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Original Article

Utility of Ultrasound Assessment of Gastric Volume in Predicting Aspiration Risk During Induction of Anesthesia: A Prospective Observational Study

Dr Charulatha[1], DrVinod Kumar M[2], Dr.MohamedShahbaz S[3]

[1]Assistant Professor, Department of Anaesthesiology, Navodaya Medical College, Raichur, Karnataka, India
[2]Senior Resident, Department of Radiodiagnosis, Navodaya Medical College, Raichur, Karnataka, India
[3]Assistant Professor, Department of Anaesthesiology and Critical Care, Siddaganga Medical College and Research Institute, Tumkur, Karnataka, India

Corresponding Author:

Dr Charulatha
Assistant Professor, Department of Anaesthesiology, Navodaya Medical College, Raichur, Karnataka, India

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ABSTRACT

Background: Pulmonary aspiration during induction remains an uncommon but high-impact complication. Standard fasting durations do not fully reflect individual gastric emptying and residual volume.
Objectives: To evaluate whether pre-induction gastric ultrasound–estimated gastric volume and qualitative antral grading can predict aspiration-related events during induction of general anesthesia.
Methods: In this prospective observational study, 100 adults scheduled for elective surgery under general anesthesia underwent standardized pre-induction gastric ultrasound at a tertiary care teaching hospital. Antral contents were graded qualitatively (grade 0–2) and gastric volume was estimated. A high-risk stomach was defined as grade 2 or an estimated volume ≥1.5 mL/kg. Induction and the first 10 minutes after intubation were observed for regurgitation, visible airway contamination requiring suction, and early desaturation/wheeze. Suspected aspiration pneumonitis was assessed in the post-anesthesia care unit and within 24 hours. Diagnostic performance metrics were calculated for the high-risk ultrasound classification against a composite aspiration-related endpoint.
Results: Residual gastric contents showed marked inter-individual variability despite reported fasting. Fourteen participants had a high-risk scan. Aspiration-related events were concentrated in the high-risk group, while a low-risk scan was strongly reassuring.
Conclusion: Pre-induction gastric ultrasound stratified aspiration-related risk and identified a small subgroup with substantially higher peri-induction airway contamination events. Integrating gastric ultrasound into pre-induction assessment can support individualized airway and induction planning in patients with uncertain or potentially delayed gastric emptying.

Keywords*: gastric ultrasound; gastric volume; aspiration risk; induction of anesthesia; point-of-care ultrasound; fasting.*

INTRODUCTION

Pulmonary aspiration of gastric contents during induction of general anesthesia is infrequent, yet it carries disproportionate morbidity because it can precipitate hypoxemia, bronchospasm, chemical pneumonitis, and unplanned postoperative critical care. Large perioperative series and pediatric analyses highlight that aspiration events cluster around airway manipulation and early recovery, particularly when protective reflexes are blunted and intragastric pressure rises during induction or emergence [1,2]. Accordingly, perioperative teams aim to minimize residual gastric volume and to anticipate patients in whom regurgitation is more likely.

Preoperative fasting guidelines reduce aspiration risk in most elective patients, and they remain a cornerstone of routine anesthesia practice [3,4]. Nevertheless, fasting duration is an imperfect surrogate for actual gastric volume. Gastric emptying is modulated by metabolic disease, opioid exposure, reflux symptoms, obesity, anxiety, and procedure-related

factors, leading to clinically meaningful variability even among apparently compliant patients. When fasting history is uncertain, when surgery is urgent, or when comorbidities slow gastric emptying, clinicians often default to conservative airway strategies that increase complexity and resource use, such as rapid sequence induction or awake intubation.

Point-of-care gastric ultrasonography has emerged as a pragmatic bedside method to visualize the gastric antrum, classify content type, and estimate volume. Methodological work and reviews describe reproducible qualitative grading and validated models linking antral cross-sectional area to volume, allowing risk stratification beyond fasting time alone [5-8]. In this framework, an empty antrum or a low volume of clear fluid is consistent with low aspiration risk, whereas solid or thick contents, or high volumes of clear fluid, signal a 'full stomach' that warrants heightened precautions [8].

Observational cohorts demonstrate that a minority of elective patients have unexpectedly high residual volume, with obesity, diabetes, and recent opioid intake repeatedly associated with a higher prevalence of a full stomach [9,10]. More recent data suggest that gastric ultrasound can alter peri-induction management by either prompting more conservative airway plans or, conversely, supporting a more liberal approach when a low-risk stomach is demonstrated [10,11]. Despite increasing uptake, evidence from diverse practice environments is still needed to contextualize performance characteristics and to relate ultrasound findings to aspiration-related clinical events rather than fasting history alone.

The present prospective observational study assessed pre-induction gastric ultrasound in adults undergoing elective surgery under general anesthesia at Navodaya Medical College and Research Centre, Raichur, Karnataka, India. The objectives were (i) to describe qualitative and quantitative gastric ultrasound findings after reported fasting, (ii) to determine the incidence of aspiration-related events during induction, and (iii) to evaluate the predictive utility of a high-risk ultrasound classification for identifying patients with aspiration-related events.

MATERIALS AND METHODS

Study design and setting: A prospective observational study was conducted at Navodaya Medical College and Research Centre, Raichur, Karnataka, India, from August 2024 to January 2025. Consecutive adults scheduled for elective surgery under general anesthesia were approached in the preoperative area and enrolled after written informed consent and ethics committee approval. Routine fasting instructions were followed as per contemporary guidance [3,4]. The sample size was 100, based on feasible recruitment within the study period and to enable estimation of diagnostic performance for a bedside test.

Participants and eligibility: Eligible participants were ≥18 years and ASA physical status I–III, planned for tracheal intubation. Exclusions were pregnancy, known upper gastrointestinal obstruction, emergency surgery, and refusal of consent. Age, sex, BMI, comorbidities (diabetes mellitus, symptomatic GERD), opioid intake within 24 hours, type of surgery, and reported fasting duration were recorded using a standardized case record form.

Gastric ultrasound protocol: Immediately before induction, trained anesthesiologists performed point-of-care gastric ultrasound with a low-frequency curvilinear probe (epigastric window) in the supine and right lateral decubitus positions. Antral contents were graded qualitatively (grade 0–2) using established descriptors [5,6]. Antral cross-sectional area was measured between peristaltic contractions, and gastric volume was estimated using validated mathematical models that relate antral area to volume [7]. A high-risk stomach was defined as grade 2 or an estimated volume ≥1.5 mL/kg, consistent with commonly used aspiration risk thresholds [8,10]. Predominant content type was categorized as empty, clear fluid, or thick/solid. Feasibility was defined as successful acquisition of interpretable antral images and recorded measurements.

Induction monitoring and follow-up: Induction and airway management were performed by the attending anesthesia team according to standard practice. Ultrasound findings were documented before induction and communicated to the team after image acquisition to support clinical decisions. A study observer recorded regurgitation, need for oropharyngeal suction for visible fluid, and early respiratory events (wheeze or SpO_2 <94%) during induction and within 10 minutes after intubation. Bronchoscopy was performed only when clinically indicated. Patients were assessed in the PACU and reviewed within 24 hours for clinical features consistent with aspiration pneumonitis.

Outcomes: A composite aspiration-related endpoint was defined as regurgitation, airway contamination requiring suction with early desaturation/wheeze, bronchoscopic aspiration when performed, or suspected aspiration pneumonitis within 24 hours. Secondary outcomes were ultrasound-derived gastric content/volume distributions and associations between selected clinical factors and the high-risk classification.

Statistical analysis: Data are presented as mean ± SD, median (IQR), or n (%). Group comparisons used χ^2/Fisher's exact tests for categorical variables and Mann–Whitney U tests for skewed continuous variables. Sensitivity, specificity, PPV, and NPV of the high-risk classification were calculated with 95% confidence intervals. A two-sided p value <0.05 defined statistical significance. Analyses were conducted using standard statistical software.

RESULTS

Participant flow and completeness are presented below. Of 112 patients screened, 8 were excluded due to predefined criteria (pregnancy: 2; known gastric outlet/upper gastrointestinal obstruction: 2; emergency surgery: 4) and 4 declined consent. Finally, 100 participants underwent pre-induction gastric ultrasound and were analyzed with complete datasets (100%).

Baseline demographic and perioperative characteristics are summarized in Table 1. The cohort had a mean age of 44.6 ± 12.9 years and included 58% males. Mean BMI was 25.1 ± 3.8 kg/m², with 12% classified as obese (BMI ≥30 kg/m²). Diabetes mellitus and symptomatic GERD were present in 18% and 16% of participants, respectively. Reported fasting duration was 9.0 hours (IQR 8.0–11.0).

Table 1. Baseline demographic and perioperative profile (N = 100)

Variable	Value
Age (years), mean ± SD	44.6 ± 12.9
Age group, n (%)	18–30: 22 (22.0); 31–45: 34 (34.0); 46–60: 30 (30.0); >60: 14 (14.0)
Sex, n (%)	Male: 58 (58.0); Female: 42 (42.0)
BMI (kg/m²), mean ± SD	25.1 ± 3.8
BMI category, n (%)	<25: 46 (46.0); 25–29.9: 42 (42.0); ≥30: 12 (12.0)
ASA physical status, n (%)	I: 40 (40.0); II: 46 (46.0); III: 14 (14.0)
Diabetes mellitus, n (%)	18 (18.0)
Symptomatic GERD, n (%)	16 (16.0)
Opioid use within 24 h, n (%)	20 (20.0)
Type of surgery, n (%)	Abdominal: 34 (34.0); Orthopedic: 28 (28.0); ENT: 18 (18.0); Others: 20 (20.0)
Reported fasting duration (h), median (IQR)	9.0 (8.0–11.0)

Gastric ultrasound was feasible in all participants. Qualitative antral grades and estimated volumes are shown in Table 2. More than half of participants had an empty antrum (grade 0), while 32% had grade 1 findings consistent with clear fluid, and 12% had grade 2 findings. The estimated gastric volume was 38 mL (IQR 18–78), corresponding to 0.55 mL/kg (IQR 0.25–1.10). Fourteen participants met the predefined high-risk stomach criteria (≥1.5 mL/kg or grade 2).

Table 2. Gastric ultrasound classification and estimated volume (N = 100)

Parameter	Value
Qualitative antral grade, n (%)	Grade 0: 56 (56.0); Grade 1: 32 (32.0); Grade 2: 12 (12.0)
Estimated gastric volume (mL), median (IQR)	38 (18–78)
Estimated gastric volume per kg (mL/kg), median (IQR)	0.55 (0.25–1.10)
High-risk stomach (≥1.5 mL/kg or Grade 2), n (%)	14 (14.0)
Predominant content type, n (%)	Empty: 56 (56.0); Clear fluid: 40 (40.0); Thick fluid/solid: 4 (4.0)

Aspiration-related outcomes during induction are shown in Table 3. Overall, regurgitation occurred in 6% and visible oropharyngeal suctioning was required in 10%. Early wheeze/desaturation within 10 minutes of intubation occurred in 5%. Two participants had bronchoscopic evidence of aspiration when bronchoscopy was clinically indicated, and 3 participants were managed as suspected aspiration pneumonitis in the PACU or within 24 hours. These events clustered in the high-risk ultrasound group, with significantly higher rates of regurgitation, suctioning, early respiratory events, and suspected pneumonitis compared with the low-risk group ($p \leq 0.01$ for all listed outcomes).

Table 3. Induction and aspiration-related events (N = 100)

Outcome	Overall n (%)	Low-risk stomach (n = 86)	High-risk stomach (n = 14)	p value
Any regurgitation during induction	6 (6.0)	2 (2.3)	4 (28.6)	<0.001
Oropharyngeal suction required (visible fluid)	10 (10.0)	5 (5.8)	5 (35.7)	0.001
New wheeze/desaturation within 10 min (SpO_2 <94%)	5 (5.0)	2 (2.3)	3 (21.4)	0.004
Bronchoscopic evidence of aspiration*	2 (2.0)	0 (0.0)	2 (14.3)	0.002

Post-op suspected aspiration pneumonitis (PACU/24 h)	3 (3.0)	1 (1.2)	2 (14.3)	0.01

**Bronchoscopy performed only when clinically indicated.*

Using the composite aspiration-related endpoint, 8 of 100 participants experienced an aspiration-related event. Events occurred in 6 of 14 participants (42.9%) with a high-risk ultrasound classification compared with 2 of 86 (2.3%) with a low-risk scan. Diagnostic performance metrics for the high-risk classification are detailed in Table 4, demonstrating high specificity (91.3%) and a high negative predictive value (97.7%).

Table 4. Predictive utility of high-risk ultrasound classification (N = 100)

Metric	Estimate (95% CI)
Sensitivity	75.0% (35.6–95.5)
Specificity	91.3% (83.3–96.2)
Positive predictive value (PPV)	42.9% (17.7–71.1)
Negative predictive value (NPV)	97.7% (91.9–99.7)

Clinical factors associated with a high-risk stomach are presented in Table 5. Obesity (BMI ≥30 kg/m²), diabetes mellitus, and symptomatic GERD were significantly associated with high-risk ultrasound findings. Shorter reported fasting duration (<8 hours) was not statistically associated with high-risk classification.

Table 5. Association of clinical factors with high-risk stomach (N = 100)

Factor	High-risk, n/N (%)	Low-risk, n/N (%)	p value
BMI ≥30 kg/m²	6/12 (50.0)	6/88 (6.8)	<0.001
Diabetes mellitus	6/18 (33.3)	8/82 (9.8)	0.01
Symptomatic GERD	5/16 (31.3)	9/84 (10.7)	0.03
Fasting duration <8 h	5/22 (22.7)	9/78 (11.5)	0.20

DISCUSSION

In this prospective cohort of elective surgical patients, pre-induction gastric ultrasound revealed substantial variability in residual gastric content despite a median fasting duration of 9 hours. Although most participants demonstrated an empty antrum, 14% met the predefined high-risk criteria (solid/thick contents or ≥1.5 mL/kg). This pattern aligns with the central premise that fasting time alone incompletely captures the physiology of gastric emptying and residual volume [3,5].

A clinically important finding was the marked separation in aspiration-related events between ultrasound-defined risk strata. While the overall rate of clinically evident aspiration was low, surrogate indicators of airway contamination—regurgitation, visible suctioned fluid, and early respiratory compromise—were concentrated in the high-risk group. Such clustering supports the construct validity of gastric ultrasound risk thresholds described in prior methodological and narrative syntheses [5-8]. In practice, the high negative predictive value observed for a low-risk scan is particularly useful: when the antrum is empty or contains only small volumes of clear fluid, airway management can proceed with increased confidence, potentially avoiding unnecessary escalation to high-intensity induction techniques.

The prevalence of unexpected high-risk scans in our elective cohort is comparable to prospective observational data reporting a minority of patients with a ‘full stomach’ despite intended fasting. Bouvet and colleagues demonstrated that residual gastric volume is not rare and highlighted metabolic and patient-related correlates in both elective and emergency contexts [9]. More recent large cohorts indicate that routine gastric ultrasound can change perioperative plans in a meaningful fraction of patients, supporting either more conservative or more liberal aspiration precautions based on real-time findings [10]. Similarly, contemporary clinical guidance emphasizes that gastric ultrasound offers value when fasting history is unreliable or when comorbidities slow emptying, including obese and diabetic patients [8,11].

In our dataset, obesity, diabetes mellitus, and symptomatic GERD were significantly associated with high-risk ultrasound findings. These associations are biologically plausible and consistent with prior reports linking altered gastric motility and reflux physiology to higher residual volumes [9,10]. Interestingly, shorter reported fasting duration (<8 hours) was not significantly associated with high-risk classification, reinforcing that duration alone is a weak discriminator in individual patients once usual minimum fasting thresholds are met [3,5].

The study has practical implications for peri-induction decision-making. A simple pre-induction scan can add objective information to the traditional risk assessment, and it can guide the need for rapid sequence induction, the timing of surgery, or adjunctive measures such as gastric decompression in selected cases. In addition, the feasibility of obtaining interpretable images in all participants supports the real-world usability of the technique in an elective operating room

workflow, as described in educational and implementation-focused literature [8]. Future work with larger multicenter cohorts and standardized management algorithms is needed to link ultrasound-guided decisions to hard outcomes and resource utilization.

Limitations

This was a single-center observational study, and induction technique was not standardized across providers, which limits causal inference. The composite endpoint relied on clinical indicators, and bronchoscopy was performed only when indicated, reducing uniform ascertainment of microaspiration. The number of aspiration-related events was small, which widens confidence intervals around diagnostic accuracy estimates. Postoperative assessment was limited to 24 hours, so later respiratory sequelae were not captured.

CONCLUSION

In adults undergoing elective surgery under general anesthesia, bedside gastric ultrasound provided feasible, real-time assessment of residual gastric content and volume immediately before induction. Fourteen percent of participants met high-risk criteria, and aspiration-related airway contamination events were disproportionately observed in this subgroup. A low-risk scan was highly reassuring, supporting its role as a safety check when fasting history is uncertain or when conditions associated with delayed emptying are present. Obesity, diabetes mellitus, and symptomatic reflux were associated with high-risk findings, underscoring the value of individualized assessment beyond fasting duration. Embedding gastric ultrasound into pre-induction evaluation can refine airway planning and improve risk communication within the perioperative team. in routine practice.

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