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ORIGINAL RESEARCH

Ultrasonography to measure gastric content in pregnant and nonpregnant female patients undergoing elective surgery

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Abstract

Background: Pulmonary aspiration in patients undergoing general anesthesia is a significant complication. Adequate fasting periods and an empty stomach preoperatively are crucial for preventing pulmonary aspiration. With limited evidence suggesting no significant difference in gastric emptying times between pregnant and nonpregnant populations, many anesthesiologists still consider pregnant patients to have "full stomachs", despite the lack of clear guidelines on fasting periods for pregnant women. **Methods**: Forty-two term pregnant patients and 42 nonpregnant patients were included in the study. Ultrasonography was performed 15 minutes before surgery to measure gastric antrum dimensions, and the stomach contents (empty, liquid, or solid) were recorded. Using the cross-sectional area (CSA), the antrum volume was calculated based on Perlas formula (mL = 27.0 + 14.6 × CSA − 1.28 × age), and differences between the groups were analyzed. **Results**: Empty stomach (8/42 = 19% versus 34/42 = 81%), liquid content (16/42 = 38% versus 7/42 = 17%), and solid content (18/42 = 43% versus 1/42 = 2%) differed ($p < 0.001$) between the pregnant and nonpregnant patients. Antrum dimensions and antrum volumes were different as well ($p < 0.001$). **Conclusions**: The gastric emptying rate of pregnant patients differs from that of the normal population, which should be considered when evaluating patients on the operating table.

Keywords

PoCUS; Pregnancy; Gastric emptying; Fasting

1. Introduction

The aspiration of gastric contents during general anesthesia is a notable concern for anesthesiologists. To mitigate this risk, a fundamental preventive strategy involves enforcing a specific period of fasting for patients before surgery. While some studies have suggested that the gastric emptying times of pregnant women are similar to those of nonpregnant individuals, this study aims to assess the accuracy of the findings [1].

Aspiration of gastric contents may lead to complications, such as pneumonia or mechanical ventilation, highlighting the importance of adequate fasting. The severity of these complications can vary based on the content, volume, and acidity of the aspirate [2].

In 2022, the European Society of Anesthesia and Intensive Care released new guidelines titled *Preoperative Fasting in Children*, which introduced updated recommendations for children based on new evidence. The aim was to prevent conditions, such as dehydration, hypotension, hypoglycemia, and ketosis, resulting from unnecessarily prolonged fasting periods [3], not only to minimize the risk of aspiration of gastric contents but also to ensure the shortest possible fasting times.

Advances in ultrasound technology and its integration into routine anesthesia practice have led to the development of antral ultrasonography methods to assess patients' fasting status. Antral ultrasonography can safely detect gastric contents and estimate gastric volume by measuring the antral section.

The primary outcome of this research is a comparison of gastric antrum cross-sectional area (CSA) and gastric volume between pregnant and nonpregnant female patients undergoing elective surgery, measured using point-of-care ultrasonography (PoCUS). This outcome aims to determine significant differences in gastric emptying rates and aspiration risk based on gastric contents and fasting durations in the two groups.

2. Materials and methods

2.1 Study design and participants

This observational study, with a retrospective classification, was conducted between 01 July and 01 November 2022, on nonpregnant women and term pregnant women, all with an American Society of Anesthesiologists (ASA) physical status

score of II; the pregnant participants were scheduled for elective cesarean section. The participants were between the ages of 20 and 40 and had similar disease histories. All eligible patients during the study period were enrolled consecutively and evaluated using a predefined ultrasonography protocol.

2.2 Inclusion criteria

Female patients aged between 20 and 40 years who were either term pregnant or nonpregnant and scheduled for elective surgery were considered eligible for participation in the study. For the pregnant group, inclusion was limited to those undergoing planned cesarean delivery. All patients were required to have an ASA physical status classification of I or II. Additional eligibility criteria included a body weight of 50–100 kg, a height of at least 150 cm, and the cognitive ability to understand the nature and purpose of the study assessments.

Patients were included if they had completed a minimum fasting period of 6 hours prior to ultrasound assessment. There was no specified upper limit for fasting duration. All eligible patients were informed about the study during preoperative anesthesia consultation and were included after providing written informed consent. The ultrasound examinations were conducted in the preoperative holding area prior to surgical procedures.

2.3 Exclusion criteria

Patients were excluded from the study if they declined to participate or were unable to establish cooperation during preoperative interviews. Additional exclusion criteria included age below 20 or above 40 years, the presence of multiple pregnancies, and any known anatomical abnormalities of the upper gastrointestinal tract.

Patients with a history of surgical interventions involving the esophagus, stomach, or upper abdominal region were also excluded. However, comorbidities, such as gastroesophageal reflux disease and diabetes mellitus, were not considered exclusion criteria.

Furthermore, patients with a fasting duration of less than 6 hours or those who had taken any pharmacological agents known to affect gastric motility (*e.g.*, prokinetics or anticholinergics) before the assessment were excluded from the study.

2.4 Data collection

Demographic and clinical data recorded for each patient included age, comorbidities, fasting duration, last meal type, and body mass index (BMI).

2.5 Ultrasonography protocol

Ultrasonography examinations were performed using an Esaote MyLab5 (Esaote S.p.A., Genoa, Italy) device equipped with a 2–5 MHz CA431 abdominal probe. All measurements were conducted by a single operator to ensure consistency and minimize interobserver variability. Patients were positioned in a 45° supine semirecumbent posture for the initial examination.

2.6 Ultrasound operator

All ultrasound assessments were performed by an anesthesiologist with four years of clinical experience, including training in PoCUS applications. Prior to data collection, the operator completed a standardized training process under the supervision of a radiologist with over 20 years of experience. During the pre-study phase, the operator conducted at least 30 supervised measurements to achieve consistency in probe positioning, the measurement technique, and anatomical recognition. These steps were taken to minimize variability and maintain methodological rigor throughout the study.

2.7 Imaging procedure

The abdominal aorta and the left lobe of the liver served as internal landmarks to establish a sagittal scanning plane in the epigastric region. The gastric antrum was visualized at the level of the aorta, situated between the left lobe of the liver and the pancreas (Fig. 1). To obtain comprehensive qualitative observations of the gastric antrum, body, cavity, and contents, the transducer was moved in a curving motion from right to left.

Following supine examination, patients were repositioned slightly to the right to facilitate gravitational flow of gastric contents into the antrum, enhancing the sensitivity of gastric ultrasound and aiding in gastric volume measurement.

2.8 Quantitative and qualitative assessments

Three consecutive measurements of the maximal anteroposterior and longitudinal diameters (serosa to serosa) were taken, and the antral CSA was calculated using the mean values of these diameters. The gastric volume was then estimated using Perlas formula (Eqn. 1):

$$Gastric\,Volume = 27.0 + 14.6 \times CSA - 1.28 \times age \quad (1)$$

For qualitative assessment, gastric content was categorized into three classes: empty, liquid, and solid (Fig. 2). A gastric volume of less than 45 mL was classified as an empty stomach. If the content was primarily liquid or solid food, the stomach was categorized as full, indicating a higher aspiration risk.

2.9 Power analysis and sample size calculation

Prior to the study, a power analysis was conducted using G*Power version 3.1.9.7 software (Heinrich Heine University Düsseldorf, Düsseldorf, NRW, Germany). The calculations were based on *t*-tests, considering the means and differences between two independent means. With an effect size of 0.8 (determined from a preliminary study), an alpha level of 0.05, a power of 0.95, and two groups, a total sample size of 84 participants was determined, with each group consisting of 42 individuals.

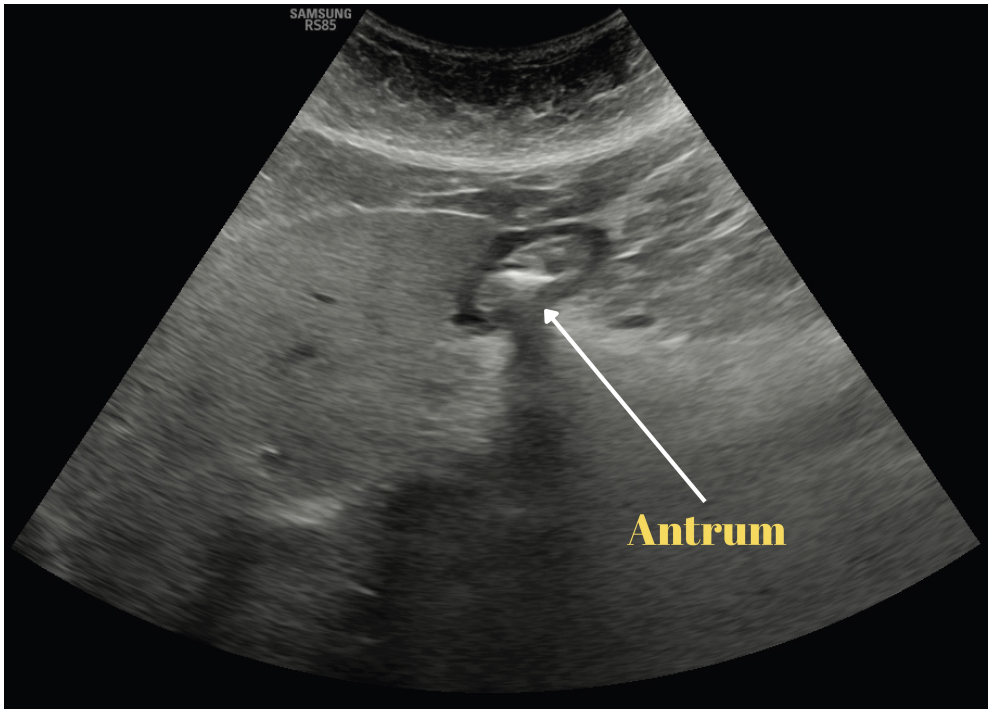

FIGURE 1. Ultrasound image of the gastric antrum in the right lateral decubitus position. Representative image of the gastric antrum obtained via ultrasonography, demonstrating the anatomical borders of the antrum in the right lateral decubitus position.

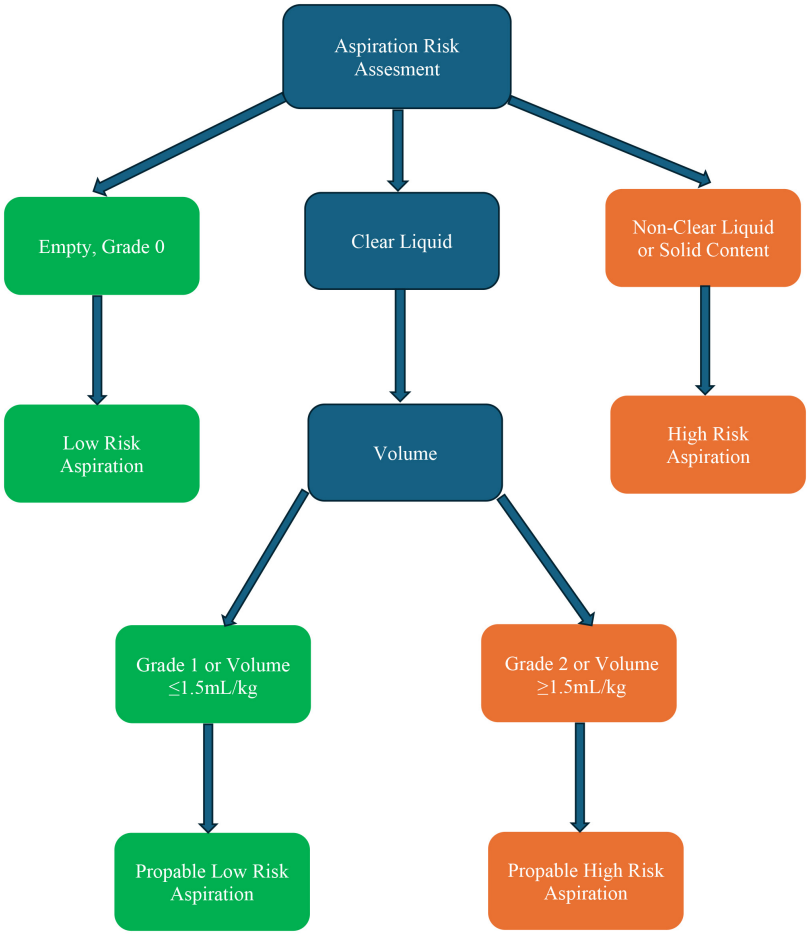

FIGURE 2. Aspiration risk assessment based on gastric antral content and volume. Flowchart describing the clinical decision-making process for aspiration risk evaluation using qualitative and quantitative gastric ultrasound findings.

2.10 Statistical analysis

The data were analyzed using IBM's Statistical Package for the Social Sciences version 25.0 (IBM Corp., Armonk, NY, USA). Normality of data distribution was assessed using the Shapiro-Wilk test. Data are presented as percentages (%), mean ± standard deviation (SD), minimum, median, and maximum values.

Comparisons between the two groups were performed using chi-square and Fisher's exact tests for categorical data. The independent *t*-test was used for parametric data following a normal distribution. The Mann-Whitney U test was employed for nonparametric data. Intragroup comparisons before and after the procedure were analyzed using Friedman's test. A *p*-value less than 0.05 was considered statistically significant.

3. Results

In our study, we included 84 patients: 42 pregnant and 42 nonpregnant individuals who met the inclusion criteria. Despite prolonged fasting periods beyond the guidelines, we found that gastric contents were empty in 42 patients (50%), liquid in 23 patients (27.4%), and solid in 19 patients (22.6%). Among the patients, 10 (11.9%) had diabetes mellitus (Table 1).

Comparing patients between the pregnant and nonpregnant groups, there were no statistically significant differences in age, BMI, comorbidities, fasting duration, or meal patterns. However, statistically significant differences were observed in antrum grade, gastric content, antral CSA, and antral volume ($p < 0.001$) (Table 1).

When comparing the antral volumes of pregnant and nonpregnant patients based on BMI, no statistically significant differences were found within the pregnant group ($p = 0.591$) or within the nonpregnant group ($p = 0.503$) in intragroup comparisons. However, in intergroup comparisons based on BMI, antral volumes were found to be significantly higher in the pregnant group than in the nonpregnant group among normal and overweight patients (Table 2).

When comparing the antral CSAs of pregnant and nonpregnant patients based on BMI, no statistically significant differences were observed in intragroup comparisons within the pregnant group ($p = 0.495$) or within the nonpregnant group ($p = 0.203$). However, intergroup comparisons based on BMI showed that antral CSA was significantly higher in the pregnant group than in the nonpregnant group across all BMI categories (Table 2).

Comparing the antral volumes of pregnant and nonpregnant patients based on fasting duration, statistically significant differences were found within the pregnant group ($p = 0.034$) and within the nonpregnant group ($p = 0.003$). Specifically, within the pregnant group, there was a significant difference in the 6–8-hour fasting subgroup compared with other groups, while within the nonpregnant group, there was a significant difference in the >10-hour fasting subgroup compared with the other groups. In intergroup comparisons based on fasting times, antral volumes were significantly higher in the pregnant group compared with the nonpregnant group in the 6–8-hour and >10-hour fasting subgroups, but no significant difference was found in the 8–10-hour fasting subgroup (Table 3).

When comparing the antral CSAs of pregnant and nonpregnant patients based on fasting duration, no statistically significant difference was found within the pregnant group ($p = 0.478$). However, within the nonpregnant group, a statistically significant difference was observed in the >10-hour fasting subgroup ($p = 0.027$). In intergroup comparisons based on fasting times, the antral CSA was significantly higher in the pregnant group than in the nonpregnant group in the 6–8-hour ($p = 0.010$) and >10-hour ($p < 0.001$) fasting subgroups, while no significant difference was found in the 8–10-hour fasting subgroup (Table 3).

When comparing the antral volumes of pregnant and nonpregnant patients based on stomach contents, no statistically significant difference was observed in the pregnant group ($p = 0.313$). However, a statistically significant difference was found within the nonpregnant group, specifically between the empty and liquid groups ($p = 0.003$) in intragroup comparisons. In intergroup comparisons according to gastric content, compared with the nonpregnant group, no statistically significant difference was detected between the empty, liquid, and solid antral volumes in the pregnant group (Table 4).

When assessing the antral CSA based on stomach contents for both pregnant and nonpregnant patients, a statistically significant difference was found in both groups. In the pregnant group ($p < 0.001$), a difference was observed between the group with an empty stomach and the group with both solid and liquid stomach contents. In the nonpregnant group ($p = 0.011$), a difference was observed between the groups with empty and liquid stomach contents. However, in intergroup comparisons according to stomach content, no statistically significant difference was identified between the pregnant and nonpregnant groups in all comparisons (Table 4).

Receiver Operating Characteristic (ROC) analysis for antral section CSA and antral volume yielded a *p*-value less than 0.001. The areas under the curve were 0.820 for antral section CSA and 0.791 for antral volume. The cutoff value for the antral section CSA was 295, with a sensitivity of 71.4% and specificity of 85.7%. The cutoff value for the antral volume was 40.5 mL, with a sensitivity and specificity of 73.8% each (Fig. 3, Table 5).

As shown in Table 6, comorbidity status (B (Unstandardized regression coefficient) = 93.577, $p < 0.001$), fasting time (B = −20.781, $p = 0.01$), and pregnancy status (B = −72.506, $p < 0.001$) were found to be statistically significant predictors of CSA. In contrast, BMI ($p = 0.706$) and last meal type ($p = 0.191$) were not significantly associated with CSA. These findings suggest that comorbid conditions and reduced fasting time are associated with increased gastric volume and that pregnancy is an independent factor that influences antral CSA, regardless of BMI or recent meal characteristics.

4. Discussion

Clinical decisions on surgical timing and airway management often rely on fasting duration, yet gastric emptying varies due to preexisting conditions, and fasting guidelines do not guarantee an empty stomach. In emergency cases or patients with delayed gastric emptying, bedside gastric ultrasound can provide a more accurate aspiration risk assessment. If imaging

TABLE 1. Comparison of demographic and clinical characteristics between pregnant and nonpregnant patients scheduled for elective surgery.

	Groups				*p* values
	Pregnant		Nonpregnant		
	n	%	n	%	
BMI					
Normal (18.5–24.9 kg/m^2)	19	45.2%	24	57.1%	
Overweight (25.0–29.9 kg/m^2)	15	35.7%	14	33.3%	0.377
Obese (≥30.0 kg/m^2)	8	19.0%	4	9.5%	
Comorbid disease					
None	36	85.7%	38	90.5%	0.500
Yes (Diabetes Mellitus)	6	14.3%	4	9.5%	
Antrum Grade					
<45 (low risk)	13	31.0%	33	78.6%	<0.001*
>45 (high risk)	29	69.0%	9	21.4%	
Fasting time (h)					
6–8	12	28.6%	6	14.3%	
8–10	13	31.0%	21	50.0%	0.135
>10	17	40.5%	15	35.7%	
Gastric content					
Empty	8	19.0%	34	81.0%	
Fluid	16	38.1%	7	16.7%	<0.001*
Solid	18	42.9%	1	2.4%	
Last meal					
Fluid	15	35.7%	15	35.7%	
Solid non-fatty	13	31.0%	18	42.9%	0.388
Solid fatty	14	33.3%	9	21.4%	

BMI: Body Mass Index. Significant p-values are indicated by an asterisk (*).

TABLE 2. Comparison of antral volume and cross-sectional area (CSA) between pregnant and nonpregnant patients according to BMI categories.

	Pregnant	Nonpregnant	*p* values
	Antrum volume	Antrum volume	
BMI			
Normal (18.5–24.9 kg/m^2)	50.00 ± 15.06	38.29 ± 11.20	<0.001*
Overweight (25.0–29.9 kg/m^2)	57.00 ± 19.01	33.21 ± 12.41	0.004*
Obese (≥30.0 kg/m^2)	57.13 ± 22.97	34.50 ± 3.51	0.154
p values	0.591	0.503	
	CSA	CSA	*p* values
BMI			
Normal BMI (18.5–24.9 kg/m^2)	317.63 ± 65.08	241.46 ± 42.97	0.011*
Overweight (25.0–29.9 kg/m^2)	324.20 ± 69.55	245.07 ± 57.96	0.001*
Obese (≥30.0 kg/m^2)	351.75 ± 93.53	275.00 ± 49.32	0.048*
p values	0.495	0.203	

BMI: Body Mass Index; CSA: Cross-sectional Area. Significant p-values are indicated by an asterisk (*).

TABLE 3. Comparison of antral volume and CSA according to fasting duration in pregnant and nonpregnant patients.

	Pregnant	Nonpregnant	*p* values
	Antrum volume	Antrum volume	
Fasting time (h)			
6–8	64.50 ± 17.77	46.33 ± 14.82	0.041*
8–10	44.77 ± 14.53	38.43 ± 10.17	0.096
>10	51.00 ± 18.31	29.13 ± 6.15	<0.001*
p values	0.034*	0.003*	
post-hoc	0.0291-3 0.0171-2	0.0222-3 0.0091-3	
	CSA	CSA	*p* values
Fasting time (h)			
6–8	345.08 ± 65.82	267.50 ± 42.39	0.010*
8–10	305.54 ± 70.51	258.24 ± 48.32	0.060
>10	329.35 ± 76.87	219.87 ± 42.65	<0.001*
p values	0.478	0.027*	
post-hoc		0.0192-3 0.0311-3	

CSA: Cross-sectional Area. Significant p-values are indicated by an asterisk (*).

TABLE 4. Comparison of antral volume and CSA according to gastric contents in pregnant and nonpregnant patients.

	Pregnant	Nonpregnant	*p* values
	Antrum volume	Antrum volume	
Gastric content			
Empty	45.88 ± 19.35	32.94 ± 8.25	0.070
Fluid	54.37 ± 18.29	52.14 ± 11.37	1.000
Solid	56.94 ± 17.20	37.00 ± 0.00	0.526
p values	0.313	0.003*	
	CSA	CSA	*p* values
Gastric content			
Empty	235.88 ± 40.16	235.32 ± 46.02	0.962
Fluid	342.81 ± 78.81	285.00 ± 31.22	0.118
Solid	352.22 ± 38.76	330.00 ± 0.00	0.737
p values	<0.001*	0.011*	

CSA: Cross-sectional Area. Significant p-values are indicated by an asterisk (*).

shows an empty stomach, the aspiration risk is low. Clear liquid content requires volume assessment per Perlas or Bouvet, while dense liquid or solid content indicates a high aspiration risk, regardless of volume [4–6].

When we categorized patients based on BMI, there were no significant differences between the groups in terms of gastric antrum CSA and antrum volume. However, a significant difference was observed between the two groups. BMI did not appear to be a factor increasing the frequency of a full stomach, but it seemed to indicate a higher risk of aspiration. Moreover, antral CSA was positively correlated with BMI and calculated gastric content volume. This suggests that an increased BMI is associated with a larger gastric content volume. These findings support the notion that obesity alone may not be a significant factor but becomes a risk factor when accompanied by comorbidities, in line with the views of Jackson *et al.* [7].

Diabetes mellitus, known to significantly affect gastroparesis, gastric volume, and gastric content, was found to cause differences in these aspects between diabetic and nondiabetic patients, consistent with other studies [8, 9].

The mean CSA for pregnant patients was 329.5 mm^2, while it was 250 mm^2 for nonpregnant patients. Regarding the fasting antral region among volunteers, our results are consistent with previously published studies. For instance, Benini *et al.* [10] reported a mean ± SD basal value of 319 ± 92 mm^2 in 19 healthy participants. Similarly, Darwiche *et al.* [11] reported a median value of 214 mm^2 (range 126–263 mm^2) before meals in eight volunteers. Wong *et al.* [12] reported mean antral CSA values of 4 ± 2.5 and 5.2 ± 2.1 cm^2. As indicated in prior research, the antral region showed discernible differences

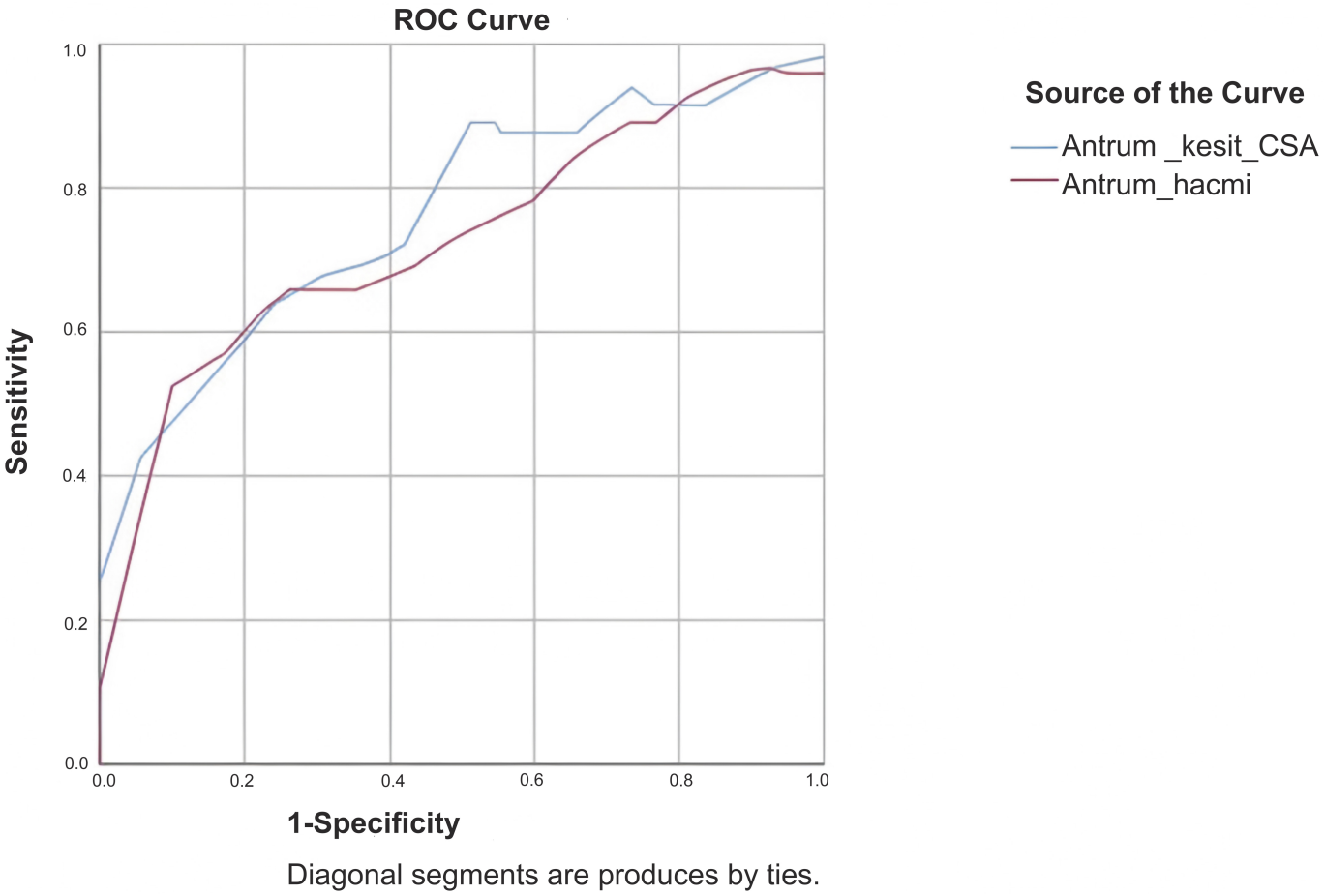

FIGURE 3. Receiver operating characteristic (ROC) curves for antral CSA and antral volume in predicting high aspiration risk. Comparison of the diagnostic performance of antral cross-sectional area (CSA) and antral volume with ROC analysis. The area under the curve (AUC) was 0.820 for CSA and 0.791 for antral volume. ROC: receiver operating characteristic; CSA: cross-sectional area.

TABLE 5. ROC analysis for gastric CSA and volume in predicting aspiration risk.

	AUC (95% CI)	Cutoff	*p*	Sensitivity (%)	Specificity (%)
CSA	0.820 (0.730–0.911)	295.0	<0.001	71.4	85.7
Antrum volume	0.791 (0.695–0.888)	40.5	<0.001	73.8	73.8

AUC: Area Under the Curve; CSA: Cross-sectional Area; CI: confidence interval. A multiple linear regression analysis was performed to identify independent predictors of antral CSA. The overall model was statistically significant ($F(5, 78) = 15.857$, $p < 0.001$) and explained approximately 50.4% of the variance in CSA ($R^2 = 0.504$, adjusted $R^2 = 0.472$).

TABLE 6. Multiple linear regression analysis of factors associated with antral cross-sectional area (CSA).

	B (Unstandardized)	Standard Error (SE)	*t*-value	*p*-value
(Constant)	403.911	30.510	13.239	<0.001*
BMI	3.259	8.611	0.378	0.706
Comorbidity	93.577	19.038	4.915	<0.001*
Fasting Time (h)	−20.781	7.850	−2.647	0.010*
Last Meal Type	10.282	7.803	1.318	0.191
Pregnancy	−72.506	11.806	−6.141	<0.001*

BMI: Body Mass Index; B: Unstandardized regression coefficient. Significant p-values are indicated by an asterisk (*).

among participants in the matched volunteer groups. It is important to note that the antral area cutoff value of 296 mm^2 reported in preliminary studies may not be applicable for assessing gastric content status in clinical practice, as it is likely to vary with patient age and height [4, 13].

When comparing antral volumes based on fasting durations, a statistically significant difference was observed between the pregnant and nonpregnant groups for fasting durations of 6–8 hours, but no significant difference was found for fasting durations of 8–10 hours. This suggests that the disparity narrows as stomach content diminishes over time due to the slower gastric emptying rate in pregnant women. The mean fasting antrum volume was 45.05 $\pm$ 17.37 mL. While there were no differences in intragroup volumes among nonpregnant patients, the pregnant group exhibited significantly different volumes compared with the nonpregnant group, which aligns with recent reports from other medical centers [14]. For example, Arzola *et al.* [15] reported a median volume of 48 mL (IQR (Interquartile Range): 45), and Rouget *et al.* [16] identified a median volume of 44 mL (IQR: 49). In addition to corroborating previous findings, the present study offers additional value by comparing obstetric subjects with a similar cohort of nonpregnant subjects (in terms of sex and age). While Rouget and colleagues [16] and Wong *et al.* [17] reported values solely for obstetric subjects, Arzola and colleagues used a historical comparative cohort of unselected elective surgery subjects [12].

In our risk-grade matching between pregnant and nonpregnant patients, pregnant patients were more likely to be at high risk. This reinforces the idea that gastric emptying rates slow down during pregnancy, leading to an increased risk of aspiration due to greater gastric contents, which is consistent with numerous studies [18, 19].

Despite the absence of underlying conditions that could delay gastric emptying, the analysis of gastric contents between the two groups revealed that 38% of pregnant patients had liquid contents and 42% had solid contents, whereas 80% of nonpregnant patients had empty stomachs. This study provides further support for the idea that gastric emptying times in pregnant women are prolonged compared with nonpregnant women, which aligns with the findings of many other studies [20, 21].

In our study, solid gastric contents were observed in 11 out of 13 pregnant patients whose last meal was fatty and solid. None of the nine nonpregnant patients who had a fatty and solid last meal were found to have solid stomach contents. This aligns with a study by Scrutton *et al.* [22] demonstrating that the antral CSA was larger and gastric contents emptied later in second- and third-trimester obstetric women who were allowed to eat during labor compared with those restricted to a clear liquid diet.

Our findings revealed significantly higher gastric antral CSA and gastric volume in pregnant patients compared with their nonpregnant counterparts, which may be attributed to physiological changes during pregnancy. Hormonal alterations—particularly increased progesterone levels—are known to reduce gastrointestinal motility and tone, while the mechanical effect of an enlarged uterus further delays gastric emptying by compressing the stomach. These mechanisms collectively contribute to a higher aspiration risk in pregnant individuals, even after standard fasting durations. This aligns with previous research suggesting delayed gastric emptying in late-term pregnancies. Additionally, our ROC analysis demonstrated that a CSA cutoff of 295 mm^2 and a gastric volume cutoff of 40.5 mL provided optimal sensitivity and specificity for identifying patients at aspiration risk. These thresholds may serve as practical guides for anesthesiologists in determining aspiration risk and tailoring perioperative management, especially in obstetric populations where fasting status is frequently uncertain.

However, it is important to interpret these thresholds with caution, as most CSA and volume cutoff values—including those cited in our study—have been derived from nonpregnant populations. The physiological and anatomical changes unique to pregnancy may necessitate different threshold values to accurately assess aspiration risk. For instance, Hakak *et al.* [23] found that even after 6 hours of fasting, 37.5% of pregnant women had estimated gastric volumes exceeding 1.5 mL/kg, a commonly cited threshold for increased aspiration risk, despite the absence of solid content. This discrepancy further supports the need for obstetric-specific validation of cutoff values to enhance clinical decision-making.

Our multivariable analysis further highlighted that comorbidity status, fasting duration, and pregnancy were independent predictors of increased antral CSA. Notably, the presence of comorbidities—particularly diabetes mellitus—was associated with significantly larger CSA values, consistent with the delayed gastric emptying reported in previous research. Additionally, shorter fasting durations were linked to higher gastric volumes, supporting the relevance of accurate preoperative fasting assessments. The fact that pregnancy remained a significant factor after adjusting for other variables underlines the unique physiological changes influencing gastric motility in obstetric patients.

Our study has several limitations. First, our proposed mathematical model, while exhibiting minimal bias, displayed wide limits of agreement. This could be a drawback, especially in low-volume situations in which precise bedside management is critical. In addition, the mathematical formula used to estimate gastric volume was initially developed and validated in nonpregnant adults and has not been comprehensively studied in pregnant patients.

Another limitation of this study lies in the use of the Perlas formula to estimate gastric volume, as this formula was originally validated in nonpregnant populations. The physiological changes associated with pregnancy—such as altered gastric motility, hormone fluctuations, and anatomical displacement due to an enlarged uterus—may affect the accuracy of this estimation method. Therefore, the direct application of the Perlas formula in pregnant women should be interpreted with caution. Although it remains a practical and commonly used tool in clinical settings, future studies should focus on validating or adapting this formula for use specifically in obstetric populations to enhance its clinical relevance and accuracy. This concern is further supported by the findings of Hakak *et al.* [23], who demonstrated that a significant proportion of term pregnant women, despite appropriate fasting, had ultrasonographically estimated gastric volumes exceeding the threshold

associated with aspiration risk, suggesting that pregnancy-specific assessment models may be necessary.

Finally, this study was conducted using a retrospective, single-center design, which inherently carries certain limitations, including the potential for selection bias and a reduced ability to control for confounding variables. These factors may affect the generalizability and external validity of our findings. Although the patient population was homogenous and the protocol was strictly followed, we acknowledge that prospective multicenter studies would provide more robust data and broader applicability. Future research should aim to include larger and more diverse populations in a prospective design to better control for potential confounders and validate our findings across different clinical settings.

Performing gastric antrum ultrasound in term pregnant patients posed several challenges. The enlarged uterus and presence of the fetus required careful probe adjustment to visualize the antrum clearly, while patient discomfort and limited mobility often made positioning difficult. Despite these limitations, all measurements were successfully obtained with appropriate maternal positioning and under expert supervision.

5. Conclusions

In conclusion, the gastric emptying rate of pregnant patients differs from that of the normal population, and this difference should be kept in mind when evaluating patients on the operating table. Our findings suggest that gastric ultrasonography holds promise as a useful tool in evaluating patients with uncertain fasting durations; however, its routine use in this context requires further validation in larger obstetric cohorts.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

SÇ and EİT—designed the research study and contributed to methodology. EİT—performed the statistical analysis. SÇ, EİT, EK, Oİ, EAİ and AR—contributed to methodology, writing, editing, and critical revision. ASŞ—provided supervision and contributed to methodology, writing, and critical revision.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval for this retrospective study was obtained from the Health Science University İstanbul Kanuni Sultan Suleyman Ethics Committee with the approval number KAEK/2022.11.216 (approval date: 22 November 2022). The study was conducted in accordance with the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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