


Transpyloric Feeding Tube Placement Using Electromagnetic Placement Device in Children

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Margaret Goggans, RD, LDN, CNSC^{1,2}; Sharon Pickard, RN, MSN, CCRN³;
Alina Nico West, MD, PhD^{4,5}; Samir Shah, MD, MBA, FRCPC^{4,5};
and Dai Kimura, MD^{4,5}

Abstract

Background: Transpyloric feeding tubes (TPT) are often recommended in critically ill children. Blind tube placement, however, can be difficult, be time-consuming, and incur multiple radiation exposures. An electromagnetic device (EMD) is available for confirmation of successful placement of TPTs. We conducted a retrospective cohort study to evaluate the efficacy of an EMD for TPT placement in children and determine its impact on placement success, radiation exposure, confirmation time, and cost for tube placement compared with traditional blind TPT placement. **Materials and Methods:** Retrospective data were collected in patients receiving a TPT before (pre-EMD group) and after implementation of an EMD (EMD group). **Results:** Need for radiographic exposure decreased significantly in the EMD group (n = 40) compared with the pre-EMD group (n = 38) (0.6 vs 1.6 x-rays, $P < .001$). TPTs were placed and confirmed without abdominal x-ray in 21 of 40 patients in the EMD group. There were no serious adverse events such as misplacement into the lung or pneumothorax or perforation injury of the stomach. Successful tube confirmation took a significantly shorter time in the EMD group than in the pre-EMD group (1.45 vs 4.59 hours, $P < .0001$). There was an estimated cost savings of \$245.10 per placement associated with decreased x-ray and fluoroscopy. **Conclusion:** The use of an EMD in children significantly decreased radiation exposure and confirmation time while maintaining TPT placement success. The use of an EMD can potentially offer large cost savings. Elimination of abdominal x-ray with EMD during TPT placement was achieved without any serious complications in approximately half of the children. (*Nutr Clin Pract.* XXXX;xx:xx-xx)

Keywords

enteral nutrition; feeding tube; feeding tube placement; x-rays; pediatrics; child

Introduction

Enteral nutrition (EN) support is the preferred route of feeding for patients unable to eat by mouth with a functional gastrointestinal (GI) tract.¹ Early EN has been shown to decrease time on the ventilator² and intensive care unit (ICU) length of stay³ while maintaining the intestinal immune system and achieving positive nitrogen balance.^{4–6} Often, a transpyloric tube (TPT) is recommended as the route for EN for reasons including delayed gastric emptying, inability to tolerate gastric feedings, impaired intestinal motility, pancreatitis, and ability to achieve nutrition goals sooner than with a nasogastric tube.^{7–9} Traditional blind bedside placement of a TPT is completed by trained nurses and is reliant on clinical intuition, patient placement, and peristalsis, with an abdominal x-ray for final confirmation.¹⁰ Blind bedside placement of a TPT can be challenging and time-consuming, involves multiple feeding tube manipulations, is costly, and exposes the patient to avoidable radiation.¹¹

The purpose of this study was to evaluate the efficacy of the use of an electromagnetic device (EMD) for TPT placement in children and to determine whether EMD use affects placement success, radiation exposure, overall placement confirmation time, and cost for tube placement compared with traditional blind TPT placement.

Methods

The electromagnetic placement system (Cortrak EAS 2; CORPAK Med Systems, Buffalo Grove, IL) was introduced at a tertiary care children's hospital in July 2014. A retrospective cohort study was conducted in October 2015 after approval by the institutional review board for pediatric patients receiving a TPT from January 2013 to July 2015.

From the ¹Department of Nutrition Therapy, Le Bonheur Children's Hospital, Memphis, Tennessee, USA; ²College of Pharmacy, University of Tennessee Health Science Center, Memphis, Tennessee, USA; ³Education Services, Le Bonheur Children's Hospital, Memphis, Tennessee, USA; ⁴Division of Critical Care Medicine, Le Bonheur Children's Hospital, Memphis, Tennessee, USA; and the ⁵Department of Pediatrics, University of Tennessee Health Science Center, Memphis, Tennessee, USA.

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Corresponding Author:

Dai Kimura, MD, Department of Pediatrics, Division of Critical Care Medicine, Le Bonheur Children's Hospital, University of Tennessee Health Science Center, CFRI, 3rd Floor, 50 N. Dunlap St, Memphis, TN 38103, USA.
Email: dkimura@uthsc.edu

Blind bedside placement by trained pediatric ICU nurses was the standard approach before EMD implementation in July 2014. An EMD was not available at the hospital during this time period (pre-EMD group). The blind procedure typically included a nurse placing a small-bore feeding tube and advancing it past the measurement for standard gastric placement. The patient was subsequently placed in a right lateral position to allow the feeding tube to migrate into the small bowel with the help of peristalsis. Nurses used their clinical judgment and preference for tube type, with or without a stylet, for blind TPT placement. Many nurses employed variable, described placement techniques to aid in transpyloric placement, including air insufflation and prokinetic agents (metoclopramide).¹² Per hospital policy, an abdominal x-ray was obtained for all patients receiving a blind TPT for confirmation prior to initiating EN. Patient data for pre-EMD group were collected retrospectively on all patients with an order for a TPT during the 1-year time period. Data collected included the number of abdominal x-rays received after initial TPT placement until the x-ray report indicated transpyloric placement or no additional attempts (the placement was considered unsuccessful if the radiologist report did not indicate transpyloric placement and no additional attempts were made), successful placement of the transpyloric feeding tube, and length of time until confirmation, in hours, defined as time from the initial insertion attempt of the feeding tube documented by the nurse in the electronic medical record up to the time the final abdominal x-ray was taken showing confirmation of its successful placement, since feeding is unable to be initiated until tube placement is confirmed.

Data for the "EMD group" were collected after the EMD was implemented as the standard of practice hospital-wide for use with TPT placement in patients who were able to receive either a size 8 French or 10 French feeding tube. Prior to data collection and implementation of the EMD, a team of 15 pediatric ICU (PICU) nurses was trained in use of the device. As recommended by the device company and other hospitals,¹³ a team of trained nurses were the sole users of the EMD to ensure competence in machine use. A team of nurses provided 24/7 TPT placement service using the EMD for all patients who were able to tolerate either an 8 French or a 10 French tube.

Hospital guidelines for the use of the device were developed before implementation. These guidelines allowed the nurse to use clinical judgment when determining if the patient was large enough to tolerate an 8 French feeding tube and if an x-ray was needed to confirm placement. An x-ray for placement verification was requested if the nurse was not confident in the feeding tube track shown on the EMD screen. Data were collected on all patients who received a feeding tube placed with the aid of the EMD from the date of implementation. Retrospective data collected included the number of abdominal x-rays required to confirm transpyloric placement, successful placement of the TPT, and length of confirmation time, in hours, from initial insertion of the feeding tube documented by the nurse in the electronic medical record until the feeding tube was confirmed transpyloric, either by the nurse from the feeding tube track or the bedside physician from the abdominal x-ray.

Any documented complications from the placements were also collected. Patients in the pre-EMD group were excluded if there was not an order for a TPT or if an abdominal x-ray was not used to confirm placement. Patients who received a TPT after EMD implementation requiring a tube smaller than 8 French were excluded, as the EMD device was not used. The estimated cost for tube placement was compared per patient using the hospital cost for an abdominal x-ray (\$215), a fluoroscopy (\$600), a Cortrak feeding tube (\$32.10), and a standard feeding tube with stylet (\$8). EMD machine cost (\$30,000) was not included as the machine was obtained by a usage contract and pricing may vary across institutions based on suppliers or usage contracts.

Data were analyzed using the Student *t* test for geographic data, radiation exposure, and time of feeding tube placement; Mann-Whitney test for time for placement attempt; and χ^2 test for success rate. The level of significance used was $P = .05$. The statistical analysis was performed using SPSS version 20 (SPSS, Inc, an IBM Company, Chicago, IL).

Results

There were a total of 38 patients in the pre-EMD group and 40 in the EMD group. Among the pre-EMD group, 60.5% (23/38) of the patients were in an ICU setting compared with 55% (22/40) in the EMD group. The pre-EMD group used a greater variety of feeding tubes ranging from 5–10 French, with 6 French being the most common size (22/38). The EMD group primarily used 8 French as this is the smallest Cortrak tube available (34/40). The patient population in the pre-EMD group was younger than the patients in the EMD group (26.6 ± 44.4 vs 56.2 ± 80.7 months, 2-tailed *t* test, $P = .047$; Table 1). There were 1.63 ± 0.75 abdominal x-rays per tube placement attempt in the pre-EMD group vs 0.6 ± 0.74 in the EMD group ($P < .0001$, Figure 1). Only 19 of the 40 patients from the EMD group received radiation exposure for confirmation of TPT placement. Few patients in both groups were difficult placements and received more than 2 abdominal x-rays, 6 in the pre-EMD group and 1 in the EMD group. Three TPT placement attempts using blind placement techniques were unsuccessful and required fluoroscopy guidance for tube placement. Twelve patients were excluded from the pre-EMD group; 8 were excluded as they did not have a TPT order, and 4 were excluded since an x-ray was not used to evaluate tube placement. There was 1 incident in the EMD group where the tube coiled, knotted during placement, and was replaced with a smaller bore feeding tube without using the EMD. Two additional patients were excluded from the EMD group after unsuccessful placement with the EMD and nurse preference to switch to a smaller bore feeding tube for better patient tolerance. One patient was excluded from the EMD group who did not have a TPT order. There were no other complications associated with the feeding tube placement during the study such as inadvertent placement into the airway or GI perforation with the tubes in either group.

There was an estimated cost savings of \$245.10 per placement associated with decreased abdominal x-ray and fluoroscopy, not including nursing time spent during placement or the

Table 1. Age, Location, and Feeding Tube Size of Patients.^a

Patient Group	Age						Location		Feeding Tube Size			
	0–5 mo	6–12 mo	1–3 y	4–9 y	10+ y	Mean \pm SD, mo	ICU	Non-ICU	5 French	6 French	8 French	10 French
Pre-EMD (n = 38)	21	4	6	3	4	26.6 \pm 44.4	23	15	5	22	8	3
EMD (n = 40)	17	7	5	1	10	56 \pm 80.7	22	18	0	0	34	6

EMD, electromagnetic device; ICU, intensive care unit.

^aPatients were older in the EMD group ($P = .047$, 2-tailed t test). The size of feeding tube was smaller in the pre-EMD group ($P < .001$, 2-tailed t test).

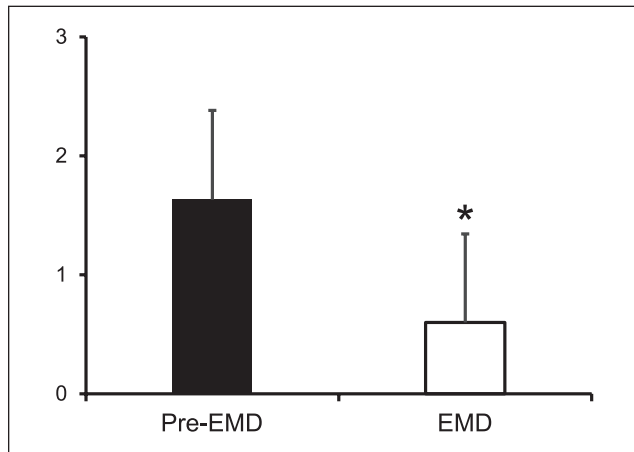


Figure 1. The number of x-rays per a transpyloric tube placement. The usage of an electromagnetic device (EMD, n = 40) significantly decreased the number of x-rays per tube placement. The tube was placed blindly in the pre-EMD group (n = 38). Data are expressed as mean and SD (1-tailed t test, $*P < .0001$).

cost of the actual Cortrak EAS2 machine as the hospital received a machine as part of a usage contract. If we had purchased the machine at a cost of \$30,000 and continued using the machine for 40 patients per year, the estimated cost saving would be used for paying off the machine cost for approximately 3 years or 122 procedures.

Successful blind TPT placement confirmation took an average of 4.6 ± 3.5 hours, and successful EMD placement confirmation took an average of 1.5 ± 2.7 hours ($P < .0001$, Figure 2), while total (successful and unsuccessful) tube placements took an average of 5.29 ± 5.15 hours for blind placement and 1.73 ± 3.00 hours for the EMD (Figure 3).

Success rate was 76.3% for the pre-EMD group and 87.5% for the EMD group. The EMD group was further divided into 2 groups, the first 20 placements and the last 20 placements, to evaluate any potential significance in success rate over continued use of and greater experience with the machine (Figure 4). Transpyloric tubes were successfully placed in all of the last 20 patients with EMD. However, there were no significant differences between the 3 groups (χ^2 test, $P = .052$). Furthermore, we conducted a subgroup analysis to compare the success rate in patients who received x-rays between the groups. There was no statistically significant difference in success rate between the groups (pre-EMD 76.3% vs EMD with x-ray 84.2%, $P = .49$, χ^2 test).

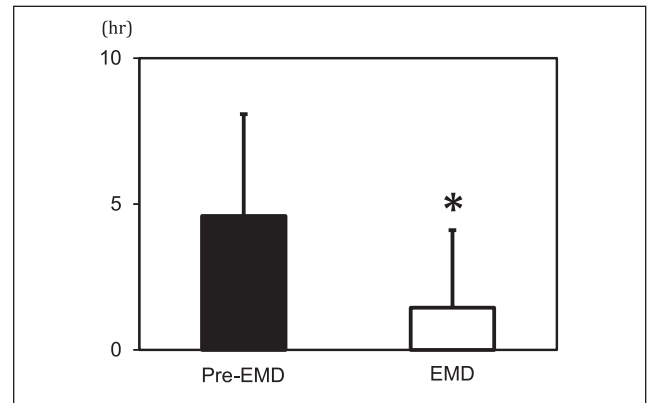


Figure 2. Time for successful placement. The electromagnetic device (EMD) significantly decreased the time (2-tailed Student t test, $*P < .0001$). Data are expressed as mean and SD.

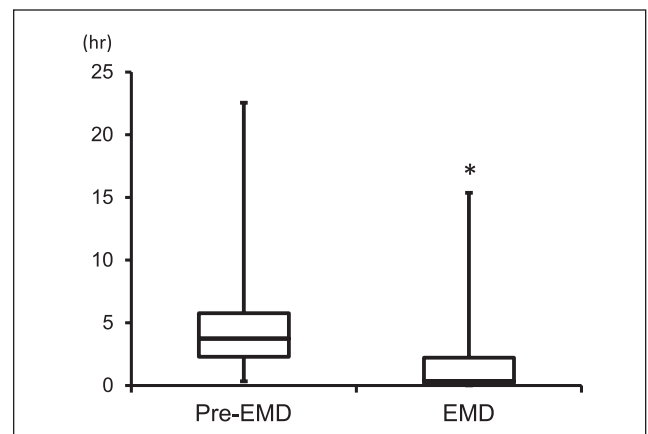


Figure 3. Time for placement attempt. The electromagnetic device (EMD) significantly decreased the time for placement attempt (pre-EMD, n = 38; EMD, n = 40; 2-tailed Mann-Whitney, $*P < .05$). Data are expressed as median and interquartile range.

Discussion

This cohort study demonstrated that the use of the EMD decreased radiation exposure per patient to 0.6 ± 0.74 ($P < .0001$), shortened tube placement confirmation time to 1.5 ± 2.7 hours ($P < .0001$), and decreased medical cost by \$245.10 per placement. Previous evaluations of the EMD in critically ill children showed a significant decrease in radiation exposure to

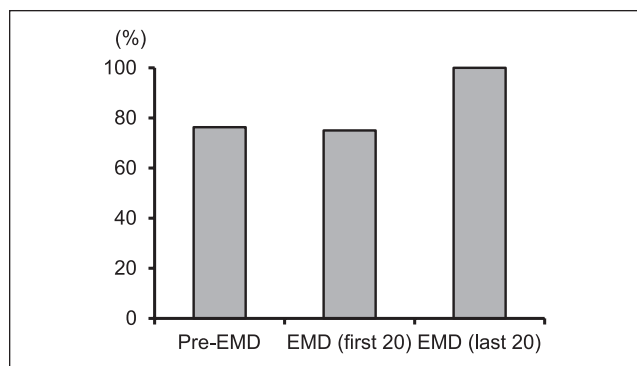


Figure 4. Success rate. Despite no significant differences, there was a trend to an increase in the success rate over time (χ^2 test, $P = .052$). EMD, electromagnetic device.

1.2 per patient,¹⁴ an increase in the success rate to 64.3%,¹⁴ a decrease in placement time to 1.7 hours,¹⁵ and a decrease in cost per tube placement by \$132.05.¹⁴ Comparatively, 1 pediatric study found that the EMD use increased time of placement¹⁶ while another study found slightly higher cost with EMD.¹⁷ The cost of the Cortrak EAS2 and Cortrak feeding tubes for our hospital may have been less than other hospitals due to a contract. Similar results are seen with evaluations in an adult population: significant reduction (50%) in radiation exposure,¹⁸ 1.07 x-rays per patient,¹³ and an increase in the success rate (83.9%).¹³

The reported safety events and Food and Drug Administration (FDA) approval were reviewed prior to implementation of the device to the institution. Since the Cortrak EAS 2 device is FDA approved for tube placement confirmation, the hospital guidelines for use permitted the trained nurses to obtain an abdominal x-ray only if they were not confident in the location of the feeding tube based on the track shown on the device screen. This cohort study showed a lower rate of radiation exposure per patient (<1 x-ray per placement), including 21 patients without x-ray, and shorter TPT placement confirmation time with application of the EMD. Cumulative radiation exposure poses risks to patients with chronic diseases, and excess, potentially unnecessary, radiation should be avoided.¹⁹ In addition, no adverse events, such as pneumothorax, misplacement into the lung, or perforation of the GI tract, were seen with the EMD group. In adults, 1 study safely eliminated x-ray for TPT placements in most cases (only 7.7% required x-ray).²⁰ Our study is the first study that safely and efficiently eliminated x-rays for TPT placement confirmation in children. However, medical device reports in the FDA Manufacturer and User Facility Device Experience (MAUDE) Database show reports of inadvertent lung placement and tube malfunction.²¹ The National Health Service (England) issued a patient safety alert in 2013 regarding misplacement of feeding tubes with the aid of a placement device.²² Patient safety remains our highest priority, and we should continue to monitor the safety alarm recommendations from the FDA and other agencies.

We hypothesize that the EMD made the nurses feel more confident in the tube placement location (in more than half of the patients, the nurse did not request an abdominal x-ray) because

they could actually see the tube track, including depth tracking, to help them determine the placement of the tube. In this study, 1 patient in the EMD group had the feeding tube knot after coiling in his stomach. In this case, the nurse noticed the tube was coiling and attempted to pull back the stylet a few inches and replace in an effort to remove the coil. During this time, the tube knotted and the stylet was unable to be replaced; the feeding tube was removed uneventfully. However, this could have occurred with any feeding tube with a stylet; the EMD allowed the nurse to identify the coil before obtaining an x-ray compared with blind placement.

TPT placement confirmation time in the EMD group was significantly shorter when comparing successful patients. Hypoglycemia is commonly observed in critically ill children and associated with neurological morbidity and mortality.^{23,24} Therefore, initiating enteral feeding quicker would be beneficial to avoid hypoglycemia and its complications. The confirmation time reduction is likely due to the omission of the abdominal x-ray, as patients can wait an average of 3.4 hours for an x-ray with a radiologist reading.²⁵ In contrast to the FDA-approved Cortrak EAS 2 and abdominal x-ray, confirmation of feeding tubes may not be as accurate from other methods, including pH, capnography, appearance of aspirate, or auscultation.²⁶ Comfort of the nurse with placing TPTs and machine use can contribute to time of tube placement. One study reported slightly increased procedure time of TPT placement with the EMD (median, 9.5 vs 5.0 minutes, EMD vs blind).¹⁶ However, their practitioners had significant experience placing TPTs blindly, and the EMD group had 100% success rate in the study.¹⁶ Also, their study did not mention the time waiting for x-rays.^{16,23} In our institution, all PICU nurses placed blind TPTs for the entire hospital compared with only a select group (the charge/lead nurses) of the PICU nurses who were trained to use the EMD. Typically, charge/lead nurses have more experience and could potentially place a TPT faster than other nurses. This could have contributed to the blind group having a longer average time per patient. However, nurses who are very skilled in blind TPT placement can be delayed with the use of technology as they may doubt their skills and become too concerned with use of the machine.¹⁶ During blind placement, nurses were also given the autonomy to choose their preferred tube, with or without stylet, for use compared with the EMD, which requires a feeding tube with a stylet. This may contribute additional variance in length of time to place the tube as a tube with a stylet may be more successful.¹⁶

There are some limitations in this study. This is a retrospective cohort study, and the patients were not randomized for the group. The skills of the nurses between the groups might be different as only charge/lead nurses, typically with more experience, were on the EMD-trained team and the non-EMD group included all PICU nurses. Order of x-ray in the EMD group is dependent on comfort levels of each nurse and may have varied across trained nurses. Time the x-ray was taken instead of time of the radiologist report was used for calculating placement confirmation time as attending physicians may view the image to determine placement before the radiologist reads the image. Procedural nursing time was not evaluated between the groups. As this was a retrospective study, the

tube insertion time is only documented in the electronic medical record and not the total nursing time spent inserting the tube. Actual procedural time for the EMD group can potentially be longer because the nurse is able to see if the tube coils or is not advancing to the small intestine in real time and adjust accordingly, potentially spending more time on the initial insertion. With blind placement, nurses cannot immediately tell if the tube is coiled or has remained in the gastric position until the abdominal x-ray, where they would need to spend additional procedural time to adjust the tube after the initial insertion. The smallest Cortrak tube available is 8 French. This may have contributed to increased placement confirmation time and x-ray use in the EMD group in younger patients who received an 8 French tube since the nurse may have preferred to use a smaller tube if it were available. In other studies including critically ill pediatric patients using only 8 French and 10 French feeding tubes, patient size was not associated with placement success.^{15,16} Also, due to tube size limitations, patients requiring smaller than 8 French were not included in the EMD study group. This may have contributed to the younger age for the pre-EMD group and may have altered placement confirmation time and radiation exposure, as these patients were included in the pre-EMD group.

Conclusion

Radiation exposure and the length of time for TPT placement confirmation significantly decreased with the assistance of an EMD in children. The use of an EMD can potentially offer large cost savings associated with decreased x-ray and fluoroscopy. Need for abdominal x-rays during TPT placement was reduced by ~50% without any serious complications, further attesting to the safety of this technique.

Statement of Authorship

All authors contributed to the conception and design of the research; S. Pickard and M. Goggans contributed to the acquisition of data; A. N. West, S. Shah, and D. Kimura contributed to the analysis and interpretation of data; and M. Goggans and D. Kimura drafted the manuscript. All authors critically revised the manuscript, gave final approval, and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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