Title Of the Article: Point of care gastric ultrasound to predict aspiration in patients undergoing urgent endotracheal intubation in the emergency medicine department.

Reshma Asokan
All India Institute of Medical Sciences, Rishikesh

Bharat Bhushan Bhardwaj (✉ bharat1352@yahoo.in)
All India Institute of Medical Sciences, Rishikesh

Naman Agrawal
All India Institute of Medical Sciences Raipur

Udit Chauhan
All India Institute of Medical Sciences, Rishikesh

Aadya Pillai
All India Institute of Medical Sciences, Rishikesh

Takshak Shankar
All India Institute of Medical Sciences, Rishikesh

D. J Lalneiruol
All India Institute of Medical Sciences, Rishikesh

Himanshi Baid
All India Institute of Medical Sciences, Rishikesh

Hannah Chawang
All India Institute of Medical Sciences, Rishikesh

Sanket Mukeshkumar Patel
Nootan Medical College and Research Centre

Research Article

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Abstract

Background:

One significant cause of morbidity and mortality in patients undergoing endotracheal intubation is the aspiration of gastric contents. Its prevalence is more in the emergency than in elective settings. Point-of-care gastric ultrasound (GUS) is a non-invasive bedside ultrasonogram that provides both qualitative and quantitative information about the stomach contents. The diagnostic accuracy of GUS in terms of gastric parameters (measured antral diameters, antral cross-sectional area, and calculated gastric volume) to predict aspiration is yet unknown. We aim to determine this in the patients undergoing urgent emergency intubation (UEI) in the emergency department.

Methodology:

A prospective observational study was conducted at the emergency department of a tertiary healthcare center in India. Patients requiring UEI were identified and a bedside gastric ultrasound was done in the right lateral decubitus position using low frequency curved array probe. The qualitative data and the antral diameters (anteroposterior and craniocaudal) were assessed. The patient's clinical parameters and history regarding the last meal were noted. The cross-sectional area of gastric antrum was calculated using CSA = (AP×CC) π/4. The gastric volume is estimated using Perla's formula: GV = 27.0+14.6(RLD CSA) –1.28(age).

Results:

A hundred patients requiring urgent endotracheal intubation were enrolled in the study. Visible aspiration was more in participants with a distended gastric status (χ²=16.880, p=<0.001). The median gastric volume in the patients who aspirated was 146.37mL, and it ranged from 111.59mL-201.01mL. Using ROC analysis, a cut-off of CC diameter ≥2.35cm (sensitivity 88%, specificity 91%) and AP diameter ≥5.15cm (sensitivity 88%, specificity 87%) predicts aspiration. A calculated USG CSA cut-off ≥9.27cm² (sensitivity 100%, specificity 87%) and an USG gastric volume ≥111.594mL (sensitivity 100%, a specificity 92%) predicts aspiration.

Conclusion:

Point-of-care gastric ultrasound is an useful non-invasive bedside tool for risk stratification for aspiration in busy emergency rooms. We present threshold gastric antral parameters that can be used to predict aspiration along with its diagnostic accuracy. This can help the treating ED physician take adequate precautions, decide on intubation techniques and treatment modifications to aid in better patient management.

Background
Airway management is of utmost priority in the emergency room. It is a high-risk procedure because of the urgency of the situation, critically unstable patients, and limited time available for preparation. One of the significant causes of morbidity and mortality in patients undergoing endotracheal intubation is gastric aspiration (1). Aspiration is the inhalation of either oral, pharyngeal or gastric contents into the lower airways (2). Aspiration risk is directly linked to the prandial status of the patient. Patients with residual gastric volume (GV) of more than 1.5 ml/kg are considered to have significant aspiration risk even though the exact threshold is not yet known (3). Paracetamol absorption, radio-labelled diet, scintigraphy, and quantification of extracted gastric contents are invasive methods to determine residual GV. In the ED, clinical history of last meal intake is the only tool available to judge gastric aspiration risk. A minimum of 2 hours of fasting after clear fluids, 6 hours for a light meal, and at least 8 hours after a full meal with high calorie or fat content are the current nil per oral (NPO) recommendations by the American Society of Anaesthesiologists (4). But it has doubtful advantage in patients with comorbidities like diabetes, gastroparesis, renal impairment, or in the critically ill, whose gastric emptying time is longer owing to many factors, including age, disease, and medications (5–7). Inadequate risk assessment due to unavailability of reliable diagnostic tools can cause poor patient outcome and is a matter of concern. This implies the need for a bedside non-invasive test for aspiration risk stratification in the emergency department.

Point-of-care gastric ultrasound (GUS) is an emerging radiographic paradigm that is reliable, accurate, brief, and repeatable (8, 9). It provides both qualitative and quantitative information about the stomach contents, thus aid in acute care to assess individual risk of aspiration in a condition of clinical uncertainty (10). The cross-sectional area (CSA) of the gastric antrum can be calculated using the formula, CSA = (AP×CC) x π/4, where AP is the anteroposterior diameter and CC is the craniocaudal diameter. It can also be measured using a free tracing tool in the USG machine. Then the GV can be calculated using the Perlas formula, GV = 27.0 + 14.6 x RLD CSA – 1.28 x age. This formula applies to adults and non-pregnant subjects whose body mass index (BMI) is less than 40 kg m⁻². It is accurate up to a predicted volume of 500mL (11).

The diagnostic accuracy of GUS to predict the incidence of aspiration (i.e., the sensitivity, specificity, and positive and negative predictive values) remains to be studied. This study aims to determine the diagnostic accuracy of each antral parameter (AP, CC, CSA, GV) in predicting the risk of aspiration in patients undergoing urgent emergency intubation (UEI) in the emergency department.

**Methods**

**Study design and settings:** A prospective observational study was performed in the Emergency Department, All India Institute of Medical Science, Rishikesh, after approval from the Ethics Committee of the university. The study was conducted over a period from April 2020 to October 2021. Study flow is shown in Figure 1.

**Inclusion criteria:**
1. Age > 18 years

2. Patients undergoing emergency endotracheal intubation

**Exclusion criteria:**

1. History suggestive of intestinal obstruction or gastric outlet obstruction.
2. Known pregnancy.
3. Morbid obesity
5. Patients in cardiac or respiratory arrest or any patients requiring crash intubation.
6. Patients with a gastric or duodenal tube in situ.
7. Patients/guardians not consenting to take part in the study.
8. Delay of more than 5 minutes in performing USG due to any cause.

**Sample size:** This was an exploratory time-bound. An exact sample size calculation cannot be done since there is a lack of literature concerning the diagnostic accuracy of gastric ultrasound in predicting aspiration. We took an arbitrary sample size of 100.

**Clinical evaluation:** Patients requiring urgent endotracheal intubation who fulfilled the inclusion criteria were promptly identified. The researcher collected detailed history, demographic data, and clinical parameters of the patient at the time of admission after informed consent. Relevant history regarding the last meal, the quantity of the last meal, and the nature (whether liquid or solid) were noted.

**Ultrasound protocol:** Patients were positioned in the right lateral decubitus (RLD) position for the study. Logroll with cervical inline stabilization was done in trauma patients. A curved array low-frequency USG probe (2-5 MHz) was used for USG gastric analysis by the trained emergency physician (Figure 2).

The most easily identified part of the stomach is its antrum. It lies superficial in the epigastric area below the xiphoid and above the umbilicus. It is imaged in a sagittal plane in the RLD position (12). It appears as a thick hollow organ with a multi-layered wall just below the left lobe of the liver and anterior to the body of the pancreas. The Inferior vena cava and the aorta lie posterior to the antrum. The gastric status is empty when the antral walls are juxtaposed and oval (Figure 3). It is distended when any stomach content is present and appears rounded (Figure 4) (13).

For quantitative evaluation, the plane at the level of the aorta is the standardized landmark. Two perpendicular diameters, the AP and the CC diameters are measured from serosa to serosa between the peristalsis when the antrum is at rest (Figure 5) (14). USG analysis was done in under 5 minutes while...
preparing for UEI, not interfering with the course of treatment. The UEI was then carried out by the professional team as per institutional protocol. Only visual aspiration of gastric content, seen as regurgitation into the oropharynx during intubation was considered as aspiration in the study (15). Any unseen aspiration or later development of clinical or radiographic signs of aspiration pneumonia during hospital stay was not taken into consideration.

**Data collection:** The study investigators were Emergency medicine Residents who had received training in GUS for 2 months. The detailed history, demographic data, and clinical parameters of the patient at the time of admission were recorded. The gastric diameters, the AP and the CC diameters were measured using ultrasound. The cross-sectional area, CSA is calculated using \( \text{CSA} = \frac{(\text{AP} \times \text{CC}) \pi}{4} \). The gastric volume, GV is estimated from the calculated CSA using Perla’s formula: \( \text{GV} = 27.0 + 14.6(\text{RLD CSA}) - 1.28(\text{age}) \). Some values of calculated GV were negative values and they were considered to be zero (26). The data was entered in an excel sheet and was analyzed using SPSS software Version-23.

**Results**

One hundred patients who came to the emergency department were enrolled in the study. Categorical variables were presented in number and percentage (%), and continuous variables were presented as mean (SD) and median (IQR) depending on the distribution of the data. The main baseline characteristics of the study population are shown in Table 1. They were described by using the mean, median, interquartile range, frequency, and percentage for different variables. The ultrasound findings are represented in Table 2.

### Table 1

**Baseline characteristics of the study population.**
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years), Mean ± SD</td>
<td>50.56 ± 14.44</td>
</tr>
<tr>
<td>Systolic BP (mmHg), Median (IQR)</td>
<td>120 (100.00-132.50)</td>
</tr>
<tr>
<td>Diastolic BP (mmHg), Median (IQR)</td>
<td>70 (60.00-88.00)</td>
</tr>
<tr>
<td>Heart Rate (BPM), Mean ± SD</td>
<td>98.47 ± 18.92</td>
</tr>
<tr>
<td>Respiratory Rate (CPM), Median (IQR)</td>
<td>24 (20.00-28.50)</td>
</tr>
<tr>
<td>Spo2 (%), Median (IQR)</td>
<td>93 (86.50-96.00)</td>
</tr>
<tr>
<td>RBS (mg/dL), Median (IQR)</td>
<td>141 (115-179)</td>
</tr>
<tr>
<td>Time since Solid Meal (hr) (n=54), Median (IQR)</td>
<td>8.00 (6.00-12.00)</td>
</tr>
<tr>
<td>Time Since Liquid Meal (hr) (n=46), Median (IQR)</td>
<td>9.50 (5.00-24.00)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Frequency (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>67 (67.0%)</td>
</tr>
<tr>
<td>Female</td>
<td>33 (33.0%)</td>
</tr>
<tr>
<td>Trauma</td>
<td>4 (4.0%)</td>
</tr>
<tr>
<td>Non-Trauma</td>
<td>96 (96.0%)</td>
</tr>
<tr>
<td>Single Attempt of intubation</td>
<td>94 (94.0%)</td>
</tr>
<tr>
<td>Multiple Attempt of intubation</td>
<td>6 (6.0%)</td>
</tr>
<tr>
<td>Aspiration Present</td>
<td>8 (8%)</td>
</tr>
<tr>
<td>Aspiration Absent</td>
<td>92 (92%)</td>
</tr>
</tbody>
</table>

**Induction Agent**

<table>
<thead>
<tr>
<th>Induction Agent</th>
<th>Frequency (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ketamine</td>
<td>61 (61%)</td>
</tr>
<tr>
<td>Etomidate</td>
<td>33 (33%)</td>
</tr>
<tr>
<td>Propofol</td>
<td>6 (6%)</td>
</tr>
</tbody>
</table>

**Comorbidities**

<table>
<thead>
<tr>
<th>Comorbidities</th>
<th>Frequency (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes mellitus (DM)</td>
<td>25 (23.4%)</td>
</tr>
<tr>
<td>Hypertension (HTN)</td>
<td>9 (8.4%)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>9 (8.4%)</td>
</tr>
<tr>
<td>Chronic liver disease (CLD)</td>
<td>7 (6.5%)</td>
</tr>
<tr>
<td>Chronic kidney disease (CKD)</td>
<td>5 (4.7%)</td>
</tr>
</tbody>
</table>
Table 2

Gastric Ultrasound Parameters

<table>
<thead>
<tr>
<th>USG GASTRIC STATUS</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty</td>
<td>66 (66.0%)</td>
</tr>
<tr>
<td>Distended</td>
<td>34 (34.0%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Antral Parameters</th>
<th>Median (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USG CC Diameter (cm), Median (IQR)</td>
<td>1.60 (1.28-2.20)</td>
</tr>
<tr>
<td>USG AP Diameter (cm), Mean ± SD</td>
<td>4.16 ± 1.09</td>
</tr>
<tr>
<td>USG CSA (cm²), Median (IQR)</td>
<td>5.15 (3.25-8.32)</td>
</tr>
<tr>
<td>USG Gastric Volume (mL), Median (IQR)</td>
<td>29.65 (13.43-85.67)</td>
</tr>
</tbody>
</table>

P-value < 0.05 (two-tailed) was considered significant. Statistical tests were applied as relevant. Chi-squared test and Fisher's exact test were used to explore the association between categorical variables. Wilcoxon-Mann-Whitney U Test was used to find the association between continuous and categorical variables when data were not normally distributed. Receiver operating characteristic (ROC) curve analysis was done to study the diagnostic accuracy of time since solid and liquid meals and GUS parameters in predicting aspiration. The results were represented as sensitivity, specificity, PPV, NPV and likelihood ratios, with a confidence interval of 95%.

**Association Between USG Gastric Status and Aspiration**

Fisher's exact test was used to explore the association between aspiration and gastric status as more than 20% of the total number of cells had an expected count of less than 5. There was a significant difference between the various groups in terms of distribution of gastric status ($\chi^2=16.880$, $p<0.001$). Strength of association between the two variables (Cramer's V) is 0.41 (Moderate Association). Major proportion of patients who had aspiration had a distended gastric status.

**Time since Solid Meal ($n = 54$) and Time since Liquid Meal ($n = 46$) to predict Aspiration**
The variable time since solid meal and time since liquid meal were not normally distributed in the two subgroups of the variable aspiration. Thus, non-parametric test (Wilcoxon-Mann-Whitney U Test) was used to make group comparisons. There was a significant difference between the two groups in terms of time since solid meal ($W=52.000, p=0.036$), the median time being highest in patients who had no aspiration. Strength of Association (Point-Biserial Correlation) is 0.15 (Small Effect Size). There was no significant difference between the two groups of aspiration regarding time since liquid meal ($W=32.500, p=0.160$).

The AUROC for time since solid meal for predicting aspiration was 0.788 (95%CI= 0.567-1), thus demonstrating fair diagnostic performance. It was statistically significant ($p=0.036$). A cut-off of time since solid meal $\leq 6.5$ hours predict aspiration with a sensitivity of 80% and a specificity of 71%. The ROC analysis and diagnostic performance of time since the liquid meal was not statistically significant.

**Aspiration in Terms of USG CC Diameter**

The median (IQR) of CC diameter in the patients who aspirated was 2.53cm (2.4cm -2.73cm) and in those who did not aspirate was 1.6cm (1.2cm – 2cm). The variable CC diameter was not normally distributed in the two subgroups of aspiration. Non-parametric test (Wilcoxon-Mann-Whitney U Test) was used to make comparisons. There was a significant difference between the two groups in terms of CC diameter(cm) ($W=708.500, p<0.001$), with the median higher in those who had aspiration. Strength of Association (Point-Biserial Correlation) is 0.48 (Large Effect Size). The AUROC for CC diameter in predicting aspiration was 0.963 (95%CI= 0.925-1), demonstrating excellent diagnostic performance (Figure 6). It was statistically significant ($p=<0.001$). A cut-off of CC diameter $\geq 2.35cm$ predicts aspiration with a sensitivity of 88%, and a specificity of 91%.

**Aspiration in Terms of USG AP Diameter**

The median (IQR) of AP diameter in the patients who aspirated was 6.05cm (5.5cm -6.58cm). The median (IQR) of AP diameter in the patients who did not aspirate was 3.95cm (3.27cm - 4.6cm). The variable AP diameter was not normally distributed in the two subgroups of aspiration. Non-parametric test (Wilcoxon-Mann-Whitney U Test) was used to make group comparisons. There was a significant difference between the two groups in terms of AP diameter ($W=696.500, p=<0.001$), with the median AP diameter being highest in those who aspirated. Strength of Association (Point-Biserial Correlation) is 0.5 (Large Effect Size). The AUROC for AP diameter for predicting aspiration was 0.946 (95%CI= 0.89-1), demonstrating excellent diagnostic performance (Figure 7). It was statistically significant ($p=<0.001$). A cut-off of AP diameter $\geq 5.15cm$ predicts aspiration with a sensitivity of 88% and a specificity of 87%.

**Aspiration in Terms of USG CSA**

The median of USG CSA in the patients who aspirated was 12.55cm² (IQR: 10.28cm² -13.86cm²), and in those who did not aspirate was 4.84cm² (3.04cm² - 7.39cm²). USG CSA was not normally distributed in the two subgroups of aspiration. Hence, Wilcoxon-Mann-Whitney U Test was used to make group
comparisons. There was a significant difference between the two groups in terms of CSA (W=708.500, p= <0.001), with the median more in the participants who had aspiration. Strength of Association (Point-Biserial Correlation) is 0.57 (Large Effect Size).

The AUROC for CSA for predicting aspiration was 0.963 (95%CI= 0.92-1), demonstrating excellent diagnostic performance (Figure 8). It was statistically significant (p=<0.001). A cut-off of USG CSA ≥ 9.27 cm² predicts aspiration with a sensitivity of 100%, and a specificity of 87%.

Aspiration in Terms of USG Gastric Volume

The median of GV in those who aspirated was 146.37mL (IQR: 120.1mL-177.4mL), and those who did not aspirate was 26.82mL (IQR: 12.09mL-58.03mL). GV was not normally distributed in the two subgroups of aspiration. Wilcoxon-Mann-Whitney U Test was used to make group comparisons. There was a significant difference between the two groups in terms of GV (W=721.000, p=<0.001), with the median higher in those who aspirated. Strength of Association (Point-Biserial Correlation) is 0.62 (Large Effect Size).

The AUROC for GV in predicting aspiration was 0.98 (95%CI= 0.953-1), demonstrating excellent diagnostic performance (Figure 9). It was statistically significant (p=<0.001). A cut-off of Gastric Volume ≥111.594mL predicts aspiration with a sensitivity of 100% and a specificity of 92%.

Comparison of the diagnostic performance of different variables in predicting aspiration is summarized in Table 3.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>AUROC</th>
<th>95% CI</th>
<th>P</th>
<th>Sn</th>
<th>Sp</th>
<th>PPV</th>
<th>NPV</th>
<th>DA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Since Liquid Meal (Hr)</td>
<td>0.748</td>
<td>0.367-1</td>
<td>0.160</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Time Since Solid Meal (Hr)</td>
<td>0.788</td>
<td>0.567-1</td>
<td>0.036</td>
<td>80%</td>
<td>71%</td>
<td>22%</td>
<td>97%</td>
<td>72%</td>
</tr>
<tr>
<td>USG: AP Diameter (cm)</td>
<td>0.946</td>
<td>0.89-1</td>
<td>&lt; 0.001</td>
<td>88%</td>
<td>87%</td>
<td>37%</td>
<td>99%</td>
<td>87%</td>
</tr>
<tr>
<td>USG: CC Diameter (cm)</td>
<td>0.963</td>
<td>0.925-1</td>
<td>&lt; 0.001</td>
<td>88%</td>
<td>91%</td>
<td>47%</td>
<td>99%</td>
<td>91%</td>
</tr>
<tr>
<td>USG: CSA (cm²)</td>
<td>0.963</td>
<td>0.92-1</td>
<td>&lt; 0.001</td>
<td>100%</td>
<td>87%</td>
<td>40%</td>
<td>100%</td>
<td>88%</td>
</tr>
<tr>
<td>USG: Gastric Volume (mL)</td>
<td>0.980</td>
<td>0.953-1</td>
<td>&lt; 0.001</td>
<td>100%</td>
<td>92%</td>
<td>53%</td>
<td>100%</td>
<td>93%</td>
</tr>
</tbody>
</table>

AUROC: Area under ROC curve; CI: Confidence interval; P: P value; Sn: Sensitivity; Sp: Specificity; PPV: Positive predictive value; NPV: Negative predictive value; DA: Diagnostic Accuracy.

Discussions
Patients who required UEI in the emergency department were included for the study. The main indications for UEI were acute respiratory failure (either fault in the oxygenation or hypercapnia associated with an inability to tolerate non-invasive ventilation), respiratory distress (with a respiratory rate of more than 34 per minute or/and usage of accessory muscles), airway protection for threatened airway, circulatory collapse, and severe metabolic acidosis. The indications were similar to a study conducted by Koenig et al. who did GUS on emergency patients before UEI (15). We did no intervention to remove the gastric contents as this would further delay intubation. Also, any attempt to pass a nasogastric or orogastric tube might provoke regurgitation by gag reflex. Thus, standard practice as per the patient assessment and institutional protocol was adhered to, while ultrasound measurements were recorded.

Our study found no significant association between aspiration and age, gender, or vasopressor use. Association of aspiration with comorbidities was not significant (p>0.05) probably due to the small number of participants who had aspiration (n=8), and hence no meaningful statistical comparison could be made with each comorbidity. There was more occurrence of aspiration in trauma patients when compared to non-trauma cases. D.J Lockey et al. also found that 38% of patients with severe trauma who required surgery had a high prevalence for aspiration as a perioperative complication (16).

In our study, the time since solid meal for empty gastric status ranged from 6-96 hours (median of 11 hours) and distended antrum ranged from 3-12 hours (median of 6 hours). The time since liquid meal for empty antrum ranged from 3-120hours (median was 10 hours) and distended antrum ranged from 1-12 hours (median was 4 hours). The French team led by Dr.Bouvet reported gastric CSA measured in the semi-recumbent position of >3.4cm² in non-pregnant patients correlated with a non-empty stomach (17). While Perlas described an empty antrum would correspond to the thickness of the gastric wall (approximately 2–5cm²) (11). We found the median of gastric CSA of an empty antrum was 3.87cm² (IQR: 2.83cm²–5.12cm²) and a distended antrum was 9.43cm² (IQR: 8.03cm²–10.5cm²). The median USG gastric volume of an empty antrum was 17.83mL (IQR: 4.04mL–28.87mL), and a distended one was 109.24mL (IQR: 82.39mL–118.95mL).

Visible aspiration was more in participants who had a distended antrum, as expected. Van de Putte mentioned that 3–5% of fasted individuals could also have a distended stomach with volume >1.5 mL/kg (18). According to Richa et al., only 14 patients out of 100 ESRD patients had an empty stomach (Perla's grade 0) 6 hours after a light meal (19). We found time since solid meal ≤7.5 hours predict USG gastric state as distended with a sensitivity of 81%, and a specificity of 86%. Time since liquid meal ≤6hours predicts USG gastric status as distended with a sensitivity of 88% and a specificity of 74%.

A cut-off of USG CC diameter ≥2.35cm predicts aspiration with a sensitivity of 88% and a specificity of 91%, while a cut-off of USG AP diameter ≥5.15cm predicts it with a sensitivity of 88% and a specificity of 87%. Sharma et al. suggested that the CC diameter can be a simple surrogate of the residual gastric volume. They found the CC diameter increased linearly with increasing gastric residual volume. A CC diameter of <10 cm predicted a gastric volume of <500mL (20).
USG CSA cut-off $\geq 9.27\text{cm}^2$ predicts aspiration with a sensitivity of 100% and a specificity of 87% using ROC analysis. According to previous studies cut-off value of antral CSA of $3.4\text{ cm}^2$ was labelled as high risk for aspiration (21). Van de Putte and Perlas(2014) stated that volumes up to $1.5\text{mL/kg}$ are considered normal and are safe (3). The values above this could possibly cause clinically significant aspiration. This GV would correlate to an antral CSA between $9\text{cm}^2$ and $10\text{cm}^2$ measured in the right lateral decubitus position according to Perlas formula (14). We report the median of GV in the patients who aspirated was $146.37\text{mL}$, and it ranged from $111.59\text{mL}$-$201.01\text{mL}$. A cut-off USG GV $\geq 111.59\text{mL}$ predicts aspiration with a sensitivity of 100% and a specificity of 92%.

Participants who were induced with ketamine had a lesser incidence of aspiration, while participants induced with etomidate and propofol had more incidence of aspiration. This difference was statistically significant in the study ($\chi^2 = 4.753, p = 0.047$). Ketamine preserves the pharyngeal and laryngeal reflexes (22). Since we took only visible aspiration into account, micro-aspiration due to secretions could have been missed. Nevertheless, this paves the way for more research on this topic. The number of attempts for intubation caused no significant difference in ($\chi^2=5.566, p=0.072$).

We have to remember that any cut-off value is not considered fool-proof. The sensitivity and specificity will change in reverse directions when the values are higher and lower. The NPV of the test parameters (USG CC, AP, CSA and GV) can be considered the most important. The correct diagnosis of an empty stomach is of higher priority during emergency airway management (14). This is due to the drastic consequences aspiration can cause. Any means to prevent aspiration and take adequate precautions is of utmost importance. This can bring down the mortality and morbidity of patients caused due to aspiration.

**Limitations:**

1. Healthy people, patients with altered gastric anatomy and children were not part of the study. Thus, this study lacks information about the study parameters on this population.

2. Micro-aspirations and follow-up development of consolidative patch in chest x-ray were not accounted for in the study. Only visible aspirations were considered, which would need larger gastric volume.

3. Quantifying a distended stomach with solid content may not be accurate as the posterior wall of the gastric antrum would be obscured in the presence of solid contents.

4. The number of patients with each comorbidity was limited as well as overlapping; thus, extrapolating the association for risk of aspiration with each comorbidity was not statistically significant.

5. The weight and BMI of the patient were not taken into consideration, and hence the exact threshold of gastric volume per kg could not be calculated.

6. Even though trauma patients have more chance of having a full stomach and aspiration, the number of trauma patients included in the study was less.
Conclusion

Point of care gastric ultrasound is a useful non-invasive bedside tool for risk stratification for aspiration. It is feasible and accurate in the busy emergency rooms to predict aspiration in patients requiring UEI. We present a threshold gastric volume and other gastric parameters (CC and AP diameters, CSA, GV) that can be used to predict aspiration along with its diagnostic accuracy. This can help the treating physician in deciding intubation techniques and treatment modifications and aid in further patient management. Larger prospective RCT with participants in two limbs – one with GUS assessment and one with no GUS assessment investigating the incidence of aspiration and appropriate intervention to reduce the same would be necessary to conclusively verify the clinical benefits of using bedside GUS before intubation.

Declarations

Ethical approval: The study was conducted after getting approval from the Institutional Ethics Committee of All India Institute of Medical Sciences, Rishikesh (Ref no – AIIMS/IEC/20/370). The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Consent to participate: Written informed consent was taken from all participants and/or legal guardian of the study.

Consent for publication: Written informed consent was taken from all participants and/or legal guardian of the study and accompanying images.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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N.A, U.C, A.P and T.S were involved in the patient care along with the critical reviewing and editing of the manuscript.

D.L, H.B, H.C and S.P collected, interpreted and statistically analysed the data for the study.

All authors reviewed the final manuscript.

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References


Figure 1

Study Flow
Figure 2

Patient in RLD position and USG done in epigastric sagittal plane
Figure 3

The antral walls juxtaposed and oval signifying empty
Figure 4

The antrum rounded signifying distended
Figure 5

USG gastric antral analysis measuring AP and CC diameters
Figure 6

ROC Curve Showing Diagnostic Performance of USG CC Diameter (cm) in Predicting Aspiration (n = 100)
Figure 7

ROC Curve Analysis Showing Diagnostic Performance of USG AP Diameter (cm) in Predicting Aspiration (n = 100)
Figure 8

ROC Curve Analysis Showing Diagnostic Performance of USG: CSA (cm²) in Predicting Aspiration (n = 100)
Figure 9

ROC Curve Analysis Showing Diagnostic Performance of USG Gastric Volume (mL) in Predicting Aspiration (n = 100)