

# World Journal of *Gastroenterology*

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## Observational Study

# Modified B-ultrasound method for measurement of antral section only to assess gastric function and guide enteral nutrition in critically ill patients

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**Author contributions:** Liu Y, Gao YK and Yao L designed the research; Liu Y, Gao YK, Yao L and Li L performed the research; Gao YK, Yao L and Li L contributed new reagents/analytic tools; Liu Y, Gao YK, Yao L and Li L analyzed the data; Liu Y wrote the paper.

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## Abstract

### AIM

To establish a modified B-ultrasound method of measuring the antral section only to assess gastric motility in healthy people, and evaluate its application in guiding enteral nutrition (EN) in critically ill patients.

### METHODS

First, 30 healthy volunteers were selected. The modified B-ultrasound method and the traditional B-ultrasound method were applied to assess gastric function. The correlation of indices of gastric function between the two groups was analyzed statistically. In addition, 64 critically ill patients were selected, and the modified B-ultrasound method and the gastric juice withdrawal method were applied to guide the implementation of EN. Daily caloric value, the time required to achieve complete EN, ICU stay, hospitalization time, and serum prealbumin and albumin levels were recorded and compared between the two groups. Kaplan-Meier survival curve was used to compare the complications of EN between the two groups.

### RESULTS

In healthy subjects, there was a good correlation among gastric emptying time, antral contraction frequency and



antral motility index between the two groups ( $r = 0.57$ ,  $0.61$  and  $0.54$ , respectively). The study on critically ill patients also revealed that a better effect of EN was achieved in the modified B-ultrasound method group, in which patients had shorter ICU stay and hospitalization time and higher levels of serum prealbumin and albumin. The Kaplan-Meier survival analysis revealed that the improved B-ultrasound method was associated with significantly fewer EN complications ( $P = 0.031$ ).

## CONCLUSION

The modified B-ultrasound method can provide a good real-time assessment of gastric function and has a better effect than the traditional method in guiding EN in critically ill patients.

**Key words:** Gastric emptying; Real-time ultrasound; Critically ill patients; Enteral nutrition

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**Core tip:** In order to provide critically ill patients with timely postoperative enteral nutrition (EN), a modified B-ultrasound method for measurement of antral section only was established. In healthy subjects, there was a good correlation among gastric emptying time, antral contraction frequency and antral motility index between the modified and traditional methods. The study on critically ill patients also revealed that a better effect of EN was achieved in the modified B-ultrasound method group with regard to patients' hospitalization conditions and the incidence of EN complications.

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## INTRODUCTION

Critically ill patients with postoperative stress response and multisystem disorders have an increased risk of infection and even death. Timely postoperative enteral nutrition (EN) support can significantly improve the prognosis of these patients<sup>[1-6]</sup>. However, critically ill patients often have varying degrees of gastrointestinal motility disorders and other disorders. Therefore, individualized EN programs should be developed for patients with varying degrees of gastrointestinal dysfunction<sup>[7-10]</sup>. In clinical practice, medical staff often uses retractable gastric tubes to withdraw residual gastric juice to assess patients' gastric motility and guide EN. Due to the miniaturization and portability of B-ultrasound equipment, some medical institutions also use B-ultrasound to measure the antral section only for

real-time guidance of EN<sup>[11,12]</sup>. Accurate measurement of residual gastric volume is very important for subsequent EN. On one hand, the gastric tube will be inserted too shallowly if the measured residual gastric volume is too small. This will cause the EN rate to be excessively high, which can cause bloating, reflux, pneumonia and other complications. On the other hand, the gastric tube will be inserted too deeply when the measured residual gastric volume is too large. This would easily lead to gastric mucosal injury during operation. Traditional B-ultrasound measurement of the antral section only requires patients to maintain the standing position while drinking 500 mL of liquid. However, critically ill patients often have difficulties tolerating such position<sup>[13,14]</sup>. Therefore, this study aimed to improve the traditional B-ultrasound method by placing patients in the semirecumbent position to fill the gastric cavity with 300 mL of ultrasound solution, which is followed by real-time monitoring of gastrointestinal motility, with an aim to provide individualized EN programs for critically ill patients.

## MATERIALS AND METHODS

### Inclusion and exclusion criteria

The inclusion criteria were: (1) critically ill patients (52 cases) admitted in the intensive care unit of our hospital from January 2014 to December 2015; (2) patients with an APACHE II score  $\geq 8$ ; and (3) patients in a stable condition during the recovery period. The exclusion criteria were: (1) patients who underwent gastric resection; (2) patients with flatulence that could not be observed; and (3) patients who were not suitable for gastrointestinal perfusion due to various reasons. At the same time, 30 healthy subjects were recruited to evaluate the feasibility of the modified B-ultrasound method in assessing gastrointestinal function. This study was approved by the Ethics Committee of Cangzhou Central Hospital. All subjects provided a signed informed consent form.

### Evaluation of the feasibility of the modified B-ultrasound method in monitoring gastric function

**Assessment of gastric emptying:** The SonoSite TITAN portable B-ultrasound machine (Bothell, WA, United States) was used for assessing gastric function in 30 healthy subjects. Indexes evaluated included: fasting antral area, the immediate maximum antral relaxation area after filling the stomach, 5-min changes in the antral diastolic area until the liquid dark area disappeared after filling the stomach, the disappearance time of the liquid dark area in the stomach after filling (gastric emptying time, GET), 5-min antral contractions after filling, and three consecutive maximum antral relaxation and contraction areas ( $S_{relaxation}$  and  $S_{contraction}$ ). Based on the above data, the following were calculated: antral area changes ( $\Delta S$ ) =  $S_{relaxation} - S_{contraction}$ ; antral contraction



Figure 1 Ultrasound measurement of the antral section only.

frequency (ACF) = the number of antral contractions within 5 min after gastric filling/5; antral contraction amplitude (ACA) =  $\Delta S/S_{\text{relaxation}}$ ; antral motility index (MI) =  $ACF \times ACA$ .

**Detection method:** The subjects were fasted for 8 h overnight, and on the next morning, the traditional B-ultrasound method was used to assess gastric function. Briefly, the subjects were placed in the supine position and instructed to drink 500 mL of ultrasound liquid within 2 min, and gastric indexes were then detected after gastric filling. The subjects were then fasted again for 8 h overnight, and on the morning of the next day, gastric function was assessed using the improved B-ultrasound method, in which the subjects were instructed to drink 300 mL of ultrasound liquid within 2 min in the semirecumbent position, and gastric indexes were then detected after gastric filling.

#### **Comparison of the effects of the modified B-ultrasound method and the gastric juice withdrawal method in guiding EN for critically ill patients**

##### **Assessment of gastric function in critically ill patients using the gastric juice withdrawal method:**

The distance from the hairline to the sternum of patients was used as the length of the indwelling gastric tube (the size was approximately 45–55 cm). Gastric remnants were measured by artificial aspiration every 50 h using a 50-mL syringe. According to the American Society for Parenteral and Enteral Nutrition guidelines on EN, the EN program was developed as follows: the target feeding amount was set at 104.6–125.5 KJ (25 to 30 kcal)/(kg•d); the EN rate was adjusted according to the patient's MI, and the gastric function of patients was detected every one hour. If MI was  $< 0.4$ , the EN rate was set at 20–30 mL/h; when MI was  $\geq 0.4$  but  $< 0.8$ , the EN rate was set at 40–60 mL/h; when MI was  $\geq 0.8$ , the EN rate was set at  $\geq 70$  mL/h.

It has been believed that full EN can be achieved when the target feeding amount reaches  $> 80\%$ . During the EN process, the tolerance of patients should be closely monitored. The incidence of adverse

complications within 10 d after the initiation of EN was recorded (reflux, vomiting, diarrhea, abdominal distension, and new-onset pneumonia).

**Research method:** According to the severity of disease, 64 critically ill patients were selected and divided into two groups ( $n = 32$  each), and the modified B-ultrasound method and the gastric juice withdrawal method were, respectively, applied to monitor gastric function and guide the implementation of EN. The following EN indexes were collected and recorded: EN start time, the time required to reach the maximum feeding rate, EN-related complications (including reflux, new-onset pneumonia, vomiting, diarrhea, abdominal distension, etc.) and the onset time, and changes in serum prealbumin and albumin.

#### **Statistical analysis**

Statistical analyses were performed using SPSS20.0 software package. Normally distributed variables are expressed as mean  $\pm$  SD, and non-normally distributed data are expressed as median (inter-quartile range). Data on gastric function of the healthy subjects were analyzed using paired *t*-test and linear correlation analysis. The two groups of critically ill patients were compared using the two independent samples *t*-test. Kaplan-Meier survival curves were used to compare differences in the complications of EN in the two groups.  $P < 0.05$  was considered statistically significant.

## **RESULTS**

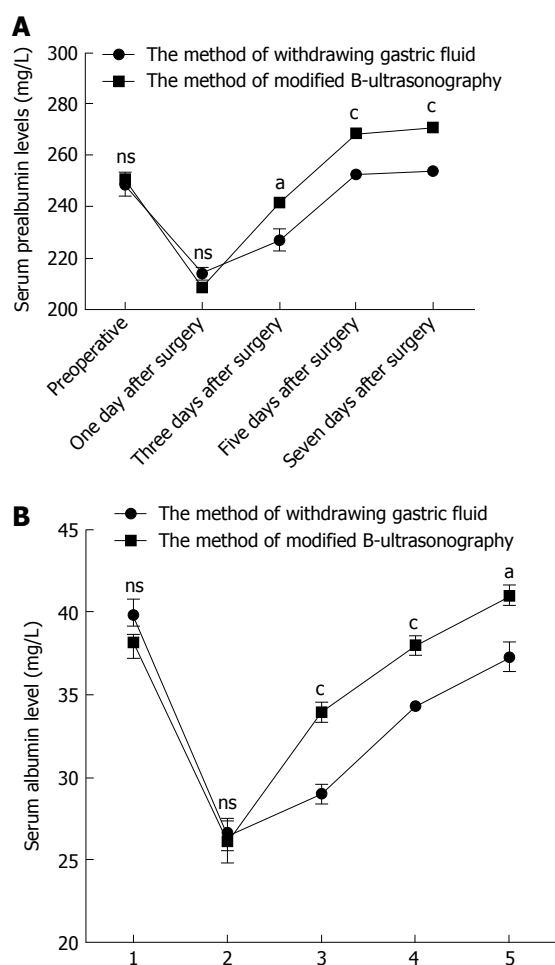
#### **Evaluation of gastric function using the modified B-ultrasound method**

The antral section was gradually detected on the abdominal surface after the ultrasound imaging revealed the superior mesenteric vein, abdominal aorta and the left lobe of the liver. This test point was used as a marker of the antral section (Figure 1) to detect related indexes. Gastric function indices were detected using the two types of B-ultrasound methods. As shown in Table 1, ACF, ACA, MI, GET and other indexes detected using the modified B-ultrasound method were significantly smaller than those detected using the traditional B-ultrasound method ( $P < 0.05$  for all). Linear correlation analysis showed that ACF, ACA and GET detected using the traditional method were highly correlated with those detected using the modified method, although there was a poor correlation for ACA (Table 2).

#### **Comparison of the effects of the modified B-ultrasound method and the gastric juice withdrawal method in guiding EN**

The effects of the two methods in guiding EN are shown in Table 3. The modified B-ultrasound method had a better effect in guiding EN. EN duration, EN





**Figure 2** Comparison of changes in prealbumin and albumin levels between the two groups of patients. A: Changes in prealbumin levels; B: Changes in albumin levels. <sup>a</sup> $P < 0.05$ , <sup>c</sup> $P < 0.01$ .

compliance time, and average daily calorie value were significantly higher in the modified B-ultrasound method group than in the gastric juice withdrawal group ( $P < 0.05$  for all). Prealbumin and albumin levels on postoperative days 3, 5 and 7 were also significantly higher in the modified B-ultrasound method group than in the gastric juice withdrawal group ( $P < 0.05$  for all) (Figures 2 and 3). Kaplan-Meier survival analysis revealed that the incidence of complications (reflux, vomiting, diarrhea, abdominal distension, and new-onset pneumonia) was significantly lower in the modified B-ultrasound method group than in the gastric juice withdrawal group ( $P = 0.031$ ).

## DISCUSSION

In both patients and healthy people, adequate intake of nutrients is important for maintaining the normal function of the body, and good nutrition helps to maintain cell metabolism, the normal structure of tissues and organs, and other functions<sup>[15-19]</sup>. At present, parenteral nutrition, usually through the intestine, provides patients with good nutritional support. The EN approach has gained the attention of clinicians, because

**Table 1** Comparison of the indices of gastric function measured using the modified and traditional B-ultrasound methods

Index	Modified method (n = 32)	Traditional method (n = 32)	t-value	P value
ACF	2.39 ± 0.24	3.22 ± 0.32	-10.580	0.000
ACA	0.36 ± 0.04	0.69 ± 0.11	-14.376	0.000
MI	3.34 ± 0.25	4.37 ± 0.34	-12.445	0.000
GET	32.65 ± 4.46	60.44 ± 4.98	-21.196	0.000

ACF: Antral contraction frequency; ACA: Antral contraction amplitude; MI: Motility index; GET: Gastric emptying time.

**Table 2** Correlation analysis of indices measured using the modified and traditional methods

Index	Correlation coefficient	P value	95%CI
ACF	0.613	0.003	0.21-0.74
ACA	0.324	0.080	-0.06-0.63
MI	0.536	0.005	0.19-0.76
GET	0.572	0.004	0.21-0.77

ACF: Antral contraction frequency; ACA: Antral contraction amplitude; MI: Motility index; GET: Gastric emptying time.

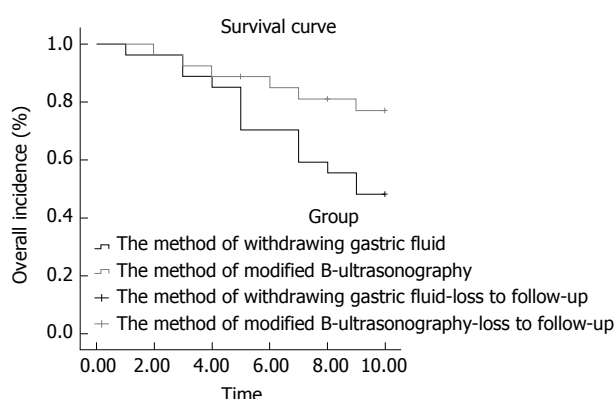
this approach is closer to the normal physiological conditions of the body's intake of nutrients<sup>[20-25]</sup>. However, for patients suffering from severe diseases, their gastrointestinal function may be impaired in varying degrees, which mainly leads to gastric emptying disorders and EN intolerance<sup>[26-33]</sup>. Therefore, it is important to monitor their gastric function in real time, in order to develop an individualized EN regimen for patient rehabilitation. In this study, our results showed that, in the normal population, the modified B-ultrasound method can also provide a good reflection of the gastric function. On this basis, its practical application in critically ill patients also suggests that the modified B-ultrasound method can guide the EN program well for patients requiring nutritional support and reduce the incidence of EN complications.

## Evaluation of the feasibility of the modified B-ultrasound method in assessing gastric function

B-ultrasound has been widely used in various departments due to its simple, convenient, accurate and reproducible features. In 1989, Marzio *et al.*<sup>[14]</sup> first proposed to use B-ultrasound to measure the antrum only for real-time monitoring of gastric emptying, in order to assess gastric function. However, this method requires the patient to maintain an upright posture while drinking 500 mL liquid. Hence, this method cannot be tolerated by many critically ill patients due to gastric dysfunction and other reasons<sup>[14]</sup>. Therefore, we improved this traditional method in this study by placing patients in the semirecumbent position while drinking 300 mL of ultrasound solution to fill the antrum. Then, guided EN was performed after portable B-ultrasound equipment was used to

**Table 3** Comparison of the implementation of enteral nutrition in the two groups of patients

	ICU time (d)	Hospitalization time (d)	Enteral nutrition time (h)	Average daily calorie value (kcal/kg)
Modified B-ultrasound method ( <i>n</i> = 26)	4.42 ± 1.92	13.35 ± 2.92	30.38 ± 9.42	28.73 ± 4.35
Gastric juice withdrawal method ( <i>n</i> = 26)	5.31 ± 2.11	16.58 ± 5.95	36.63 ± 10.26	25.69 ± 3.74
<i>t</i> -value	-1.620	-2.482	-2.123	2.702
<i>P</i> value	0.111	0.016	0.039	0.009

**Figure 3** Comparison of complications between the two groups of patients.

detect relevant indexes of gastric function in patients. The differences in and correlations of various gastric function indexes between the modified and traditional methods were investigated in a normal population using a self-controlled method to verify the reliability of the improved B-ultrasound method in assessing gastric function.

Stomach contents can stimulate gastric emptying, and the mechanical stimulation of the vagus nerve reflex in the gastric wall increases stomach movement. In general, the rate of gastric emptying is proportional to the amount of stomach contents<sup>[34-43]</sup>. In the present study, the difference in gastric wall nerve stimulation was caused by the different volumes of ultrasound liquid. The indexes (ACA, ACF, MI and GET) detected using the modified B-ultrasound method were significantly smaller than those obtained using the conventional method. Since the rate of gastric emptying is regulated by nerves, body fluids and a variety of factors, ACA derived by these two detection methods had a poor correlation. However, the rest important indexes (ACF, GET and MI) are highly correlated between the two methods. This suggests that the modified B-ultrasound method has the potential to enable the real-time detection of gastric function.

### Comparison of the effects of the modified B-ultrasound method and the gastric juice withdrawal method in guiding EN

The self-controlled study of healthy people revealed that the modified B-ultrasound method has a potential to detect gastric function. We therefore further investigated the effects of the modified B-ultrasound method and the gastric fluid withdrawal method in guiding EN

in critically ill patients.

The gastric juice withdrawal method is a method of guiding EN by detecting gastric residues, which has been widely used in many hospitals<sup>[44-51]</sup>. However, a variety of factors including the length and location of the indwelling tube would result in the lack of accuracy of the test results, and some deficiencies often occur in the implementation of this method for guiding EN. If the indwelling tube is inserted too shallowly, this causes the amount of residual calorie measurement to be small and would increase EN speed, which often results in bloating, reflux, new-onset pneumonia and other complications. If the indwelling tube is placed too deeply, the measured residual gastric volume will be excessively large, which often causes gastric mucosal damage. Hence, there is an urgent need for a more effective method for clinical applications.

When comparing the effects of the two methods in guiding EN, the average calorie intake of patients receiving EN was significantly higher when the modified B-ultrasound method was used. Furthermore, the time required to achieve complete EN was also significantly less for the modified B-ultrasound method. As a result, patients who used the modified B-ultrasound method obtained better nutritional support. In addition, the modified B-ultrasound method exhibited a significant advantage in reflecting the nutritional status of patients with regard to plasma prealbumin and albumin levels and other indexes. The recovery rates of prealbumin and albumin levels within 7 d after surgery were higher in patients of the modified B-ultrasound method group than in the traditional gastric juice withdrawal group. According to a multicenter survey that involved 26 hospitals in Europe, the nutritional status of patients was significantly negatively correlated with hospital stay, complications and mortality, and patients who received good nutritional support had shorter hospital stay, fewer complications and increased survival rate<sup>[52-55]</sup>. In the present study, the Kaplan-Meier survival analysis revealed that the complications of patients with good nutritional support were significantly fewer than those in the traditional gastric juice withdrawal group. Furthermore, the durations of ICU stay and hospital stay in the modified B-ultrasound method group were also significantly shorter than those in the traditional method group. The underlying reason for this is that patients had a better recovery in the modified B-ultrasound method group, because the modified method can more accurately assess the gastric function of patients, and is conducive for clinicians to accurately

control the EN speed. As a result, the incidence of vomiting, bloating, new-onset pneumonia and other complications was also significantly lower. These results suggest that the modified B-ultrasound method is an effective method for guiding EN.

However, since the B-ultrasound method is susceptible to stomach gas interference, B-ultrasound detection was not performed in our three patients due to severe flatulence. Therefore, future studies should be required to further evaluate the types of disease suitable for B-ultrasound detection.

In summary, the modified B-ultrasound method can better assess gastric function and guide EN in critically ill patients than the traditional gastric juice withdrawal method, showing good clinical value.

## COMMENTS

### Background

Enteral nutrition (EN) is widely used widely in clinical practice for the reason that this approach is closer to the normal physiological conditions of the body's intake of nutrients. However, since critically ill patients often suffer from varying degrees of gastric dysfunction and have EN intolerance, it is important to monitor their gastric function in real time, in order to develop an individualized EN regimen for patient rehabilitation.

### Research frontiers

In clinical practice, medical staff often uses retractable gastric tubes to withdraw residual gastric juice to assess patients' gastric motility and guide EN. Due to the miniaturization and portability of B-ultrasound equipment, some medical institutions also use B-ultrasound to measure the antral section only for real-time guidance of EN. Given the fact that this method has some deficiencies, more methods should be developed to provide crucially ill patients with EN in real time.

### Innovations and breakthroughs

In this study, a modified B-ultrasound method for measuring the antral section only was established. In healthy subjects, there was a good correlation among gastric emptying time, antral contraction frequency and antral motility index between the modified and normal methods. When guided by the modified method, the study on critically ill patients also revealed that a better effect of EN was achieved with regard to patients' hospitalization conditions and the incidence of EN complications.

### Applications

The modified method that has a better effect in providing guidance of EN can better provide nutritional support for critically ill patients, and contribute to the rehabilitation of patients.

### Peer-review

This is an interesting study about the establishment of a modified B-ultrasound method for measurement of the antral section only and its application value in guiding EN in critically ill patients.

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