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Pre-operative Ultrasound Assessment of Gastric Contents in Diabetic and Non-diabetic Patients Undergoing Elective Surgery: A Cross-sectional Analytical Study

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Abstract

Background: Pulmonary aspiration remains a potentially catastrophic perioperative complication. Although current fasting guidelines reduce aspiration risk in most patients, delayed gastric emptying is frequently encountered in patients with diabetes mellitus because of autonomic neuropathy and diabetic gastroparesis. Consequently, standard fasting periods may not reliably ensure an empty stomach in diabetic patients. Point-of-care gastric ultrasonography has emerged as a rapid, non-invasive bedside tool for qualitative and quantitative assessment of gastric contents and may facilitate individualized anesthetic planning. **Objectives:** The objective of the study was to compare pre-operative gastric antral cross-sectional area (CSA), estimated gastric volume, qualitative gastric contents, and aspiration risk between diabetic and non-diabetic patients undergoing elective surgery using bedside gastric ultrasonography. **Materials and Methods:** A hospital-based cross-sectional analytical study was conducted in 100 adult patients scheduled for elective surgery. Fifty diabetic patients (Group D) and 15 non-diabetic patients (Group ND) who complied with standard fasting guidelines underwent pre-operative gastric ultrasonography using a 3–5 MHz curvilinear probe. Gastric antral CSA was measured in both the supine and right lateral decubitus (RLD) positions. Estimated gastric volume was calculated using the validated Perlas formula. Gastric contents were graded qualitatively according to the Perlas grading system, and aspiration risk was categorized accordingly. Statistical analysis was performed using Student's *t*-test and Chi-square test, with $P < 0.05$ considered statistically significant. **Results:** Diabetic patients demonstrated significantly larger gastric antral CSA in both the supine (5.88 ± 0.53 cm^2 vs. 3.25 ± 0.34 cm^2; $P < 0.001$) and RLD positions (7.32 ± 0.87 cm^2 vs. 3.78 ± 0.42 cm^2; $P < 0.001$). Estimated gastric volume was significantly greater in diabetic patients than non-diabetic patients (58.69 ± 17.63 mL vs. 25.28 ± 16.85 mL; $P < 0.001$). Grade 2 stomachs were identified exclusively among diabetic patients (12%), whereas none of the non-diabetic patients demonstrated high-risk gastric contents. High aspiration risk was observed in 12% of diabetic patients compared with 0% of non-diabetic patients ($P = 0.012$). **Conclusion:** Despite adherence to standard fasting guidelines, diabetic patients exhibited significantly greater residual gastric volume and a higher prevalence of high-risk gastric contents than non-diabetic patients. Bedside gastric ultrasonography provides a valuable individualized assessment of gastric contents and may improve perioperative risk stratification and anesthetic decision-making in diabetic patients.

Keywords: Aspiration risk, Diabetes mellitus, Elective surgery, Gastric ultrasound, Point-of-care ultrasound

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Introduction

Pulmonary aspiration of gastric contents remains an important cause of perioperative morbidity and mortality despite adherence to recommended pre-operative fasting guidelines. Standard fasting alone cannot reliably exclude significant residual gastric contents, particularly in patients with conditions associated with delayed gastric emptying. Consequently, there is increasing interest in individualized pre-operative assessment of gastric contents rather than relying solely on fasting history.[1]

Diabetes mellitus is a recognized risk factor for delayed gastric emptying because of autonomic neuropathy and impaired gastric motility. Many diabetic patients remain asymptomatic despite having increased residual gastric volume, making clinical assessment alone inadequate for identifying those at increased risk of aspiration.[2,3]

Point-of-care gastric ultrasonography (POCGUS) has emerged as a rapid, non-invasive, and validated bedside tool for qualitative and quantitative assessment of gastric contents. Gastric antral cross-sectional area (CSA) measured in the right lateral decubitus (RLD) position correlates well with gastric volume, while the Perlas grading system facilitates aspiration risk stratification.[4-6] Recent evidence, including systematic reviews, supports the utility of gastric ultrasound in identifying diabetic patients with a higher likelihood of a full stomach despite guideline-compliant fasting.[7-10]

Recent Indian data have also demonstrated increased gastric antral cross-sectional area and/or gastric volume in diabetic patients compared with non-diabetic patients undergoing elective surgery.[8-11] However, data from the Indian population remain limited. Therefore, this study compared pre-operative

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gastric antral CSA, estimated gastric volume, qualitative gastric contents, and aspiration risk between diabetic and non-diabetic patients undergoing elective surgery using POCGUS.[11,12]

Materials and Methods

Study Design and Setting

This hospital-based cross-sectional analytical study was conducted in the Department of Anesthesiology of a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants before enrolment. The study was conducted over the approved study period after ethical clearance [Figure 1].

Study Population

A total of 100 adult patients aged 18–70 years scheduled for elective surgery under general or regional anaesthesia were included in the study. Patients were divided into two equal groups:

- Group D (Diabetic group): 50 patients with diagnosed diabetes mellitus
- Group ND (Non-diabetic group): 50 patients without diabetes mellitus.

All participants complied with the institutional pre-operative fasting protocol based on the American Society of Anesthesiologists (ASA) fasting recommendations before surgery. Patients received standard premedication with ranitidine and metoclopramide on the night before surgery and on the morning of surgery according to institutional protocol. This should be considered while interpreting gastric volume measurements, as prokinetic therapy may reduce residual gastric volume.

Inclusion Criteria

Patients aged 18–70 years with ASA physical status I–III who were scheduled for elective surgery under anaesthesia were eligible for inclusion. All participants provided written informed consent before enrolment and were categorized into diabetic and non-diabetic groups according to their documented diabetic status.

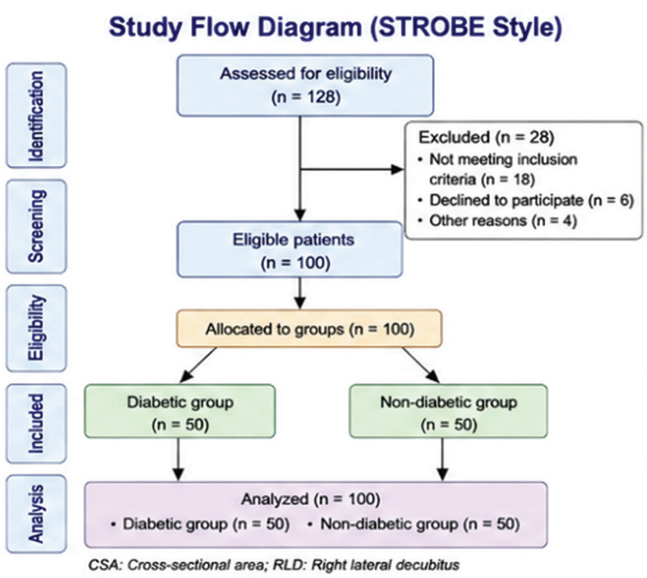

Figure 1: Strengthening the reporting of observational studies in epidemiology flow diagram

Exclusion Criteria

Patients were excluded if they were pregnant, underwent emergency surgery, and had a history of upper gastrointestinal surgery, known upper gastrointestinal obstruction, hiatus hernia, or other significant gastro-oesophageal pathology that could alter gastric emptying or interfere with gastric ultrasonographic assessment.

Pre-operative Assessment

Demographic characteristics, including age, sex, body mass index (BMI), ASA physical status, duration of diabetes, and random blood glucose levels, were recorded before surgery. Standard pre-anesthetic evaluation was performed in all patients according to departmental protocol.

Gastric Ultrasonography

Pre-operative gastric ultrasonography was performed immediately before induction of anaesthesia by an experienced anesthesiologist trained in point-of-care gastric ultrasound using a low-frequency (3–5 MHz) curvilinear transducer.

The gastric antrum was identified using standard anatomical landmarks, including the left lobe of the liver anteriorly and the abdominal aorta and pancreas posteriorly. Examinations were performed in both the supine and RLD positions, with the RLD position considered the preferred position for quantitative gastric assessment because it provides improved visualization of gastric contents [Figure 2].[4,5,12]

The gastric antral CSA was measured by tracing the serosal border of the antrum at the end of expiration. Three consecutive measurements were obtained, and the average value was used for analysis to minimize measurement variability. The use of repeated measurements and standardized positioning improves the reproducibility of gastric ultrasound assessment.[13,14]

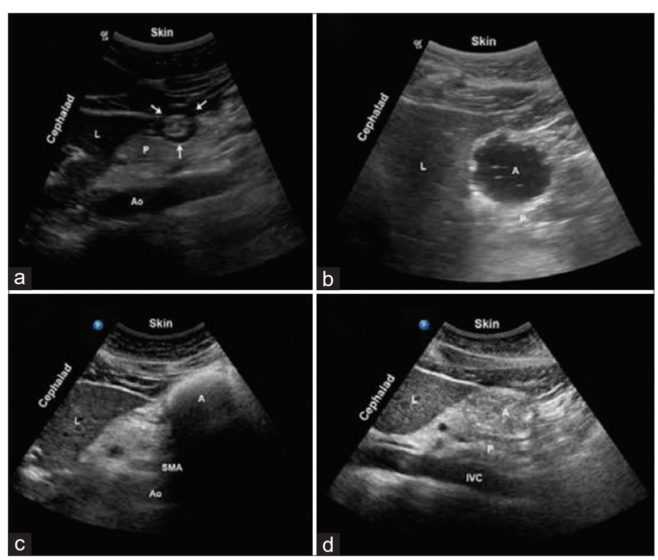

Figure 2: (a-d) Gastric point-of-care ultrasound images[25]

Estimation of Gastric Volume

Estimated gastric volume was calculated using the validated Perlas mathematical model based on the gastric antral CSA measured in the RLD position:

Gastric volume (mL) = 27.0 + (14.6 × RLD CSA)−(1.28 × Age)

The calculated gastric volume was used for quantitative assessment of residual gastric contents and aspiration risk.[6]

Qualitative Assessment of Gastric Contents

Qualitative assessment was performed according to the Perlas grading system [Figure 3].[4-6]

- 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, indicating increased gastric volume.

Aspiration Risk Stratification

Based on gastric ultrasound findings, patients were categorized into two aspiration risk groups: Gastric ultrasound provides a bedside approach for identifying patients with potentially significant gastric contents and assists in individualized aspiration-risk assessment.[12,15]

- Low risk: Grade 0 or Grade 1 stomach with estimated gastric volume <1.5 mL/kg
- High risk: Grade 2 stomach or estimated gastric volume >1.5 mL/kg.

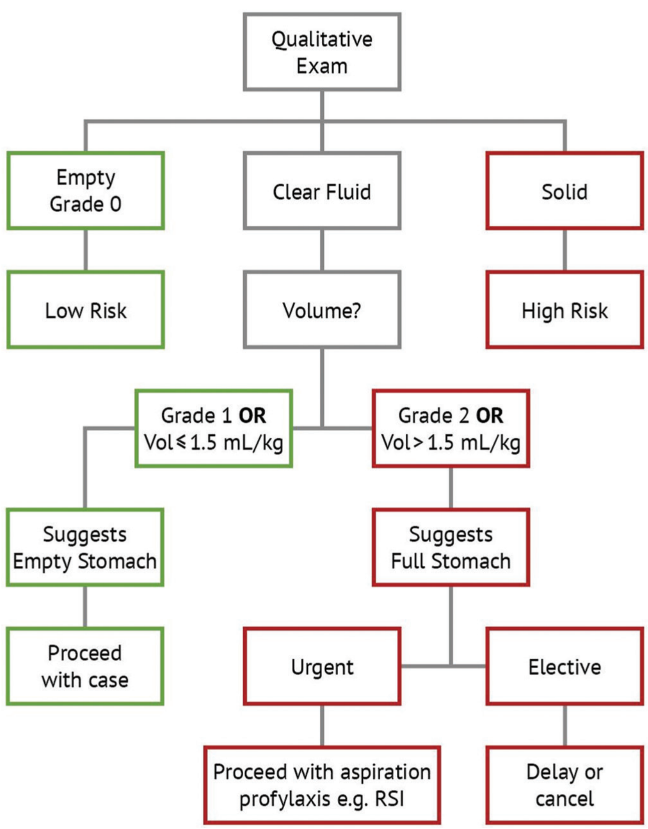

Figure 3: Grading of gastric contents[25]

This classification was used to identify patients with potentially increased perioperative aspiration risk.[4-7,23-25]

Outcome Measures

Primary outcome

Comparison of estimated gastric volume between diabetic and non-diabetic patients.

Secondary outcomes

It included comparison of gastric antral CSA in the supine and RLD positions, qualitative assessment of gastric contents using the Perlas grading system, aspiration risk classification based on gastric ultrasonographic findings, and evaluation of the association between demographic variables and estimated gastric volume.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages.

Comparisons between groups for continuous variables were performed using the independent Student's *t*-test. Categorical variables were analysed using the Chi-square test or Fisher's exact test where appropriate. A two-tailed $P < 0.05$ was considered statistically significant.

Results

Baseline Characteristics

A total of 100 patients undergoing elective surgery were included in the study, comprising 50 diabetic patients (Group D) and 50 non-diabetic patients (Group ND). Baseline demographic characteristics are summarized [Table 1].

The diabetic group was significantly older than the non-diabetic group (56.2 ± 8.7 years vs. 45.3 ± 12.1 years; $P < 0.001$). There was no significant difference in sex distribution (male/female: 32/18 vs. 34/16; $P = 0.68$) or BMI (24.5 ± 4.5 kg/m^2 vs. 23.5 ± 4.8 kg/m^2; $P = 0.28$). Diabetic patients had higher ASA physical status grades than non-diabetic patients ($P < 0.001$).

Table 1: Baseline demographic and clinical characteristics

Variable	*Diabetic (n=50)*	*Non-diabetic (n=50)*	*P-value*
Age (years)	56.2±8.7	45.3±12.1	<0.001
Male/Female	32/18	34/16	0.68
BMI (kg/m^2)	24.5±4.5	23.5±4.8	0.28
ASA I	0	31	
ASA II	29	18	
ASA III	21	1	<0.001

BMI: Body mass index, ASA: American Society of Anesthesiologists

Table 2: Comparison of gastric antral CSA (supine and RLD)

Parameter	*Diabetic (n=50)*	*Non-diabetic (n=50)*	*P-value*
CSA Supine (cm^2)	5.88±0.53	3.25±0.34	<0.001
CSA RLD (cm^2)	7.32±0.87	3.78±0.42	<0.001

CSA: Cross-sectional area, RLD: Right lateral decubitus

Gastric Antral CSA

The gastric antral CSA was significantly larger in diabetic patients in both the supine and RLD positions [Table 2, Figures 4 and 5].

In the supine position, the mean CSA was 5.88 ± 0.53 cm^2 in diabetic patients compared with 3.25 ± 0.34 cm^2 in non-diabetic patients ($P < 0.001$). Similarly, in the RLD position, diabetic patients demonstrated a significantly greater CSA (7.32 ± 0.87 cm^2 vs. 3.78 ± 0.42 cm^2; $P < 0.001$).

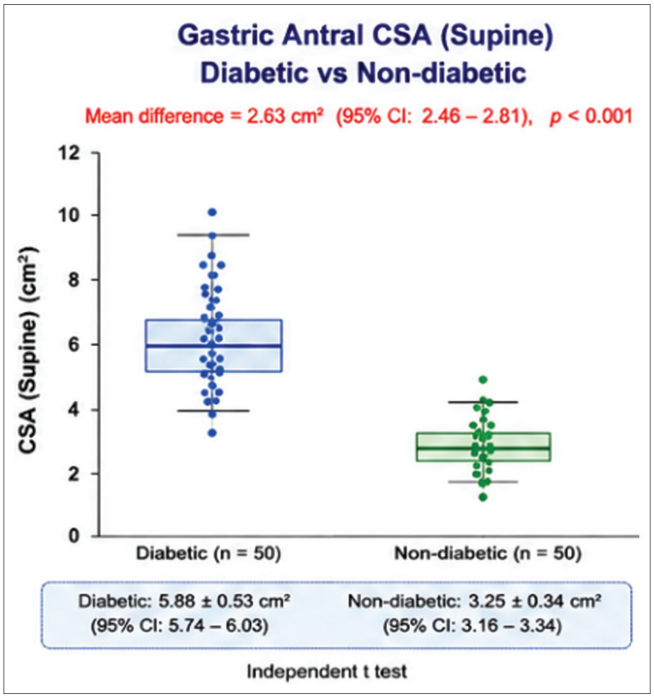

Figure 4: Bar graph comparing gastric antral cross-sectional area in supine position

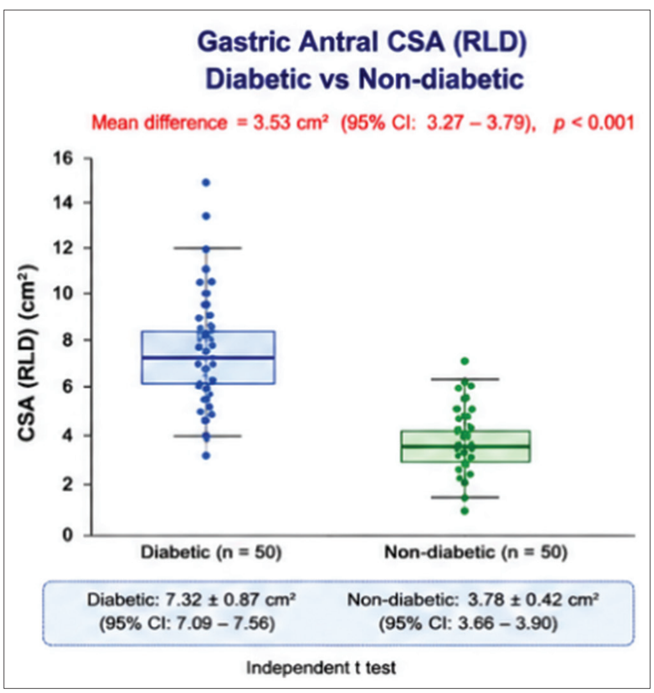

Figure 5: Bar graph comparing gasrtic antral cross sectional area in right lateraldecubitus position(RLD) position

Estimated Gastric Volume

The estimated gastric volume was significantly greater among diabetic patients than non-diabetic patients (58.69 ± 17.63 mL vs. 25.28 ± 16.85 mL). The mean difference was statistically significant ($t = 9.68$, $P < 0.001$), indicating a substantially larger residual gastric volume in diabetic patients despite adherence to standard fasting guidelines [Table 3 and Figure 6].

Qualitative Assessment of Gastric Contents

Qualitative assessment using the Perlas grading system demonstrated significant differences between the two groups ($\chi^2 = 30.68$, $P < 0.0001$). Grade 0 stomachs were observed in 22% of diabetic patients and 76% of non-diabetic patients. Grade 1 stomachs were identified in 66% of diabetic patients and 24% of non-diabetic patients. Grade 2 stomachs were detected exclusively in diabetic patients (12%) [Table 4 and Figure 7].

Aspiration Risk Stratification

Based on gastric ultrasonography, all non-diabetic patients were classified as low risk for aspiration. In contrast, six diabetic patients (12%) were categorized as high risk. The association between diabetes status and aspiration risk was statistically significant ($\chi^2 = 6.38$, $P = 0.012$) [Table 5 and Figure 8].

Perioperative Outcomes

No intraoperative or perioperative complications, including pulmonary aspiration, regurgitation, or respiratory compromise, were observed in either study group.

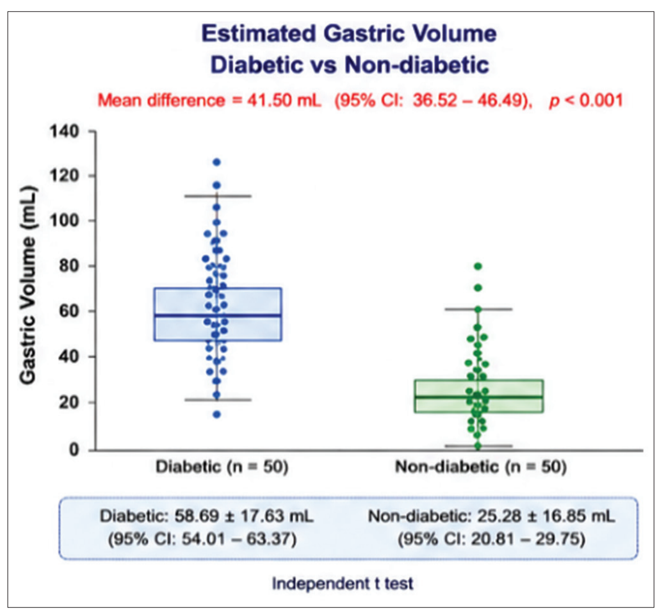

Figure 6: Box plot of estimated gastric volume

Discussion

The present findings are consistent with previous studies demonstrating delayed gastric emptying and increased residual gastric contents in diabetic patients despite compliance with standard fasting guidelines. Perlas *et al.* established gastric ultrasonography as a reliable bedside technique for qualitative and quantitative assessment of gastric contents and demonstrated that gastric antral CSA measured in the RLD position correlates closely with actual gastric volume.[4-6] In the present study, CSA measured in both the supine and RLD positions was significantly greater in diabetic patients, with the RLD position consistently providing larger measurements, reaffirming its superiority for quantitative gastric assessment. Similar observations have been reported in studies evaluating gastric ultrasound in elective surgical patients. Bouvet *et al.* demonstrated the usefulness of standardized antral ultrasonographic measurements for assessment of gastric contents, while subsequent work identified clinical factors associated with a full stomach.[16,17] Indian studies have also demonstrated differences in gastric volume and antral CSA between diabetic and non-diabetic patients.[8,9] More recent prospective multicentre and Indian comparative data further support the association between diabetes and increased residual gastric contents.[10,11]

The estimated gastric volume in the diabetic group was more than twice that of the non-diabetic group (58.69 ± 17.63 mL vs. 25.28 ± 16.85 mL; $P < 0.001$), supporting previous evidence that delayed gastric emptying persists despite recommended fasting intervals. A recent systematic review and meta-analysis reported that patients with diabetes have an increased likelihood of a high-risk stomach on preoperative gastric ultrasound.[7] Qualitative assessment using the Perlas grading system further strengthened these findings, with Grade 2 stomachs identified exclusively in diabetic patients, whereas the majority of non-diabetic patients had Grade 0 stomachs. Consequently, 12% of diabetic patients were categorized as having a high risk of aspiration compared with none of the non-diabetic patients. Recent systematic reviews have likewise concluded that diabetic patients have a significantly higher likelihood of a full stomach despite guideline-compliant fasting, supporting the increasing role of gastric ultrasonography in perioperative risk assessment.[9,10,23-25]

The observed increase in residual gastric volume is biologically plausible and reflects the multifactorial pathophysiology of diabetic gastroparesis. Chronic hyperglycemia contributes to autonomic neuropathy, impaired vagal function, loss of interstitial cells of Cajal, reduced gastric smooth muscle contractility, and altered neurohormonal regulation of gastric motility, collectively resulting in delayed gastric emptying.[18,19] Earlier literature has also described delayed gastric emptying and diabetic gastroparesis in patients who may have variable or minimal gastrointestinal symptoms.[20,21] Clinical guidelines recognize diabetes as an important underlying cause of gastroparesis and emphasize objective assessment when clinically indicated.[22]

Since some patients may remain asymptomatic despite delayed gastric emptying, fasting history alone may not accurately

Table 3: Comparison of estimated gastric volume

Variable	*Diabetic (n=50)*	*Non-diabetic (n=50)*	*t-value*	*P-value*
Gastric volume (mL)	58.69±17.63	25.28±16.85	9.68	<0.001

Table 4: Perlas grading distribution

Perlas grade	*Diabetic (n=50) (%)*	*Non-diabetic (n=50) (%)*	*P-value*
Grade 0	11 (22)	38 (76)	
Grade 1	33 (66)	12 (24)	
Grade 2	6 (12)	0	<0.0001

Table 5: Aspiration risk classification

Risk category	*Diabetic (n=50) (%)*	*Non-diabetic (n=50) (%)*	*P-value*
Low risk	44 (88)	50 (100)	
High risk	6 (12)	0	0.012

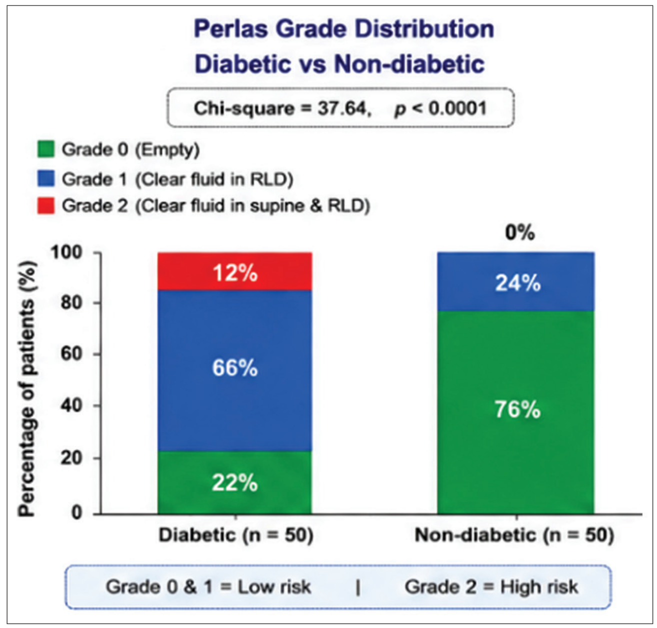

Figure 7: Stacked bar chart of Perlas grades

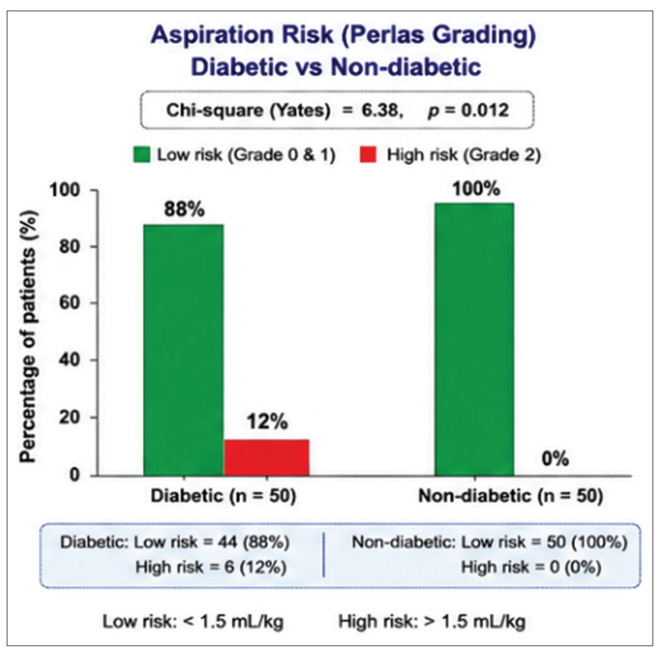

Figure 8: Aspiration risk comparison

predict residual gastric contents. This highlights the potential limitation of relying solely on conventional fasting protocols in selected patients at increased risk of delayed gastric emptying.

Clinical Implications

Although no episodes of pulmonary aspiration occurred in the present study, aspiration is an uncommon event, and studies evaluating gastric ultrasonography are primarily designed to assess aspiration risk rather than aspiration itself.[23,25] The ability of POCGUS to identify patients with clinically significant residual gastric contents before induction of anaesthesia provides an opportunity for individualized perioperative management. Information obtained from gastric ultrasonography may guide airway management strategies, including rapid-sequence induction, gastric decompression, modification of anesthetic technique, or postponement of surgery when appropriate. Recent international perioperative fasting recommendations increasingly advocate individualized assessment in patients at risk of delayed gastric emptying, and gastric ultrasonography has emerged as a valuable adjunct for improving perioperative decision-making and patient safety.[1,4-10,22-25]

Strengths and Limitations

The strengths of this study include its prospective comparative design, inclusion of equal numbers of diabetic and non-diabetic patients, and the use of a standardized gastric ultrasonography protocol based on the validated Perlas methodology.[4-6] Both qualitative (Perlas grading) and quantitative (CSA and estimated gastric volume) assessments were performed in the supine and RLD positions, providing a comprehensive evaluation of gastric contents and aspiration risk. However, several limitations should be acknowledged. The study was conducted at a single tertiary care center with a relatively modest sample size, which may limit the generalizability of the findings. The diabetic group was significantly older than the non-diabetic group, and age itself may influence gastric emptying.[15,17,25] In addition, all participants received pre-operative ranitidine and metoclopramide according to the institutional protocol. Although these medications may have reduced residual gastric volume and underestimated the true prevalence of delayed gastric emptying, the persistence of significant differences between the two groups despite pharmacological intervention strengthens the association between diabetes mellitus and increased residual gastric contents. Furthermore, gastric volume was estimated using a validated ultrasonographic model rather than direct measurement,[5] and important determinants such as glycemic control (hemoglobin A1c), duration of diabetes, autonomic neuropathy, and diabetic microvascular complications were not evaluated as independent predictors.[2,3,16,17]

Future Directions

Future multicenter studies involving larger and more diverse patient populations should evaluate the influence of glycemic control, duration of diabetes, autonomic neuropathy, and diabetic complications on gastric emptying.[2,3,16-20] Prospective studies incorporating perioperative and post-operative follow-up to determine actual gastric emptying times may facilitate the development of evidence-based, diabetes-specific pre-operative fasting recommendations. In addition, randomized studies evaluating gastric ultrasound-guided perioperative management and its impact on aspiration-related complications, perioperative outcomes, and healthcare resource utilization are warranted to further define the role of routine gastric ultrasonography in contemporary anesthetic practice.[9,23-25]

Conclusion

Diabetic patients had significantly higher gastric residual volumes, larger gastric antral CSA, and a greater prevalence of high-risk gastric contents despite standard preoperative fasting. Point-of-care gastric ultrasonography is a simple, non-invasive bedside tool that may help identify patients with increased aspiration risk and facilitate individualized anaesthetic planning. Despite the higher gastric volumes observed in diabetics, no aspiration-related complications occurred, suggesting that current fasting practices may remain adequate in this population. However, given the small sample size, larger studies are required to confirm these findings and clarify the role of gastric ultrasonography and prokinetic therapy in perioperative risk assessment.

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