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Original Research Article

Gastric Volume Assessment Using Point-of-Care Ultrasound in Parturients Undergoing Caesarean Section

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Abstract

Background: Pregnancy-related physiological changes and variability in gastric emptying increase the risk of pulmonary aspiration during anaesthesia. Fasting duration alone may not accurately predict residual gastric volume. Point-of-care gastric ultrasonography provides a non-invasive method for objective assessment of gastric contents and aspiration risk.

Objective: To assess gastric volume using point-of-care ultrasound in parturients undergoing caesarean section and evaluate its association with maternal and clinical characteristics.

Methods: This prospective observational study included 110 term parturients undergoing caesarean section. Gastric antrum was assessed using bedside ultrasonography in supine and right lateral decubitus positions. Qualitative assessment was performed using gastric antral grading, while quantitative assessment was performed by measuring antral cross-sectional area (CSA) and estimating gastric volume using a validated mathematical model. Associations between gastric volume and demographic, obstetric, and perioperative variables were analysed.

Results: Among 110 participants, Grade 0 gastric antrum was observed in 55 (50.0%), Grade 1 in 43 (39.1%), and Grade 2 in 12 (10.9%) women. The mean gastric antral CSA was 4.32 ± 1.18 cm² in the supine position and 6.18 ± 1.67 cm² in the right lateral decubitus position. The mean estimated gastric volume was 58.4 ± 29.6 mL (0.82 ± 0.41 mL/kg). Nine (8.2%) participants had gastric volume >1.5 mL/kg, indicating increased aspiration risk. Gastric volume showed a strong correlation with RLD antral CSA ($r=0.884$, $p<0.001$). BMI and emergency caesarean section were independent predictors of increased gastric volume, whereas longer fasting duration was associated with lower gastric volume.

Conclusion: Point-of-care gastric ultrasound provides an objective assessment of gastric volume in parturients undergoing caesarean section. It may assist in individualized aspiration risk stratification and optimize anaesthetic management, particularly in high-risk obstetric situations.

Keywords: Gastric Ultrasound; Point-Of-Care Ultrasound; Gastric Volume; Caesarean Section; Parturients; Aspiration Risk; Antral Cross-Sectional Area.

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Introduction

Pregnancy is associated with profound physiological and anatomical changes that increase the risk of pulmonary aspiration during general anaesthesia.[1] Hormonal relaxation of the lower oesophageal sphincter, increased intra-abdominal pressure caused by the gravid uterus, and delayed gastric emptying contribute to gastro-oesophageal reflux and increased residual gastric contents. Consequently, pulmonary aspiration remains a serious complication of obstetric anaesthesia despite its relatively low incidence.[2]Current international and national guidelines recommend adequate preoperative fasting and pharmacological aspiration prophylaxis before elective surgery. [3] However, fasting duration alone does not reliably predict residual gastric volume because gastric

emptying varies considerably among individuals. Therefore, assessment based solely on fasting history may either underestimate or overestimate the risk of aspiration.[4]Point-of-care gastric ultrasonography (POCGUS) has emerged as a rapid, non-invasive, reliable, and reproducible bedside technique for evaluating gastric contents and estimating gastric volume. [5,6] Ultrasonographic assessment of the gastric antrum provides both qualitative information regarding the nature of gastric contents and quantitative estimation of gastric volume through measurement of the antral cross-sectional area using validated mathematical models.[7,8]

The role of gastric ultrasound has become increasingly important in obstetric anaesthesia because pregnant women are traditionally considered to have a "full stomach" and are routinely managed with aspiration precautions during general anaesthesia. Recent studies have demonstrated that bedside gastric ultrasonography accurately identifies residual gastric contents, correlates well with actual gastric volume, and facilitates individualized aspiration risk assessment in term parturients undergoing caesarean section.[9,10]

Despite increasing evidence supporting gastric ultrasonography, its routine use in obstetric anaesthesia remains limited in many centres, particularly in developing countries. Additional prospective studies are needed to evaluate gastric volume among parturients undergoing caesarean section and to establish the role of point-of-care gastric ultrasound in routine preoperative assessment. Therefore, the present prospective observational study was designed to assess gastric volume using point-of-care ultrasound in parturients undergoing caesarean section and to determine the proportion of patients with increased aspiration risk based on ultrasonographic findings.

Materials and Methodology

This prospective observational study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital. The study included pregnant women scheduled to undergo elective or emergency lower segment caesarean section (LSCS) under anaesthesia. A total of 110 parturients fulfilling the eligibility criteria were enrolled consecutively during the study period.

Inclusion Criteria

- Pregnant women aged 18–40 years.
- Singleton pregnancy with gestational age ≥37 weeks.
- American Society of Anesthesiologists (ASA) physical status II or III.
- Scheduled for elective or emergency caesarean section.
- Willingness to participate in the study with written informed consent.

Exclusion Criteria

- Known upper gastrointestinal disease (hiatal hernia, gastric outlet obstruction, peptic ulcer disease).
- Previous upper gastrointestinal surgery.
- Multiple pregnancy.
- Polyhydramnios.
- Active labour with severe pain or haemodynamic instability.
- Patients receiving enteral feeding.
- Inability to cooperate for ultrasonographic examination.
- Refusal to participate.

Study Procedure: All enrolled parturients underwent a detailed pre-anaesthetic evaluation including demographic characteristics (age, height, weight, body mass index), obstetric history (gravidity, parity, gestational age), indication for caesarean section, associated comorbidities, fasting duration for solids and clear fluids, and ASA physical status. Before induction of anaesthesia, bedside gastric ultrasonography was performed using a portable ultrasound machine equipped with a low-frequency curvilinear transducer (2–5 MHz). The examination was carried out by an anaesthesiologist trained in gastric ultrasonography. Initially, the gastric antrum was identified in the epigastric region in the sagittal plane using the left lobe of the liver anteriorly and the pancreas, abdominal aorta, and inferior vena cava posteriorly as anatomical landmarks. The gastric antrum was examined first in the supine position and subsequently in the right lateral decubitus (RLD) position, which improves visualization and enhances the sensitivity for detecting gastric contents.

Qualitative assessment of gastric contents was performed using the established Perlas grading system:

- Grade 0: Empty antrum in both supine and RLD positions.
- Grade 1: Clear fluid visible only in the RLD position.
- Grade 2: Clear fluid visible in both supine and RLD positions or presence of solid gastric contents.

For quantitative assessment, the anteroposterior (AP) and craniocaudal (CC) diameters of the gastric antrum were measured between peristaltic contractions. The antral cross-sectional area (CSA) was calculated using the standard ellipse formula:

$$CSA\ (cm^2) = (AP \times CC \times \pi)/4$$

The estimated gastric volume was also expressed as mL/kg body weight. A gastric volume greater than

1.5 mL/kg was considered indicative of an increased risk of pulmonary aspiration. The following study variables were recorded:

- Age (years)
- Height (cm)
- Weight (kg)
- Body mass index (kg/m²)
- Gestational age (weeks)
- Gravidity and parity
- ASA physical status
- Duration of fasting for solids and clear fluids
- Nature of surgery (elective/emergency)
- Qualitative gastric ultrasound grade
- Antral cross-sectional area in supine position
- Antral cross-sectional area in right lateral decubitus position
- Estimated gastric volume (mL)
- Gastric volume per kilogram body weight (mL/kg)

Outcome Measures

Primary Outcome: Estimation of gastric volume using point-of-care gastric ultrasonography in parturients undergoing caesarean section.

Secondary Outcomes

- Qualitative grading of gastric contents.
- Measurement of gastric antral cross-sectional area in supine and right lateral decubitus positions.
- Incidence of patients with gastric volume >1.5 mL/kg.
- Correlation of gastric volume with demographic, obstetric, and fasting characteristics.

Study Setting and Duration: The study was conducted at Gandhi Medical College, Bhopal, a tertiary care teaching hospital, for 6 months duration.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range depending on data distribution, while categorical variables were presented as frequencies and percentages. Normality of continuous variables was assessed using the Shapiro–Wilk test.

Comparisons between groups were performed using the independent Student's t-test or Mann–Whitney U test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables, as appropriate. Correlations between gastric volume and continuous variables were analysed using Pearson's or Spearman's correlation coefficients. Multivariable linear regression analysis was performed to identify independent predictors of increased gastric volume. A p-value <0.05 was considered statistically significant.

Results

A total of 110 term parturients undergoing caesarean section were included in this prospective observational study. All participants completed the study protocol and were included in the final analysis without exclusions or missing data.

The baseline demographic and obstetric characteristics are presented in Table 1. The mean age was 27.9 ± 4.2 years, with mean BMI of 28.6 ± 3.4 kg/m² and gestational age of 38.5 ± 1.1 weeks. Multigravida women constituted 58.2% of the study population, while 87.3% were ASA II. Elective caesarean section was performed in 74.5% of cases, and the mean fasting duration for solids and clear fluids was 8.4 ± 1.2 hours and 3.5 ± 0.9 hours, respectively (Table 1).

Qualitative gastric ultrasound assessment showed Grade 0 antrum in 55 (50.0%) participants, Grade 1 in 43 (39.1%), and Grade 2 in 12 (10.9%) women. Regarding gastric contents, 50.0% had an empty stomach, 44.5% had clear fluid, and 5.5% had solid contents (Table 2).Quantitative gastric ultrasound measurements demonstrated a mean gastric antral CSA of 4.32 ± 1.18 cm² in the supine position and 6.18 ± 1.67 cm² in the RLD position. The mean estimated gastric volume was 58.4 ± 29.6 mL, with a gastric volume of 0.82 ± 0.41 mL/kg (Table 3). Based on the aspiration risk threshold of 1.5 mL/kg, 101 (91.8%) participants had low-risk gastric volumes, while 9 (8.2%) had increased gastric volume (Table 5).

Comparison between elective and emergency caesarean sections showed a higher proportion of Grade 2 antrum among emergency cases (28.5% vs 4.9%, p = 0.002). Emergency caesarean section patients also had significantly higher gastric volume (76.2 ± 31.4 mL vs 52.3 ± 24.1 mL, p < 0.001) and a higher proportion of gastric volume >1.5 mL/kg (21.4% vs 3.7%, p = 0.004) (Table 4; Figure 1).Association of maternal characteristics with high gastric volume showed that women with gastric volume >1.5 mL/kg had significantly higher BMI (32.4 ± 3.8 vs 28.2 ± 3.1 kg/m², p = 0.001), shorter fasting duration (7.3 ± 1.2 vs 8.6 ± 1.1 hours, p = 0.007), and a higher frequency of emergency LSCS (66.7% vs 21.8%, p = 0.004). Age and gestational age were not significantly associated with increased gastric volume (Table 5).Correlation analysis revealed a strong positive correlation between RLD gastric antral CSA and gastric volume (r = 0.884, p < 0.001).

Supine CSA also showed significant correlation with gastric volume (r = 0.741, p < 0.001). BMI and maternal weight showed positive correlations

with gastric volume, whereas fasting duration demonstrated a negative correlation. Gestational age was not significantly correlated with gastric volume (Table 6; Figure 2).Multivariable linear regression analysis identified BMI (β = 2.84, p = 0.001), emergency LSCS (β = 18.62, p = 0.002), fasting duration (β = −4.76, p = 0.004), and maternal weight (β = 0.42, p = 0.022) as independent predictors of gastric volume. Gestational age and primigravida status were not significant predictors (Table 7; Figure 3).

Table 1: Baseline Demographic and Obstetric Characteristics of the Study Population (n = 110)

Variable	Value
Age (years), mean ± SD	27.9 ± 4.2
Height (cm), mean ± SD	158.7 ± 5.4
Weight (kg), mean ± SD	71.8 ± 8.6
BMI (kg/m²), mean ± SD	28.6 ± 3.4
Gestational age (weeks), mean ± SD	38.5 ± 1.1
Primigravida, n (%)	46 (41.8)
Multigravida, n (%)	64 (58.2)
ASA II, n (%)	96 (87.3)
ASA III, n (%)	14 (12.7)
Elective LSCS, n (%)	82 (74.5)
Emergency LSCS, n (%)	28 (25.5)
Fasting duration for solids (hours), mean ± SD	8.4 ± 1.2
Fasting duration for clear fluids (hours), mean ± SD	3.5 ± 0.9

Table 2: Qualitative Gastric Ultrasound Assessment (n = 110)

Parameter	Frequency (n)	Percentage (%)
Grade 0 antrum	55	50.0
Grade 1 antrum	43	39.1
Grade 2 antrum	12	10.9
Empty stomach	55	50.0
Clear fluid	49	44.5
Solid contents	6	5.5

Table 3: Quantitative Gastric Ultrasound Measurements (n = 110)

Parameter	Mean ± SD
Gastric antral CSA (Supine), cm²	4.32 ± 1.18
Gastric antral CSA (RLD), cm²	6.18 ± 1.67
Estimated gastric volume (mL)	58.4 ± 29.6
Gastric volume (mL/kg)	0.82 ± 0.41

Table 4: Comparison of Gastric Ultrasound Findings between Elective and Emergency Caesarean Section

Variable	Elective (n=82)	Emergency (n=28)	p-value
Grade 0	47 (57.3%)	8 (28.6%)	
Grade 1	31 (37.8%)	12 (42.9%)	
Grade 2	4 (4.9%)	8 (28.5%)	0.002
Gastric volume (mL)	52.3 ± 24.1	76.2 ± 31.4	<0.001
Gastric volume >1.5 mL/kg	3 (3.7%)	6 (21.4%)	0.004

Chi-square test/Independent Student's t-test.

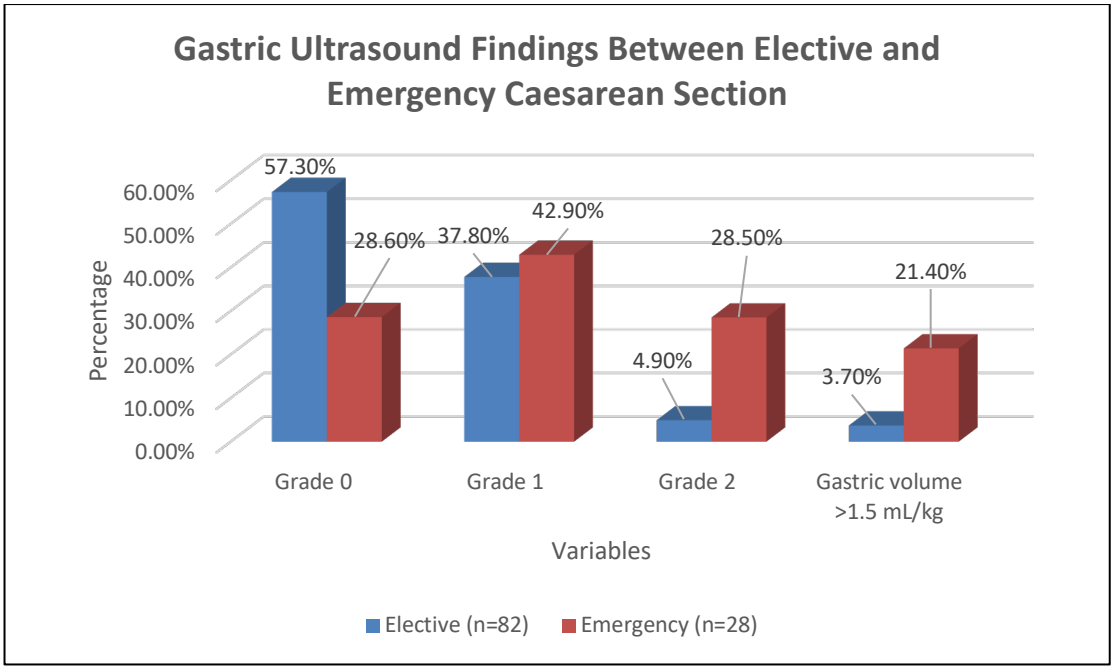

Figure 1: Comparison of Gastric Ultrasound Findings between Elective and Emergency Caesarean Section

Table 5: Association of Maternal Characteristics with High Gastric Volume (>1.5 mL/kg)

Variable	Gastric Volume ≤1.5 mL/kg (n=101)	Gastric Volume >1.5 mL/kg (n=9)	p-value
Age (years)	27.8 ± 4.2	29.2 ± 4.5	0.298
BMI (kg/m²)	28.2 ± 3.1	32.4 ± 3.8	0.001
Gestational age (weeks)	38.5 ± 1.1	38.8 ± 0.9	0.346
Fasting duration (hours)	8.6 ± 1.1	7.3 ± 1.2	0.007
Emergency LSCS	22 (21.8%)	6 (66.7%)	0.004

Independent Student's t-test/Chi-square test.

Table 6: Correlation between Gastric Ultrasound Measurements and Clinical Variables (n = 110)

Variables	Pearson's r	p-value
Gastric antral CSA (RLD) vs Gastric volume (mL)	0.884	<0.001
Gastric antral CSA (Supine) vs Gastric volume (mL)	0.741	<0.001
BMI vs Gastric volume	0.361	<0.001
Fasting duration vs Gastric volume	−0.276	0.004
Gestational age vs Gastric volume	0.132	0.169
Maternal weight vs Gastric volume	0.404	<0.001

Pearson's correlation coefficient.

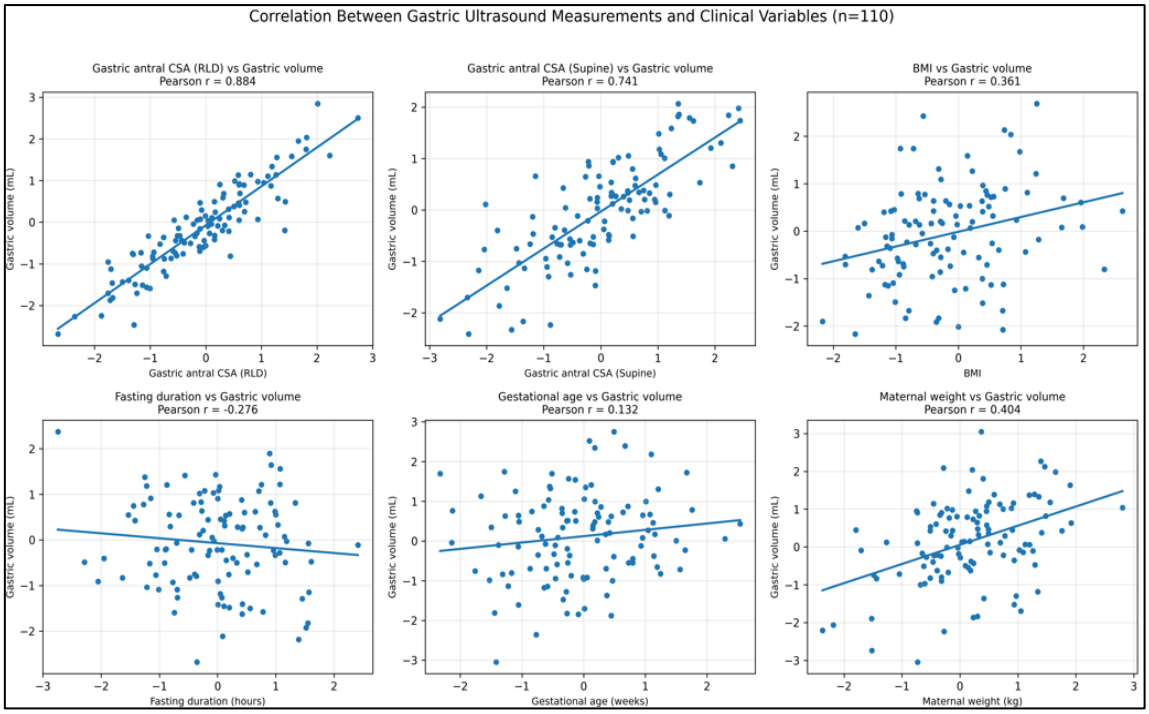

Figure 2: Correlation between Gastric Ultrasound Measurements and Clinical Variables (n = 110)

Table 7: Multivariable Linear Regression Analysis Showing Independent Predictors of Gastric Volume (mL) (n = 110)

Predictor Variable	Regression Coefficient (β)	Standard Error	95% Confidence Interval	p-value
BMI (kg/m²)	2.84	0.86	1.14 – 4.54	0.001
Emergency LSCS (Yes vs No)	18.62	5.91	6.91 – 30.33	0.002
Fasting duration (hours)	−4.76	1.62	−7.98 to −1.54	0.004
Maternal weight (kg)	0.42	0.18	0.06 – 0.78	0.022
Gestational age (weeks)	3.21	2.14	−1.03 – 7.45	0.136
Primigravida status	2.76	3.84	−4.86 – 10.38	0.475

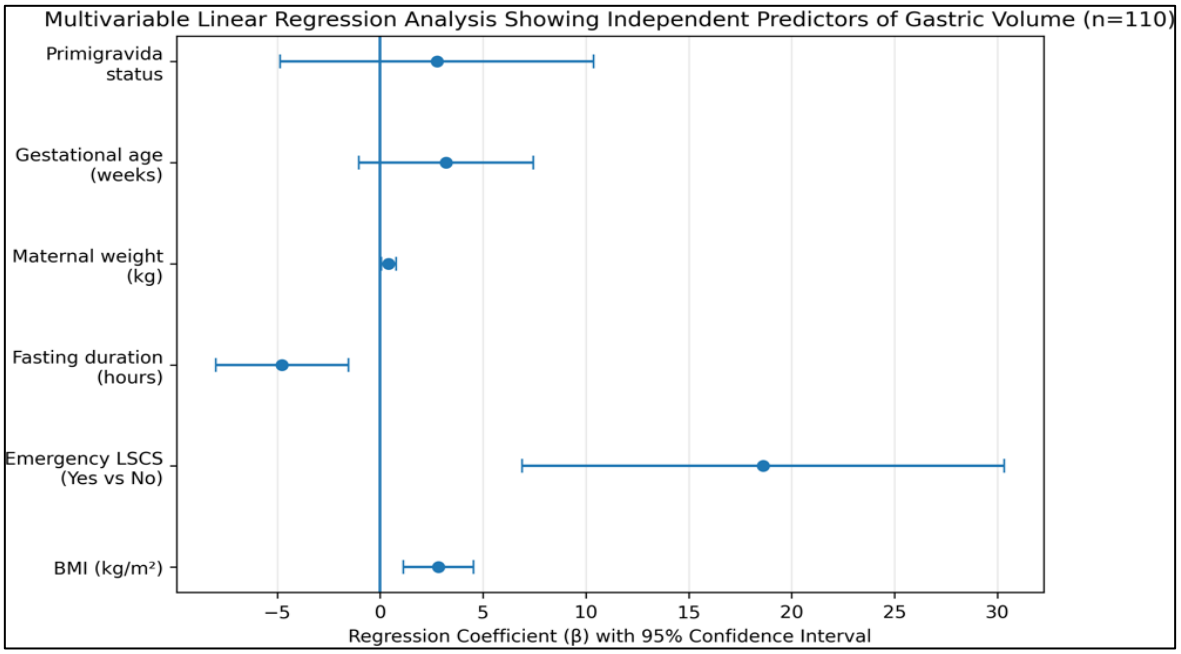

Figure 3: Multivariable Linear Regression Analysis Showing Independent Predictors of Gastric Volume (mL) (n = 110)

Discussion

The present prospective observational study evaluated gastric volume using point-of-care gastric ultrasonography in 110 parturients undergoing caesarean section. The study demonstrated that most women had low-risk gastric volumes after fasting; however, a clinically relevant proportion showed increased residual gastric contents. Gastric antral CSA showed a strong correlation with estimated gastric volume, while BMI, emergency caesarean section, and fasting duration were identified as important predictors of gastric volume.

In our study, the mean age was 27.9 ± 4.2 years, mean BMI was 28.6 ± 3.4 kg/m², and mean gestational age was 38.5 ± 1.1 weeks. Most women were multigravida (58.2%), ASA II (87.3%), and underwent elective caesarean section (74.5%). The mean fasting duration for solids and clear fluids was 8.4 ± 1.2 hours and 3.5 ± 0.9 hours, respectively. Dhanger et al. [9] evaluated 234 term parturients undergoing elective caesarean section and reported similar demographic characteristics with mean age 28.6 ± 3.8 years and BMI 25.2 ± 2.8 kg/m². Hakak et al. [11] also reported a comparable population of healthy term pregnant women undergoing elective caesarean delivery after fasting, supporting the similarity of our study cohort. In our study, Grade 0 antrum was observed in 55 (50%), Grade 1 in 43 (39.1%), and Grade 2 in 12 (10.9%) parturients. Solid gastric contents were detected in 6 (5.5%) women. Dhanger et al. [9] reported Grade 0, Grade 1, and Grade 2 findings in 81.6%, 17.9%, and 0.4% of term parturients, respectively. The higher incidence of Grade 2 findings in our study may be related to inclusion of emergency caesarean sections and higher BMI range. Hakak et al. [11] reported Grade 0 in 51.5%, Grade 1 in 47.6%, and Grade 2 in approximately 1% of women after six hours of fasting, which was comparable with our observation that most fasted women had low-risk gastric ultrasound patterns. The mean gastric antral CSA in our study was 4.32 ± 1.18 cm² in the supine position and 6.18 ± 1.67 cm² in the right lateral decubitus position. The mean estimated gastric volume was 58.4 ± 29.6 mL (0.82 ± 0.41 mL/kg). Dhanger et al. [9] reported a median gastric volume of 47.5 mL (0.73 mL/kg) among fasted term parturients, which was comparable with our findings. Zieleskiewicz et al. [12] demonstrated that gastric antral CSA accurately estimated gastric fluid volume in parturients, supporting the use of quantitative ultrasound assessment. Perlas et al. [6] validated the ultrasound-based gastric volume model and demonstrated a strong correlation between ultrasound measurements and actual gastric volume obtained by gastroscopy, establishing the scientific basis for gastric ultrasound assessment. Emergency caesarean section was associated with significantly higher gastric volume in our study. Grade 2 antrum was present in 28.5% of emergency cases compared with 4.9% of elective cases (p=0.002). Mean gastric volume was also higher in emergency procedures (76.2 ± 31.4 mL vs 52.3 ± 24.1 mL). Bataille et al. [13] evaluated gastric contents during labour under epidural analgesia and reported increased gastric contents associated with labour-related factors. Their findings support the influence of obstetric circumstances on gastric emptying and aspiration risk.BMI showed a significant positive association with gastric volume in our study. Women with BMI ≥30 kg/m² had higher gastric volumes, and BMI remained an independent predictor on multivariable regression analysis. Riveros-Perez et al. [14] reported that increasing BMI was associated with increased gastric antral CSA and gastric volume in term pregnant women, supporting our findings. Khalil et al. [15] similarly demonstrated significantly higher gastric antral CSA among obese patients compared with non-obese individuals using gastric ultrasound. Garg et al. [16] evaluated gastric volume in diabetic and non-diabetic surgical patients and highlighted that patient-related factors may influence gastric emptying and residual gastric volume, emphasizing the importance of individualized assessment.

In our study, gastric antral CSA in the RLD position showed a strong positive correlation with gastric volume ($r=0.884$, $p<0.001$), while supine CSA also showed significant correlation ($r=0.741$, $p<0.001$). BMI correlated positively with gastric volume ($r=0.361$, $p<0.001$), whereas fasting duration showed a weak negative correlation ($r=-0.276$, $p=0.004$). Perlas et al. [7] demonstrated a strong correlation between antral CSA and actual gastric volume during validation studies. Bouvet et al. further confirmed that ultrasonographic measurement of antral area could identify patients with increased gastric volume and aspiration risk. Kruisselbrink et al. [8] demonstrated excellent intra- and inter-observer reliability of gastric ultrasound measurements, supporting its reproducibility in clinical practice.

Conclusion

Point-of-care gastric ultrasonography is a feasible, non-invasive, and reliable method for assessing gastric volume in parturients undergoing caesarean section. Although most women had low-risk gastric volumes after fasting, a clinically important proportion showed increased residual gastric contents, particularly in emergency procedures and those with higher BMI. Gastric ultrasound may provide individualized aspiration risk assessment and improve perioperative airway management in obstetric anaesthesia.

Limitations: The study was conducted at a single centre with a relatively limited sample size, which may restrict the generalizability of findings. Actual gastric volume was not validated using invasive methods, and inter-observer variability could not be completely excluded.

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