**Name of journal:** ***World Journal of*** ***Gastroenterology***

**Manuscript NO:** 34539

**Manuscript Type: ORIGINAL ARTICLE**

***Observational Study***

**Establishment of a modified single antral section B-ultrasound method and its application value on enteral nutrition for critically ill patients**

Liu Y *et al*. Enteral nutrition guided by modified B-ultrasound

Ying Liu, Ya-Kun Gao, Lei Yao, Li Li

**Ying Liu, Ya-Kun Gao, Lei Yao, Li Li,** Department of Ultrasound, Cangzhou Central Hospital, Cangzhou 061001, Hebei Province, China

**Author contributions:** Ying Liu contributed equally to this work; Ying Liu, Ya-KunGao, Lei Yao designed research; Ying Liu, Ya-KunGao, Lei Yao, Li Li performed research; Ya-KunGao, Lei Yao, Li Li contributed new reagents/analytic tools; Ying Liu, Ya-KunGao, Lei Yao, Li Li analyzed data; Ying Liu wrote the paper.

**Supported by** Cangzhou Science and Technology Project, No. 131302097.

**Institutional review board statement:** This study was reviewed and approved by Cangzhou Central Hospital Institutional Review Board.

**Informed consent statement:** All study participants, or their legal guardian, provided informed written consent prior to study enrolment.

**Conflict-of-interest statement:** We declare that there are no conflicts of interest to disclose.

**Data sharing statement:** No additional data are available.

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**Manuscript source:** Unsolicited Manuscript

**Correspondence to: Ying Liu, MD, Attending Physician,** Department of Ultrasound, Cangzhou Central Hospital, No. 201 Xinhua Road, Cangzhou 061001, Hebei Province, China. 13315703225@163.com

**Telephone**: +86-13315703225

**Fax**: +86-317-2075790

**Received:** May 3, 2017

**Peer-review started:** May 4, 2017

**First decision:** June 1, 2017

**Revised:** June 13, 2017

**Accepted:**June 18, 2017

**Article in press:**

**Published online:**

**Abstract**

***AIM***

To establish a modified single antral section B-ultrasound method to assess gastrointestinal motility in healthy people, and evaluate its application value on enteral nutrition for critically ill patients.

***Methods***

First, 30 healthy volunteers were selected. The modified single antral section B-ultrasound method and the traditional B-ultrasound method were applied to detect gastric function. The correlation between indices was analyzed by *t*-test and single-factor regression method. In addition, 64 critically ill patients were selected, and the modified single antral section B-ultrasound method and gastric juice withdrawal method were applied to guide the enteral nutrition implementation. Daily caloric value, the time required for complete enteral nutrition, ICU monitoring time, hospitalization time, as well as differences in serum prealbumin and albumin levels were recorded and compared between the two groups. At the same time, Kaplan-Meier survival curve was used to compare enteral nutrition complications between the two groups.

***RESULTS***

The comparative study of autologous healthy subjectsrevealed that there was a good correlation among gastric emptying time (GET), antral contraction frequency (ACF) and the antral motility index (MI) in the improved single antral section B-ultrasound method (*r*=0.57, 0.61 and 0.54). The study on critically ill patients also revealed that enteral nutrition achieved a better effect when guided by the modified single antral section B-ultrasound method, in which patients had less ICU monitoring time, shorter hospitalization time, and higher levels of serum prealbumin and albumin. In addition, the Kaplan-Meier survival curve also revealed that patients who underwent the improved B-ultrasound method had significantly less enteral nutrition complications, compared to the other group of patients (*P* = 0.031).

***CONCLUSION***

The modified single antral section B-ultrasound method and the traditional method can both provide a good real-time assessment of gastric function. The method that has a better effect in providing guidance for enteral nutrition can better provide nutritional support for critically ill patients, and contribute to the rehabilitation of patients.

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

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**Core tip:** In order to provide critically ill patientswithtimely postoperative enteral nutrition, a modified single antral section B-ultrasound method was established. The comparative study of autologous healthy subjects revealed that there was a good correlation among gastric emptying time, antral contraction frequency and the antral motility index between the modified and normal method. When guided by the modified method, the study on critically ill patients also revealed that enteral nutrition achieved a better effect in the aspects of patients' hospitalization conditions and the incidence of postoperative.

Liu Y, Gao YK, Yao L, Li L. Establishment of a modified single antral section B-ultrasound method and its application value on enteral nutrition for critically ill patients. *World J Gastroenterol* 2017; In press

**INTRODUCTION**

Critically ill patients with postoperative stress response and multiple system disorders will have increase the risk of infection and even death. Hence, timely postoperative enteral nutrition (EN) supportive treatment can significantly improve the prognosis of patients[1-6]. However, severe patients are often accompanied by varying degrees of gastrointestinal motility disorders and other disorders. Therefore, an individualized EN program should be developed for the gastrointestinal function of patients[7-10]. In clinical practice, medical staff often uses retractable gastric tubes to withdraw stomach residual fluid to assess the patient's gastric motility and guide EN. Due to the miniaturization and portability of B-ultrasound equipment, some medical units also use antral single section B-ultrasound on patient for real-time guidance of EN[11,12]. However, there is a lack of actual operation for these two methods. On the one hand, gastric tube is too shallow when the measurement of the gastric residual volume is small. This causes the EN rate to be excessively high, which in turn cause bloating, reflux, as well as pneumonia and other complications. On the other hand, gastric tube retention is too deep when the measurement of the gastric residual volume is too large. This would easily lead to gastric mucosal injury during the operation. The antral single section B–ultrasound method requires severe patients to maintain the upper body position while drinking 500 mL of liquid. Severe patients often have difficulties tolerating such requirement[13,14]. Therefore, in this study, the traditional B-ultrasound method was improved. Patients were placed in the semi-lying position to fill the gastric cavity with 300mL of ultrasound solution, followed by real-time monitoring of the patient's gastrointestinal motility. In this study, the traditional B-ultrasound method was improved, and was designed to reduce the stimulus of critically ill patients while obtaining accurate patient gastrointestinal function, with a view to providing individualized EN programs for critically ill patients.

**MATERIAL AND METHODS**

***Inclusion and exclusion criteria***

Inclusion criteria: (1) critically ill patients (52 cases) admitted in the ICU ward of our hospital from January 2014 to December 2015; (2) patients with an APACHE II score ≥ 8; and (3) patients in stable condition and in a stable recovery period.Exclusion criteria: (1) patients who underwent gastric resection; (2) patients with flatulence that could not be observed; and (3) patients who are not suitable to undergo gastrointestinal perfusion due to various reasons. At the same time, the hospital staff recruited 30 healthy subjects to evaluate the effect of the modified B ultrasound in detecting gastrointestinal function. This research was approved by the hospital Ethics Committee. All subjects provided a signed informed consent.

***Evaluation of the effect of the modified B-ultrasound method in monitoring the gastrointestinal tract***

**Detection of gastric emptying using the B-ultrasound method:** Gastric emptying detection using the B-ultrasound method: The SonoSite TITAN portable B-ultrasound machine (Bothell, WA, USA) was used for the timely detection of the gastrointestinal function changes in subjects. Detection indicators include :fasting antral area size (S fasting), the immediate antral maximum relaxation area after filling the stomach (S filling), 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 areas in the stomach after filling (gastric emptying time, GET),5-minute antral contractions after filling, three consecutive an trial maximum relaxation and contraction areas (Srelaxation, Scontraction). Based on the above data, the following were calculated: antral area changes (ΔS) =Srelaxation – Scontraction; antral contraction frequency (ACF) = the number of antral contractions within five minutes after filling / 5; antral contraction amplitude (ACA) = ΔS / Srelaxation; antral motility index (MI) = ACF × ACA.

**Research methods:** Gastric function was detected in 30 healthy subjects using the self-control method. The subject fasted with water for eight hours. On the morning of the first day, the traditional B-ultrasound method was used to detect gastrointestinal function. That is, subjects were placed in the supine position, instructed to drink 500 mL of the B-ultrasound developer liquid for two minutes, and related gastrointestinal indicators were detected after filling the stomach cavity. On the morning of the 2nd day, the subjects fasted again with water for eight hours, were instructed to drink 300 mL of the B-ultrasound developer liquid within two minutes in a 45° half-lying position, and related gastrointestinal indicators detected after filling the stomach.

***Comparison of the effects of the modified single antrial section B-ultrasound method and gastric acid withdrawal method in guiding enteral nutrition for critically ill patients***

**Detection of gastric function in critically ill patients using the gastric acid withdrawal method:** The length 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).At the same time, gastric remnants were measured by artificial aspiration every 50 h using a 50-mL syringe. According to American society for parenteral and enteral nutrition (ASPEN) guidelines on EN, combined with the actual situation in our hospital, the EN program was developed as follows: the target feeding amount for patients was set to 104.6-125.5 KJ (25 to 30 kcal)/(kg • d). The EN rate was controlled according to the patient’s MI, and the gastric function of patients was detected every one hour. If MI was < 0.4, EN rate was set to 20-30 mL/h; when 0.4 ≤ MI < 0.8, EN rate is set to 40-60 mL/h; when MI ≥ 0.8, infusion rate was ≥ 70 mL/h.

It has been considered 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 of pneumonia).

**Research methods:** According to the severity of the disease and disease selection of the 64 critically ill patients, these patients were divided into two groups (each group, *n* = 32), and the modified B-ultrasound method and gastric acid withdrawal method were respectively applied to monitor gastrointestinal function and guide the implementation of EN.

The following EN indicators of patients in the two groups were collected and recorded: EN start time and the time required to reach the maximum feeding rate, EN-related complications and the time of occurrence (including reflux, new onset of pneumonia, vomiting, diarrhea, abdominal distension, *etc*.), and changes inserum prealbumin and albumin before and after operation.

***Statistical analysis***

Analysis was performed using the SPSS 20.0 software package, normally distributed variables were expressed as mean ± SD, and non-normal distribution data are expressed as median (quartile). The gastric function data 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. On this basis, Kaplan-Meier survival curves were used to further compare differences in the complications of EN in the two groups. *P* < 0.05 was considered statistically significant.

**RESULTS**

***Evaluation of gastrointestinal effects using the modified B-ultrasound method***

The antral section was gradually detected in 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), and to detect related indicators. Gastric function indices were detected using the two types of B-ultrasound methods, as shown in Table 1. ACF, ACA, MI, GET and other indicators detected using the modified B-ultrasound method were significantly smaller than those detected using the traditional B-ultrasound method, and the differences were statistically significant (all, *P* < 0.05). At the same time, in the linear correlation analysis shown in Table 2, the ACF, ACA and GET results detected using the traditional and modified methods were highly correlated. However, ACA was poorly correlated.

***Comparison of the effects of the modified single antral section B-ultrasound method and gastric acid withdrawal method in enteral nutrition***

The effect of the two methods of guiding EN is shown in Table 3.Results revealed that the modified B-ultrasound method had a better effect on patients in guiding EN, and that the EN duration, EN compliance time, and daily average calorie value of these group of patients were higher than in the gastric juice withdrawal group; and the differences were statistically significant (all, *P* < 0.05). At the same time, prealbumin and albumin levels in patients also revealed similar results (Figures 2 and 3). Furthermore, prealbumin and albumin levels were higher in patients who used the modified B-ultrasound method for guiding EN in postoperative 3, 5 and 7 d; and the differences were also statistically significant (all, *P* < 0.05). The Kaplan-Meier survival curve was used to compare the incidence of EN complications in both groups. Results revealed that patients who used the modified B-ultrasound method for guiding EN had adverse complications (reflux, vomiting, diarrhea, abdominal distension, and new onset of pneumonia), but its incidence was significantly lower than the gastric juice withdrawal group; and the difference was statistically significant (*P* = 0.031).

**DISCUSSION**

Whether for patients or healthy people, adequate intake of nutrients is important for maintaining the normal functions of the body, and good nutrition helps to maintain cell metabolism, and in maintaining the normal structure of tissues and organs, and other functions[15-19]. At present, usually through the intestine, parenteral nutrition provides patients with good nutritional support. The enteral nutrition approach has gained the attention of clinicians, because this approach is closer to the normal physiological conditions of the body’s intake of nutrients[20-25]. However, for severe patients suffering from severe diseases, gastrointestinal function can be inhibited in varying degrees, and is mainly performed for gastric emptying disorders and enteral nutrition intolerance[26-33]. Therefore, it is important to monitor the patient's stomach function in real time, in order to develop an individualized EN regimen for patient rehabilitation. In this study, for modified antral single section B-ultrasound method, and in the normal population, studies have shown that the modified B-ultrasound 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 for guiding the EN program can be well provided for patients with nutritional support, and this can also reduce the incidence of EN complications.

***Evaluation of the effect of the modified B-ultrasound method in detecting the gastrointestinal tract***

B-ultrasound has been widely used in various departments due to its simple, convenient, accurate and good repeatability features. In 1989, Marzio*etal*[14] first proposed to use the antrum single section B-ultrasound measurement method for real-time monitoring of gastric emptying, in order to assess gastrointestinal function. However, this method requires that the patient to maintain an upright posture while drinking 500 mL liquid. Hence, this method cannot often be tolerated by critically ill patients due to stomach dysfunction and other reasons[14].Therefore, in this study, this method was improved. That is, patients were instructed to maintain a semi-recumbent position while drink 300 mL of the B-ultrasound developer solution to fill the antrum. Then, guided EN was performed after portable B-ultrasound equipment was used to detect relevant indicators of gastric function in patients. The differences and relevance of various gastric function indicators for the modified and traditional methods were investigated in a normal population using a self-controlled method to verify the reliability of the effect of the improved B-ultrasound method.

Stomach contents stimulate the power of gastric emptying, and the mechanical stimulation of the wall of the vagus nerve reflex increases stomach movement. In general, the rate of gastric emptying is proportional to the stomach contents[34-43]. In the present study, differences in gastric wall nerve stimulation were caused by the different volumes of B-ultrasound-contrast liquid. The indicators (ACA, ACF, MI and GET) detected using the modified B-ultrasound method were significantly lesser than those obtained using the conventional method, and the differences were statistically significant. Since the rate of gastric emptying is regulated by nerves, body fluids and a variety of factors, ACA indicators derived by these two detection methods have a low correlation phenomenon. However, the rest of the important indicators (ACF, GET and MI) are highly correlation between these two methods. This suggests that the modified B-ultrasound method has the potential to enable the real-time detection of gastrointestinal function.

***Comparison of the effect of using the modified single antral section B-ultrasound method and gastric acid withdrawal method for enteral nutrition***

The self-controlled study of healthy people revealed that the modified B-ultrasound has a potential to detect gastrointestinal function. This study further investigated the difference effects of using the modified antral single section B-ultrasound method and gastric acid withdrawal method when guiding EN in critically ill patients.

The gastric acid withdrawal method is a method of guiding EN by detecting gastric residues, which has been widely used in most hospitals[44-51]. 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 too shallow, this causes the amount of residual calorie measurement to be small; and this would increases EN speed, allowing bloating, reflux, new onset of pneumonia and other complications to easily occur. If the indwelling tube is too deep, it not only makes the gastric residual volume measurement value excessively large, but also causes gastric mucosal damage. Hence, there is an urgent need for a more effective method of detection for clinical applications.

When comparing the effects of the different methods of guiding EN, the average calorie intake of patients receiving EN was significantly higher when the modified B-ultrasound method was used, than when the traditional gastric acid withdrawal method was used. Furthermore, the time required to reach complete EN is also significantly lesser than the traditional gastric acid withdrawal method; and the differences were statistically significant. As a result, patients who used the modified B-ultrasound method obtained better nutritional support. Furthermore, the modified B-ultrasound method exhibited a significant advantage in reflecting the nutritional status of the body through the detection plasma prealbumin, albumin and other indicators in patients. That is, the recovery rate of prealbumin and albumin levels was higher in this group of patients within seven days after surgery, compared with the traditional gastric acid withdrawal group. According to a multicenter survey that involved 26 hospitals in Europe, the nutritional status of patients and hospital stay, complications and mortality were significantly negatively correlated. Hence, hospital stay and complications were reduced, while increasing the survival rate, in patients who received good nutritional support[52-55]. In the present study, the Kaplan-Meier survival curve further revealed that the complications of patients with good nutritional support were significantly lesser than in the traditional gastric acid withdrawal group. Furthermore, ICU time and hospital stay in this group of patients were also significantly lesser than in the traditional group. The reason for this is that patients obtain a better recovery effect due to the support provided by the modified B-ultrasound method in guiding EN. In addition, the modified B-ultrasound method can more accurately assess the gastric function patients, and is conducive for doctors to accurately control the EN speed. This causes the incidence of vomiting, bloating, new onset of pneumonia and other complications to be significantly lower. These results show that the modified B-ultrasound method is a good method for guiding EN, which has promotional value.

However, since the B-ultrasound method is susceptible to stomach gas interference, B-ultrasound detection was not performed in three patients during the course of the study due to severe flatulence. Therefore, future studies should be further evaluate the types of disease suitable for B-ultrasound detection, in order to provide appropriate guidance for the doctor's targeted selection method.

In summary, the modified B-ultrasound method can reflect gastric function, and its effect on EN was better than in the traditional gastric juice withdrawal group, showing good clinical value.

**comments**

***Background***

The enteral nutrition (EN) is widely used widely in clinic for the reason that this approach is closer to the normal physiological conditions of the body’s intake of nutrients. However, for severe patients suffering from severe diseases, gastrointestinal function can be inhibited in varying degrees, and is mainly performed for gastric emptying disorders and EN intolerance. Therefore, it is important to monitor the patient's stomach 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 stomach residual fluid to assess the patient's gastric motility and guide EN. Due to the miniaturization and portability of B-ultrasound equipment, some medical units also use antral single section B-ultrasound on patient for real-time guidance of EN. Given the fact that these two methods both have some deficiencies such as lack of accuracy and high requirements of operation, more methods should be developed to provide crucially ill patients with enteral nutrition in real time.

***Innovations and breakthroughs***

In this study, a modified single antral section B-ultrasound method was established. The comparative study of autologous healthy subjects revealed that there was a good correlation among gastric emptying time, antral contraction frequency and the antral motility index between the modified and normal method. When guided by the modified method, the study on critically ill patients also revealed that enteral nutrition achieved a better effect in the aspects of patients' hospitalization conditions and the incidence of postoperative.

***Applications***

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

***Peer- review***

This an interesting study about the establishment of a modified single antral section B-ultrasound method and its application value on enteral nutrition for critically ill patients.

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**P-Reviewer:** McCarthy M, Provenzale D **S-Editor:** Wang JL

**L-Editor: E-Editor:**

**Specialty type:** Gastroenterology and hepatology

**Country of origin:** China

**Peer-review report classification**

Grade A (Excellent): 0

Grade B (Very good): B

Grade C (Good): C

Grade D (Fair): 0

Grade E (Poor): 0

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Index** | **Modified method ( *n*= 32)** | **Traditional method ( *n*= 32)** | ***t*** | ***P*** |
| 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: enteral nutrition.

**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: enteral nutrition.

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

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



**Figure 1 Single antral section image detected by ultrasound.**



**Figure 2 Comparison of prealbumin and albumin level changes between the two groups of patients.** A: Changes in prealbumin levels; B: Changes in albumin levels. \*\**P* ＜ 0.01; \**P* ＜ 0.05.



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