ORIGINAL RESEARCH

Bedside Ultrasound-guided Nasointestinal Tube Placement in Critically Ill Patients in Intensive Care Unit

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ABSTRACT

Objective • To verify the efficacy and safety of bedside ultrasound-guided nasointestinal tube (NIT) placement techniques in critically ill patients in the ICU.

Methods • 100 Critically ill patients were selected and were randomly enrolled into a bedside ultrasound guidance (BUG) group (BUG guiding the NIT placement) and a traditional blind insertion (TBI) group, with 50 cases in both. The efficacy and safety of these tube placements were compared.

Results • The success rate of intubation in the BUG group (74%) was higher than that in the TBI group (44%). The proportion of patients in the BUG group who had catheterization sites in the intestine (72%) was higher than that in the TBI group (46%) ($P < .05$). The average number of tube insertions and mean time of successful intubation time in the BUG group was slightly higher than those in the TBI group [(1.22 ± 0.00) times vs. (1.20 ± 1.00) times and (24.40 ± 0.50) min vs. (20.72 ± 0.50) min) ($P > .05$) respectively].

Conclusions • Bedside ultrasound-guided nasojejunal tube has a good outcome in ICU patients with critical conditions, can improve the success rate of intubation, and has a certain safety. (*Altern Ther Health Med.* 2023;29(8):178-182).

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INTRODUCTION

Enteral nutrition therapy is generally considered to be better than parenteral nutrition therapy for critically ill patients. The commonly adopted routes of enteral nutrition in clinical practice are gastric tube feeding and post-pyloric small intestinal nutrition. Studies have shown that compared with gastric nutrition in critically ill patients, small intestinal nutrition may be easier to achieve nutritional goals and reduce the risk of hospital-acquired pneumonia.[1,2] However, meta-analysis suggested that the risk of hospital-acquired pneumonia did not differ between duodenal and jejunal nutrition.[3]

The latest guidelines of the American Society of Critical Care Medicine/Parenteral and Enteral Nutrition Society and the European Society of Critical Care Medicine both recommend post-pyloric nutrition for patients with high risk of aspiration.[4,5] The former lists high risk factors for aspiration including advanced age, mechanical ventilation, disturbance of consciousness, loss of airway protection ability, and ICU transportation. Almost every critically ill patient admitted to ICU has more than two of these high-risk factors in addition to risk of delayed gastric emptying.[6,7] Most critically ill patients in ICU may require small intestinal nutrition.

The main factor determining whether early small intestinal nutrition is possible is successful placement of the nasointestinal tube (NIT); this is often difficult. The Canadian Nutrition Guidelines for critically ill patients cited survey data that indicated that the biggest gap between the clinical nutrition practice and the guidelines for critically ill patients was that NIT was not inserted in time for patients with high gastric retention or those who could not receive adequate gastric feeding[8]. The results of the relevant questionnaire survey for ICU also suggested that the main reason for the implementation of enteral nutrition was the difficulty and delay of small bowel catheterization.[9]

At present, the commonly used and reliable methods of indwelling NIT are fluoroscopy or endoscopic catheterization,[10] but these two techniques have their own obvious shortcomings and risks for patients in ICU. Although it is convenient, the results of blind insertion and indwelling

NIT are inconsistent, especially in critically ill patients, and are associated with poor reliability and certain complications.[11,12] Therefore, it is necessary to find a simple, convenient, and safe method with high success rate of small bowel tube placement for patients in ICU. It has been reported that ultrasound-guided NIT technology has been applied to patients in ICU at home and abroad, and the success rate of catheterization is about 80%. It is safe and convenient and can be implemented by almost one person at the bedside, showing a good application prospect. However, the number of cases in current studies is small, and none of them are randomized controlled studies.[13-16] Recent studies have confirmed that ultrasound can reliably locate the placement of NITs in the duodenal bulb of critically ill patients.[17]

The aim was to determine the success rate of intestinal placement and verify the efficacy and safety of bedside ultrasound-guided versus blind NIT insertion technique in ICU patients. This was a clinical prospective randomized controlled trial.

PATIENTS AND METHODS

Subjects

100 critically ill patients admitted to the ICU of Second Affiliated Hospital of Jiaxing University from January 2021 to March 2022 were enrolled. Inclusion criteria: patients were ≥18 years old; critically ill patients who were admitted to the ICU and required indwelling small intestinal feeding tube; and, patients who were informed about this trial and signed the consent form. Exclusion criteria: patients were pregnant or lactating; patients aged <18 years; patients with severe coagulopathy; patients with platelet (PLT) <20 000/μL; patients with severe skull base fracture; patients with nasopharyngeal or esophageal obstruction; and, patients with contraindications to nasojejunal tube placement (nasopharyngeal surgery, esophageal varices, gastrointestinal bleeding, gastrointestinal failure, intestinal obstruction, intestinal ischemia). There were 65 men and 35 women. The age of patients ranged from 24 to 95, with an average age of 66.55 ± 14.00. The body mass index (BMI) of patients was 17.71-34.6 kg/m^2, with the mean BMI of (22.62 ± 0.63) kg/m^2. The patients were randomly divided into two groups using a random number table method: BUG (n = 50) and TBI groups (n = 50). BUG group were given with bedside ultrasound-guided NIT insertion, and TBI group were treated with traditional blind NIT insertion method. The clinical efficacy and safety of two indwelling NIT methods were compared.

NIT implantation method

TBI group: nasojejunal tube (Wilson-Cook Medical Incorporated, USA, Model: NJFT-8, NJFT-10) were performed by an ICU doctor with professional training. Metoclopramide (Hunan Huateng Pharmaceutical Co., LTD., specification: 10 mg/mL, Changsha, China) was intravenously injected 30 minutes before the operation, which promotes gastrointestinal motility. Then, the length of the ear lobe-nasal tip and the tip-xiphoid process was measured, i.e., the length of tube required to reach the gastro-esophageal junction. After that, the patient was instructed to lie on the back, and the patient's nasal cavity and the guide wire were soaked with physiological sodium chloride solution (Sichuan Kelun Pharmaceutical Co., LTD., specification: 4.5 g/500 mL, Chengdu, China), and the NIT was lubricated with paraffin oil (Hengshui Shengkang Chemical Co., LTD., Hengshui, China). The nasojejunal tube was placed through the nasal cavity and moved slowly forward with the patient's breathing and swallowing, then was sent to the marked site to stop pushing. The traditional inflation auscultation method was used to determine whether the tube tip had entered the stomach, and the wire was applied to suspend and fix. The position of the catheter was determined by X-ray examination of the gastric cavity by an ICU nurse and doctor within 24 hours after the catheter was placed.

BUG group: the operating doctors had the Zhejiang Ultrasound post training qualification certificate and the critical ultrasound training certification certificate, and they were able to locate and identify the anatomical structure of the digestive tract by the bedside ultrasound system. Mylab Gold25 ultrasound (Esaote, Italy) and ultrasound CA123, IOE323 probe (5-8 MHz, 2.5-5 MHZ) were used to guide positioning. Before intubation, the catheter depth is marked, and the patient is positioned. The nasal cavity and the catheter are moistened. The surface of the NIT is lubricated, consistent with the TBI group. The guidewire is kept in place inside the NIT. Generally, pushing the NIT forward for 55-65 cm is sufficient to reach the stomach. The patient is placed in a supine position and the NIT is inserted forward from the nasal cavity until it reaches the posterior pharyngeal wall. When the patient is awake, they are instructed to swallow repeatedly. During the insertion of the NIT, another ICU physician uses real-time ultrasound monitoring to ensure the correct positioning and to prevent any unforeseen complications.

All patients were evaluated by bedside ultrasound to determine whether the tube was in the small intestine via the ultrasound localization method. This method uses a low-frequency convex array probe to detect below the xiphoid process, transversely, transitioning to the right upper abdomen for surface localization of the anterior wall of the stomach, transitioning to the pyloric region, and transitioning to the duodenal area. If repeated placement failed, rescue placement was carried out under gastroscope guidance.

Statistical data

The general clinical characteristics of all patients such as gender, age, BMI, bladder pressure, tracheal intubation/tracheotomy, vasopressor drug use, coagulation function index PT and PLT levels, acute physiology and chronic health evaluation II (APACHE II) score, main diagnosis of disease, and other general data were collected and statistically analyzed.

Observation indicators

(1) The number of patients with successful intubation (into the small intestine) in the two groups was recorded, and then the intubation success rate (ISR) was calculated.

(a) $$ISR = \frac{N_{(s)}}{N_{(all)}} \times 100\%$$

$N_{(s)}$ represents the number of patients who were successfully intubated; $N_{(all)}$ represents the total number of patients in that group who were intubated.

(2) The number of intubations was recorded, and the number of intubations in patients with successful intubation was the number from the first to successful intubation. The number of intubations in patients with failed intubation was the number from the first to rescue intubation.

(3) The successful catheterization time of patients was recorded. The successful catheterization time of patients with successful intubation was the time from the first to successful intubation. For patients with failed intubation, the time of successful intubation was defined as the time from the first to rescue intubation.

(4) Abdominal ultrasound was applied to observe the placement sites (including jejunum, descending duodenum, antrum, intragastric, and pylorus), and different tube positions ratio (TPR) was computed.

(b) $$TPR = \frac{N_{(position)}}{N_{(all)}} \times 100\%$$

$N_{(position)}$ means the number of patients whose tube was at that site.

(5) The incidence of related complications (such as catheter displacement and gastrointestinal perforation) during catheterization was observed, and the incidence of complications (IOC) was computed.

(c) $$IOC = \frac{N_{(Complication)}}{N_{(all)}} \times 100\%$$

$N_{(Complication)}$ means the number of patients with associated complications.

Statistical analysis

Statistical Product and Service Solutions (SPSS) 22.0 software (IBM, Armonk, NY, USA) was adopted for statistical analysis. Measurement data were presented as mean ± standard deviation ($\bar{x} \pm s$), repeated measurement data were compared by repeated measurement analysis of variance, and further contrast was carried out by t test. Count data were presented as rate (%) and χ^2 test was applied. P <0.05 was considered statistically meaningful.

RESULTS

Statistics of general clinical characteristics

The general clinical characteristics of patients in the TBI group and the BUG group were compared in terms of gender, age, BMI, bladder pressure, intubation/tracheostomy status, use of vasoactive drugs, coagulation function indicators (PT), platelet levels, acute physiological and chronic health evaluation (APACHE II) score, and main diagnosis. The statistical analysis is presented in Table 1. After comparison, there were no significant differences in gender, average age, average BMI, average bladder pressure, intubation/tracheostomy status, use of vasoactive drugs, average PT, average PLT, and average APACHE II score between the two groups (P>.05).

Table 1. General Data of Patients

Index		TBI group (n = 50)	BUG group (n = 50)
Gender (n)	Male	33	32
	Female	17	18
Age (years)	Range	16.5 - 90	27 - 95
	$\bar{x} \pm s$	65.32 ± 16.50	67.78 ± 15.50
BMI (kg/m^2)	Range	18.23 - 26.81	17.71 - 34.6
	$\bar{x} \pm s$	22.41 ± 3.00	22.82 ± 0.87
Bladder pressure (cm H_2O)	Range	4 - 18	3 - 36
	$\bar{x} \pm s$	7.52 ± 5.50	7.32 ± 4.50
Tracheal intubation/ tracheotomy or not (n)	Yes	42	40
	No	8	10
Vasopressor use or not (n)	Yes	2	6
	No	48	44
PT (s)	Range	11 - 16.8	10.5 - 24.1
	$\bar{x} \pm s$	14.04 ± 0.25	14.66 ± 0.45
PLT (×10^9)	Range	67 - 540	43 - 464
	$\bar{x} \pm s$	194.36 ± 156	173.96 ± 40
APACHE II	Range	11 - 29	11 - 42
	$\bar{x} \pm s$	19.4 ± 7.00	19.89 ± 4.00

Table 2. Comparison of the Distribution of Main Symptoms in Two Patient Groups

Main Symptoms	TBI group (n = 50)	BUG group (n = 50)
Respiratory diseases (%(n))	28(14)	26(13)
Brain disorders (%(n))	46(23)	46(23)
Abdominal diseases (%(n))	6(3)	10(5)
Traumatic injuries/fractures (%(n))	8(4)	8(4)
Others (cancer, heart diseases) (%(n))	12(6)	10(5)

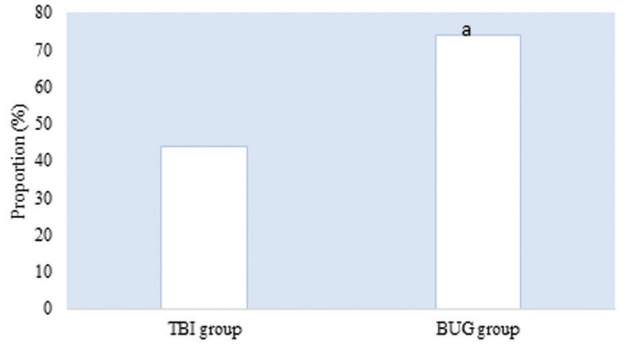
Distribution of main diseases

The distribution of main diseases among patients in the TBI group and the BUG group was analyzed, including lung diseases, brain disorders, abdominal diseases, traumatic conditions, fractures, cancer, heart diseases, and others. The statistical analysis is presented in Table 2. After comparison, there were no significant statistical differences in the distribution of main diseases between the two groups (P>.05).

Success rate of intubation

In the TBI group, there were 22 successful intubation cases, accounting for 44% of the total. In the BUG group, there were 37 successful intubation cases, accounting for 74% of the total. After comparison, the success rate of intubation was significantly higher in the BUG group compared to the TBI group, with a statistically significant difference (P<.05), as shown in Figure 1.

Figure 1. Comparison of Intubation Success Rates Between the Two Groups



[a]Indicates Statistical Significance Compared to the TBI Group, $P < .05$)

Figure 2. Comparison of Time to Successful Intubation Between the Two Groups

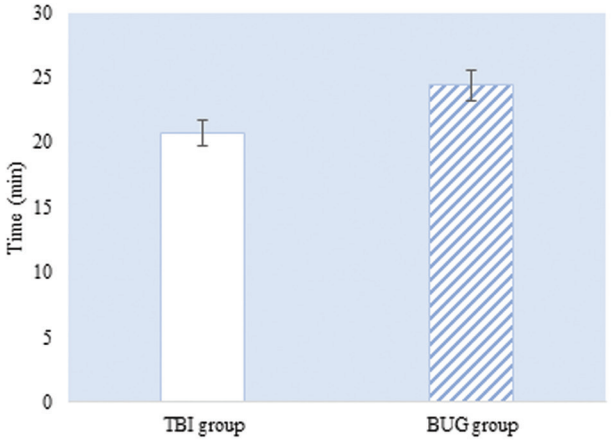


Figure 3. Translation: Placement of Catheters in Two Patient Groups (**A**. Jejunostomy Tube Enters the Gastric Antrum via the Angle of his, **B**. Jejunostomy Tube Enters the Pylorus into the Duodenal Bulb, **C**. Jejunostomy Tube Enters the Horizontal Portion of the Duodenum, **D**. Jejunostomy Tube in the Gastric Angle and Horizontal Portion of the Duodenum)

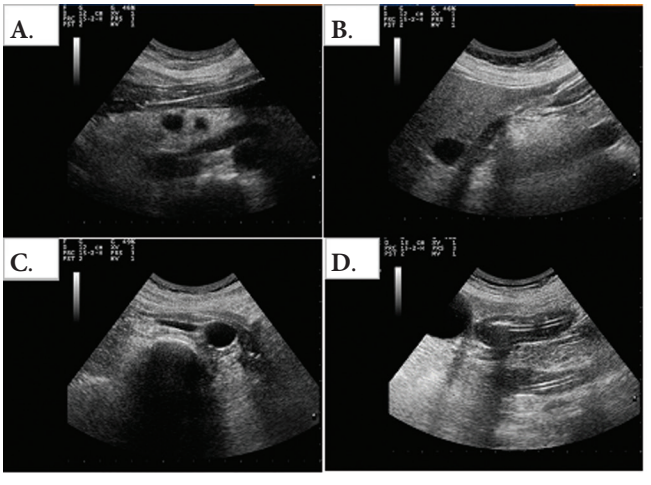


Table 3. Statistical Distribution of the Number of Catheter Insertions in Two Patient Groups

Group	TBI group (n = 50)	BUG group (n = 50)
1 (%(n))	86(43)	82(41)
2 (%(n))	10(5)	14(7)
3 (%(n))	2(1)	4(2)
4 (%(n))	2(1)	0
1+2 (%(n))	96% (48)	96% (48)
Average times	1.20 ± 1.00	1.22 ± 0.00

Table 4. Statistics of Catheter Placement Sites in Two Patient Groups

Catheter site	TBI group (n = 50)	BUG group (n = 50)
Jejunum (%(n))	28(14)	36(18)
Duodenum (%(n))	18(9)	36(18)
Antrum (%(n))	18(8)	6(3)
Stomach (%(n))	32(16)	18(9)
Pylorus (%(n))	4(2)	2(1)
Treitz ligament (%(n))	2(1)	2(1)
Enteric (%(n))	46(23)	72(36)

Statistics of intubation times

During the study, the distribution of intubation attempts was recorded for both the TBI and BUG groups. The specific distribution is shown in Table 3. Comparative analysis revealed no statistically significant differences ($P > .05$) in the proportion of patients in each group who underwent 1, 2, 3, or 4 intubation attempts, as well as in the average number of intubation attempts.

Statistics of successful catheterization time

The successful intubation time of TBI group was 6-60 min, and the average time was (20.72 ± 0.50) min. The successful intubation time of the BUG group was 3-120 min, and the average time was (24.40 ± 0.50) min. The time taken for successful catheterization seems to be slightly higher in the BUG group, whereas there was no statistical difference between the two groups ($P > .05$) (Figure 2).

Statistics of catheterization sites

The placement sites of the catheters were observed and recorded for both the TBI and BUG groups, as shown in Table 4. The placement sites included the jejunum, duodenum, gastric antrum, stomach, pyloric region, and ligament of Treitz. Analysis of the data revealed that the proportion of patients with catheters placed in the intestines was higher in the BUG group (72%) compared to the TBI group (46%) ($P < .05$). This further suggests that the success rate of small bowel intubation was higher in the BUG group compared to the TBI group. Figure 3 shows the results of the ultrasound observations.

Statistics of intubation-related complications

The related complications such as catheter displacement and gastrointestinal perforation in two groups were checked, and the results revealed that there were no related complications.

DISCUSSION

We found that ultrasound-guided NIT placement technology is simple and safe, with relatively low technical requirements, and can be implemented by almost a single person at the bedside of ICU,[18] so there have been reports of clinical application in recent years. The efficacy and safety of bedside ultrasound-guided NIT placement in patients in ICU was evaluated through a prospective randomized controlled trial. The BUG placement had a higher success rate of intubation compared to TBI placement (74% vs. 44%, $P < .05$). It revealed that the proportion of patients with intestinal catheterization was higher in BUG group (72%) relative to TBI group (46%) ($P < .05$). These findings further suggest that the success rate of small bowel intubation is higher in the BUG group compared to the TBI group, and it is easier to access the intestines. This indicates that ultrasound guidance can improve the success rate of NIT placement and facilitate enteral nutrition delivery. It also addresses the limitations of radiation exposure associated with current fluoroscopic methods for tube placement in the stomach and duodenum, which are technically challenging, require a high level of expertise, and have varying success rates with blind insertion methods, thus making them unreliable[19,20]. Liu et al.[21] adopted ultrasound-guided Freka-Trelumina enteral nutrition tube placement to treat acute pancreatitis, and concluded that bedside ultrasound-guided Freka-Trelumina feeding tube placement was non-invasive, safe, and convenient. This work also found that there were no related complications in both groups of patients, indicating that both tube placement methods have a high level of safety. This is consistent with the notion that enteral nutrition can improve gastrointestinal barrier function, reduce infection caused by intestinal flora displacement, and have a lower incidence of complications while achieving better nutritional outcomes[22]. Li et al.[23] also confirmed that semi-automated ultrasound-guided nasojejunal tube placement is reliable. This work found that the average number of tube insertions in the BUG group was slightly higher than that in the TBI group ((1.22 ± 0.00) times vs. (1.20 ± 1.00) times), but there was no significant statistical difference ($P > .05$), suggesting that ultrasound guidance did not improve the efficiency of operation or reduce the number of operations. Ultrasound guidance has been used as an auxiliary application in a variety of clinical treatment methods, such as gastrostomy tube placement,[24] central venous catheterization,[25] and intracavitary gallbladder drainage in patients with acute cholecystitis.[26] It indicates that ultrasound guidance can improve the effectiveness of the operation. This result is not consistent with it, which may be related to the lack of proficiency of the operators and the compliance of the patients. It requires further clinical exploration.

CONCLUSION

Bedside ultrasound-guidance appears to improve success over blind nasojejunal tube placement in critically ill patients in ICU. However, procedure time was similar between the two groups. The future clinical application of bedside ultrasound guidance needs to be explored to provide effective research data.

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AUTHOR DISCLOSURE STATEMENT

The authors declared no conflict of interest.

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QW and ZL designed the study and performed the experiments, JC and LS collected the data, QZ, YZ and CZ analyzed the data, and QW and ZL prepared the manuscript. All authors read and approved the final manuscript.

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