessful efforts at one facility to minimize bronchopulmonary misplacement of SBFT's that included use of larger diameter (12 Fr) tubes, attempts at passage without stylettes, and even limiting complicated placements to GI Fellows. The author noted that although a radiograph to check tube placement was mandatory before starting feeding, it was obvious that a single radiograph would not prevent nasopulmonary intubation (24). The editorial concluded that although the exact incidence of nasopulmonary intubation was not yet documented, "we must extend our efforts to reduce the incidence of this complication." In the intervening years a number of observational studies have reported the incidence of bronchopulmonary misadventures related to SBFT placement (25–32). There are also a number of clinical approaches, protocols and devices intended to reduce the incidence of bronchopulmonary injury related to SBFT's. The goal of this article is to review the incidence of bronchopulmonary complications of SBFT placement and discuss protocols and devices to decrease these complications.

INCIDENCE

The observational studies that have described the incidence of bronchopulmonary displacement of SBFT's over more than 25 years have naturally reported varying results depending on the patient population, size of the sample, method of identifying tube displacements, and experience of those placing the tube. See Table 1 for a summary of the details of the studies that report on the incidence of SBFT displacement and injury.

A review in 1985 documented 5 known cases of bronchopulmonary placement of SBFT's in an intensive care unit (ICU) patients of a university hospital over 28 months (25). All of the patients had a cuffed endotracheal tube or tracheostomy airway intubation. Of the misplaced SBFT's, two were inserted by critical care nurses two, resident physicians inserted two, and a nutrition support nurse inserted one. Four of the patients with misplaced feeding tubes developed a pneumothorax, and the other patient had a thoracos-

Table 1.
Incidence of Bronchopulmonary Displacement and Injury

Study	*Population*	*# blind tube placements*	*Misplacements Number (%)*	*Complications number (%)*	*Tube type*	*Placed by*
Valentine (1985)	ICU	1652	NR*	5 (0.25%)	8 Fr	3 – RN, 2-MD
Ghahremani (1986)	Mixed	340	7 (2.3%)	1 (0.3%)	8 Fr	Resident MD
McWey (1988)	Mixed	1100	13 (1.2%)	7 (0.64%)	NR*	Resident MD
Harris (1989)	ICU	71	NR*	3 (4.0%)	8 Fr	NR*
Rassias (1998)	ICU	740	14 (2%)	5 (0.7%)	ENtube3 (Size NR)	MD and RN's
Marderstein (2004)		1847	26 (1.4%)	7 (0.38%)	NR*	MD and RN's
Sorokin (2006)	Mixed	3789	50 (1.3%)	14 (0.37%)	NR*	NR*
de Aguilar-Nascimento (2007)	Mixed	1633	27 (1.7%)	9 (1.2)	NR*	NR*

*Not reported
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tomy tube in position at the time of the misplacement. In one instance feedings were commenced with the SBFT in the pulmonary space after an X-ray was incorrectly interpreted as gastric placement. No deaths were attributed directly to the misplaced feeding tubes. The authors reported that a total of 1652 SBFT's were inserted in ICU patients during the 28 month period, which is a 0.3% incidence of SBFT misplacement and a 0.2% incidence of injury. This report details the outcome of a sample of 5 known SBFT misplacements, but the methods section of this study does not mention if the review was conducted prospectively or retrospectively (25). Additionally, the report does not provide information on who was responsible for review of the 1652 radiographs and reporting/recording misplacements, thus it is conceivable that not all misplacements in the time span were captured, especially those that did not result in morbidity.

A 1986 study reported on the results of all radiographs from 340 mixed ICU and floor hospitalized patients that received a nasogastric tube (26). Resident physicians placed the SBFT's in all cases. The investigators identified 7 SBFT's misplaced into the airway that were removed without injury and 1 SBFT, which resulted in pneumothorax (2.3% bronchopulmonary misplacement, 0.3% morbidity).

McWey et al. in 1988 published the results of a retrospective review of radiographs for feeding tube placement at a university hospital (27). The facility used 1100 feeding tubes over 18 months, and all tubes were placed by resident physicians, or in 2 cases, by medical students supervised by a resident. The investigators discovered 13 tubes with bronchopulmonary position on radiograph (1.2% of tubes). Complications from displaced SBFT's were reported in 7 patients (0.64% of tubes), and included pneumothorax, hydrothorax, empyema, and pneumonia.

Harris and Huseby published the results of a prospective study of 71 feeding tube placements in 26

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ICU patients in 1989 (28). The authors reported 3 patients that developed pulmonary complications as a result of bronchopulmonary placed tubes (4% complication rate). However, the study did not specify if there were tubes that deviated into the airway and removed without injury.

A prospective, descriptive study published in 1998 reported the incidence of bronchopulmonary displacement and injury related to SBFT placement over a 2-year period in an 18-bed multidisciplinary ICU of a university hospital (29). The authors reported that 740 SBFT's were placed during the study period. Abdominal x-rays identified 14 cases where feeding tubes were inserted into the bronchopulmonary system that went undetected by clinical findings. Five of the 14 patients with a misplaced SBFT suffered a major complication from the feeding tube (pneumothorax or hemopneumothorax). Two patients died of complications directly related to the malposition of the feeding tube. In all SBFT's placed over two years, 2% had bronchopulmonary displacement, 0.7% resulted in a major complication and 0.3% of all placements directly contributed to patient death. One notable aspect of this study was that there were 2 instances of misinterpretation of the position of the feeding tube on the abdominal film. In one case the mistake was discovered before the patient received feeding, but in the other case the patient received feeding into the pleural space and subsequently expired.

Marderstein et al documented in 2004 the incidence of bronchopulmonary displacement and injury related to SBFT's at a university hospital before and after a enhanced-safety procedural change for SBFT placement. (30). A retrospective text word search of electronic medical records was followed by a manual search of medical records and all radiographs for detected reports. The investigators identified 1847 SBFT placements prior to the policy change, with 26 bronchopulmonary tube displacement (1.4%) and 7 pneumothorax (0.38% of tubes).

Sorokin et al in 2006 reported the incidence of feeding tube misplacement and injury at a tertiary academic hospital before and after adopting a protocol to reduce SBFT misplacements.(31) The investigators identified 3789 SBFT's placed over 4 years in 2079 patients by searching incident reports, a key word search of the radiograph database and including known cases not identified in the searches. There were 50 confirmed cases of bronchopulmonary misplacement (1.3% of all tubes, 2.4% of patients), 14 complications (0.37% tubes, 0.67% of patients) and 2 deaths (0.1% of patients) related to the tube misplacement. The investigators noted that only 2 of the tube complications and none of the misplacements were recorded by incident reports. Notably, the researchers reported that there were no tube misplacements in the last 18 months of data collection, after the hospital placed a moratorium on blind placements of feeding tubes by the resident staff for intubated or sedated patients.

A retrospective study of all SBFT's placed over a 1 year period at a 450-bed tertiary referral hospital was published in 2007 (32). The investigators identified 1822 SBFT's placed in 729 adult patients, with 65.7% of patients in the ICU and 34.3% on general hospital floors at the time of tube placement. The majority of SBFT's were placed blindly by nurses, with only 189 (10.3%) tubes requiring fluoroscopic placement. The authors reported that 27 tubes had bronchopulmonary misplacement, which is 1.5% of all tubes placed, but 1.7% of all the tubes were placed without fluoroscopy. Some patients had multiple tube placements and misplacements, resulting in 3.2% of patients with misplaced feeding tubes. There were 9 episodes of pneumothorax (1.2% of patients) and 4 fatalities (0.5%) attributed to complications related to feeding tube misplacement.

Several authors of these observational studies commented that the incidence of misplacements and injuries were very likely underestimated due to the possibility of missed events. In at least one of the studies the authors mentioned cases they personally knew about that were not identified by the search methods of the study.

RISK FACTORS FOR BRONCHOPLEURAL DISPLACEMENT

A number of patient characteristics appear to increase the risk of bronchopulmonary displacement during blind placement of SBFT's. See Table 2 for risk factors for bronchopulmonary displacement of feeding tubes. A consistent trend is noted from the earliest case

reviews through the most current studies that identifies patients with altered mental status or sedation, critical illness, endotracheal tube or tracheostomy, absent cough reflex, or with difficult or repeat SBFT placement (8,20,21,33,34).

The presence of a cuffed tracheal tube does not offer protection against airway placement of SBFT's, and actually appears to increase risk of bronchopulmonary displacement of SBFT's. Virtually all case reviews and observational studies have identified patients with endotracheal tubes or tracheostomies to be at increased risk for airway displacement of feeding tubes. Although there are populations that appear to be at increased risk for bronchopulmonary misplacement of feeding tubes, observational studies have identified patients without major risk factors for SBFT misplacement that nevertheless had pulmonary placement and/or injury from SBFT's (31,33). Considering the patient population that requires specialized nutrition support, it would appear that the vast majority of candidates for SBFT placement would be at risk.

The experience of the clinician placing the feeding tube would also seem to be an obvious factor influencing the risk of displacement. However, data from controlled conditions in a study of experienced clinicians on tube placement teams identified that between 0.9 to 2.3% of tubes were clinically undetected intrabronchial placements (35,36).

Table 2.
Risk Factors for Bronchopulmonary Displacement of Feeding Tubes

- Altered mental status
- Receiving sedative or pain medications
- Tracheostomy or endotracheal tube
- Critical illness
- Absent cough reflex
- Difficult tube placement
- Non-cooperative patients
- Patients requiring multiple tube placements
- Anatomic abnormalities

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PREVENTION OF BRONCHOPULMONARY INJURY

A number of placement techniques and protocols have been proposed or tested since the problem of bronchopulmonary injury from SBFT's was identified. Lipman et al. demonstrated that increasing the diameter of the SBFT to 12 French did not prevent passage of the tube through smaller bronchioles and lung tissue (24). Other techniques such as withdrawal of the stylette after the initial portion of the placement, or limiting difficult placements to more senior staff was also of limited success (24). Awareness of the potential for iatrogenic injury related to tube placement and education on proper tube placement techniques with clinical evaluation techniques have undoubtedly contributed to minimizing injury from SBFT placement (37). However, a recent study confirm that even with experienced practitioners and good technique that clinically undetected pulmonary misplacement of feeding tubes still occurs (35).

Insertion of SBFT guided by fluoroscopy, direct laryngoscopy or endoscopy is effective for preventing passage of feeding tubes into the airway (38). However, methods for direct visualization of feeding tube placement such as fluoroscopy require trained specialists and equipment, and are generally not feasible for all SBFT placements due to the expense and limited availability.

One technique that appears to be effective to decrease or eliminate bronchopulmonary injury is to evaluate the feeding tube after it has been placed to a limited length (25–35 cm) where the tube is committed to either the esophagus or bronchi, but before it has reached the point where pulmonary injury can occur (30,33,39). Raff et al recommended listening to the end of the tube for air passage or placing the end of the tube in water and inspecting for bubbles after placement to 25 cm (39). However, there is not always sufficient air passage through tubes with a narrow lumen to allow clinical detection. Roubenoff and Ravich in 1989 proposed a two-step protocol that requires a first radiograph after the SBFT had been placed to 30 cm, and only after airway position was ruled out was the tube advanced further. A second radiograph is obtained after the tube is fully advanced to confirm proper position of the feeding tube in the GI tract (33). This

Figure 1. CO2nfirm Now™ CO_2 detector. (www.co2nfirmnow.com)

2-radiograph technique was effective in eliminating pulmonary complications from SBFT placement in a cohort of 607 feeding tube placements (33). Marderstein documented that a 2-radiograph placement protocol for SBFT placement was effective in eliminating pulmonary injury when the protocol was followed. Evaluation of 3311 feeding tube placements documented that the 2-step protocol reduced, but did not eliminate pulmonary injury due to noncompliance with the protocol in some instances. The establishment of an enteral access team and full compliance with the 2-radiograph protocol in all SBFT placements eliminated pulmonary injury related to SBFT placement (30). The 2-radiograph technique allows a much lower total radiation dose than most fluoroscopic placements (33). However, compared to blind SBFT placement, the 2-step protocol is more time consuming because the first radiograph must be read before the feeding tube can be advanced beyond 30 cm.

Capnographs and colorimetric carbon dioxide (CO_2) detectors have been successfully used to assess the position of SBFT's placed to 30cm (35,40-46). Capnographs and colorimetric detectors are very sensitive and specific indicators for the presence of CO_2, and will identify a tube placed into the airway, and allow repositioning before pulmonary injury can occur (43). Carbon dioxide detection will not verify proper position in the GI tract, and thus a single radiograph is still required to verify final tube position. However, use of a capnograph or colorimetric CO_2 detector is not as time consuming and is less expensive than a 2-radiograph protocol (35). Capnographs require a trained caregiver to interpret the waveform, and generally a limited number of these expensive devices are available in a given facility. Colorimetric CO_2 detectors are relative inexpensive, readable by a simple color change and have demonstrated equivalent accuracy as capnography (43). Several studies have reported a 100% sensitivity and specificity with use of colorimetric CO_2 detection, but one study reported a 0.5% false negative result compared to the 2 radiograph technique (35,41,42). A "false negative" test for CO_2 is possible in the event of a kink in the tube or if lubricant or body fluids occlude the tube and prevent free passage of CO_2. One commercial colorimetric CO_2 detector (CO2nfirm Now™ Covidien) includes a small plastic bellows with each device so that CO_2 passage will be assured even through a narrow lumen feeding tube.

Audits of reports of device inaccuracy at our facility have determined that user error (such as failure to use the bellows or not closing a side cap of a 2 port tube) was the source of all reports initially ascribed to device inaccuracy (43). In the initial reports of using capnography to evaluate the position of SBFT the investigators were required to remove the metal stylette from the tube in order to check for the presence of CO_2, and then replace the stylette for further tube advancement (40,47). Removal and replacement of a stylette while the tube is in a patient is discouraged by all manufacturers of SBFT, and the need for stylette removal for CO_2 detection may be one reason for a lack of initial popularity for this method. However, most SBFT's currently allow a colorimetric CO_2 detector to be placed over the end of the tube with the stylette in place, and use of colorimetric CO_2 detection to be rapid and safe.

Another method that has the potential to dramatically decrease or eliminate bronchopulmonary injury with SBFT placement is electromagnetic visualization of feeding tubes during placement (7,48–50). Electomagnetic visualization of feeding tubes utilizes an elec-

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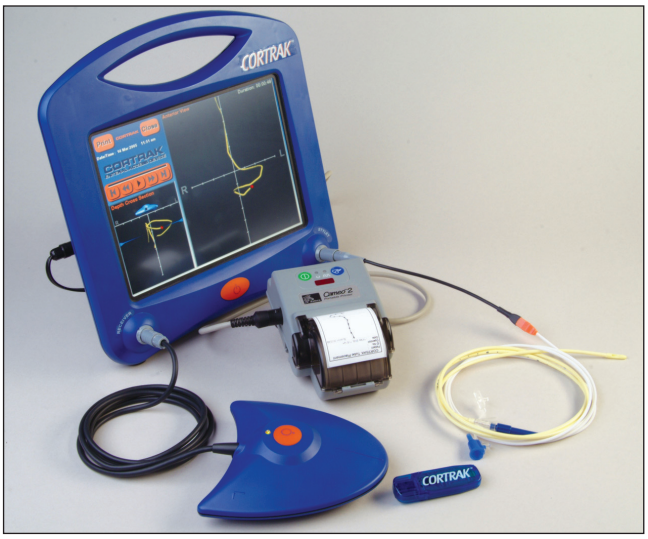

Figure 2. Cortrak Enteral Access System. (www.corpakmedsystems.com/product_main/cortrak.html)

tromagnetic transmitter in the tip of the feeding tube stylette. An external receiver unit is placed over the zyphoid process and a monitor shows a real time display of the tube position in both anterior and cross-sectional view (see Figure 2). A retrospective study of electromagnetic guided placement of 1154 feeding tubes by a tube placement team demonstrated elimination of airway placed feeding tubes, and a significant cost savings related to a reduction in need for abdominal radiographs and fluoroscopic tube placement compared to blind feeding tube placement (7). Several other groups have demonstrated the effectiveness of electromagnetic guided feeding tube placement in both adults and children (48–50). Electromagnetic guided feeding tube placement may eventually allow the confirmatory radiograph to be abandoned because the dual view (anterior and cross-section) has the potential to provide more information in a quicker and more cost-effective way than a single abdominal radiograph. An additional advantage of electromagnetic visualization is the ability to facilitate transpyloric passage of feeding tubes when small bowel feeding is clinically indicated.

The disadvantage of electromagnetic visualization of feeding tubes is the increased cost of specialized feeding tubes with a transmitter in the stylette, and a limited number of the devices to monitor and display tube position (often only one device/hospital) and the need for trained operators to be available when feeding tubes need to be placed. If the proper equipment and/or trained staff is not readily available a delay in tube placement or a temptation to place the tube blindly may result. Studies have documented both a delay in tube placement and disregard for safety protocols for SBFT placement with resultant patient injury when safety protocols were not readily available or deemed time consuming (7,30).

DISCUSSION

Examining the data regarding blind placement of feeding tubes reveals a remarkable consistency from the first case reports through the most recent investigations. Small bowel feeding tubes are misplaced into the airway between 1.2 to 2% of tube placements, and 0.3 to 0.7% of all SBFT placements cause pulmonary injury to patients. The most recent studies have provided mortality information related to SBFT misplacements, and this data suggests that 0.1 to 0.3% of all patients that have blindly placed SBFT's die as a result of bronchopulmonary injury from misplaced tubes (31,32). Although the percentage of morbidity and mortality related to SBFT's appears low, the large numbers of feeding tubes used each year translates to a substantial number of injuries and deaths each year. It is estimated that approximately 1.2 million feeding tubes are placed each year in the United States alone (7). If these tubes were placed blindly this would translate to 3,600 to 8,400 pulmonary injuries, and between 1,200 to 3,600 deaths in the United States each year. Considering that there are approximately 6,000 hospitals in the United States, but more than 27,000 hospitals worldwide, the actual scope of this problem is much more substantial. The tragedy of these injuries and deaths is that they are largely preventable, since technology and placement techniques are readily available that dramatically reduce or eliminate bronchopulmonary feeding tube misplacements.

As patient safety has become the primary focus of most hospitals, it is alarming that any hospital would permit blind placement of SBFT's. However, it appears that the majority of hospitals have not yet adopted an enhanced-safety protocol for SBFT placement. While there is as yet limited published data, our

preliminary results of a survey suggest that more than 66% of facilities routinely use blind placement for SBFT's (unpublished data).

The reason why blind placement of feeding tubes remains routine is likely multifactorial. The first reason is an under appreciation for how many patients are injured from blind feeding tube placement, in part due to lack of familiarity with studies documenting the problems from blind placement. Additionally, the relative infrequency of bronchopulmonary misplacement, and the fact that many misplaced tubes are removed from the airway without pulmonary injury means that many healthcare clinicians remain unaware of most misplacements. Our experience while introducing a safety-enhanced protocol at our facility was that there appeared to be a "culture of denial" initially for the need for such a protocol among experienced practitioners. Sorokin documented that only 2 of the tube complications and none of the misplacements were recorded by incident reports, thus most clinicians would be unaware of feeding tube sequella even when injury occurs (this was true for our facility as well). Sorokin also documents that it often takes a sentinel event for the problem of morbidity and mortality from feeding tube placement to come to the attention of physicians or administrators for policy changes to occur (31).

The standard of practice for placement of SBFT's that developed by the early 1980's was blind placement at the bedside, with radiographic confirmation of tube position prior to use. Current guidelines still endorse blind SBFT placement, but as new data has emerged recent guidelines encourage CO_2 monitoring as a safety-enhanced protocol (51). Roubenoff demonstrated the effectiveness of the 2-radiograph technique more than 20 years ago, and new devices such as electromagnetic monitoring and colorimetric CO_2 detectors make establishing a safety-enhanced feeding tube protocol easier and more economical (33). Now that current data demonstrates that safety-enhanced protocols can dramatically reduce or eliminate pulmonary injury from SBFT placement, it is conceivable that failure to adopt methods to minimize risk during enteral intubation may expose institutions and individuals to litigation (7).

Implementing a safety-enhanced protocol or introducing safety technology into the hospital is not sufficient to eliminate pulmonary injury from feeding tubes. Several investigators have documented that there was a certain "regression towards the mean" in regards to feeding tube safety protocols, with certain users deciding that either the patient characteristics or the clinician skills justified blind tube placement, with resultant misplacements and injury. In practice we have noted that single or even multiple in-services of our safety-enhanced protocol was insufficient for universal compliance, and have witnessed staff placing feeding tubes blindly.

CONCLUSION

The best available data is that pulmonary morbidity and mortality is an inevitable consequence from blind placement of feeding tubes. The frequent use of SBFT's translates to large numbers of patients injured from feeding tubes each year. Current data supports the use of safety-enhanced protocols or devices to dramatically reduce or eliminate morbidity and mortality from feeding tube placement. There is a need to encourage more universal implementation of safety protocols to decrease morbidity and mortality associated with feeding tube placement. Efforts to decrease medical mistakes and increase the safety of patients admitted to medical facilities should include a moratorium on blind placement of small bore feeding tubes. ■

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