INTRODUCTION

Anatomical and hormonal changes during pregnancy pose an increased risk of aspiration during general anaesthesia. The volume of gastric contents is another significant variable that causes regurgitation. The threshold value that can define a ‘full’ stomach and pose significant aspiration risk is still unproven. This problem will be compounded, especially in difficult or failed intubation when mask ventilation may be required. Preoperative adequate fasting and pharmacologic prophylaxis may decrease aspiration risk, but these are similar for obstetric and non-obstetric surgeries despite the physiological difference between them. Point-of-care ultrasonography (USG) of the gastric antrum will help to evaluate the aspiration risk. Qualitative USG of gastric antrum defines the gastric content (solid or liquid), and the quantitative assessment measures volume of the gastric antrum.
This prospective observational descriptive study was planned to assess the gastric antrum in term parturients scheduled for elective caesarean section using bedside USG. The primary objective was to find the incidence of grade 2 antrum in parturients scheduled for elective caesarean delivery. The secondary objective was to measure the antral cross-section area (CSA) in both supine and right lateral decubitus position (RLD) and correlate with patient characteristics.

**METHODS**

This study was conducted in a tertiary health care centre between August 2019 and January 2020 in accordance with the declaration of Helsinki and good clinical practice. After the institutional ethics committee approval (No. 7/153/IEC/PP/2018) and Clinical Trial Registry of India registration (CTRI/2019/07/019980), 250 parturients scheduled for elective caesarean delivery were enrolled for the study after obtaining written informed consent. Parturients of more than 36 weeks gestational age, weight 50–120 kg, body mass index (BMI) 18.5–30 kg/m$^2$, and American Society of Anesthesiologists (ASA) physical status II and III scheduled for caesarean section under anaesthesia were included. Parturients with multiple gestations, abnormal upper gastrointestinal tract anatomy, or previous upper abdominal surgery were excluded from the study [Figure 1].

Parturients were instructed to follow present standard ASA fasting guidelines[4] and were kept nil per oral for 6 h. Premedication was given in the injectable form intravenously (metaclopramide 10 mg diluted with 5 ml normal saline and pantoprazole 40 mg, 1 h before surgery) to avoid confounding.[6,7] A checklist for fasting guidelines was followed and verified individually for all parturients in the preoperative area, and an ultrasonographic examination was done using a 2–5 MHz curved array transducer M-Turbo® Ultrasound Machine (Sonosite Inc., Bothell, WA, USA) in both, the supine and RLD position [Figure 2]. To prevent operator bias, two skilled anaesthesiologists, who had previously performed more than 75 obstetric gastric scans, performed the ultrasound examination, and the average value of three scans was taken.

Under qualitative assessment, the category of gastric contents (empty, fluid, or solid content) was identified and was classified into three grades,[8] Grade 0 – absence of fluid in both supine and RLD positions; Grade 1 – fluid is observed only in the RLD position but not in the supine position; and Grade 2 – fluid evident in both supine and RLD positions.

Under quantitative assessment, CSA of the gastric antrum was estimated. The mean value was obtained by performing three consecutive measurements of the craniocaudal (CC) and anteroposterior (AP) diameters of the gastric antrum.[9] CSA was calculated according to the following formula: $\text{CSA (cm}^2\text{)} = \frac{\text{AP} \times \text{CC} \times \pi}{4}$

The gastric volume was derived from the formula described by Perlas et al.[8]
Volume (ml) = 27.0 + 14.6 × right-lateral CSA (cm²) − 1.28 × age (years)

The attending anaesthesiologist was unaware of the ultrasound findings, and the rest of the anaesthetic management proceeded according to the departmental protocol.

Sample size was calculated using OpenEpi version-3 for incidence of grade 2 antrum among parturients based on a previous study that showed a 3.5% prevalence of grade 2 antrum in fasted non-pregnant patients.[8] With 5% frequency of outcome factor, confidence level of 95%, and absolute precision 5%, we arrived at a sample size of 210. Considering a dropout of 20%, we assessed eligibility in a total of 250 parturients and enrolled 236 patients.

Data collected were analysed using Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, version 19.0 for Windows) statistical software. The parametric data were expressed as mean ± standard deviation (SD), and non-parametric data were expressed as median (range) or number (percentage). Antral CSAs and grades in both supine and RLD positions were compared using Bland–Altman analysis. Linear relation and interaction between the antral CSA and subject characteristics were evaluated using a multivariate analysis.

RESULTS

A total of 250 parturients were assessed for eligibility; out of them, nine parturients underwent emergency caesarean delivery the day before the scheduled surgery, and five declined to participate in the study. Hence, a total of 236 parturients were included after getting written informed consent and they underwent ultrasound examination. Two parturients were excluded from the analysis because of insufficient data in both the positions because of presence of air in the antral area. Finally, 234 parturients were analysed for the gastric USG data. All parturients underwent uneventful spinal anaesthesia except five parturients who required general anaesthesia because of failed spinal anaesthesia.

Demographic characteristics, such as age, BMI, gravidity, parity, and gestational age, are summarised in Table 1. None of the parturients were found to have solid gastric content. Majority of the parturients (191/234, 82%) had grade 0 gastric antrum, whereas 18% (42/234) parturients had grade 1 antrum. Only one parturient had grade 2 gastric antrum.

Among 236 patients, 83% had an antral CSA ≤4.16 cm² [95% confidence interval (CI), 2.52–5.60 cm²] in the supine position and 4.19 cm² [95% CI, 2.92–5.67 cm²] in the RLD position [Table 2]. The mean antral CSA was greater in RLD position compared to the supine position [4.50 [2.64–5.63] versus 4.16 [2.52–5.67] P < 0.05] and the mean difference in antral CSA between both positions in grade 0 (median 0.05 cm², P value 0.018) was statistically significant; similarly, in grade 1, the difference (median 0.13 cm², P value 0.003) was statistically significant. Antral CSA in RLD for grades 0, 1, and 2 was 4.19, 4.61, and 6.65 cm², respectively, whereas antral CSA in the supine position for grades 0, 1, and 2 was 4.16, 4.55, and 5.09 cm², respectively. The median gastric volume was 44.06 (inter-quartile range [IQR] 32–68) ml or 0.70 ml/kg, 63.72 (IQR 38–78) ml or 1.05 ml/kg and 78.00 or 1.28 ml/kg for grade 0, 1, and 2, respectively, and the difference was statistically significant (P value < 0.001).

Spearman’s rank correlation test was applied to determine the relationship between patient’s characteristics (age, BMI, and gastric volume) and antral area in both positions (supine and RLD position) [Table 3]. Among all parameters, gastric volume in ml (r = 0.249; P < 0.001) and ml/kg (r = 0.218; P = 0.002) showed a significant correlation with the CSA in supine position and gastric volume in ml (r = 0.244) and ml/kg (r = 0.177) showed a significant correlation (P < 0.001) with CSA in the RLD position. Although there was a weak positive correlation between antral CSA and gastric volume, the difference was statistically significant.

DISCUSSION

In this prospective observational study, gastric ultrasound was done in parturients scheduled for elective caesarean section after the standard fasting guidelines. We found that there was no solid food content in any of the study parturients, and grade 0 antrum was found in 85% of parturients (191), whereas 18% parturients (42) had grade 1 antrum. Only one participant had grade 2 antrum despite following the ASA fasting guidelines.

Our findings coincide with those of Rouget et al.[12] study, in which 74% of pregnant women had grade 0
Table 1: Demographic profile

| Parameter                  | Grade 0 (n=191) | Grade 1 (n=42) | Grade 2 (n=1)  | Total (n=234) |
|----------------------------|-----------------|----------------|---------------|---------------|
| Age (in years)             | 28.64 (21-36)   | 30.24 (23-34)  | 33.00         | 28.93 (3.827) |
| BMI (in kg/m²)             | 21.64 (18.6-24.45) | 21.84 (18.32-26.32) | 20.80         | 21.67 (1.264) |
| Gestational age (in weeks) | 37.76 (36-40)   | 37.65 (36-40)  | 37.00         | 37.74 (0.996) |
| Gestational hypertension   | 2               | 2              | 1             | 5             |
| Gestational diabetes mellitus | 3            | 2              | 2             | 7             |

BMI=body mass index, n=number. Data are represented by median (inter-quartile range).

Table 2: Comparison of antral area and volume in different grades using Kruskal-Wallis test

| Parameter                  | Grade 0 (n=191) | Grade 1 (n=42) | Grade 2 (n=1)  | Total (n=234) | P     |
|----------------------------|-----------------|----------------|---------------|---------------|-------|
| Antral area: supine (cm²)  | 4.16 (2.52-5.67)| 4.55 (2.64-5.63)| 5.09          | 4.23 (0.798)  | 0.018*|
| Antral area: RLD (cm²)     | 4.19 (2.92-5.68)| 4.61 (3.13-6.12)| 6.65          | 4.27 (0.792)  | <0.001*|
| Gastric volume (ml)        | 44.06 (32-68)   | 63.71 (38-78)  | 78.00         | 47.50 (10.458)| <0.001*|
| Gastric volume (ml/kg)     | 0.70 (0.49-1.29)| 1.05 (0.56-1.43)| 1.28          | 0.73 (0.19)   | <0.001*|

RLD=right lateral decubitus, n=number. Data are represented by median (inter-quartile range). *P<0.05 was significant.

Table 3: Correlation between patient characteristics and antral cross-sectional area (cm²) (n=234)

| Parameter                  | Correlation coefficient | P       | Correlation coefficient | P       |
|----------------------------|-------------------------|---------|-------------------------|---------|
| Age in years               | 0.062                   | 0.378   | 0.080                   | 0.197   |
| BMI in kg/m²               | 0.032                   | 0.650   | 0.047                   | 0.444   |
| Gastric volume(ml)         | 0.249                   | <0.001* | 0.244                   | <0.001* |
| Gastric volume (ml/kg)     | 0.218                   | 0.002*  | 0.177                   | <0.001* |

RLD=right lateral decubitus position, BMI=body mass index. *P<0.05 was significant.

The grade 2 antrum parturient in our study was a primigravida with a history of gestational diabetes receiving intermittent regular insulin injections subcutaneously. Her predicted gastric volume was 78 ml (1.2 ml/kg). Steinsvick et al. had assessed gastric motility in diabetic patients and proven that good glycaemic control aids in increased antral motility. In the diabetic parturient in this study, the grade 2 antrum might have been secondary to poor glycaemic control. The surgery was uneventful under spinal anaesthesia. In the postoperative ward, she had a few episodes of vomiting, but aspiration pneumonia was not reported.

Both underweight and overweight parturients are likely to have abnormal gastric CSA. Prior gastric surgery or a large hiatal hernia may interfere with image acquisition in any position. In parturients with previous lower oesophageal or gastric surgery and with hiatal hernia, volume assessment may not be accurate. Hence, there were ruled out by history and the presence of a scar in the upper abdomen, and were excluded from the study. Qualitative antral grading by Perlas et al. is a simple screening method that predicts gastric contents equally in both pregnant and non-pregnant women. Identification of lesser antral grades (0 and 1) helps an anaesthesiologist to diagnose low gastric volume. In contrast, higher grade (grade 2) indicates a higher stomach volume with an increased risk for aspiration.

The median IQR for the antral CSA in our study was 4.16 (2.52–5.67) cm² for grade 0 antrum with an estimated gastric volume of 44.06 (32–68) ml, whereas the gastric volume in grade 1 was 63.71 (38–78) ml and the gastric volume was 78.00 ml in grade 2 antrum. The difference was statistically significant (P < 0.001). Mohammad Khalil et al. found that the antrum was slightly bigger (median 6.07, IQR 5.59–6.63 cm²) in the obese patient compared to the non-obese patient (median 3.93, IQR 3.5–4.61 cm²), whereas in the current study, a majority of the parturients had a mean antral size of 4.16 (IQR 2.52–5.67 cm²). This difference could be because of anatomical changes during pregnancy. The study by Zielierskiwicz et al. showed that antral CSA cutoff value of 387 mm² in the supine position can predict a volume >0.4 ml/kg, and a value of 608 mm² can detect a fluid volume of >1.5 ml/kg. Both the studies proposed that parturients with antral CSA of equal to or more than 3.2 cm² in the supine position would be at risk of aspiration in the perioperative period. However, this finding was based on a small study population, and the gestational age was also not specified.
Bataille et al.,[27] reported a maximum antral CSA of 1.51 cm² in the supine position, which is significantly lower compared to 5.09 cm² observed in our study. We measured the antral CSA of 5.09 cm² and 6.0 cm² in grade 2 antrum after 6 h of fasting, which was within the limits given by Hakak et al.,[18]Riveros-Perez et al.,[19] mentioned a positive correlation between BMI and CSA in term parturients. In a sample of 42 patients, it was observed that there is an increase of 0.288 SD in CSA for every one SD increase in BMI. However, we did not find any significant correlation between age, BMI, and antral CSA [Table 3]. This could be because we included the parturients with BMI between 18.5–30 kg/m².

Studies have shown that a gastric volume of >1.5 ml/kg increased aspiration risk in both pregnant[9] and non-pregnant adults[20] in the perioperative period. However, in the present study, the maximum gastric volume was 1.2 ml/kg (in grade 2 antrum), which was below the safe range as reported from earlier studies. A gastric volume of 1.28 ml/kg in RLD position was observed in healthy fasted adults by Arzola et al.,[21] Our finding of the median estimated gastric volume (1.15 ml/kg) in RLD correlates with the results of Arzola et al. Gastric antral area in RLD has a statistically significant correlation with gastric volume in ml and ml/kg. Our study had a linear coefficient of 0.218 for CSA in supine and 0.177 in RLD position.

The present study did not cover special populations such as emergency caesarean section, obese, parturients in labour, and diabetics in whom gastric antral sonography can play a significant role and timely precautionary measures can be taken. This was the limitation of the study. Also, future research with a larger sample size is required to quantify gastric volumes on the basis of antral CSA in term parturients.

**CONCLUSION**

This study establishes CSA and gastric volume cutoff values for the fasted near-term parturient. Although the study supports the validity of applying both ASA and Indian Society of Anaesthesiologists fasting guidelines[4] for the parturient, we suggest that the preoperative antral sonographic assessment should be inculcated in the anaesthesiologists armamentarium as a routine practice, especially in obstetric emergency surgeries where the risk of aspiration is more because of inadequate fasting, labour pain, and anxiety.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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