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A non-interventional, cross-sectional study to observe the correlation between the duration of fasting and ultrasound derived gastric volume in patients posted for surgery

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Abstract
Perioperative aspiration of gastric content is one of the most dreaded complications in Anaesthesia. It is associated with more than 9% of total anaesthesia related deaths and about 20% of hospital mortality, The American Society of Anaesthesiologists has laid down guidelines for fasting intervals in elective surgeries for all healthy patients. Despite this, these guidelines may not be reliable in all conditions and for all patients. Certain medical conditions like diabetics, patients with chronic kidney disease, obesity, parturient, gastrointestinal obstruction, incompetent LOS - hiatus hernia, previous gastrointestinal surgeries are all associated with delayed gastric emptying time and may present with more gastric content at the time of induction in spite of adequate fasting period. Gastric emptying is also hampered in stressful conditions in presence of pain, anxiety and use of certain drugs like opioids. Likewise prolonged fasting can also present with undesirable outcomes like anxiety, dehydration, hypotension, electrolyte imbalance, insulin resistance resulting in hypoglycaemia and increased risk of postoperative nausea and vomiting.
In all such situations bedside gastric ultrasound can act as a rescue tool for anaesthesiologist by helping them in not only deciding the appropriate plan of action for giving anaesthesia but also prevent the aspiration risk and catastrophes associated with it.

Keywords: Gastric aspiration, anaesthesia, fasting guidelines, gastric ultrasound, perioperative complications

Introduction
Point of care ultrasound refers to the practice of using ultrasound to diagnose and treat patients faster by giving them more accurate, precise and reliable information about their condition in a non-invasive manner.
The main objective of POC gastric ultrasound is to help anaesthesiologist to risk stratify patients by the qualitative and quantitative assessment of gastric contents and when the NPO status is uncertain right before the surgery.

The I-AIM Framework [8]
The I-AIM Framework directs us the correct way to go about POC Gastric ultrasound scanning

- *It stands for-*
- Indication
- Acquisition
- Interpretation
- Medical decision making

Indication
Some of the most common and important conditions where gastric ultrasound is a rescue tool for an anaesthesiologist are-

1. Uncertain NPO status-decreased level of consciousness, communication barriers, paediatric population, no caretaker accompanying the patient.
2. Trauma and other Emergency surgeries
3. Medical conditions that can delay gastric emptying-diabetes, chronic kidney disease,

neurological or liver dysfunction, obesity,
4. Previous gastrointestinal surgery, GI obstruction, Hiatus hernia, cardiac achalasia, raised abdominal pressure (ascites, intra - abdominal mass)
5. Pregnancy (especially in labour)
6. Elderly age- gastric emptying increases with age

Acquisition-

Next step is to procure proper scans of gastric antrum to understand the status of the stomach.
For that we need to know the anatomy of the stomach.

Anatomy of Stomach

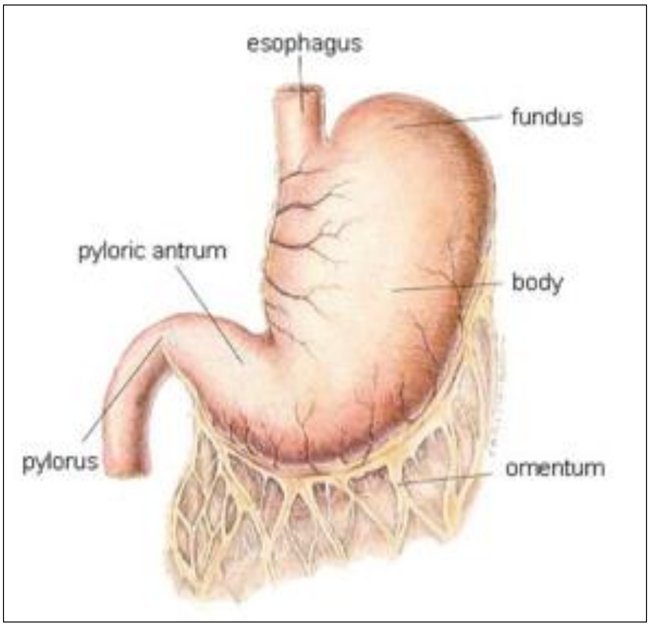

Fig 1: Anatomy of antrum [9]

The stomach has 3 anatomical parts-1) Fundus, 2) Body, and 3) Antrum & Pylorus.

- Out of the three, ANTRUM correlates best with the content and volume of entire stomach and is apt for POC gastric scanning
- It's the most distal and superficial part of the stomach hence provides an easily accessible soft tissue window for scanning. It is consistently located in the epigastric region, inferior to the left lobe of the liver, anterior to the pancreas, aorta and the inferior vena cava.

It's peculiar shape and presence of least amount of air pockets as compared to the body which has abundant air pockets enabling easy penetration of ultrasound beam.

Scanning Technique

1. **Equipment:** A portable ultrasound with a low-frequency curvilinear transducer (2-5 MHz) using standard abdominal settings is suitable for adult scanning. A high-frequency linear transducer is preferred for lean or paediatric patients, or for detailed imaging of the gastric wall.
2. **Patient Positioning:** Begin in the supine position, followed by right lateral decubitus (RLD) to enhance sensitivity by allowing gastric contents to settle in the antrum by gravity. If RLD is not feasible (e.g., trauma, discomfort, critical illness), a semi-recumbent position with the head elevated to 45° is the next best alternative.
3. **Scanning Technique:** Place the transducer sagittally in the epigastrium, just below the xiphoid, perpendicular to the skin. Sweep from left to right costal margin using a heel-to-toe motion.

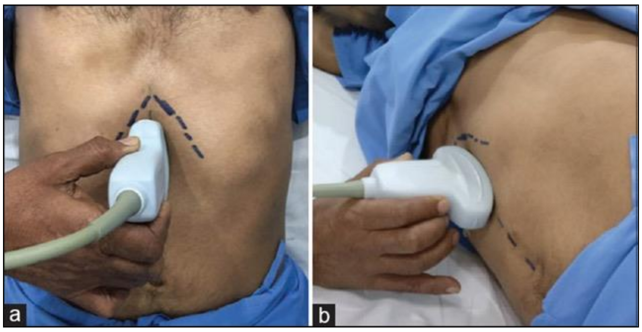

Fig 2: Scanning technique in A] supine position B] right lateral position with probe placed in sagittal plane [10].

Observe the following landmarks

- Vertebral bodies
- Long axis of abdominal aorta
- Body of Pancreas
- Left lobe of Liver
- Short axis of gastric antrum

Other vascular landmark- Inferior vena cava, Superior mesenteric artery or vein

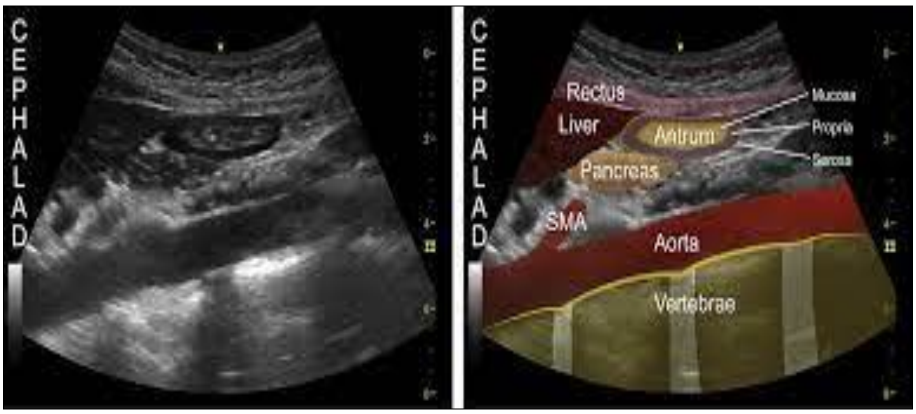

Fig 3: Sono anatomy of Antrum and its landmarks [2].

Interpretation

Once an adequate image is obtained it should then be deciphered for its qualitative and quantitative analysis.

Qualitative Analysis: Stomach can be either empty or full.

A) Empty: In empty stomach is lumen is completely collapsed giving it a characteristic bull's eye pattern on ultrasound.

Fig 4a: Bull eye appearance of an Empty antrum

B] Liquid: Clear liquids such as water, black tea, non-pulpy juices appear anechoic or hypoechoic in contrast to thick fluids like milk, pulpy fruit juices appear more homogenous and echoic.

Fig 5b: Distended antrum with starry sky appearance

C] Solid: The antrum with solid contents, appears as a "frosted glass" appearance on ultrasound.

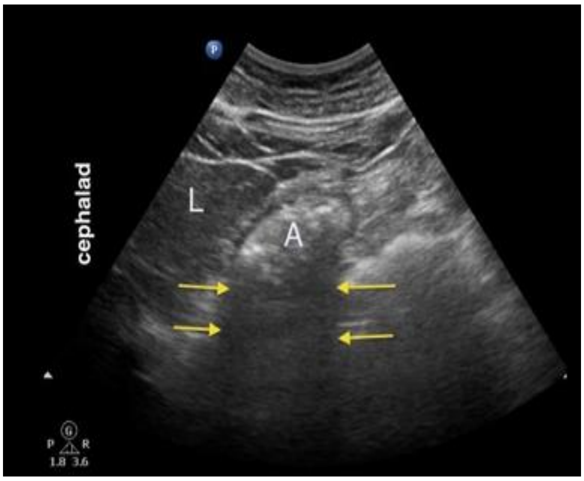

Fig 6c: Posterior wall of Stomach obscured by air pockets pointed by Yellow arrows pockets. Seen after recent solid meal ingestion9

Quantitative Analysis

The mean basal gastric secretions are around 0.4 to 0.6 ml/kg [13]. For quantification purpose most widely used cut off of 1.5ml/kg of body weight is used to assess the aspiration risk which is the upper limit of gastric acid secretion in a normal fasted individual (95th percentile) i.e. around 100-130 ml for an average adult. [2]

Several mathematical models were outlined to calculate the gastric volume but the one i.e. most widely used is given by Perlas and colleagues [14].

Volume (mL) = 27.0 + 14.6 x right lateral CSA (cm2) - 1.28 x age (years)

Medical Decision Making

Based on qualitative and quantitative analysis risk stratification can be done as follows.

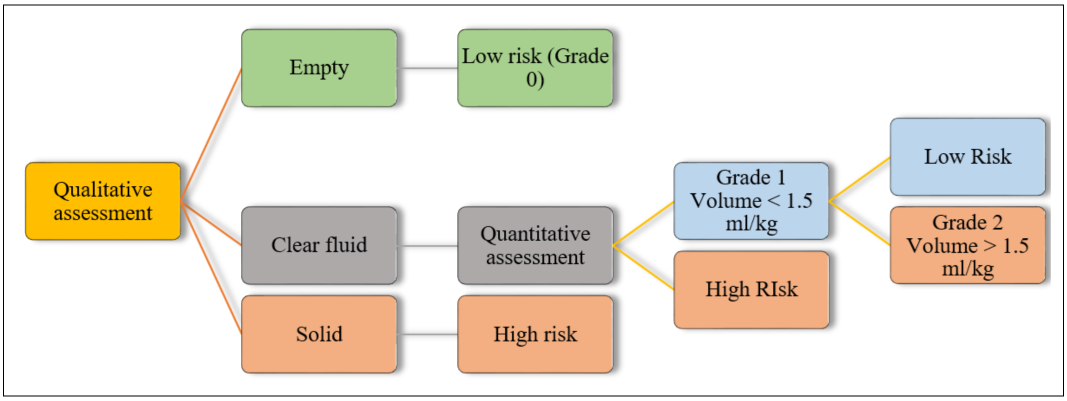

Fig 7: Step wise algorithm to assess the aspiration risk in patients

Materials and Methods

- **Study Design** -This was a prospective observational, non-interventional cross-sectional study
- **Study *Area:*** The study was conducted at P.D. Hinduja National Hospital and MRC, Mahim, Mumbai-400016.
- **Study Population:** Adult patients of either of sex between age group of 18yrs -65 yrs. were included in the study who were scheduled for surgery under anaesthesia.
- **Sample Size**-135 cases

Inclusion criteria

1. ASA Grade I, II, III patients
2. Age group 18 to 65 years
3. Both sexes

Exclusion criteria

1. Patients not willing to participate in the study.
2. Patients who are not NBM (Or full stomach patients)
3. Pregnant women
4. Age <18years and >65 years
5. Patients with Acute abdomen and Gastric outlet obstruction
6. Patients with Ryle's tube in-situ
7. Patients who cannot lie in lateral position
8. ASA IV patients

Patients were assessed a day before surgery, with details on age, height, weight, and ASA grading recorded. After meeting inclusion/exclusion criteria, consent was obtained. A final re-assessment was done on the surgery day, noting the time of the last solid and liquid meals. Gastric ultrasound was done in supine position and then in right lateral decubitus position. First 20 cases in the study were done under the supervision of a radiologist.

Gastric volume was then calculated using the formulae given by Perlas *et al.*

Gastric Volume = 27 +14.6 * Right lateral CSA-1.28* age [14]

Results

Following inferences were noted

- The Mean CSA and volume were found to be more in the Right Lateral Decubitus (RLD) than in supine position (Table 1)
- Though only 3 CKD patients were included in our study, all showed larger CSA and antral volume in RLD. Two had Perlas grading of 2, and one had grading of 1. (Table 2)
- Antral CSA was larger in individuals with higher BMI, older age, diabetes, and CKD, even with similar fasting durations. (Table 3)
- The study showed a significant p-value of 0.031 for antral CSA in RLD, with the highest mean CSA in ASA class III patients (7.588±3.55 mm²). While no significant correlation was found for antral volume, it was found to be increased with ASA severity. (Table 4)

- 14.1% showed significant antral volume i.e. antral volume>1.5ml/kg BW (Fig 9)
- P value was found to be >0.05 and hence we were unable to achieve the correlation between fasting hours and antral volume but after categorizing all the patients

for aspiration risk we found that around 68.4%of patients who had high aspiration risk had fasted for more than 10 hours, 26.30% in patient with FH of 6-10 hours, 5.30% in patients with FH <6 hours and hence we can say that the conventional belief of prolonged fasting duration results in an empty stomach does not hold true.(Fig 10)

Most patients had a fasting duration of 8-12 hours, with gastric volumes ranging from 37 ml (2 hours fasting) to 80 ml (17-18 hours fasting). (Fig 11)

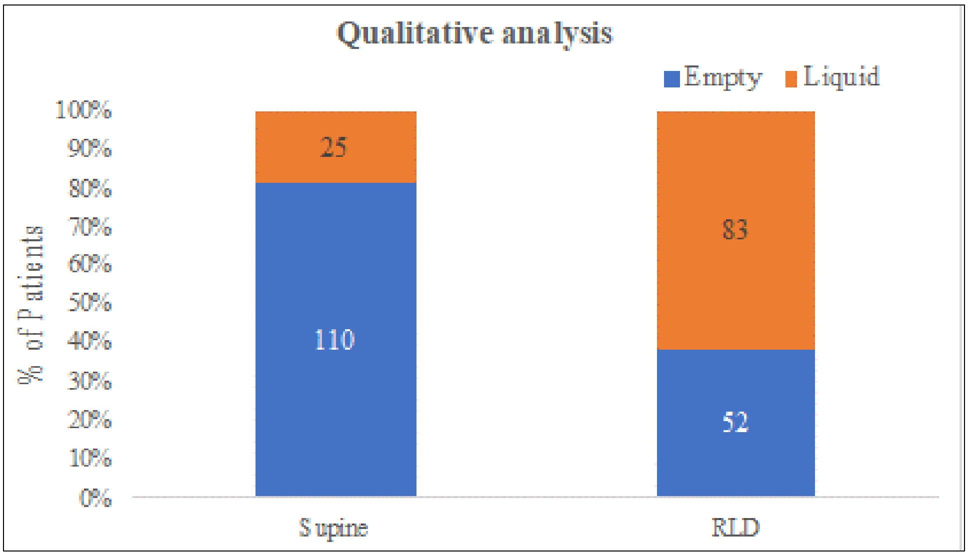

Fig 8: Bar Graph representation for Qualitative analysis of Gastric antrum appearance in 135 patients in Supine and RLD

Table 1: Comparisons of Mean and median CSA and antral volume in RLD and supine position in all 135 sample cases.

	N	Minimum	Maximum	Mean	Median	SD	25 - 75 P
Supine CSA	135	1.20	9.32	4.46	4.19	1.52	3.405 to 5.453
Supine ANTRAL VOLUME	135	27.20	87.24	29.81	30.66	24.13	11.030 to 44.650
Right Lateral CSA	135	1.98	20.72	6.60	6.12	2.81	4.857 to 8.020
Right Lateral ANTRAL VOLUME	135	19.66	251.48	61.08	57.33	40.31	36.722 to 81.318

Table 2: Comparison of Gastric Content in patients with and without significant comorbidities

		Gastric Content (RLD)		Gastric Content (Supine)	
Patient category	**N**	**Empty**	**Liquid**	**Empty**	**Liquid**
All Patients	135	52	83	110	25
No Comorbidities	36	13	23	32	4
DM	40	16	24	31	9
CKD	3	0	3	2	1
BMI(25-30)	52	23	29	41	11
BM(>30)	31	11	20	24	7

Table 3: Comparison of Gastric volume in patients with and without significant comorbidities

		Gastric CSA (mean +/- SD)		Gastric Volume (mean +/- SD)	
Patient category	**N**	**Supine**	**RLD**	**Supine**	**RLD**
All Patients	135	4.46+/-1.52	6.6+/-2.81	29.81+/-24.13	61.08+/-40.31
No Comorbidities	36	4.3+/-1.5	6.18+/-2.23	37.05+/-22.35	64.4+/-28.77
DM	40	4.83+/-1.49	7.29+/-3.61	27.35+/-25.08	63.16+/-52.78
CKD	3	5.18+/-1.3	9.04+/-0.92	34.4+/-18.29	90.74+/-33.24
BMI(25-30)	52	4.33+/-1.48	6.26+/-2.99	27.82+/-26.19	55.93+/-43.86
BM(>30)	31	4.97+/-1.84	7.44+/-3.36	33.83+/-23.79	69.95+/-47.81

Unit of gastric CSA in mt^2 and gastric volume in ml

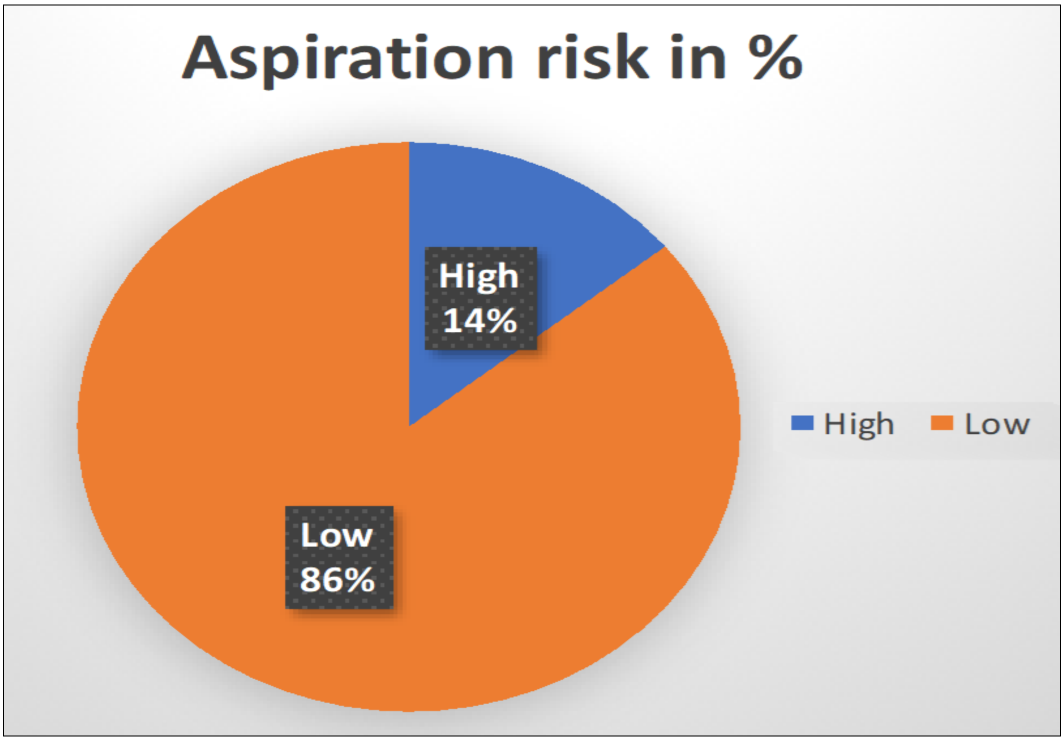

Fig 9: Distribution of 135 cases based on antral volume in RLD position

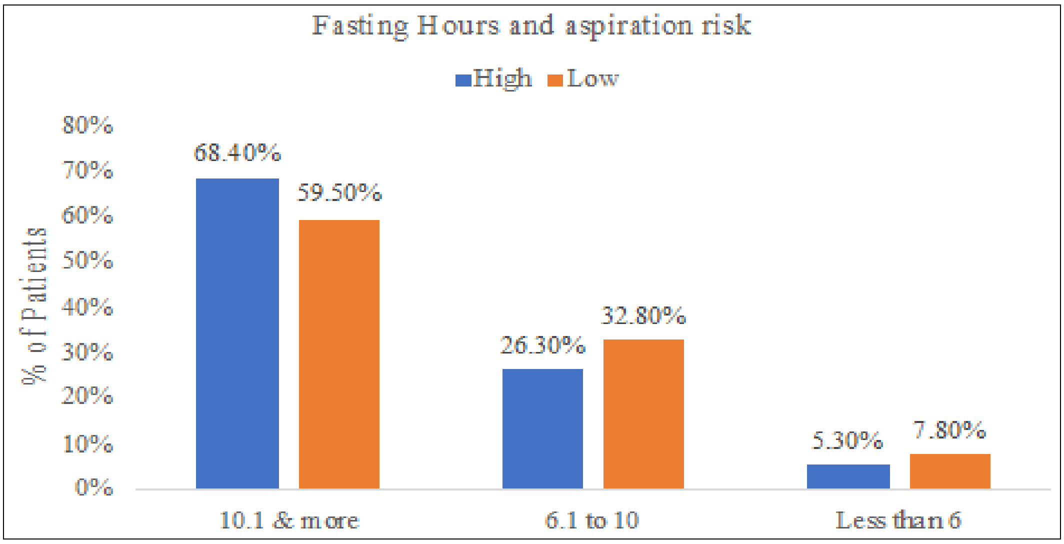

Fig 10: Histogram Chart- Comparing aspiration risk in patients with A) FH > 10hours, B) FH between 6-10 hours, C) <6 hours.

Correlation between duration of fasting hour and antral volume-

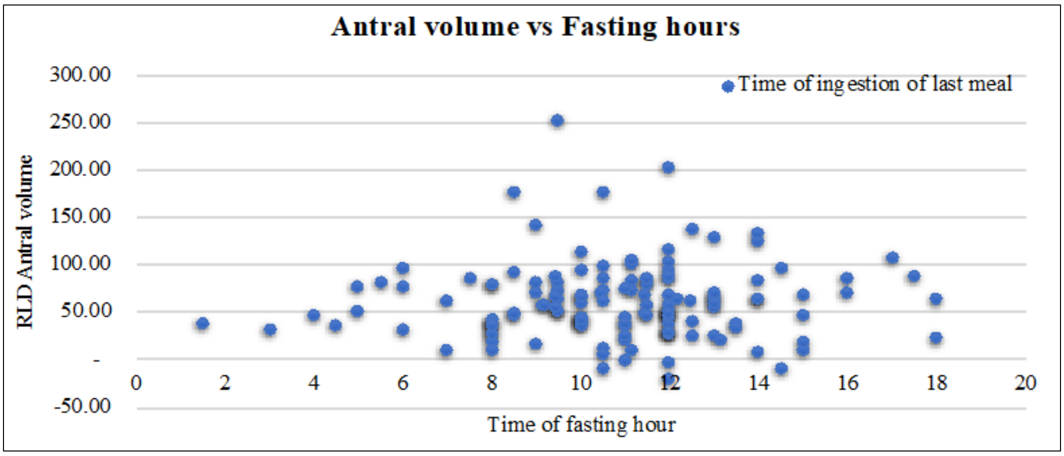

Fig 11: Scatter diagram depicting Gastric Antral volume (ml) in each case with respect to fasting hour.

ASA Grading

Table 4: Comparison of Median Gastric antral CSA and volume using Kruskal Wallis test in patients with ASA class I, II, III.

Position	ASA	N	Mean	Median	SD	p value
Supine ANTRAL VOLUME	I	30	38.025	35.880	21.500	0.094
	II	62	26.208	28.030	26.249	
	III	43	29.258	29.380	21.686	
Supine CSA	I	30	4.143	3.785	1.427	0.057
	II	62	4.336	4.040	1.625	
	III	43	4.848	4.520	1.380	
Right Lateral CSA	I	30	5.975	5.590	2.001	0.031
	II	62	6.213	5.535	2.396	
	III	43	7.588	6.570	3.553	
Right Lateral Antral Volume	I	30	64.762	63.590	26.816	0.188
	II	62	53.629	51.000	34.590	
	III	43	69.255	59.450	52.809	

Discussion

Our study highlights the value of incorporating bedside gastric ultrasound into the preoperative assessment of all surgical patients, especially those considered high-risk or undergoing emergency procedures. Relying solely on standard fasting guidelines may not reliably ensure adequate gastric emptying. Interestingly, extended fasting durations can paradoxically lead to increased antral volumes, thereby elevating the risk of aspiration.

Among the 135 patients enrolled in our study, 40 were diabetic, 3 had chronic kidney disease (CKD), and 83 had a BMI greater than 25. Notably, all three CKD patients had detectable fluid in the antrum, with one exhibiting an antral volume indicative of a increased aspiration risk.

An increase in BMI was associated with a corresponding rise in antral cross-sectional area (CSA) and gastric volume. Similarly, among diabetic patients, both CSA and gastric volume were greater in the right lateral decubitus (RLD) position compared to the supine position. Of the 40 diabetic patients, 24 had fluid present in the antrum while in the RLD position, and 4 of these exhibited significant antral volumes exceeding 1.5 mL/kg.

This study was conducted at a tertiary care center under controlled conditions, where patients' acute health issues were thoroughly stabilized before evaluation. This careful preoptimization may have enhanced gastric emptying and could limit some of our findings.

Conclusion

Gastric Ultrasound (POCUS) is a reliable, non-invasive tool for assessing the gastric antrum in real-time, offering accurate and repeatable measurements. It provides valuable insights to anaesthesiologists, helping identify aspiration risks in advance.

Key findings from our study include:

- **Fasting Duration vs. Antral Volume**: Longer fasting hours correlate with increased antral volume, though a direct correlation with gastric volume was not established.
- **Antral Content Assessment**: Ultrasound effectively identified gastric content based on the last meal. No solid content was found in patients fasting for 6+ hours.
- **Comorbidities and Antral Volume**: Patients with comorbidities had higher antral volumes despite similar fasting durations. The small sample size of CKD patients limited further analysis.
- **Positioning for Ultrasound**: The Right Lateral Decubitus (RLD) position is more reliable for assessing antral volume and aspiration risk than the supine position.

Incorporating bedside gastric ultrasound into routine preoperative assessments should be standard practice to guide anaesthesia decisions and ensure patient safety.

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