

Ultrasonographic Gastric Antral Diameter as a Bedside Indicator of Intragastric Volume in Critically Ill Patients Receiving Enteral Nutrition via Gastrostomy

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Abstract

Purpose:

Enteral nutrition delivered via gastrostomy is commonly used for long-term nutritional support in critically ill patients. Monitoring gastric residual volume (GRV) is commonly used to evaluate tolerance to enteral feeding and reduce the risk of regurgitation and aspiration. However, conventional GRV measurement by aspiration through a nasogastric tube is invasive and may not accurately reflect true gastric contents. Gastric ultrasonography has emerged as a non-invasive bedside tool for evaluating gastric contents and estimating gastric volume. Nevertheless, data regarding the use of gastric ultrasonography in enterally tube-fed intensive care unit (ICU) patients remain limited.

Methods:

This prospective observational study included 50 critically ill patients receiving enteral nutrition via gastrostomy. Gastric antral diameter was measured using ultrasonography at baseline and after sequential administration of 100, 200, 300, 400, and 500 mL of enteral feeding solution. Measurements were repeated to assess reproducibility. Statistical analysis included Wilcoxon signed-rank test, Spearman correlation, linear regression analysis, and receiver operating characteristic (ROC) curve analysis.

Results:

Gastric antral diameter increased progressively with intragastric volume ($p < 0.001$). Significant correlations were observed between repeated measurements at lower volume levels ($r = 0.321-0.612$). Linear regression analysis demonstrated a strong relationship between antral diameter and gastric volume ($R^2 \approx 0.88$, $p < 0.001$), with the equation: gastric volume (mL) = $-72 + 21.5 \times$ antral diameter (mm). ROC analysis showed excellent diagnostic performance for predicting clinically relevant gastric volumes. The optimal cut-off value was 16 mm for predicting ≥ 200 mL (AUC = 0.93, 95% CI: 0.88–0.98), 18 mm for ≥ 300 mL (AUC = 0.93, 95% CI: 0.88–0.98), and 19 mm for ≥ 400 mL (AUC = 0.91, 95% CI: 0.85–0.96).

Conclusion:

Ultrasonographic measurement of gastric antral diameter increases significantly with increasing intragastric volume in critically ill patients receiving enteral nutrition. Gastric ultrasound is a practical, non-invasive, and reproducible bedside tool for monitoring gastric volume changes in critically ill patients receiving enteral nutrition. Its use may enhance feeding tolerance assessment and guide enteral nutrition management in the ICU.

Introduction

Enteral nutrition delivered via gastrostomy tubes is widely used for nutritional support in critically ill patients requiring prolonged enteral feeding. Early enteral feeding has been shown to preserve gastrointestinal integrity, support immune function, and reduce infectious complications compared with parenteral nutrition [1, 2]. Despite these advantages, intolerance to enteral feeding remains a common clinical challenge in intensive care units (ICUs). One of the most frequently used indicators of feeding intolerance is the accumulation of gastric residual volume (GRV), which may increase the risk of regurgitation, aspiration, and aspiration pneumonia in critically ill patients [3].

Traditionally, GRV is assessed by aspirating gastric contents through a nasogastric tube. However, this technique has several limitations. It is invasive, uncomfortable for patients, and its reliability has been questioned because the aspirated volume may not accurately reflect the true gastric content. Incomplete aspiration, tube position, and operator-dependent variability may lead to significant inaccuracies in GRV estimation [4]. These limitations have prompted the search for alternative and non-invasive methods for assessing gastric contents and feeding tolerance in critically ill patients. Unnecessary interruptions of enteral nutrition due to inaccurate GRV measurement can lead to caloric deficits and worse clinical outcomes, highlighting the need for a more reliable assessment method [5].

Point-of-care gastric ultrasonography has recently emerged as a promising bedside technique for evaluating gastric content and estimating gastric volume. Ultrasonographic assessment of the gastric antrum provides indirect information about gastric volume, as the size of the antral region correlates with the amount of gastric content. Previous studies have demonstrated a strong relationship between gastric antral measurements and intragastric volume in healthy volunteers and elective surgical patients [5–7]. However, critically ill patients represent a distinct population with altered gastrointestinal physiology due to factors such as mechanical ventilation, sedation, opioid administration, and hemodynamic instability. These factors may significantly affect gastric motility and gastric emptying, making extrapolation of findings from healthy or surgical populations to ICU patients problematic [8].

In addition, most previous studies investigating gastric ultrasonography have focused primarily on preoperative fasting assessment rather than on monitoring gastric volume during enteral feeding. In critically ill patients receiving enteral nutrition, monitoring gastric residual volume is important for evaluating feeding tolerance and reducing the risk of complications such as regurgitation and aspiration. Despite its potential clinical relevance, data evaluating ultrasonographic assessment of gastric volume specifically in enterally tube-fed ICU patients remain limited.

It is important to emphasize that our study specifically focuses on enterally tube-fed critically ill patients. In this population, the feeding tube provides a direct conduit for administering nutrition and also allows for sequential administration of precisely measured volumes, enabling systematic evaluation of the relationship between intragastric volume and antral diameter. This methodology would not be feasible in non-intubated patients or healthy volunteers, highlighting the unique value of studying this specific patient population. Furthermore, tube-fed ICU patients represent the group in whom monitoring gastric

residual volume is most clinically relevant, as enteral feeding intolerance is a common challenge in this setting.

Despite increasing interest in gastric ultrasonography, data evaluating the relationship between ultrasonographic antral measurements and intragastric volume specifically in critically ill patients receiving enteral nutrition via gastrostomy remain scarce.

Therefore, the aim of this study was to evaluate the relationship between intragastric volume and ultrasonographic gastric antral diameter in critically ill patients receiving enteral nutrition via gastrostomy tubes. In addition, we sought to assess the reproducibility of antral measurements obtained at different gastric volumes and to investigate the potential influence of demographic factors such as age and body mass index on these measurements.

We hypothesized that ultrasonographic measurement of gastric antral diameter would increase proportionally with intragastric volume in enterally tube-fed critically ill patients and that this method would demonstrate high reproducibility. If confirmed, gastric ultrasound could provide a reliable and non-invasive bedside tool for monitoring gastric residual volume and guiding enteral nutrition management in the ICU.

Methods

Study Design and Ethical Approval

This prospective observational study was conducted in the intensive care unit of Van Yuzuncu Yil University Dursun Odabaş Medical Center between February 2018 and February 2019. The study protocol was approved by the Institutional Ethics Committee of Van Yuzuncu Yil University (Approval No: 05, Date: 16/02/2018). The study was performed in accordance with the principles of the Declaration of Helsinki. As this was an observational study without therapeutic intervention, clinical trial registration was not required.

Patient Population

Adult critically ill patients receiving enteral nutrition via gastrostomy tubes were screened for eligibility.

Inclusion criteria

- Age $\geq$ 18 years
- Admission to the intensive care unit
- Receiving enteral nutrition through a gastrostomy tube

Exclusion criteria

- History of upper gastrointestinal surgery
- Known gastric outlet obstruction
- Active gastrointestinal bleeding
- Pregnancy
- Inability to obtain adequate ultrasonographic visualization of the gastric antrum

Ultrasound Examination

Gastric ultrasonography was performed using a standard ultrasound system equipped with a low-frequency curvilinear probe (2–5 MHz).

All examinations were performed by an experienced clinician trained in gastric ultrasonography.

Patients were examined in the semi-recumbent position (approximately 45°). The gastric antrum was identified in the epigastric region using the left lobe of the liver anteriorly and the abdominal aorta posteriorly as anatomical landmarks.

The antrum was visualized in the sagittal plane at the level of the superior mesenteric artery, and measurements were obtained between peristaltic contractions.

For each measurement, the anteroposterior and craniocaudal diameters of the gastric antrum were recorded. The mean of these two measurements was calculated and used as the antral diameter for statistical analysis.

Volume Administration Protocol

For each patient, gastric ultrasonography was first performed with an empty stomach (baseline measurement).

Enteral feeding solution was subsequently administered through the gastrostomy tube. Each patient received increasing intragastric volumes of 100, 200, 300, 400, and 500 mL.

After each volume administration, ultrasonographic measurements of the gastric antrum were obtained before the next volume was administered.

Thus, six consecutive measurements were obtained for each patient (baseline, 100 mL, 200 mL, 300 mL, 400 mL, and 500 mL).

Ultrasonographic measurements were performed immediately after administration of each predefined intragastric volume in order to minimize the potential influence of gastric emptying and to ensure

consistency across measurements.

To evaluate measurement reproducibility, the entire protocol was repeated once more in the same patient, resulting in two measurement series for each volume level. This sequential within-patient design allowed each individual to serve as their own control, minimizing inter-individual variability and enhancing the precision of the volume–diameter relationship.

Data Collection

The following demographic and clinical data were recorded:

- age
- sex
- height
- body weight
- body mass index (BMI)

BMI was calculated using the following formula:

$$\text{BMI} = \text{weight (kg)} / \text{height}^2 (\text{m}^2)$$

For each patient and each volume level, the mean gastric antral diameter was recorded.

Statistical Analysis

Statistical analyses were performed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation (SD), median, and minimum–maximum values, while categorical variables were presented as frequencies and percentages. The distribution of variables was evaluated using the Kolmogorov–Smirnov test and the Shapiro–Wilk test. Normality tests demonstrated that antral diameter measurements across the evaluated intragastric volume levels were not normally distributed; therefore, non-parametric tests were used for statistical comparisons. Because the data were not normally distributed, comparisons of dependent quantitative variables were performed using the Wilcoxon signed-rank test. Correlation analyses between repeated measurements were performed using the Spearman correlation coefficient. The agreement between the first and second measurement series was evaluated using the intraclass correlation coefficient (ICC). A p-value < 0.05 was considered statistically significant.

Diagnostic performance of gastric antral diameter for predicting predefined gastric volume thresholds (200 mL, 300 mL, and 400 mL) was evaluated using receiver operating characteristic (ROC) curve analysis. In addition, linear regression analysis was performed to assess the relationship between gastric antral diameter and intragastric volume. The area under the curve (AUC) was calculated for each threshold. Optimal cut-off values were determined using the Youden index ($J = \text{sensitivity} + \text{specificity} -$

1). ROC analysis was performed using all available measurements across volume levels. Cut-off values were selected based on ROC analysis and clinical interpretability.

Results

Patient Characteristics

A total of 50 critically ill patients receiving enteral nutrition via gastrostomy tubes were included in the study.

The mean age of the patients was 56.7 ± 18.7 years (range 21–92). The mean body height was 168.0 ± 9.8 cm, and the mean body weight was 67.9 ± 10.2 kg. The mean body mass index (BMI) was 24.0 ± 2.8 kg/m².

Baseline ultrasonographic measurements demonstrated a mean gastric antral diameter of 9.0 ± 2.8 mm in the empty stomach. Detailed demographic characteristics of the study population are presented in Table 1.

Table 1
Demographic and Baseline Characteristics of the Study Population

Variable	Min–Max	Median	Mean $\pm$ SD
Age (years)	21–92	57	56.7 ± 18.7
Height (cm)	150–185	169.5	168.0 ± 9.8
Weight (kg)	48–90	66	67.9 ± 10.2
BMI (kg/m ²)	17.6–29.3	24.1	24.0 ± 2.8
Empty stomach antral diameter (mm)	5–17	8	9.0 ± 2.8

Changes in Antral Diameter with Increasing Intragastric Volume

Ultrasonographic measurements demonstrated a progressive increase in gastric antral diameter with increasing intragastric volume.

The mean antral diameter increased from 9.0 ± 2.8 mm in the empty stomach to 11.2 ± 3.5 mm, 15.2 ± 4.3 mm, 19.3 ± 4.9 mm, 23.2 ± 5.7 mm, and 26.8 ± 5.3 mm after administration of 100, 200, 300, 400, and 500 mL, respectively.

Wilcoxon signed-rank test demonstrated that the antral diameter measured at all filled stomach volumes (100–500 mL) was significantly higher compared with the empty stomach ($p < 0.001$). Furthermore, pairwise comparisons between consecutive volume levels (0–100 mL, 100–200 mL, 200–300 mL, 300–400 mL, and 400–500 mL) also revealed statistically significant increases in antral diameter ($p < 0.05$ for

all comparisons). As shown in Fig. 1, gastric antral diameter increased progressively with increasing intragastric volume. Detailed descriptive statistics of antral diameter at each volume level are provided in Table 2.

Linear Regression Analysis

Linear regression analysis demonstrated a strong relationship between gastric antral diameter and intragastric volume ($R^2 \approx 0.88$, $p < 0.001$). The derived regression model indicated that gastric volume could be estimated using the following equation: gastric volume (mL) = $-72 + 21.5 \times$ antral diameter (mm). Accordingly, each 1 mm increase in antral diameter was associated with an approximate increase of 21.5 mL in gastric volume.

Figure 1. Relationship between intragastric volume and ultrasonographic gastric antral diameter in critically ill patients receiving enteral nutrition via gastrostomy. Data are presented as mean $\pm$ SD.

Table 2
Gastric Antral Diameter at Different Intragastric Volumes (First Measurement Series)

Volume (mL)	Min–Max (mm)	Median (mm)	Mean $\pm$ SD (mm)
0 (empty)	5–17	8	9.0 $\pm$ 2.8
100	6–18	10	11.2 $\pm$ 3.5
200	8–23	15	15.2 $\pm$ 4.3
300	10–30	19	19.3 $\pm$ 4.9
400	13–37	23	23.2 $\pm$ 5.7
500	16–39	27	26.8 $\pm$ 5.3

Wilcoxon signed-rank test demonstrated that antral diameters at all filled volumes were significantly greater than in the empty stomach ($p < 0.001$ for all comparisons). Pairwise comparisons between consecutive volume levels also showed significant increases in antral diameter ($p < 0.05$).

Reproducibility of Ultrasonographic Measurements

Measurement reproducibility was assessed by comparing the first and second measurement series obtained at each volume level.

Significant positive correlations were observed between the two measurement series for the empty stomach and for 100, 200, and 300 mL volume levels. Correlation coefficients ranged from $r = 0.321$ to $r = 0.612$, indicating moderate agreement between repeated measurements. The strongest correlation was observed for the empty stomach measurements ($r = 0.612$, $p = 0.001$). Significant correlations were also found for 100 mL ($r = 0.585$, $p = 0.001$), 200 mL ($r = 0.441$, $p = 0.022$), and 300 mL ($r = 0.380$, $p = 0.049$). Intraclass correlation coefficient (ICC) analysis further confirmed moderate agreement between

the two measurement series across the evaluated volume levels. As illustrated in Fig. 2 and summarized in Table 3, moderate agreement was observed between repeated measurements across volume levels.

Figure 2. Correlation between the first and second ultrasonographic measurements of gastric antral diameter obtained at different intragastric volume levels. The dashed line represents the line of identity ($x = y$).

Table 3 Reproducibility of Ultrasonographic Antral Diameter Measurements Between Two Measurement Series				
Volume Level	First Series (mm)	Second Series (mm)	Correlation	ICC (95% CI)
	Mean ± SD (Median)	Mean ± SD (Median)	r (p-value)	
Empty stomach	9.0 ± 2.8 (8.0)	9.5 ± 2.8 (9.0)	0.612 (0.001)	0.612 (0.315–0.780)
100 mL	11.2 ± 3.5 (10.0)	11.9 ± 4.2 (11.0)	0.585 (0.001)	0.585 (0.269–0.765)
200 mL	15.2 ± 4.3 (15.0)	15.3 ± 4.3 (14.0)	0.441 (0.022)	0.441 (0.015–0.683)
300 mL	19.3 ± 4.9 (19.0)	17.8 ± 4.3 (17.0)	0.380 (0.049)	0.380 (-0.093–0.648)
400 mL	23.2 ± 5.7 (23.0)	21.3 ± 4.6 (20.0)	0.346 (0.070)	0.346 (-0.152–0.629)
500 mL	26.8 ± 5.3 (27.0)	24.1 ± 4.3 (23.0)	0.321 (0.090)	0.321 (-0.197–0.615)
ICC: Intraclass Correlation Coefficient; CI: Confidence Interval. Statistically significant p-values (< 0.05) are shown in bold.				

Diagnostic Performance of Antral Diameter

ROC curve analysis was performed to assess the ability of antral diameter to predict clinically relevant gastric volume thresholds. The area under the curve (AUC) was 0.93 for predicting a gastric volume of 200 mL, 0.93 for 300 mL, and 0.91 for 400 mL (Fig. 3). The optimal cut-off values derived from the Youden index were 16 mm for 200 mL (sensitivity: 73.5%, specificity: 92.0%), 18 mm for 300 mL (sensitivity: 82.0%, specificity: 88.0%), and 19 mm for 400 mL (sensitivity: 84.0%, specificity: 80.0%). Detailed diagnostic performance metrics, including AUC, sensitivity, specificity, and optimal cut-off values, are presented in Table 4. These findings support the diagnostic utility of antral diameter for predicting clinically relevant gastric volume thresholds.

Table 4

Diagnostic performance of gastric antral diameter for predicting different intragastric volume thresholds

Volume threshold (mL)	AUC	95% CI	Optimal cut-off (mm)	Sensitivity (%)	Specificity (%)	Youden index
200	0.93	(0.88–0.98)	16	73.5	92.0	0.655
300	0.93	(0.88–0.98)	18	82.0	88.0	0.700
400	0.91	(0.85–0.96)	19	84.0	80.0	0.640

Note: AUC and 95% CI values were obtained from the ROC analysis. Optimal cut-off values were determined using the Youden index ($J = \text{sensitivity} + \text{specificity} - 1$).

Figure 3. Receiver operating characteristic (ROC) curves demonstrating high diagnostic performance of antral diameter for predicting gastric volume thresholds.

Influence of Demographic Variables

Spearman correlation analysis was performed to evaluate the potential relationship between demographic variables and gastric antral measurements.

No significant correlations were found between antral diameter and body height, body weight, or BMI across all volume levels ($p > 0.05$).

Age demonstrated a weak positive correlation with antral diameter at the 200 mL volume level ($r = 0.294$, $p = 0.038$); however, no significant association was observed at other volume levels.

The correlations between demographic variables and antral diameter measurements are summarized in Table 5.

Table 5
Correlation Between Demographic Variables and Antral Diameter

Volume	Age	Height	Weight	BMI
	r (p)	r (p)	r (p)	r (p)
Empty stomach	0.143 (0.320)	-0.147 (0.308)	0.045 (0.757)	0.199 (0.167)
100 mL	0.276 (0.052)	-0.065 (0.652)	0.109 (0.451)	0.186 (0.195)
200 mL	0.294 (0.038)	-0.069 (0.633)	0.024 (0.868)	0.157 (0.276)
300 mL	0.164 (0.255)	-0.028 (0.849)	0.073 (0.612)	0.108 (0.454)
400 mL	-0.175 (0.225)	0.016 (0.913)	0.124 (0.390)	0.140 (0.332)
500 mL	-0.051 (0.723)	0.133 (0.358)	0.204 (0.156)	0.063 (0.662)
Statistically significant p-values (< 0.05) are shown in bold.				

Discussion

The present study evaluated the relationship between intragastric volume and ultrasonographic gastric antral diameter in critically ill patients receiving enteral nutrition via gastrostomy tubes. The main finding of our study is that gastric antral diameter increased progressively with increasing intragastric volume. In addition, ultrasonographic measurements demonstrated moderate reproducibility between repeated measurement series. These findings suggest that gastric ultrasonography can provide a reliable bedside tool for monitoring gastric volume changes in critically ill patients receiving enteral nutrition.

Monitoring gastric residual volume (GRV) has long been used as an indicator of feeding intolerance in critically ill patients receiving enteral nutrition. However, the clinical value of routine GRV measurement remains controversial. Traditional GRV assessment using aspiration through nasogastric tubes has several limitations, including incomplete aspiration, tube occlusion, and operator-dependent variability, which may lead to inaccurate estimation of gastric contents [1–3]. Furthermore, several studies have suggested that routine GRV monitoring may unnecessarily interrupt enteral feeding without improving patient outcomes [4, 5].

Gastric ultrasonography has emerged as a promising non-invasive method for evaluating gastric contents and estimating gastric volume at the bedside. Ultrasonographic measurement of the gastric antrum provides indirect information about gastric volume because the antral region distends proportionally to the amount of gastric content [6–8]. Previous studies have demonstrated a strong correlation between ultrasonographic antral measurements and intragastric volume in both healthy volunteers and elective surgical patients [8–10]. Our findings are consistent with previous studies demonstrating a strong relationship between gastric antral measurements and intragastric volume in both healthy volunteers and surgical patients. In addition to correlation and ROC analysis, our study provides a quantitative predictive model for estimating gastric volume based on antral diameter. This

regression-based approach may enhance the clinical utility of gastric ultrasonography by allowing bedside estimation of gastric volume rather than simple categorization.

An important methodological feature of our study is the within-patient repeated measurement design. Each patient underwent sequential measurements at progressively increasing intragastric volumes, allowing each patient to serve as their own control. This design reduces inter-individual variability and enables a more precise evaluation of the relationship between administered gastric volume and ultrasonographic antral diameter.

Despite growing interest in gastric ultrasound, most previous studies have focused primarily on preoperative fasting assessment rather than on monitoring gastric volume during enteral feeding. Critically ill patients represent a unique population in whom gastrointestinal physiology may be significantly altered. Mechanical ventilation, sedative medications, opioid administration, and hemodynamic instability may impair gastric motility and delay gastric emptying in critically ill patients. Previous studies have also highlighted the complex interplay between gastric motility, critical illness, and enteral feeding intolerance, further supporting the clinical relevance of our findings [11, 12, 26–30].

A key strength of our study is its focus on enterally tube-fed critically ill patients. Unlike previous studies conducted in healthy volunteers or fasting preoperative patients, our study population represents the exact clinical scenario in which gastric volume monitoring is most relevant. Gastrostomy feeding is commonly used in critically ill patients who require prolonged enteral nutrition, making accurate assessment of gastric volume particularly relevant in this population. In ICU settings, enteral nutrition is considered the preferred method of nutritional support because it maintains gut integrity and reduces infectious complications compared with parenteral nutrition [1, 13]. However, feeding intolerance and gastric retention remain common problems in critically ill patients receiving enteral nutrition and may increase the risk of regurgitation and aspiration pneumonia [14, 15, 29, 30].

Another important finding of our study was the reproducibility of ultrasonographic measurements. The correlation analysis demonstrated significant agreement between repeated measurement series, indicating that gastric ultrasound can provide consistent measurements when performed using a standardized protocol. Previous studies have similarly reported good intra-observer and inter-observer reliability for gastric ultrasound measurements [16–18].

Interestingly, the reproducibility of antral diameter measurements appeared to decrease at higher intragastric volumes (400–500 mL), where correlations between repeated measurements were no longer statistically significant. Several factors may explain this finding. At higher gastric volumes, increased gastric distension and peristaltic activity may lead to greater variability in antral configuration during ultrasonographic assessment. In addition, partial gastric emptying may occur during sequential measurements, particularly at higher volumes, which could influence the actual intragastric volume at the time of examination. Furthermore, at higher intragastric volumes the shape and position of the stomach may change due to gastric distension, which can make ultrasonographic visualization of the antrum technically more challenging and contribute to increased measurement variability. These

physiological and technical factors may contribute to the reduced measurement consistency observed at higher volume levels.

Our analysis also suggested that body mass index and other demographic characteristics had no consistent influence on antral measurements. These findings are generally consistent with previous studies investigating gastric ultrasound measurements in different patient populations [10, 19]. Although a weak positive correlation between age and antral diameter was observed at the 200 mL volume level, this finding was not consistent across other volume levels and may represent a chance association rather than a clinically meaningful relationship.

The clinical implications of our findings are noteworthy. The diagnostic performance of antral diameter was further supported by ROC analysis, which demonstrated excellent discriminatory ability for predicting gastric volumes of 200 mL and 300 mL (AUC = 0.93) and good discriminatory ability for 400 mL (AUC = 0.91). For instance, an antral diameter ≥ 16 mm suggests a gastric volume exceeding 200 mL, whereas a diameter ≥ 18 mm indicates volumes above 300 mL. Different thresholds may be preferred depending on whether sensitivity or specificity is prioritized in clinical practice. These findings support the use of point-of-care ultrasound as a valid alternative to traditional GRV aspiration, potentially reducing unnecessary feeding interruptions and improving nutritional management in the ICU. These cut-off values may help define clinically actionable thresholds for gastric residual volume, particularly in guiding decisions to continue or interrupt enteral feeding. Gastric ultrasonography may provide clinicians with a rapid, repeatable, and non-invasive bedside method for evaluating gastric contents and guiding enteral feeding management in critically ill patients. Such an approach may assist in clinical decision-making regarding continuation or adjustment of enteral nutrition and could potentially reduce unnecessary interruptions of feeding. In addition, bedside gastric ultrasound may assist in identifying patients at increased risk of regurgitation and aspiration [20–22]. Furthermore, the ability to estimate intragastric volume at the bedside may provide a practical tool for guiding enteral nutrition strategies and supporting more individualized and safer nutritional management. Future studies are warranted to evaluate whether ultrasound-guided assessment of gastric volume can improve clinical outcomes and optimize feeding protocols in this patient population. Our findings contribute to the growing body of evidence supporting the role of gastric ultrasonography in the management of critically ill patients receiving enteral nutrition. For instance, a sudden increase in antral diameter during feeding could prompt the clinician to pause feeding and reassess gastric emptying, thereby reducing aspiration risk.

Several limitations of the present study should be acknowledged. First, the study was conducted in a single center with a relatively limited sample size, which may affect the generalizability of the results. Second, gastric ultrasound is an operator-dependent technique, and although examinations were performed using a standardized protocol, variability between operators may occur. Third, ultrasonographic antral diameter was used as a surrogate marker for gastric volume rather than direct measurement of gastric contents. Gastric emptying may occur during sequential volume administration, which could slightly influence the measured intragastric volume at the time of ultrasonographic assessment. Because multiple measurements were obtained from the same patients, ROC analysis was

performed assuming independence between observations, which may introduce bias and should be interpreted with caution. Furthermore, a formal a priori sample size calculation was not performed; although 50 patients were included and significant differences were demonstrated across gastric volumes, the sample size may have limited the statistical power to detect weaker correlations, particularly for higher volume levels (400–500 mL) and demographic associations. Nevertheless, the repeated-measurement design—in which multiple volume measurements were obtained from each patient—may partially offset this limitation by increasing statistical efficiency. We also did not systematically record or adjust for potential confounding factors such as sedation status, mechanical ventilation, or the use of opioids and prokinetic agents, which are known to influence gastric motility. However, because each patient served as their own control in a sequential within-patient design, the confounding effect of these factors on the relationship between antral diameter and intragastric volume is likely minimal. Future studies with larger patient populations are needed to validate these findings and to develop predictive models for estimating gastric volume in critically ill patients receiving enteral nutrition [23–25].

Conclusion

Ultrasonographic measurement of gastric antral diameter increases proportionally with intragastric volume in critically ill patients receiving enteral nutrition via gastrostomy. Gastric ultrasound is a reliable, non-invasive bedside tool for evaluating gastric volume and guiding enteral feeding decisions in the ICU, with the potential to improve patient safety and nutritional management. These findings position gastric ultrasound as a practical alternative to traditional GRV assessment.

Declarations

Previous Presentation in Conferences

No

Conflict of Interest:

The authors declare no conflict of interest.

IRB Number

Clinical Research Ethics Committee Van YYU (approval dated 16.02.2018, No. 05)

Funding:

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Conflicts of Interest:

The authors declare no conflict of interest.

Ethical Approval:

The study was approved by the Institutional Ethics Committee of Van Yuzuncu Yıl University (Approval No: 05, Date: 16/02/2018).

Informed Consent:

Informed consent was waived due to the observational nature of the study.

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Author Contribution

A.K.O. conceived and designed the study. A.K.O. performed data collection, statistical analysis, and wrote the main manuscript. A.E.T., Y.E.T., M.U., R.Ç., M.B.A., M.Ö., and H.D. contributed to data interpretation and critically revised the manuscript. All authors reviewed and approved the final manuscript.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available due to patient privacy considerations but are available from the corresponding author on reasonable request.

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Figures

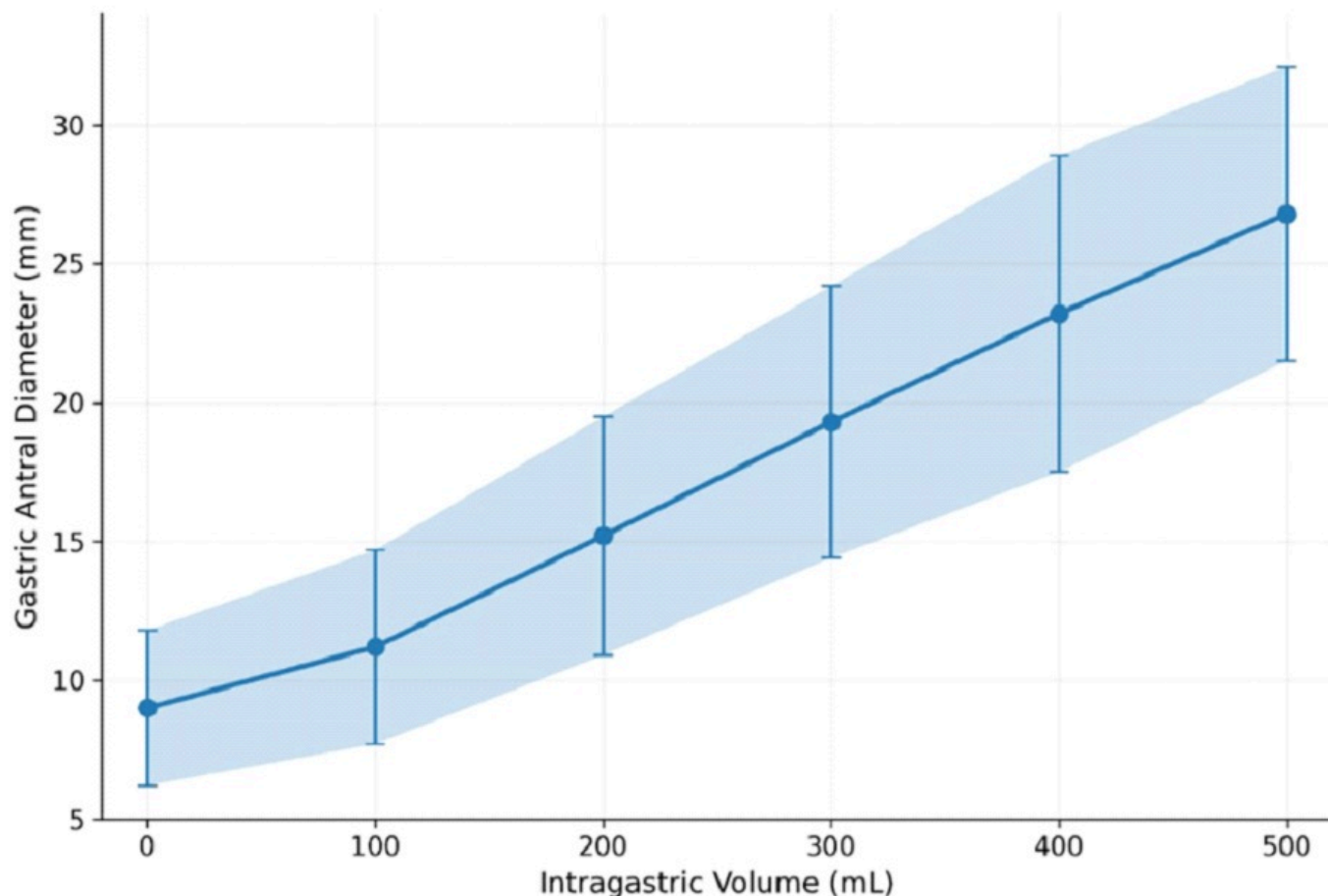


Figure 1

Relationship between intragastric volume and ultrasonographic gastric antral diameter in critically ill patients receiving enteral nutrition via gastrostomy. Data are presented as mean $\pm$ SD.

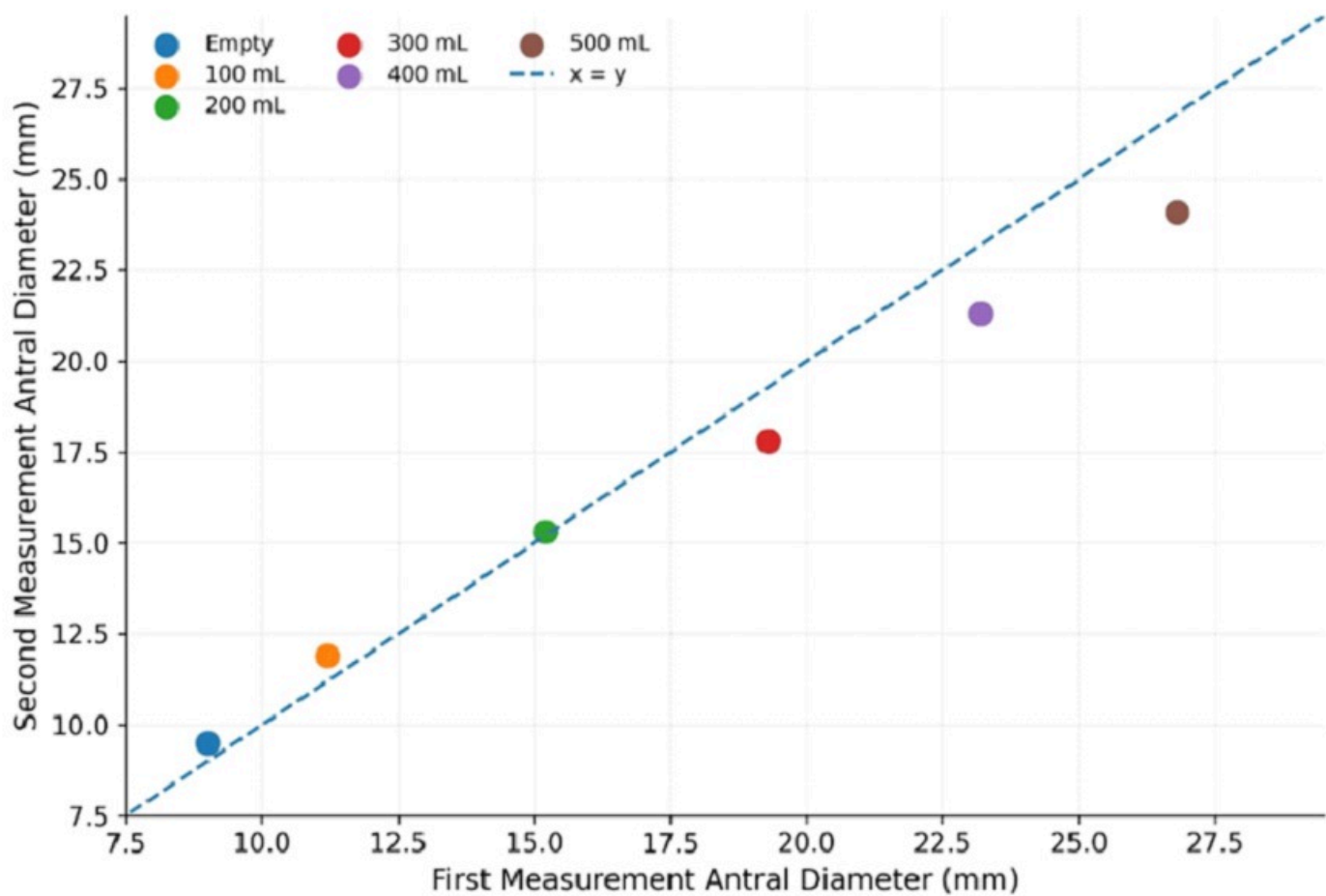


Figure 2

Correlation between the first and second ultrasonographic measurements of gastric antral diameter obtained at different intragastric volume levels. The dashed line represents the line of identity ($x = y$).

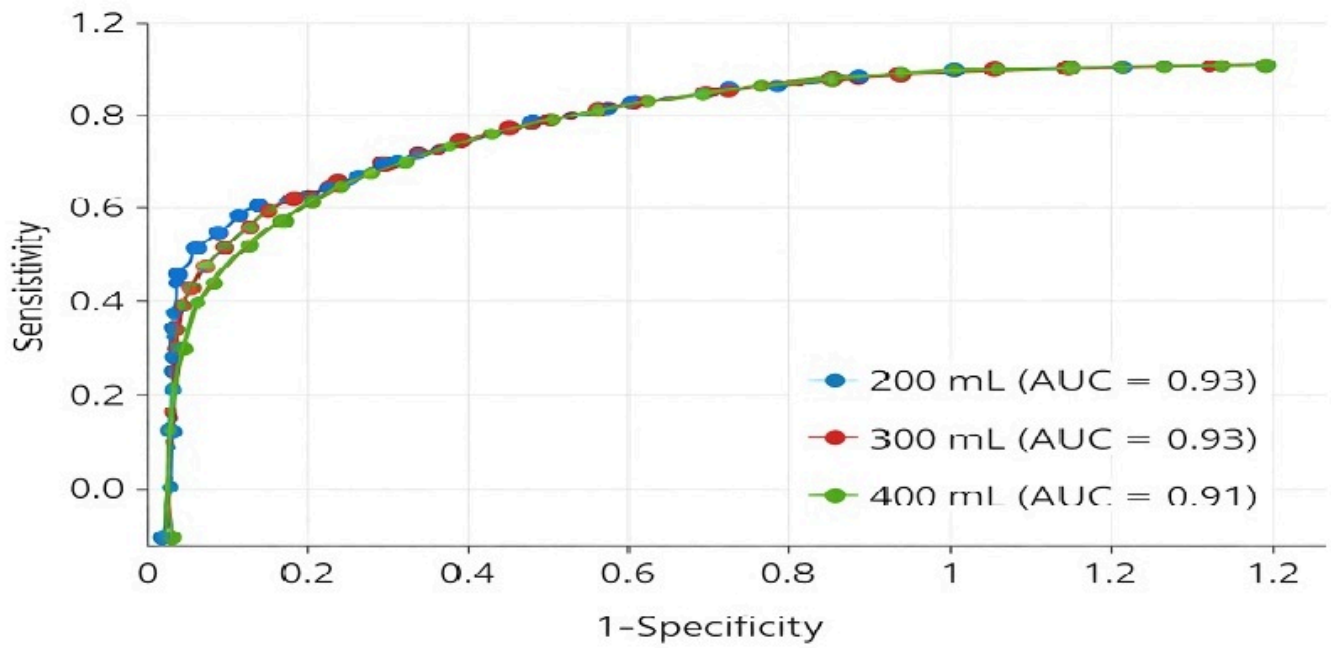


Figure 3

Receiver operating characteristic (ROC) curves demonstrating high diagnostic performance of antral diameter for predicting gastric volume thresholds.