Use of an electromagnetic-guided device to assist with post-pyloric placement of a nasoenteral feeding tube: A systematic review and meta-analysis

Authors
Fabio Catache Mancini1, Diogo Turiani Hourneaux de Moura1, Mateus Pereira Funari1, Igor Braga Ribeiro1, Fernando Lopes Ponte Neto1, Pastor Joaquin Ortiz Mendieta1, Thomas R. McCarty2, Wanderley Marques Bernardo1, Sergio Carlos Nahas1, Eduardo Guimarães Hourneaux de Moura1

Institutions
1 Gastrointestinal Endoscopy Unit, Hospital das Clínicas, University of São Paulo School of Medicine, São Paulo, Brazil
2 Division of Gastroenterology, Hepatology and Endoscopy – Brigham and Women’s Hospital – Harvard Medical School

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Bibliography
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Corresponding author
Igor Braga Ribeiro, mean difference (MD), Gastrointestinal Endoscopy Unit, Hospital das Clínicas, University of São Paulo School of Medicine, São Paulo, Brazil, Av. Dr Enéas de Carvalho Aguiar, 225, 60 andar, bloco 3, Cerqueira Cesar 05403-010 – São Paulo, SP, Brazil
Fax: +55112661-6467
igorbraga1@gmail.com

ABSTRACT

Background and study aims While endoscopic-guided placement (EGP) of a post-pyloric nasoenteral feeding tube may improve caloric intake and reduce the risk of bronchoaspiration, an electromagnetic-guided placement (EMGP) method may obviate the need for endoscopic procedures. Therefore, the primary aim of this study was to perform a systematic review and meta-analysis of randomized trials comparing the efficacy and safety of EMGP versus EGP of a post-pyloric feeding tube.

Methods Protocolized searches were performed from the inception through January 2021 following PRISMA guidelines. Only randomized controlled trials were included comparing EMGP versus EGP. Study outcomes included: technical success (defined as appropriate post-pyloric positioning), tube and patient associated adverse events (AEs), time to enteral nutrition, procedure-associated cost, and procedure time. Pooled risk difference (RD) and mean difference (MD) were calculated using a fixed-effects model and heterogeneity evaluated using Higgins test (I²).

Results Four randomized trials (n = 536) were included. A total of 287 patients were included in the EMGP group and 249 patients in the EGP group. There was no difference between EMGP versus EGP regarding technical success, tube-related AEs, patient-related AEs, procedure time, and time in the right position. Time to enteral nutrition favored EMGP (MD: –134.37 [–162.13, –106.61]; I² = 35%); with significantly decreased associated cost (MD: –127.77 ($) [–135.8–119.73]; I² = 0%).

Conclusions Based on this study, EMGP and EGP were associated with similar levels of technical success and safety as well as time to complete the procedure. Despite this, EMGP was associated with reduced cost and time to initiation of nutrition.

Introduction
Nasoenteral feeding tubes remain a key procedure to aid clinical conditions that make oral intake impossible and diseases that result in a catabolic state where oral intake becomes insufficient [1]. This type of enteral feeding has the advantage of being temporary and easily removable, with very infrequent adverse events (AEs) occurring as a result of tube placement or use [2]. Despite this advantageous safety profile, some patients...
may require post-pyloric placement of a feeding tube with nutrition delivered directly to the small intestine for a variety of reasons [3]. Given the low success rate of post-pyloric placement due to the blind passage of the tube, fluoroscopy or endoscopy may be commonly employed given the ability to afford direct visualization and higher associated success rates with proper placement [3, 4].

While endoscopic-guided placement (EGP) may be performed via a variety of techniques, placement of a nasoenteral feeding tube alongside the endoscope is traditionally the most common strategy employed. This method may make use of friction of the gastroscope in parallel to the tube to guide the tube to a post-pyloric location, involving the use of a wire on the distal end of the feeding tube and traction provided with forceps, or include use of a guidewire. While a variety of techniques can be employed to achieve EGP, this is usually the preferred method of choice, with very low complication rates and success rates in the literature approaching 90% to 95% [5]. Despite being the most common and widespread method, endoscopy is not without limitations. These include invasiveness of the technique, necessity for a specialist physician or endoscopist, staff mobilization, as well as use of resources (i.e., need for various devices, materials, and cost). As such, newer technologies designed to overcome these limitations have been explored.

In the last several years, use of magnetic energy has emerged as way to assist with feeding tube placement [6]. In 2008, an electromagnetic-guided placement (EMGP) device was introduced, which is capable of real-time tracking and displays both the traveled path and the ultimate location of the feeding tube. This EMGP is performed similarly to the traditional blind passing for a nasoenteral tube and can be performed at the bedside, with no sedation or need for a radiograph to confirm position [7]. However, the system consists of a transmitting guidewire, which is passed inside the feeding tube. A receptor is then placed external to the patient at the xiphoid process to capture the signal emitted by the guidewire, displaying at a monitor the path of the feeding tube in real-time, thus providing instant feedback during placement and confirming the post-pyloric location (Fig. 1) [4].

Although EMGP may obviate the need for sedation and endoscopy, this system is not available at all centers. In addition, high-quality comparative data have been lacking for EMGP and EGP of nasoenteral tubes. A previous systematic review showed highly variable results for these techniques; however, important clinical outcomes regarding cost and procedure time have not been evaluated to date [8]. An additional meta-analysis was also performed comparing EGMP, EGP, and fluoroscopic placement techniques; however, that study included lower-quality observational data and fewer randomized studies [4]. The primary aim of this study was to perform a structured systematic review and meta-analysis of randomized trials comparing efficacy and safety of EMGP as well as clinical outcomes versus traditional post-pyloric nasoenteral feeding tube.

Methods

Protocol and registration

The study was prospectively registered in the International prospective register of systematic reviews (PROSPERO) under the code CRD42020207635 and was approved by the Ethics Committee of the Hospital das Clínicas at the University of São Paulo Medical School. This study followed the principles in the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (PRISMA) [9].

Search strategy and eligibility

We searched through MEDLINE, EMBASE, Central Cochrane, Lilacs, and gray literature, from inception to January 2021. Our search strategy in MEDLINE was “(Enteral Nutrition OR Enteral Feeding OR Force Feeding OR Feeding Tube OR Gastrointestinal Intubation OR Nasogastric Intubation OR nasoenteral tube OR nasoenteral intubation OR duodenal tube OR duodenal intubation) AND (electromagnetic OR magnetic OR navigation OR cortrak)”, and on the other databases “(Feeding Tube OR Gastrointestinal Intubation OR Nasogastric Intubation OR nasoenteral tube OR nasoenteral intubation OR duodenal tube OR duodenal intubation) AND (electromagnetic OR magnetic OR navigation OR cortrak)”. Only randomized controlled trials (RCTs) published in full-text form (i.e., full-text published, peer-reviewed manuscripts) were considered. There was no language restriction used when evaluating studies. Study inclusion criteria were limited to patients in need of enteral nutrition provided via post-pyloric feeding tube (i.e., traditional nasogastric tube placement was excluded). In terms of the study population, studies were required to report placement of an electromagnetic-guided nasoenteral feeding tube. The comparison arms included place-
ment of an endoscopic-guided feeding tube, with no alternative procedures or devices included.

**Measured outcomes**

The primary outcome of this systematic review and meta-analysis was efficacy and safety of EMGP versus EGP. Technical success was defined by ability to achieve post-pyloric placement of the nasoenteral feeding tube (either via endoscopic confirmation and/or radiographic confirmation) [10–13].

AEs were stratified by those that appeared to be feeding tube-related (i.e., tube migration, obstruction, and accidental removal), as well as additional events which included patient-related AEs (i.e., epistaxis, desaturation, and vomiting). Additional measured outcomes included time to enteral feeding (defined as time between physician order and initiation of feeding) as well as procedure-associated cost (in US dollars – $). Duration of procedure (i.e., time between the passage of the tube through the nares to removal of endoscope or EMGP device), and time in the correct position were also abstracted and compared between the two techniques.

**Data analysis, summary measures, and synthesis of results**

Data from the selected studies regarding the outcomes (either dichotomous or continuous) were aggregated (meta-analyzed) using Mantel-Haenszel method for dichotomous variables and inverse variance through software RevMan 5.4 (Cochrane Collaboration, Copenhagen, Denmark). For dichotomous variables, risk difference (RD) was calculated, with corresponding 95% confidence intervals (CIs). For continuous variables, the mean value of difference (MD) was calculated and the results are presented as point estimate with 95% CI. Such a calculation considered the mean, standard deviation, and size of each sample. For this analysis, all point estimates were presented with 95% CI and \( P<0.05 \) was considered statistically significant.

Results are shown using forest plots. Heterogeneity among studies was quantified using the Higgins test (I²). Furthermore, pooled proportions and differences between the two techniques were evaluated using a fixed-effects model. For outcomes with \( I^2 > 50 \% \), we utilized Egger’s sensitivity test to identify possible outliers through funnel plot analysis.

**Risk of bias and quality of studies**

To assess the risk of bias, we utilized the tool Risk of Bias version 2 for randomized clinical trials of Central Cochrane (RoB-2). This tool comprises five domains applied to each study: 1) randomization; 2) deviations from intended interventions; 3) missing data; 4) measurement of outcomes; and 5) selection of results. Each of these domains was classified as low risk, unclear risk, or high risk. Quality of evidence was then assessed according to the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) working group [14, 15].

**Results**

**Study selection**

A total of 924 studies were identified through the initial search. After assessing titles and abstracts, four RCTs remained and were included in this study (Fig.2). The characteristics of the included studies are described in Table 1 (Population, Intervention, Comparison and Outcomes – PICO). Summarized results and characteristics for each study were simplified for the analyses [10].

**Risk of bias and quality of studies**

The four assessed studies presented a low risk of bias after applying the RoB-2 tool, as shown in Table 2 (Summary of risk of bias in the included studies according to RoB-2) [14].

**Technical success**

Technical success was reported in three studies [11–13], with a total of 466 patients (243 in the EMGP group and 223 in the EGP group). There was no statistical difference regarding technical success between methods (87% versus 88%; RD: –0.01 [–0.07, 0.05]; \( I^2 = 0\% \)) (Fig. 3). The GRADE analysis revealed a moderate level of certainty. Results from the assessed outcomes in the four RCTs are highlighted in Table 3.
Tube-related complications
Feed tube-related AEs were reported in three studies [11–13] with a total of 470 patients (243 in the EMGP group and 237 in the EGP group). There was no statistical difference regarding tube-related complications between methods (33% versus 25%; RD: 0.07 [0.01, 0.15]; I² = 0%) (Fig. 4). The GRADE analysis revealed a high level of certainty.

Patient-related complications
Patient-reported AEs were documented in four studies [10–13] with a total of 536 patients (287 in the EMGP group and 249 in the EGP group). There was no statistical difference between methods (5% versus 6%; RD: −0.01 [−0.05, 0.02]; I² = 0%) (Fig. 5). The GRADE analysis revealed a moderate level of certainty.

Procedure Time
Procedure duration was detailed in three studies [10, 12, 13] with a total of 382 patients (207 in the EMGP group and 175 in the EGP group). There was no statistical difference between methods (MD: 0.65 [−0.20, 1.51]; I² = 99%) (Fig. 6). The GRADE analysis revealed a very low level of certainty.

Time to enteral nutrition
For the outcome of time to enteral nutrition, two studies [11, 13] including a total of 315 patients (161 in the EMGP group and 154 in the EGP group) reported these data. The mean difference showed a 162-minute advantage in the EMGP group (MD: −134.37 [−162.13, −106.61]; I² = 35%) (Fig. 7). The GRADE analysis revealed a moderate level of certainty.
### Table 3 Summary of selected outcomes for each study.

| Study                  | Holzinger et al [10] | Gerritsen et al [11] | Kappelle et al [12] | Gao et al [13] |
|------------------------|-----------------------|----------------------|---------------------|----------------|
| Post-pyloric position  | EMGP –                | 67/80                | 67/82               | 78/81          |
|                        | EGP –                 | 62/74                | 58/73               | 78/80          |
| Procedure time (minutes) | EMGP 11.7 ± 3.7       | 33 ± 5.8 (16.7 ± 5)  | 20 ± 5.8            | 18 ± 3         |
|                        | EGP 15.2 ± 3.2        | 61.2 ± 13 (12 ± 2.9) | 10 ± 1.75           | 26 ± 6         |
| Time in the right position (days) | EMGP 9.8 ± 3.5       | 7.5 ± 2.9            | –                   | 8.2 ± 3.7      |
|                        | EGP 13.7 ± 3.2        | 6.5 ± 1.7            | –                   | 8.3 ± 4        |
| Time until feeding (minutes) | EMGP –               | 565 ± 260            | –                   | 313 ± 85       |
|                        | EGP –                 | 757 ± 334            | –                   | 442 ± 102      |
| Patient-related complications | EMGP 8/44        | 2/80                 | 4/82                | 2/81           |
|                        | EGP 4/22              | 4 + 1/74*            | 4/73                | 2/80           |
| Tube-related complications | EMGP –               | 43/80                | 27/82               | 11/81          |
|                        | EGP –                 | 36/74                | 14/73               | 9/80           |
| Cost (dollars)          | EMGP –                | 585.2 ± 47.6         | 543.3 ± 335.8       | 333 ± 24       |
|                        | EGP –                 | 705 ± 72.1           | 631.8 ± 332.5       | 461 ± 28       |

### Fig. 3 Forest plot of technical success.

### Fig. 4 Forest plot of tube-related complications.
| Study or Subgroup | EMGP Events | Total | EGP Events | Total | Weight | Risk difference M-H, Fixed, 95% CI | Total Events | Total Weight |
|------------------|-------------|-------|------------|-------|--------|----------------------------------|--------------|-------------|
| Gao, 2018        | 2           | 81    | 2          | 80    | 30.5%  | −0.00 [−0.05, 0.05]              | 2            | 30.5%       |
| Gerritsen, 2016  | 2           | 80    | 5          | 74    | 29.1%  | −0.04 [−0.11, 0.02]              | 5            | 29.1%       |
| Holzinger, 2016  | 8           | 44    | 4          | 22    | 11.1%  | 0.00 [−0.20, 0.20]               | 22           | 11.1%       |
| Kapelle, 2018    | 4           | 82    | 4          | 73    | 29.3%  | −0.01 [−0.08, 0.06]              | 73           | 29.3%       |
| **Total (95% CI)** | **287**    | **249** | **100.0 %** | **287** | **249** | **−0.01 [−0.05, 0.02]**               | **287**    | **249** |

**Total events**: 16

Heterogeneity: Chi² = 1.09, df = 3 (P = 0.78); I² = 0%

Test for overall effect: Z = 0.72 (P = 0.47)

▶ Fig. 5 Forest plot of patient-related complications.

| Study or Subgroup | EMGP Mean | SD | Total | EGP Mean | SD | Total | Weight | Mean difference IV, Fixed, 95% CI | Total Mean | Total SD | Total | Weight |
|------------------|-----------|----|-------|----------|----|-------|--------|----------------------------------|------------|----------|-------|--------|
| Gao, 2018        | 18        | 3  | 81    | 26       | 6 | 80    | 33.7%  | −8.00 [−9.47, −6.53]              | 18         | 5        | 80    | 91.5%  |
| Gerritsen, 2016  | 16.7      | 5  | 80    | 12       | 2.9| 74    | not estimable | not estimable | 12 | 2.9 | 74 |
| Holzinger, 2016  | 11.7      | 3.7| 44    | 15.2     | 3.2| 22    | 24.3%  | −3.50 [−5.23, −1.77]              | 15.2       | 3.2      | 22    | 24.3%  |
| Kapelle, 2018    | 20        | 5.5| 82    | 10       | 1.7| 73    | 42.0%  | 10.00 [8.69, 11.31]               | 10.00      | 8.69     | 11.31 |
| **Total (95% CI)** | **207**   | **175** | **100.0 %** | **207** | **175** | **0.65 [−0.20, 1.51]**               | **207**   | **175** |

Heterogeneity: Chi² = 349.87, df = 2 (P < 0.00001); I² = 99%

Test for overall effect: Z = 1.51 (P = 0.13)

▶ Fig. 6 Forest plot of procedure time.

| Study or Subgroup | EMGP Mean | SD | Total | EGP Mean | SD | Total | Weight | Mean difference IV, Fixed, 95% CI | Total Mean | Total SD | Total | Weight |
|------------------|-----------|----|-------|----------|----|-------|--------|----------------------------------|------------|----------|-------|--------|
| Gao, 2018        | 313       | 85 | 81    | 442      | 102| 80    | 91.5%  | −129.00 [−136.02, −119.98]        | 442        | 102      | 80    | 91.5%  |
| Gerritsen, 2016  | 565       | 260| 80    | 757      | 334| 74    | 8.5%   | −192.00 [−287.06, −96.94]         | 757        | 334      | 74    | 8.5%   |
| **Total (95% CI)** | **161**   | **154** | **100.0 %** | **161** | **154** | **−134.37 [−162.13, −106.61]**    | **161**   | **154** |

Heterogeneity: Chi² = 1.54, df = 1 (P = 0.21); I² = 35%

Test for overall effect: Z = 9.49 (P < 0.00001)

▶ Fig. 7 Forest plot of time to enteral nutrition.

| Study or Subgroup | EMGP Mean | SD | Total | EGP Mean | SD | Total | Weight | Mean difference IV, Fixed, 95% CI | Total Mean | Total SD | Total | Weight |
|------------------|-----------|----|-------|----------|----|-------|--------|----------------------------------|------------|----------|-------|--------|
| Gao, 2018        | 333       | 24 | 81    | 461      | 28 | 80    | 99.4%  | −128.00 [−136.06, −119.94]        | 461        | 28       | 80    | 99.4%  |
| Gerritsen, 2016  | 585       | 47 | 80    | 705      | 72 | 74    | Not estimable | Not estimable | 705 | 72 | 74 |
| Kapelle, 2018    | 543       | 335| 82    | 631      | 332| 73    | 0.6%   | −88.00 [−193.16, 17.16]            | 631        | 332      | 73    | 0.6%   |
| **Total (95% CI)** | **163**   | **153** | **100.0 %** | **163** | **153** | **−127.77 [−135.80, −119.73]**    | **163**   | **153** |

Heterogeneity: Chi² = 0.55, df = 1 (P = 0.46); I² = 0%

Test for overall effect: Z = 31.16 (P < 0.00001)

▶ Fig. 8 Forest plot of cost analysis of methods.
Cost

With regard to cost, three studies [11–13], with a total of 470 patients (243 in the EMGP group and 237 in the EGP group). The mean difference showed a $126 reduction in the EMGP patients (243 in the EMGP group and 237 in the EGP group).

Importantly, through the nose, requiring little or no sedation. Interestingly, the first users of EMGP considered anatomical alterations of the upper digestive tract as a relative contraindication. However, the studies included in this meta-analysis did not incorporate subgroup analyses to determine if altered anatomy impacted placement of nasoenteral feeding tubes. Nevertheless, additional, non-randomized comparative studies have demonstrated equal effectiveness and safety of EMGP among patients with altered anatomy [16, 17]. As such, this technique is likely applicable to a broad patient population; however, this study did not specifically evaluate this alternative EGP strategy; however, in Gerritsen et al trial, a slim gastroscope through the nostrils was employed and was found to have a lower rate of technical success compared to EGMP [11].

EMGP has been available since 2008, but the strategy is not widely available at all centers. Acknowledging that is critically important when evaluating novel tools and portending adoption patterns as well as assessing learning curves. Given that the device is placed similarly to a traditional blind passage of an enteral tube, we believe our findings may translate well to everyday, real-world clinical practice. In our own experience, EMGP is intuitive, easy to perform, and can readily be implemented in clinical practice. In addition, it does not require a physician or endoscopist to perform or confirm placement. While formal cost-effectiveness analyses have not been performed, the reduction in cost and time to enteral nutrition suggests a substantial healthcare savings opportunity with reduced length of stay for patients requiring enteral nutrition.

Understanding and recognition of hospital resources is also critically important. Endoscopic placement may require patient transportation to endoscopy suites, staff (including endoscopy and anesthesiology providers), sedation, and the need for confirmatory radiography. These factors likely relate to EMGP being a cost-saving procedure compared to traditional endoscopy. Regarding the cost of procedures, EMGP was shown to be cost-effective compared to a more traditional EGP approach. Regarding cost in this systematic review and meta-analysis, three studies reported associated monetary costs (two in US dollars and one in euros). Removing the European cost, we found EMGP to be cost-saving. However, it remains critically important to consider monetary unit, availability of the devices, staff, and particularities of each institution as well as the cost of endoscopy in different locations when the decision is made to begin enteral nutrition.

Importantly, EMGP provides many potential advantages over EGP that were not specifically evaluated in this systematic review and meta-analysis. Most importantly, EMGP is less invasive and does not require the use of deep or conscious sedation to achieve placement. Importantly, EMGP may be placed by a trained medical professional without direct involvement of a physician or endoscopist. In this study, outcomes of EMGP were compared to traditional EGP. While EGP traditionally requires sedation (moderate or deep based upon individual patient comorbid conditions and risks of sedation/anesthesia), an additional endoscopic placement strategy, though less commonly available among non-tertiary care centers, includes use of a slim gastroscope that allows for placement of a guidewire through the nose, requiring little or no sedation. Importantly, understanding and recognition of hospital resources is also critically important. Endoscopic placement may require patient transportation to endoscopy suites, staff (including endoscopy and anesthesiology providers), sedation, and the need for confirmatory radiography. These factors likely relate to EMGP being a cost-saving procedure compared to traditional endoscopy. While formal cost-effectiveness analyses have not been performed, the reduction in cost and time to enteral nutrition suggests a substantial healthcare savings opportunity with reduced length of stay for patients requiring enteral nutrition.
Specific anatomic alterations may make placement more challenging (similar to issues with endoscopic placement). While more data specific to patients with surgically altered anatomy are needed to validate these findings, it remains critically important to emphasize that clinicians need to understand the anatomy of all patients before attempting blind, endoscopic, or EMGP of nasoenteral feeding tubes.

While important, it should be noted that a traditional blind approach is likely to remain a first-line strategy for nasogastric tube placement in patients with unremarkable anatomy. However, for some patients, such as those with Zenker’s diverticulum, j-shaped stomach, or duodenal anatomic abnormalities, EGP may be preferred to EMGP, and also in cases of failed EMGP placement. At this time, endoscopy offers the additional ability to provide direct visualization as well as use of endoluminal instruments, including a guidewire, forceps, or countertraction from the endoscope itself [18, 19]. Importantly, studies to assess the role of EMGP in the setting of failed traditional placement or EGP as a rescue technique after inability to place a nasoenteral tube after EMGP have not been performed to date.

Despite the findings in the systematic review and meta-analysis, it is important to acknowledge this study is not without limitations. Although all included studies were RCTs, outcomes were not included uniformly across the studies. Furthermore, variable definitions of technical success were used by various study authors (i.e., endoscopic and/or radiographic confirmation of post-pyloric placement) which may limit the generalizability of these results. Procedure time was also noted to be highly variable based upon variable definitions used by the study authors, with one study by Gerritsen removed due to poor definition. In addition, familiarity with the EMGP device as well as interoperator variability (i.e., EGP and EMGP) may impact these results. While technical success rates were lower for EGP than some reported in the literature, this may be related more to exclusion of retrospective data (i.e., selection bias). Therefore, to resolve any lingering questions, it may be necessary to perform a new RCT to evaluate the outcomes objectively.

Despite these limitations, this systematic review and meta-analysis has several strengths. Most importantly, this study included only RCTs, minimizing the potential for selection bias and controlling for measured and unmeasured confounders. Furthermore, given the frequent need for nasoenteral feeding, the topic is of high clinical importance with easy translation into direct clinical practice. Lastly, outcomes were chosen based upon objective measures, further increasing the generalizability and applicability of these results, including cost, which may be a consideration more and more when implementing novel technologies or strategies in healthcare.

Conclusions

In this study, EMGP and EGP appeared equivalent regarding technical success and AE rates, as well as procedure duration. However, EMGP was associated with lower costs and reduced time to nutritional intake. As such, EMGP of post-pyloric enteral feeding tubes may be recommended as the first-line strategy, with EGP reserved for particular patients, such as those with altered anatomy, postoperative scenarios, or when EMGP fails.

Competing interests

Dr. Hourneaux de Moura is a consultant for Boston Scientific and Olympus.

References

[1] Arvanitakis M, Gkolfinakis P, Despott EJ et al. Endoscopic management of enteral tubes in adult patients – Part 1: Definitions and indications. European Society of Gastrointestinal Endoscopy (ESGE) Guideline. Endoscopy 2021; 53: 81–92

[2] Smithard D, Barrett NA, Hargroves D et al. Electromagnetic sensor-guided enteral access systems: a literature review. Dysphagia 2015; 30: 275–285

[3] Windle EM, Beddow D, Hall E et al. Implementation of an electromagnetic imaging system to facilitate nasogastric and post-pyloric feeding tube placement in patients with and without critical illness. J Hum Nutr Diet 2010; 23: 61–68

[4] Gerritsen A, van der Poel MJ, de Rooij T et al. Systematic review on bedside electromagnetic-guided, endoscopic, and fluoroscopic placement of nasoenteral feeding tubes. Gastrointest Endosc 2015; 81: 836–847.e2

[5] Byrne KR, Fang JC. Endoscopic placement of enteral feeding catheters. Curr Opin Gastroenterol 2006; 22: 546–550

[6] Ozdemir B, Frost M, Hayes J et al. Placement of nasoenteral feeding tubes using magnetic guidance: retesting a new technique. J Am Coll Nutr 2000; 19: 446–451

[7] Rao MM, Kallam R, Flindall I et al. Use of Cortrak® – an electromagnetic sensing device in placement of enteral feeding tubes. Proc Nutr Soc 2008; 67: E109

[8] Wei Y, Jin Z, Zhu Y et al. Electromagnetic-guided versus endoscopic placement of post-pyloric enteral feeding tubes: a systematic review and meta-analysis of randomised controlled trials. J Intensive Care 2020; 8: 92

[9] Moher D, Liberati A, Tetzlaff J. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ 2009; 339: b2535–b2535

[10] Holzinger U, Brunner R, Miehsler W et al. jejunal tube placement in critically ill patients: A prospective, randomized trial comparing the endoscopic technique with the electromagnetically visualized method. Crit Care Med 2011; 39: 73–77

[11] Gerritsen A, de Rooij T, Dijkstra MG et al. Electromagnetic-guided bedside placement of nasoenteral feeding tubes by nurses is non-inferior to endoscopic placement by gastroenterologists: a multicenter randomized controlled trial. Am J Gastroenterol 2016; 111: 1123–1132

[12] Kappelle WFW, Walter D, Stadhouwers PH et al. Electromagnetic-guided placement of nasoduodenal feeding tubes versus endoscopic placement: a randomized, multicenter trial. Gastrointest Endosc 2018; 87: 110–118

[13] Gao X, Zhang L, Zhao J et al. Bedside electromagnetic-guided placement of nasoenteral feeding tubes among critically ill patients: A single-centre randomized controlled trial. J Crit Care 2018; 48: 216–221

[14] Sterne JAC, Savović J, Page MJ et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ 2019; 366: i4898
[15] Guyatt GH, Oxman AD, Vist GE et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008; 336: 924–926

[16] Gerritsen A, Duflou A, Ramali M et al. Electromagnetic-guided versus endoscopic placement of nasojejunal feeding tubes after pancreateoduodenectomy. Pancreas 2016; 45: 254–259

[17] Kaffarnik MF, Lock JF, Wassilew G et al. The use of bedside electro-magnetically guided nasointestinal tube for jejunal feeding of critical ill surgical patients. Technol Heal Care 2013; 21: 1–8

[18] Tsatsanidi KN, Pugaev AV, Krendal AP et al. [Endoscopic placement of a jejunal tube and a method of conducting enteral feeding with special mixtures]. Vestn Khir Im I I Grek 1987; 139: 61–66

[19] Paski SC, Dominitz JA. Endoscopic solutions to challenging enteral feeding problems. Curr Opin Gastroenterol 2012; 28: 427–431