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ORIGINAL RESEARCH

Evaluation of Gastric Residual Volume Using Ultrasound in Fasting Diabetic and Non Diabetic Patients Scheduled for Elective Surgeries: A Comparative Study

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ABSTRACT

Background: Gastric residual volume is vital for assessing gastric emptying and gastrointestinal function. Traditional methods of measuring gastric residual volume (GRV), like aspiration through a nasogastric (NG) tube, are invasive and uncomfortable. Ultrasonography (USG) emerged as a non-invasive, reliable alternative. Hence, the present study evaluates gastric volume among diabetic and nondiabetic patients to minimize intraoperative and postoperative complications like pulmonary aspiration. This study considered factors such as diabetes duration, blood sugar levels, HbA1c and fasting duration in evaluating gastric residual volume. **Methodology:** The present study was conducted on 104 patients undergoing elective surgeries divided into two groups, 52 in each group, after taking written informed consent and fulfilling the inclusion criteria. Group D was diabetic patients, and Group ND was nondiabetic patients. Patients were explained about the procedure, and ultrasonography was done lying down, followed by right lateral decubitus. Ultrasonography images of both were measured with the following diameters such as anteroposterior(AP), craniocaudal(CC), gastric volume and cross-sectional area(CSA) is measured using CC and AP diameters. **Results:** It was found that the mean age of study groups was 40.62±9.16yrs with 75(72.11%) were male patients and 29(27.88%) were female patients. Diabetic patients had significantly better mean CC, AP, and CSA than nondiabetic patients both in the right lateral position and supine position. ($p<0.05$) Patients with a history of diabetes had a much larger gastric volume (39.07±8.39 mL) than patients who were nondiabetic (9.28±4.11 mL). ($p< 0.05$). **Conclusion:** Diabetic patients have significantly higher fasting gastric volumes, as measured by using ultrasonography, than nondiabetic patients preoperatively.

Keywords: Gastric emptying; pyloric antrum; Gastric residual volume; ultrasonography.

INTRODUCTION

Gastric residual volume (GRV) measures liquid and undigested food in the stomach, a measurement of GRV commonly used in critically ill patients on enteral feeding. It is essential for preoperative patient evaluation. The traditional method involves invasive techniques like nasogastric aspiration, which can cause patient discomfort and complications despite being effective.

Diabetes Mellitus (DM) presents acute and chronic disease manifestations, increasing the likelihood of surgical procedures for affected individuals. The complications that most diabetics develop in multiple organ systems need to be identified before surgery. It affects about 25% of surgical patients, who have attracted considerable attention concerning gastric residual volumes following sufficient fasting before anesthesia. Individuals with diabetes mellitus, especially with gastropathy associated with autonomic dysfunction, are prone to delay in gastric emptying, increasing the susceptibility to aspiration risk compared to non-diabetic individuals [1,2].

Patients receiving general anesthesia are susceptible to pulmonary aspiration, a severe perioperative complication. Gastroparesis in diabetic patients may increase the risk of aspiration despite standard fasting. Pneumonitis was reported in up to 47% of patients who suffer from pulmonary aspiration [3]. People

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with diabetes have a higher risk of gastroparesis due to delayed gastric emptying and aspiration. Incidence of gastroparesis: 1% in type 2 DM, 4.8% in type 1 DM, and 0.1% in non-diabetic people [4]. The longer a person has diabetes, the higher the prevalence of diabetic autonomic neuropathy (DAN). It can be detected in individuals when they are first diagnosed with diabetes in as many as 7 percent of cases [5], but this number can increase to 50 percent after 15 years [6]. DAN is present in individuals with either type 1 or type 2 diabetes mellitus [7].

The European Society of Anesthesiology released fasting standards in 2011 that say diabetic patients can follow similar guidelines to normal individuals. The American Society of Anesthesiologists (ASA) reported in 2017 that individuals with various diseases have lengthier gastric emptying. This suggests that the standard eight-hour nil per oral period does not need to be followed or changed [8].

Ultrasonography allows high-resolution imaging of anatomical structures during the perioperative period, particularly in patients with unknown gastric content. This assessment can help tailor anesthesia to individual aspiration risk and improve perioperative safety.

Hence, in this study, we evaluated the GRV with ultrasonography among fasting diabetic and non-diabetic patients scheduled for elective surgeries relative to blood sugar levels, HbA1c, and fasting duration.

MATERIALS & METHODS

Study design

This was a randomized comparative study conducted from April 2023 to June 2024 in the Department of Anesthesiology, Shri BM Patil Medical College, Hospital and Research Center, BLDE (Deemed to be University), vijayapura, Karnataka, India. After obtaining the approval of the institutional ethical committee (Approval Letter-BLDE(DU)/IEC/788/2022-23). Inclusion criteria were ASA grades I, II, and III, Patients aged between 20 and 80 years. Exclusion criteria were pregnant women, Obese patients, Co-existing autoimmune diseases, Patients with H/o gastric surgeries, and Patients unable to position in the right lateral decubitus position. Written informed consent was obtained from all the patients included in the study.

Sample size

The G*Power ver. 3.1.9.4 Software was used to calculate the sample size for this study. The CSA supine position (mm2) was measured for both non-diabetic patients (Mean=8.8, SD=3.7037) and diabetes patients (Mean=13.8, SD=7.407). The study required a total sample size of 104, with 52 patients in each group assuming equal size. In order to attain a 99% power for detecting a difference using t-tests with a 5% significance level.

Procedure

A detailed history and general and systemic examinations were carried out the previous day during the pre-anesthetic evaluation. A history of any significant medical illness was taken and medication history was noted. The airway, respiratory system and cardiovascular system were assessed. Written informed consent was obtained. Routine investigations such as complete blood profile, random blood sugar, fasting blood sugar, HbA1c(glycosylated hemoglobin), and serological tests were performed.

Patients were shifted to a preoperative room, NPO(Nil per oral) was confirmed, and fasting duration was noted. The Gastric ultrasonography was done in the preoperative room by an anesthesiologist using a Sonosite M Turbo portable ultrasound machine with a curvilinear probe(2-5MHz). The gastric ultrasonography was done lying down and then in the right lateral position. AP, CC&CSA diameters of the gastric antrum in the RLD are calculated using the Perlas formula (Gastric Volume = 27.0 + 14.6 x right lateral CSA - 1.28 x age) [9].

RESULTS

We examined a total of 104 patients who were divided into two groups, Group D (n=52) and Group ND(n=52), posted for elective surgeries (Figure *1*); the mean age in Group D was 48.11±6.58 and in Group ND was 33.13±3.54, The gender distribution in Group D 15(28.84%) were females and 37(71.15%) were males. In contrast, in Group ND, 14(26.92%) were females, and 38(73.07%) were males; the mean BMI in Group D was 25.15±1.66 and in Group ND 23.86±2.52. (Table *1*)

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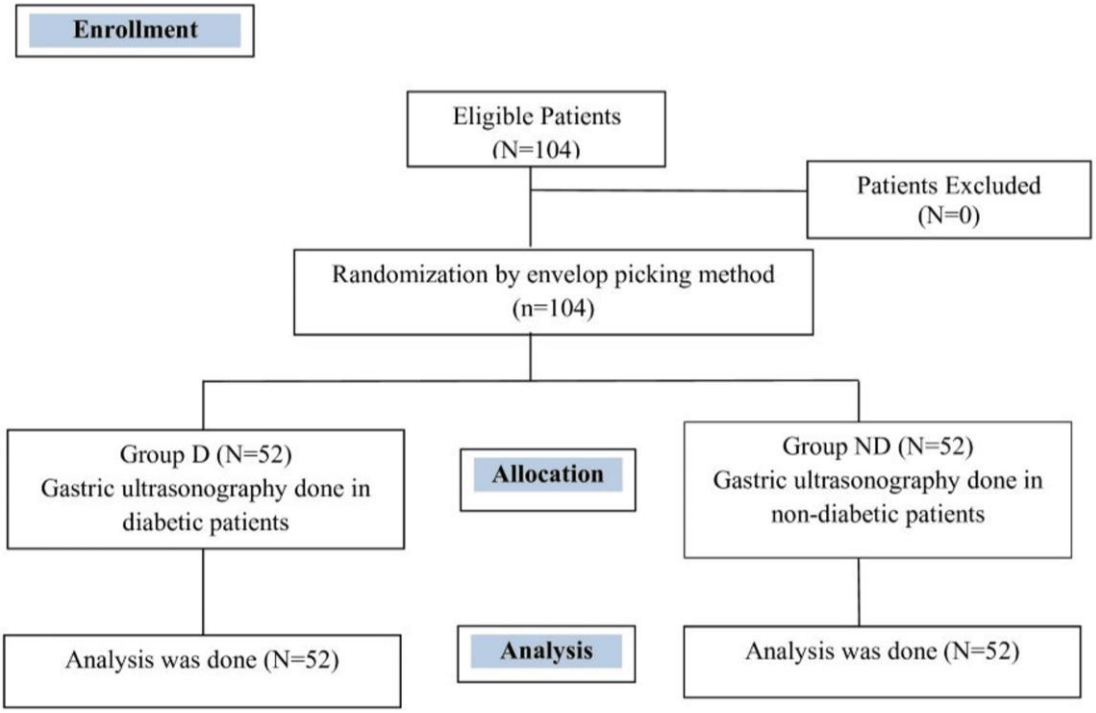

Table 1: Demographic characteristics

Demographics		Group D (n=52)	Group ND (n=52)	P Value
Age (yrs) Mean±SD		48.11+6.58	33.13+3.54	<0.001
Gender	Male	37(71.15%)	38(73.07%)	0.8269
	Female	15(28.84%)	14(26.92%)	
ASA Grading	I	1(1.92%)	49(94.23%)	<0.001
	II	33(63.46%)	2(3.84%)	
	III	18(34.61%)	1(1.92%)	
BMI(kg/m^2) Mean±SD		25.15+1.66	23.86+2.52	0.0013

SD-Standard Deviation ; BMI-Body Mass Index ; yrs-years

22(42.3%) of diabetic patients have 6 to 8 years of diabetes,17(32.69%) of diabetic patients have 8 to 10 years of diabetes, and 13(25%)of diabetic patients have more than 10 yrs of diabetes. (Figure *2*)

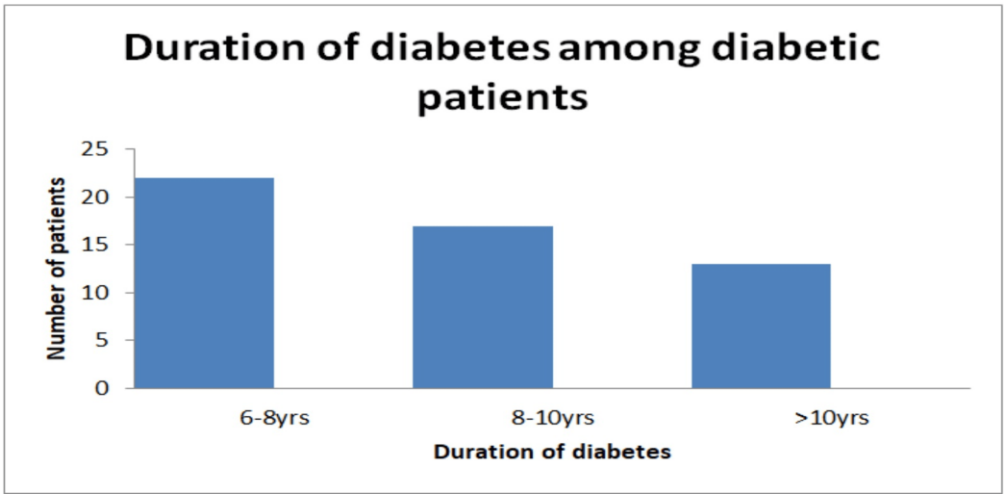

Figure 2: Duration of diabetes among the diabetic patients

Mean FBS among diabetic patients is 107±9.80 and 89±5.86 among nondiabetic patients; mean FBS is higher in diabetic patients and the differences between the groups were statistically significant (p<0.001). (Figure *3*)

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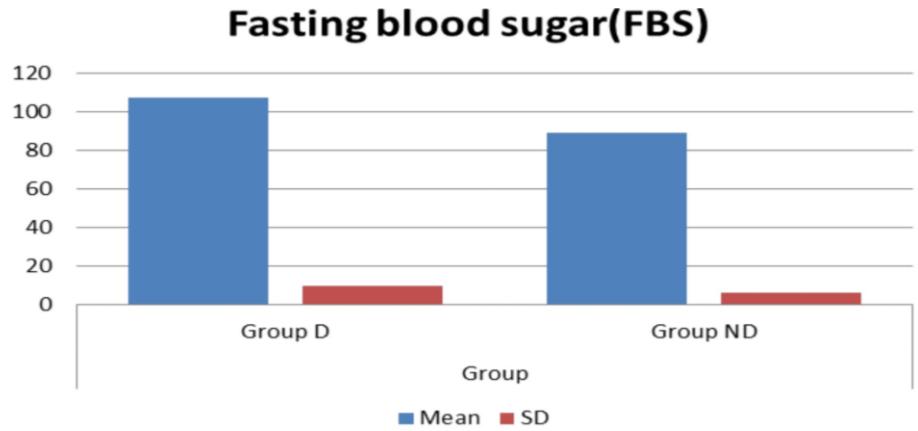

Figure 3: Comparison of Fasting blood sugars among diabetic and non diabetic patients

Group D - Diabetic patients; Group ND - Non Diabetic patients

Mean RBS among diabetic patients is 195.90±20.59 and 112±8.11 among nondiabetic patients; mean RBS is higher in diabetic patients and the differences between the groups were statistically significant ($p<0.001$).(Figure *4*)

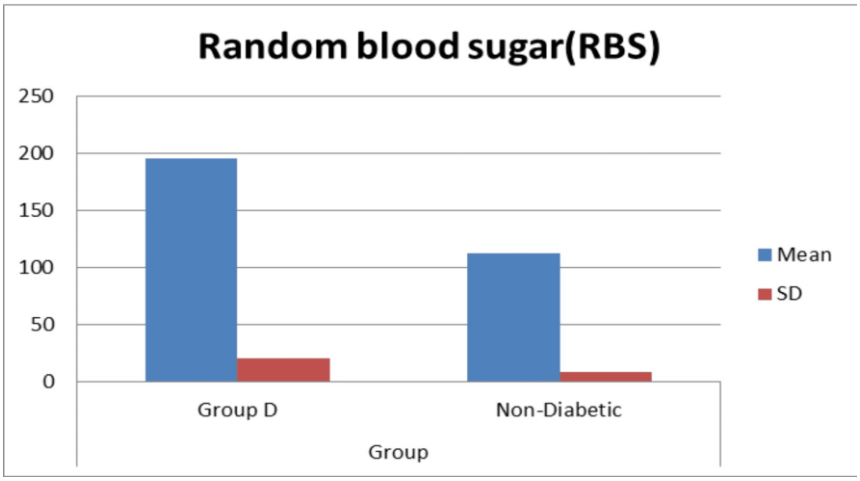

Figure 4: Comparing Random blood sugars among diabetic and non diabetic patients

Group D - Diabetic patients ; Group ND - Non Diabetic patients

HbA1C distribution between the groups was statistically significant; among diabetic patients, the majority were between 6-10% and the majority were <6% in the nondiabetic group. The mean HbA1C among the person with diabetes is 8.46±1.89. (Figure *5*)

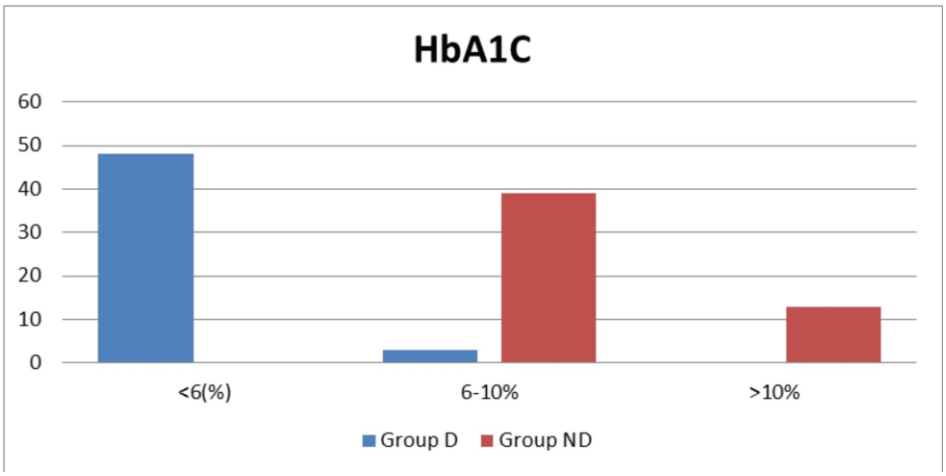

Figure 5: Comparison of HbA1C among the study groups

Group D - Diabetic patients ; Group ND - Non diabetic patients

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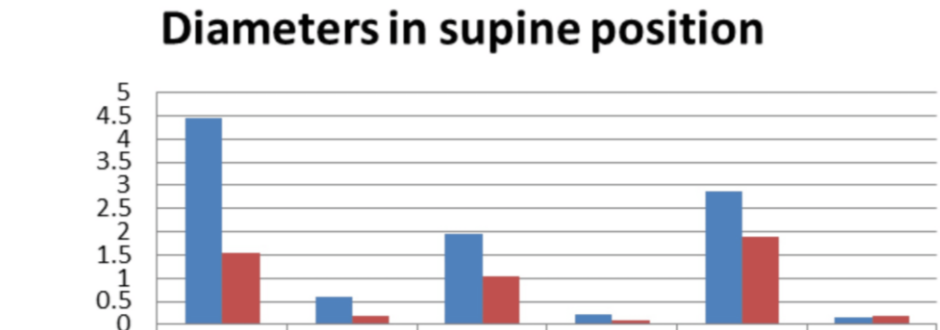
Group D had a CC diameter of 2.86±0.16, an AP diameter of 1.97±0.21, and a CSA of 4.45±0.59 when they were in the supine position. Group ND had a CC diameter of 1.9+0.19, an AP diameter of 1.04±0.09, and a CSA of 1.56±0.2. Group D's mean CC, AP, and CSA among the study groups was substantially more significant than that of Group ND. (Figure *6*)



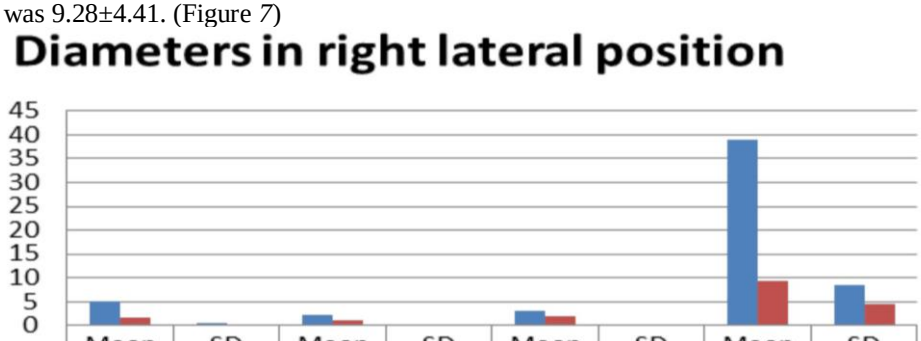
	Mean	SD	Mean	SD	Mean	SD
	CSA at Supine Position(Cm2)		AP Diameter In Supine Position(mm)		CC Diameter In Supine Position(mm)	
Group D	4.45	0.59	1.97	0.21	2.86	0.16
Group ND	1.56	0.2	1.04	0.09	1.9	0.19

Figure 6: Comparison of diameters among the study groups

Group D- Diabetic Patients ; Group ND- Non Diabetic Patients

CC- Craniocaudal ; AP- Anteroposterior ; CSA- Cross-sectional area of antrum in cm^2

The following dimensions were measured in the right lateral position: Group D diameter measurements were 2.99±0.17 for the CC, 2.13±0.18 for the AP, and 5.04+0.68 for the CSA. The CC, AP, and CSA diameters in Group ND were 1.94±0.1, 1.11+0.05, and 1.69±0.13, respectively. Group D had a considerably greater mean CC, AP, and CSA than Group ND. In RLD, the mean GRV was 39.07±8.39 in Group D, whereas the ND group's mean GRV was 9.28±4.41. (Figure *7*)



	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	CSA at Right Lateral Position(cm2)		AP Diameter In Right Lateral Position(mm)		CC Diameter In Right Lateral Position(mm)		GRV	
Group D	5.04	0.68	2.13	0.18	2.99	0.17	39.07	8.39
Group ND	1.69	0.13	1.11	0.05	1.94	0.1	9.28	4.41

Figure 7: Comparison of GRV with diameters among the study groups

Group D- Diabetic Patients ; Group ND- Non Diabetic Patients

CC- Craniocaudal ; AP- Anteroposterior ; CSA- Cross-sectional area of antrum in cm^2 ; GRV- Gastric Residual Volume

Correlation was done with fasting blood sugars, HbA1C and fasting duration with gastric residual volume to assess the degree of correlation. A positive correlation was observed between FBS, HbA1C, and fasting duration with gastric residual volume, which was statistically significant($p<0.001$). (Table *2*)

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Table 2: Correlation between FBS,HbA1C,Fasting Duration with Gastric Residual Volume

Parameters	Gastric Volume	
	R-value	P-value
FBS(mg/dl)	0.731**	<0.001
HbA1C(%)	0.924**	<0.001
Fasting Duration(hrs)	0.706**	<0.001

**Strong positive correlation

DISCUSSION

Delayed gastric emptying is commonly seen in patients with long-standing diabetes, with 30-50% experiencing this condition. Diabetic patients are considered high-risk individuals, presenting a major problem to anesthesiologists, particularly in terms of pulmonary aspiration [10].

Although diabetes is a high risk, no real-time study has effectively categorized their fasting gastric volume status or evaluated GRV using ultrasonography; with the introduction of ERAS protocol, ultrasonography might prove beneficial in assessing gastric residual volume in patients during perioperative care. The consequence of pulmonary aspiration is severe and rarely associated with general anesthesia, posing various difficulties to anesthesiologists, particularly patients with a history of diabetes who are often considered to have full stomach due to autonomic neuropathy [11].

In the present study, the mean age in Group D is 48.11±6.58 and in Group ND, 33.13±3.54.Most patients were males in both groups, 71.15% in Group D and 73.7% in Group ND. Mean BMI was higher among the diabetic patients, with 25.15±1.66 in Group D and 23.8±2.52 in Group ND and statistical significance was noted(p=0.0013); when compared to patients without diabetes, we found that the mean BMI and mean age of diabetic patients were significantly higher; similarly a study conducted by kenchey et al., observed that mean BMI and mean age were more among patients with a history of diabetes [12].

This study found that the standard fasting interval did not guarantee sufficient gastric emptying. We noticed that 24 patients (46.15%) had grade 1 stomach contents and 15 patients(28.84%) had grade 2 contents among the diabetic patients. Similarly, a retrospective study by Putt et al. on 538 patients revealed that 32 had fasting gastric volumes higher than the acceptable limit; as a result, the anesthetic induction plan was modified [13].

In this study, we observed that mean FBS among the diabetic patients was 107±9.80and 89±5.86 among non-diabetic patients and the gastric volume was significantly higher in diabetic patients with fasting blood sugar >110mg/dl(45.34±6.43) when compared with patients having fasting blood sugar <110mg/dl(37.48±8.92), similarly a study conducted on 65patients for identifying low risk and high risk of aspiration by Aydin et al, noted that delayed stomach emptying. A higher risk of aspiration is associated with hyperglycemia [14].

In the present study, we observed that mean HbA1c among diabetic patients was 8.46±1.89 and gastric volumes were higher in the patients with HbA1C >10%(46.41±8.33) when compared to patients with HbA1C 6-8%(33.19±4.75), which says that uncontrolled diabetic status associated with increased risk of aspiration, similarly a study conducted on 180 patients by kenchey et al., observed that mean HbA1C diabetic was 8.93+2.16, according to their research, delayed gastric emptying and neuropathic gastrointestinal complications have a positive correlation with poor glycemic control in diabetics [15].

Both in the supine and RLD positions, we found that the mean CC, CSA, and AP diameters of the diabetic patients were greater than those of the non-diabetic patients in the current study. The mean difference between the two groups was statistically significant($p<0.05$). Similarly, a study conducted by Demirel et al. observed that approximately 15% of patients with type 2 DM showed full stomach despite following preoperative fasting guidelines set by ASA; they showed significantly higher parameters like BMI, age, duration of fasting and CSA values [16]. Another study by Khan et al. observed that despite 8-hour fasting, preoperative gastric ultrasonography shows patients with diabetes had higher mean CSA&GV values than non-diabetic patients. However, the results were not statistically significant [17]. Most patients with type 2 diabetes have a full stomach, so ultrasonography perioperatively is advised to measure gastric residual volume [18].

The strengths of our study were that we evaluated the GRV with ultrasonography among fasting diabetic and non-diabetic patients scheduled for elective surgeries relative to blood sugar levels, HbA1c, and fasting duration when compared to other studies in which individual parameters were studied rather than correlation among all parameters (like blood sugar levels, HbA1c, and fasting duration). Very few studies were done in the literature to measure the gastric residual volume.

Limitations

The sample size studied was relatively small to conclude. The effect of obesity on fasting gastric volume was not evaluated, as obesity coexists in diabetics and can be a confounding factor. We did not study the effect on gastric volume using an H2 blocker.

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CONCLUSIONS

Pre-operative gastric ultrasonography reveals that patients with diabetes have increased cross-sectional area of the antrum and gastric residual volume, indicating a delay in gastric emptying; even with sufficient fasting, long-term diabetic patients remain susceptible to increased risk of aspiration perioperatively.

Hence, gastric ultrasonography is a simple and non-invasive method for assessing gastric residual volume, as demonstrated by our observations and compared to other investigations. This method is highly effective for assessing aspiration risk preoperatively, especially while providing anesthesia in high-risk patients.

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