Original Article

Auscultation-assisted bedside postpyloric placement of feeding tube in critically ill patients: a prospective, observational study

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Background and Objectives: To assess the efficacy and safety of auscultation-assisted bedside postpyloric feeding tube (ABPFT) placement in early enteral nutritional support for critically ill patients. **Methods and Study Design:** A prospective observational study was conducted and 92 critically ill patients who met the inclusion criteria undergoing ABPFT placement after the intravenous injection of 10 mg of metoclopramide were included. Abdominal X-ray was performed to confirm the location of the catheter tip. End points investigated were the success rate of tube placement, rate of jejunal tube placement, duration of the procedure, length of insertion, and number of attempts. Operational-related adverse events or complications were also documented and evaluated. **Results:** The total success rate of postpyloric feeding tube implantation was 97.8% (90/92), among which, 89.1% (82/92) of the tubes were placed proximal to the jejunum. The first-attempt success rate was 91.3% (84/92) and the mean attempt per individual patient was 1.11±0.38 times. The mean operation time was 28.6±17.7 minutes, and the mean insertion length of tube was 106±9.6 cm. A total of 27 adverse events occurred in 19.6% (18/92) patients and there was no serious adverse events or complications during the study period. **Conclusions:** Assistance by auscultation can significantly improve the success rate of nasal feeding tube placement. This simple, safe and fast approach is feasible for the application among health practitioners in the intensive care unit.

Key Words: blind bedside, postpyloric placement, auscultation, nasojejunal tube, enteral nutrition

INTRODUCTION

Enteral nutritional support is one of the crucial treatment modalities for critically ill patients, which can significantly improve the prognosis of these patients compared with parenteral nutrition.[1] Jejunal nasogastric tube feeding, as a well-established treatment operation, has become an essential nutritional approach in patients with diseases such as severe acute pancreatitis, esophageal fistula, and severe gastroparesis. In addition, considering the risk factors for enteral feeding intolerance often seen in critically ill patient such as advanced age, mechanical ventilation, sedation, muscle relaxation, supine position, large volume feeding, previous gastroesophageal reflux, unconsciousness, and high-level paraplegia,[2,3] various practice guidelines recommend postpyloric feeding to be considered in these circumstances[4-8] to achieve the target feeding rate as soon as possible, and reduce the risk of aspiration pneumonia.[9-12]

At present, X-ray and endoscopy are the most commonly used guiding approaches for the placement of jejunum feeding tubes, with a success rate of almost 100%.[13-15] However, it often requires transferring the patients to the radiology department or endoscopic center, which would not only increase preparation time for the procedure and workload of healthcare staff, but is also limited by the disease severity of critically ill patients and their tolerance to transport.[16] Therefore, bedside approaches for jejunum nasogastric feeding tube placement are gaining momentum recently, such as electromagnetic navigation and ultrasound guidance.[17-19] However, the shortcomings of these techniques are their uncertain success rate and dependency on the device and equipment. Recently, many have reported a bedside blind placement of jejunum tube

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but with various success rate and unsatisfactory reliability.[20-25] The latest study found that only 5.5% of ICU patients had a transnasal feeding tube,[26] indicating a lack of a universal and safe method for the bedside placement of transnasal jejunal tube. The purpose of this prospective study was to evaluate the safety and efficacy of auscultation-assisted bedside postpyloric feeding tube (ABPFT) placement.

METHODS

Study design

This study is a single-center and prospective observational study approved by the ethics committee of the General Hospital of PLA (No. S2017-054-01) and registered at http://www.chiric.org.cn (ChiCTR-OOC-17012108).[27] The patients were fully informed of the content of the study prior to the start of the study and informed consent forms were signed by the patient or the patient's next of kin (authorized family member). The study design is consistent with requirements of an observational study in clinical epidemiology.[28]

Patients

Critically ill patients admitted in the ICU who had enteral nutrition support since July 24, 2017 were enrolled into this study if they had one of the following comorbidities or risk factors for gastric feeding intolerance: 1) severe acute pancreatitis; 2) mechanical ventilation ≥48 hours; 3) history of gastroesophageal reflux disease; 4) impairment of consciousness (Glasgow score ≤8); 5) high-level paraplegia; 6) need for continuous use of sedatives or muscle relaxants; 7) intolerance to gastric feeding; 8) esophageal fistula. Patients were excluded if they met one of the following criteria: 1) the presence of gastrointestinal bleeding, obstruction or lower gastrointestinal fistula and enteral nutrition was not possible; 2) nasopharyngeal tumors, bleeding, surgery and other conditions making nasal cannulation impossible; 3) contraindications for metoclopramide; 4) history of esophageal varices confirmed by endoscopy or computed tomography (CT) scan; 5) progressively deteriorating disease without effective control.

Materials and medications

A total of two types of nasogastric tubes were used in this study: a 10-F convolute nasogastric tube (Flocare Bengmark, CH10-145 cm, NUTRICIA, The Netherlands) and a Frey Trelumina feeding tube (CH16/9-150 cm, FRESENIUS KABI, Germany). Other equipment used were 20ml syringes, stethoscopes, measuring rulers, paraffin oil, and metoclopramide (injection).

Technique of auscultation-assisted bedside postpyloric placement of feeding tube

Different from other bedside blind jejunal feeding tube placement methods, this study introduces an auscultation-assisted approach that is characterized by intermittent injection of a small amount of gas (5mL/time) to the lumen while simultaneously checking the catheter tip position via auscultation by stethoscopes. The specific auscultation sites and their corresponding anatomic locations were shown in Figure 1.

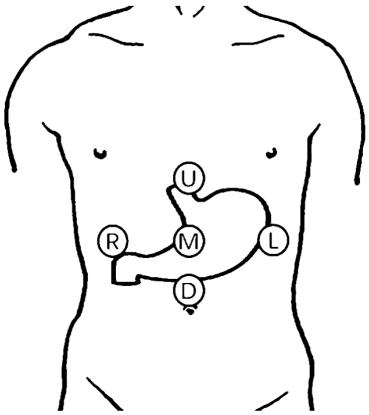

Figure 1. Auscultation sites and anatomic locations. U: the subxyphoid, corresponding to the gastric fundus; D: the umbilical cord, corresponding to the junction between the great curvature of the stomach and the antrum; M: the middle point between point U and point D, corresponding to the middle of the gastric cavity; R: the intersection point between the horizontal line through M and the midline of the right clavicle, corresponding to the bulbar and descending part of the duodenum; L: the intersection point between the horizontal line through M and the midline of the left clavicle, corresponding to the junction of stomach body and fundus on the greater curvature side.

Ethics approval and consent to participate

All subjects provided informed consent. This study was approved by the medical ethics committee of the General Hospital of PLA (No. S2017-054-01) and registered at http://www.chiric.org.cn (ChiCTR-OOC-17012108)

Preparation

There is no special requirement for patient position, although the supine position is most commonly adopted with head elevation of 30 to 45 degrees. A slow intravenous injection of metoclopramide (10mg) was given 10 minutes prior to the procedure. Sedative agents may also be given when indicated. One of the two types of feeding tubes was randomly selected, and the tube and guidewire were fully lubricated with paraffin oil. The length from the earlobe through the tip of the nose to the subxyphoid (U) and to the umbilicus (D) were measured (recorded as L1 and L2, respectively), as well as the length from D to R (recorded as L3).

The procedure

The procedure was performed by intensive care physicians or nurses who have undergone standardized training previously, and all of them had previous experience of blind insertion of jejunum tube by other bedside methods.

The feeding tube with guide wire was inserted through the nasal cavity, and then carefully forwarded with the same approach as nasogastric tube placement. After the feeding tube is confirmed to be in the stomach (approximately the length of L1) by Whoosh test[29] or aspiration of gastric fluid, the tube was further advanced to the length L2. A sufficient suction was then done with a syringe to maximally empty the gas and fluid within the stomach, before rapid gas injection of 5mL with simultaneous auscultation with a stethoscope at point M to feel the strength of the sound.

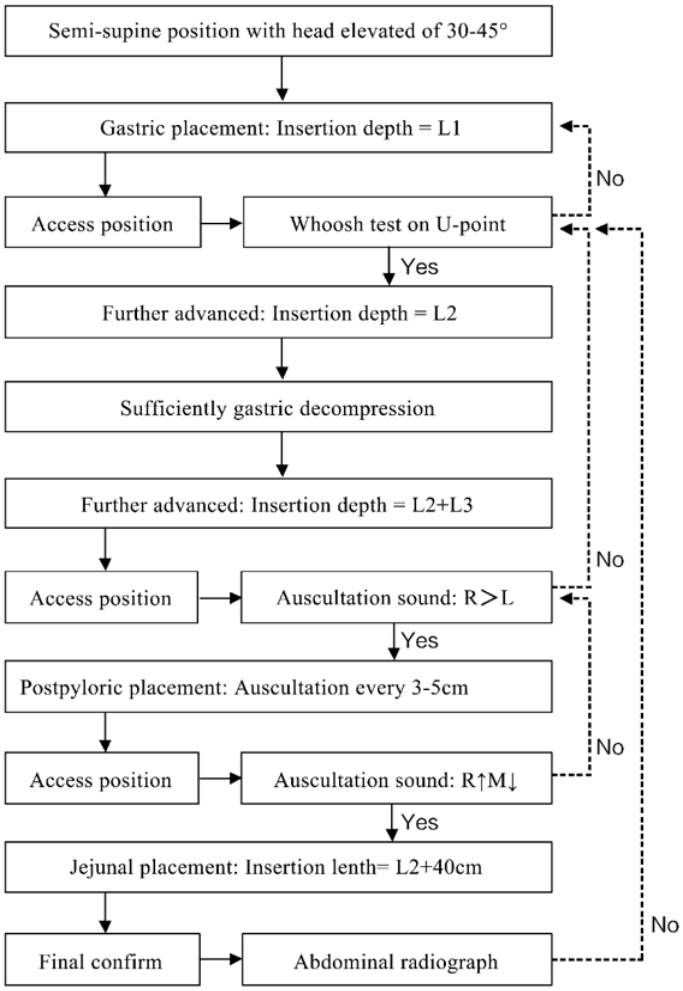

Figure 2. Steps of auscultation-assisted bedside postpyloric feeding tube (ABPFT) placement. U: the subxyphoid; D: the umbilical cord; M: the middle point between point U and point D; L: the intersection point between the horizontal line through M and the midline of the left clavicle; L1: the length from the earlobe through the tip of the nose to U; L2: the length from the earlobe through the tip of the nose to D; L3: the length from D to R.

Subsequently, the jejunal tube was slowly inserted with a gentle force and the resistance was felt by the operator. When inserted at the length of (L2 + L3), auscultation was performed at the five auscultation points (U, D, L, R and M). The 5 mL of gas was injected with the same rate and complete suction afterwards. If the point with the strongest sound was located at R or between R and D, the operator should continue to advance the feeding tube slowly and repeat auscultation every 3-5 cm until the strongest sound reached point R while the sound at point M was abruptly turned down, indicating that the feeding tube has passed through the pylorus into the duodenal bulb or its descending part. If the strongest sound was located at U or L and the insertion resistance significantly reduced, the tube should be retracted to the length of L1 and the above procedure should be repeated.

When the feeding tube is advanced beyond the pylorus, the operator should continue advancing the tube slowly while repeating auscultation every 5-10 cm to identify whether the strongest part of sound is consistent with the shape of the duodenum consistent until the inserted length reaches 100-110cm (calculated based on patient height or empirically [L2 + 40] cm). The feeding tube is then fixed to the alar area with tape followed by a bedside X-ray. If the tip of the feeding tube has reached the Treitz ligament, the guidewire could be removed slowly and then enteral feeding could also be given. If X-ray result is indeterminant about whether the feeding tube has passed the pylorus, the operator should retract the feeding tube back to L2 and repeat the above operation. The detail of procedure steps is shown in Figure 2.

Outcomes and endpoints

Clinical parameters prior to intubation were collected, including baseline characteristics, disease diagnosis, presence or absence of mechanical ventilation, use of vasopressors or sedatives, and results of disease severity assessment such as acute physiology and chronic health evaluation (APACHE) II, sequential organ failure assessment (SOFA), and nutrition risk in the critically ill (NUTRIC) scores.

The intubation process was performed under supervision. The variables documented were: the duration of the procedure, the length of intubation, the number of attempts (number of X-ray examinations), the adverse events from intubation or metoclopramide. Meanwhile, the changes in vital signs during intubation, including heart rate (HR), respiratory rate (RR), mean arterial pressure (MAP), pulse oximetry (SpO_2), and electrocardiographic were also documented.

The primary endpoint was the success rate of the feeding tube insertion into the pylorus, defined as tube reaching or exceeding the first part of the duodenum, as judged by bedside radiographs by intensive care physicians and experienced radiologists. Secondary endpoints included the rate at which the tube was placed further to the Treitz ligament, duration of the procedure, length of insertion, and number of attempts. The failure of the procedure was defined as three unsuccessful attempts to place the feeding tube into the pylorus and other approaches must be used.

Safety endpoints included catheter-related adverse events or vital signs events, the latter is defined as over 20% change in preoperative HR, RR or MAP, or SpO2 below 90% during the procedure.

Statistical analysis

All statistical analyses were conducted using SPSS21.0 software (IBM Corp., Armonk, NY, USA). Quantitative variables were expressed as median or mean ± standard deviation, and qualitative variables were expressed as the number of cases or percentages.

RESULTS

From July 2017 to March 2018, a total of 683 critically ill patients were admitted to the department, and 92 of them were eventually enrolled in the study according to the inclusive and exclusive criteria. Among which, 81 (88%) had APACHE II scores >8, 63 (68.5%) needed mechanical ventilation, 28 (30.4%) required chronic renal replacement therapy (CRRT), and 15 (16.3%) required vasoactive drugs for blood pressure maintenance. The baseline characteristics of the included patients were presented in Table 1.

Endpoints

Ninety (97.8%) out of the 92 patients had successful placements of transnasal jejunal feeding tube distal to the pylorus with assistance of auscultation, and 82 of which had feeding tube placed proximal to the jejunum (Table 2). The first-attempt success rate in tube placement was 91.3% (84/92), with an average of 1.11±0.38 attempts per patient, a mean operation time of 28.6±17.7 minutes, and a mean catheter length of 106±9.6 cm. Two patients who had failed tube placement both had history of radical resection of esophageal cancer. The feeding tube was then successfully placed under the guidance of a bedside upper endoscopy on the next day, and 1 patient was found with severe gastroptosis under endoscopy.

Complications and adverse events

A total of 27 adverse events occurred in 19.6% (18/92) of included patients, including vital sign fluctuations, nausea, mucosal injury, and pain due to intolerance to intubation that required additional sedation and analgesic agents (Table 3). The vital sign fluctuation presented mainly with heart rate and respiration rate changes that would typically returned to the baseline level after the procedure. No significant changes of blood pressure and SpO_2, nor serious adverse events such as aspiration or misplacement into the trachea or drug reactions to metoclopramide were found.

DISCUSSION

The most challenging part of transnasal jejunal feeding tube placement is ensuring the tube to pass through the pylorus. Some of the traditional assistive methods, including pushing a tube with external force through the pylorus under direct vision (endoscope), or with indirect assistive approaches (such as chest X-ray and electromagnetic navigation) to determine the location of the tip of the tube, can be used with a relatively high success rate. This indicates that if assisted with direct or indirect monitoring or guidance, jejunal feeding tube can become a relatively easy procedure for clinicians. However, the above approaches have substantial dependency on equipment or exposure to radiation damage, which would pose consid-

Table 1. General characteristics and clinical data of patients enrolled†

Characteristics	Values (n=92)
Age (years)	53.1±13.2
Gender, male	69 (75.0)
Height (cm)	169±7.7
Weight (kg)	69.2±11.4
BMI (kg/m^2)	24.2±3.1
Primary diagnosis	
Severe acute pancreatitis	31 (33.7)
Gastrointestinal	22 (23.9)
Neurologic	17 (18.5)
Multiple trauma	8 (8.7)
Sepsis	6 (6.5)
Respiratory	4 (4.3)
Cardiovascular	2 (2.2)
Others	2 (2.2)
Preexisting diseases	
Hypertension	24 (26.1)
Previous gastrointestinal surgery	11 (12.0)
Coronary heart disease	9 (9.8)
Gastroesophageal reflux disease	5 (5.4)
APACHE II score	16.5±8.0
SOFA score	6.5±4.1
NUTRIC score	4.1±2.3
Mechanical ventilation	63 (68.5)
CRRT	28 (30.4)
Vasopressors	15 (16.3)
Sedatives & Analgesics	36 (39.1)

BMI: body mass index; APACHE II: acute physiology and chronic health evaluation II; SOFA: sequential organ failure assessment; NUTRIC: nutrition risk in the critically ill; CRRT: continuous renal replacement therapy.
†Data is presented as mean±standard division or number (percentage).

Table 2. Primary and second endpoints of the procedures†

Endpoints	Values (n=92)
Primary endpoint	
Postpyloric placement	90 (97.8)
Secondary endpoints	
Placed at the proximal jejunum	82 (89.1)
Time to insertion (min)	28.6±17.7
Number of attempts	1.11±0.38
Success in first attempt	84 (91.3)
Length of insertion (cm)	106±9.6

†Data is presented as mean±standard division or number (percentage).

Table 3. Major procedure-associated events during the insertion[†]

Procedure-associated events	Values (n=27)
Vital signs events[‡]	7 (25.9)
Increased sedation or analgesia during procedure	7 (25.9)
Nausea	6 (22.2)
Nasal or pharyngolaryngeal mucosa bleeding	3 (11.1)
Nasal or pharyngolaryngeal pain	2 (7.4)
Vomiting	1 (3.7)
Abdominal distention	1 (3.7)

[†]Data is presented as number (percentage).
[‡]Defined as vital sign fluctuate over the range of ±20% or pulse oxygen saturation drop to less than 90% during the insertion.

erable risks for critically ill patients.

Therefore, many recent studies are investigating the role of portable equipment (such as ultrasound and electrocardiogram devices) on the assistance of feeding tube placement[18,19] or blind bedside transnasal jejunal tube,[20-25] aiming at minimizing the equipment dependence of this procedure and facilitate the popularization of the technique. However, the success rates of the above methods were not satisfactory. A recent study investigating blind bedside placement in 127 critically ill patients reported a success rate of 81.9% for postpyloric feeding tube placement.[30] Therefore, the accuracy and reliability of these instruments, as well as the pH test and vacuum test, are still not sufficient to satisfactorily guide the tube placement procedure.

In this study, transnasal jejunum tube was placed with the bedside approach assisted by abdominal auscultation. The success rate of postpylorus tube placement (97.8%, 90/92), the first-attempt success rate (91.3%), and the mean number of attempts per patient (1.11±0.38) were all significantly more favorable compared with previous studies, indicating that the auscultation-assisted technique can accurately determine the position of the tip of the feeding tube and serve as a reliable "eye" for the blind procedure, which can significantly improve the success rate. Two patients with failed intubation both had history of radical esophageal cancer resection and one of them had severe gastroptosis, which made the accurate localization through auscultation almost impossible. Therefore, this approach may not be suitable for patients with anatomical changes of the upper gastrointestinal tract after surgery.

Another reason for the high success rate of this study may be the adequate decompression of the gastrointestinal tract prior to the procedure and prompt aspiration of the gastric air during the procedure, so that the volume of the gastric cavity could be minimized, and the tube would not easily be reverted in the stomach. These facilitated a smooth passage of the tube through the pylorus. In addition, when the tube wall is too soft, it may not be able to overcome the friction of the stomach wall and would be easily reverted. The two types of feeding tube used in this study are more tenacious and can better transduce force, which might have contributed to the higher success rate in this study.

Multiple previous studies reported that a blind transnasal tube placement is safe,[20,21,30-32] but some also found that the blind jejunal tube placement could lead to more serious complications such as perforation of the alimentary tract and misplacement into the trachea.[33,34] The mean APACHE II score in patients included in this study was 16.5 ± 8.0 (up to 37). In addition, the proportion of patients requiring mechanical ventilation, CRRT, or vasoactive drugs was 68.5%, 30.4%, and 16.3%, respectively. Although the overall risk was high, all patients successfully underwent the operation. The overall incidence of adverse events was 27 in 18 patients (19.6%) consisting mainly of minor life events such as nausea, mucous membrane bleeding, tachycardia and shortness of breath that quickly alleviated after the procedure. This indicates that it is safe to avoid forced advance of the tube via the auscultation-assisted approach, which can be carried out in a wider range of critically ill patients.

In the previous study by Lv et al,[30] the insertion length of the feeding tube was 95.6±9.3 cm, and in 33.9% of the patients the tube was managed to reach the proximal jejunum. In comparison, the mean insertion length of tube in our study was 106±9.6 and 89.1% of the patients the tube was delivered distal to the Treitz ligament, and the incidence of adverse events was relatively low. Our findings indicate that the deeper placement of jejunal feeding tube is safe.

Early enteral nutrition in critically ill patients may be associated with shorter ICU length of stay and better prognosis.[6] Many studies suggest that jejunal nutrition can reduce feeding intolerance regurgitation more effectively and thus reduce the incidence of aspiration.[2,3,5,7] Therefore, ABPFT can provide a reliable way for the implementation of early enteral nutrition, and significantly reduce operating time and cost compared with other methods such as navigations by endoscopy, fluoroscopy or magnet.

All operators of this study were both doctors and nurses, and they all had previous experience of blind nasojejunal intubation. It should also be taken into account that the success rate of this procedure may also depend on the operator's experience and technique. Therefore, for beginners, basic skills training may be needed. And whether this method can still maintain a high success rate may need to be further validated by future studies with multicentral nature and larger patient volume.

Conclusion

Auscultation-assisted bedside postpyloric feeding tube placement is a simple, safe and lowcost method that allows feasible bedside procedure at any time without the need for special additional equipment. It is potentially a more effective way of early enteral nutritional support for

critically ill patients. The method is easy to learn and master, and is ready for application and popularization among ICU medical personnel.

AUTHOS DISCLOSURES

The authors declare no conflict of interest.

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