Original Article

Comparison of ultrasound-guided residual gastric volume measurement between diabetic and non-diabetic patients scheduled for elective surgery under general anesthesia

ABSTRACT

Background and Aims: The presence of gastric content increases the risk of aspiration during general anesthesia. Diabetic patients have delayed gastric emptying; however, despite adequate fasting because of diabetic gastroparesis these patients have a high risk of aspiration. This study aimed to compare ultrasound-guided measurement of residual gastric volume between diabetic and non-diabetic patients scheduled for elective surgery under general anesthesia.

Methods: This prospective observational study included 80 patients divided into two groups of 40 diabetic patients with a minimum of 8 years history of diabetes and 40 nondiabetic patients aged >18 years, American Society of Anesthesiologists' physical status I–II kept with similar fasting intervals. Before induction of general anesthesia, gastric ultrasound was performed using standard gastric scanning protocol to measure craniocaudal (CC) and anteroposterior (AP) diameters followed by calculation of antral cross-sectional area (CSA) and gastric volume in semi-sitting (SS) and right lateral decubitus (RLD) position using curved array probe. The gastric antrum volume (GV) was classified as Grade 0, 1, or 2, and risk stratification for aspiration was done. The nasogastric tube was inserted after induction of anesthesia to aspirate and compare the gastric content.

Results: In the semi-sitting position, the mean CC and AP diameters were 16.38 ± 3.31 mm and 10.1 ± 2.53 mm in the non-diabetic group and 25.19 ± 4.08 mm and 15.8 ± 3.51 mm in the diabetic group, respectively. In RLD, CC was 1.91 ± 0.38 cm and AP was 1.19 ± 0.34 cm in the non-diabetic group as compared to the CC of 2.78 ± 0.4 cm and AP of 1.81 ± 0.39 cm in the diabetic group. The calculated CSA of 318.23 ± 97.14 mm^2 and 4 ± 1.1 cm^2 in diabetic were significantly higher than 133.12 ± 58.56 mm^2 and 1.83 ± 0.83 cm^2 of non-diabetic, in SS ($p < 0.0001$) and RLD ($p < 0.0001$) positions, respectively. The GV of 15.48 ± 11.18 ml in the diabetic group was significantly higher than (-) 9.77 ± 18.56 ml in the non-diabetic group ($p < 0.0001$). Despite the differences in CSA and GV between diabetic and non-diabetic groups, both groups showed a low gastric residual volume (<1.5 ml/kg). The gastric tube aspirate in the non-diabetic and diabetic groups was 0.3 ± 0.78 ml and 1.24 ± 1.46 ml, respectively, and was statistically significant ($p = 0.0006$).

Conclusion: Patients with long-standing diabetes showed higher gastric residual and antral CSA when compared with non-diabetic patients. The clinical significance of these findings needs further evidence for the formulation of specific guidelines for diabetic patients.

Key words: Aspiration, diabetes, fasting, gastric volume, gastroparesis, ultrasound

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Introduction

Pulmonary aspiration is the leading cause of mortality and major morbidity related to general anesthesia.[1] The overall incidence of gastric content aspiration ranges between <0.1% and 19% and aspiration pneumonia account for 9% of all anesthesia-related mortality.[2] Mendelson described the pathophysiological mechanisms of pulmonary aspiration, which led to the development of strategies to prevent pulmonary aspiration.[3]

For centuries, it has been known that there is an association between delayed gastric emptying and diabetes. Delayed gastric emptying in diabetic patients was first observed and reported by Boas in 1925.[4] Delayed gastric emptying in these patients is resultant of gastroparesis and may be associated with upper gastrointestinal symptoms without any mechanical obstruction.[4]

The fasting guidelines of the American Society of Anesthesiologists (ASA) for elective surgeries[5] do not consider patients with certain co-morbidities such as diabetes and also no separate recommendations are made for emergency surgeries. Similarly, the European Society of Anaesthesiology (ESA) 2011 guidelines[6] also do not recommend specific fasting guidelines for diabetic patients. So, currently, there is no consensus guideline for the fasting period for diabetics to prevent pulmonary aspiration. There is no significant aspiration risk in healthy, fasted patients having a residual gastric volume of up to 1.5 ml/kg, which is a critical volume threshold of gastric fluid for aspiration.[2]

Various methods to measure gastric volume are described such as paracetamol absorption, radiolabeled diet, polyethylene glycol dilution, electrical impedance tomography, and gastric content aspiration but these are difficult to be performed in the peri-operative period as these are cumbersome, invasive, and need time, specific instruments, machines, and expertise.[2] Point of care ultrasound is another modality, which can be used for gastric volume assessment. It is simple, readily available, non-invasive, and easy to perform with inter- and intra-observer reliability.[7] As gastric antrum has a reliable location and anatomical landmarks that are available for localizing antrum, it can be easily visualized and measured. The measured cross-section area is linearly related to the gastric volume, which has been validated against standard gastric volume estimation by gastroscopy in adults and nasogastric tube aspiration in the pediatric population.[8] This can be utilized for estimation of residual gastric volume pre-surgery by a quantitative or semi-quantitative approach based on various techniques. In these techniques, position-specific validated formulas are used where measured values of the antral cross-section are put and gastric volumes are calculated.[8,9] Also, the gastric fluid volume can be calculated using mathematical models or scales based on visualizing gastric fluid in different positions.

Methods

This study was conducted after approval by the Institutional Ethics Committee and registration with the Clinical Trials Registry of India. Written informed consent was taken from all participants before enrollment. The study included and enrolled patients of both sexes, aged >18 years of ASA grade I to II and with at least 8 years of history of diabetes (only in the diabetic group) posted for elective surgery. Patients with gastrointestinal obstructive disease, pregnancy, non-diabetic autonomic-neurological diseases, gastroesophageal reflux diseases, previous gastrointestinal surgery, chronic kidney diseases, recent abdominal trauma, body mass index (BMI) >30 kg/m^2, and posted for emergency surgery were excluded from the study.

Patients were divided into two groups. Group D (diabetic) included patients with a history of diabetes mellitus (DM) for at least 8 years and the other group had non-diabetic patients with or without other co-morbidities, labeled as group ND (non-diabetic). Patients having DM were assessed for the duration of diabetes, medication history, and glycemic control.

On the day of surgery, the patient was shifted to the preoperative room where focused gastric ultrasound was performed before induction of anesthesia by a trained operator blinded to the patient's study group. A curved array, low-frequency (2–5 MHz) transducer of ultrasound machine was used (M-Turbo® Ultrasound system Sonosite®, FUJIFILM SonoSite, Inc., USA). The scan was first performed in a semi-sitting (SS) position followed by a right lateral decubitus (RLD) position. The antrum of the stomach was localized in the epigastrium in the sagittal plane with a sweep of the probe from left to right subcostal margins. The left lobe of the liver anteriorly and the descending abdominal aorta together with the mesenteric artery posteriorly were used as landmarks. The sonographic appearance of the gastric antrum was classified based on *Perlas et al*.[8] as Grade 0, 1, and 2, signifying empty antrum, fluid detected in RLD position only, and antral fluid in both supine and RLD positions, respectively, based on the appearance in both the positions.

Cross-sectional area (CSA) was calculated by using two perpendicular diameters, anteroposterior (AP) and craniocaudal (CC) with the use of a formula for area:

CSA = (AP × CC × π)/4.

The gastric volume was calculated using the previously validated formulas according to the patient's position as follows:

Bouvet and colleagues equation9 for patients in semi-sitting position:

Gastric residual volume (mL) = -215 + 57 log CSA (mm^2) − 0.78 age (year) − 0.16 height (cm) − 0.25 weight (kg) − 0.80 ASA.

Perlas and colleagues equation8 for the right lateral position:

Gastric residual volume (mL) = 27.0 + 14.6 × right-lat CSA − 1.28 × age.

For the assessment of the risk of aspiration, we used the classification described by Van de Putte and Perlas2 as follows:

(a) Low risk of aspiration: patients with empty antrum or patients with a gastric residual volume less than 1.5 mL/kg.
(b) High risk of aspiration: patients with solid contents or patients with a gastric residual volume more than 1.5 mL/kg.

An 18-French nasogastric tube was inserted after induction of general anesthesia. After confirmation of the position of the nasogastric tube, aspiration of gastric contents was performed and measured through gentle suction using a 50 mL syringe.

The sample size calculation came out to be 36 patients in each group based on a study by Rabab Sabry *et al*.[10] with a prediction of 95% power and 5% level of significance. We enrolled 40 patients in each diabetic and non-diabetic group to take care of dropouts. Age, height, weight, BMI, CSA of the antrum, gastric volumes, and gastric tube aspirate are noted and presented as mean ± SD and analyzed using an independent *t*-test. Visibility of antrum with grading in ultrasound findings is represented as frequencies or percentages. Ultrasound grades were analyzed with Fisher's exact test. Data analysis was done using SPSS version 21.0 (IBM, USA) and Microsoft Excel 2010 (Microsoft, USA).

Results

A total of 80 patients were included with each 40 patients in group ND and group D. The demographic data of the two groups are presented in Table 1. The mean duration of diabetes was 9.19 years with interquartile range of 8–10 years.

The difference in ultrasound grading between the two groups is presented in Table 2.

The measurement of AP and CC diameters is depicted in Table 3 and Figure 1. A comparison of diameters, CSA, and volume in both the groups in SS as well as RLD position is presented in Table 3. In semi-sitting position, CC and AP diameters were 16.38 ± 3.31 mm and 10.1 ± 2.53 mm in group ND and 25.19 ± 4.08 mm and 15.8 ± 3.51 mm in group D, respectively. In RLD, the CC diameter was 1.91 ± 0.38 cm and the AP diameter was 1.19 ± 0.34 cm in group ND. However, in group D, the CC diameter was 2.78 ± 0.4 cm and the AP diameter was 1.81 ± 0.39 cm.

Table 1: Demographic data (Original)

Socio-demographic characteristics	Group D (*n*=40)	Group ND (*n*=40)	Total	*P*
Age (years)				
Mean±SD	54.68±9.68	49.58±11.9	52.12±11.08	0.039*
Gender				
Female	22 (55%)	15 (37.50%)	37 (46.25%)	0.116‡
Male	18 (45%)	25 (62.50%)	43 (53.75%)	
ASA grade				
I	0 (0%)	23 (57.50%)	23 (28.75%)	<.0001†
II	40 (100%)	17 (42.50%)	57 (71.25%)	
Height (cm)				
Mean±SD	163.15±6.22	163.52±9.06	163.34±7.73	0.83*
Weight (kg)				
Mean±SD	67±7.77	63.9±6.61	65.45±7.34	0.058*
Body mass index (BMI)(kg/m^2)				
18.5-24.99{Normal BMI}	17 (42.50%)	30 (75%)	47 (58.75%)	0.003‡
25-29.99{Overweight}	23 (57.50%)	10 (25%)	33 (41.25%)	
Mean±SD	25.1±1.86	23.92±2.18	24.51±2.1	0.011*

Calculated using independent *t*-test, †Fisher's exact test, ‡Chi-square test. Group D - Diabetic, Group ND - Non-diabetic, SD - standard deviation, ASA - American Society of Anesthesiologists. *Denotes statistical significance (statistical significant- $P<0.05$)

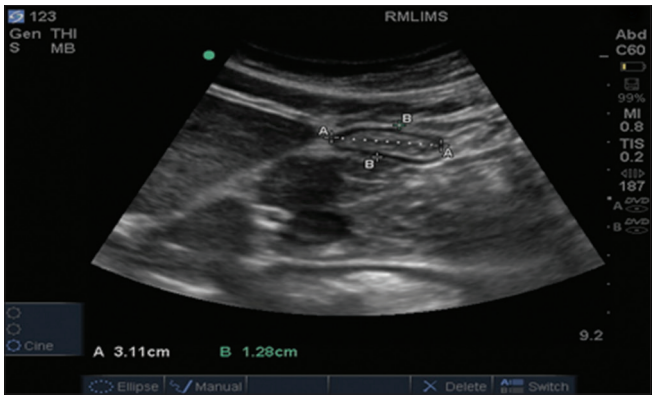

Figure 1: Craniocaudal (CC) and anteroposterior (AP) diameters for calculating the gastric antrum cross sectional area (CSA)

Table 2: Comparison of the qualitative grade of assessment of gastric volume (Original)

Qualitative grade of assessment	Group D (*n*=40)	Group ND (*n*=40)	Total	*P*
0	4 (10%)	29 (72.50%)	33 (41.25%)	<.0001†
1	36 (90%)	11 (27.50%)	47 (58.75%)	
2	0 (0%)	0 (0%)	0 (0%)	
Total	40 (100%)	40 (100%)	80 (100%)	

†Fisher's exact test, Group D - Diabetic, Group ND - Non-diabetic

The calculated CSA-semi-sitting was 318.23 ± 97.14 mm^2 in group ND and 133.12 ± 58.56 mm^2 in group D. The CSA-lateral obtained in group ND was 1.83 ± 0.83 cm^2 and 4 ± 1.1 cm^2 in group D (p = 0.0001). The mean gastric volumes calculated were -9.77 ± 18.56 ml in non-diabetic subjects as compared to 15.48 ± 11.18 ml in diabetic patients (p = 0.0001) [Table 3].

Discussion

The aspiration of gastric content is rare but a major complication related to general anesthesia. DM in many aspects is considered a major challenge to anesthesiologists. Diabetic patients are considered as full stomach and are at elevated risk of pulmonary aspiration due to autonomic gastropathy4. In 2011, Camilleri *et al.*[11] observed gastroduodenal motor abnormalities causing delayed gastric emptying in diabetic patients. Van de Putte *et al.*[2] performed a retrospective cohort study on patients posted for elective surgery under general anesthesia for assessment of gastric content using ultrasound examination. The study concluded a small portion (6.2%) of patients posted for elective surgery can present with a full stomach2.

In the era of the availability of real-time ultrasound at the bedside or point of care ultrasonography, the antral ultrasound for measuring gastric volume could be part of an algorithm to stratify the risk of pulmonary aspiration before induction of general anesthesia in diabetic patients.

Limited studies have been done to compare preoperative fasting residual gastric volume in diabetic and non-diabetic patients. Our study was conducted to compare the diabetic and non-diabetic patients undergoing elective surgeries for preoperative residual gastric volume and risk of aspiration using ultrasonography.

In this study, the mean age of the study population in group D was 54.68 ± 9.68 and 49.58 ± 11.9 in group ND (p-value = 0.039) with a minimum age of 20 years and a maximum of 70 years. The diabetic group had older patients compared to non-diabetic patients. This difference was statistically significant and a similar age difference was there in studies by Rabab Sabry *et al.*[10] and Heena Garg *et al.*[12] This age difference was probably due to criteria of a minimum of 8 years from diagnosis in the diabetic group. Though both the groups were similar and comparable regarding gender, height, and weight and no statistically significant difference was found.

In our study, the gastric volume derived from calculation was having negative values in patients with a lesser CSA of the antrum similar to previous studies. Perlas *et al.*[8] conducted a study for validation of gastric volume measured by mathematical models using ultrasound with help of gastroscopic examination. This study showed a negative value in gastric volume while calculating and concluded that a negative volume value indicates an empty stomach.

Out of 40 patients, 17 patients in group ND were controlled hypertensive and were ASA II physical status. The mean BMI of the study population in group D was 25.1 ± 1.86 and 23.92 ± 2.18 in group ND (p = 0.011). There was statistical significance in BMI even with controlled blood sugars in diabetic patients. There was an increased incidence of weight with a mean of 67 ± 7.77 in the diabetic group and 63.9 ± 6.61 in the non-diabetic group. But there was no statistical difference in weight between the two groups (p = 0.058).

Among the 40 patients of diabetic group, 36 patients (90%) had grade 1 antral volume and rest four patients (10%) had grade zero antral volume. Whereas, in non-diabetic group 11 patients (27.5%) had grade 1 antral volume and other 29 patients (72.5%) had grade zero antral volume . These findings in antral volume were statistically significant with a p value of <0.0001 and all 80 patients having grade 0 and 1 antral volume representing within the safe limit for aspiration risk. These findings were in line with Gassan Darwiche *et al.*[13] who reported prolonged gastric emptying in diabetics compared to non-diabetics when compared with ultrasonography.

Table 3: Comparison of the ultrasound measurements (Original)

Parameters	Group D (n=40)	Group ND (n=40)	Total	*P*
AP diameter (mm) (Semi-sitting)				
Mean±SD	15.8±3.51	10.1±2.53	12.95±4.18	<.0001*
CC diameter (mm) (Semi-sitting)				
Mean±SD	25.19±4.08	16.38±3.31	20.79±5.77	<.0001*
CSA (mm^2) (Semi-sitting)				
Mean±SD	318.23±97.14	133.12±58.56	225.67±122.58	<.0001*
Gastric volume (ml) (Semi-sitting)				
Mean±SD	-161.26±8.56	-177.6±13.28	-169.43±13.81	<.0001*
AP diameter (cm) (Right lateral decubitus)				
Mean±SD	1.81±0.39	1.19±0.34	1.5±0.48	<.0001*
CC diameter (cm) (Right lateral decubitus)				
Mean±SD	2.78±0.4	1.91±0.38	2.35±0.59	<.0001*
CSA (cm^2) (Right lateral decubitus)				
Mean±SD	4±1.1	1.83±0.83	2.92±1.46	<.0001*
Gastric volume (ml) (Right lateral decubitus)				
Mean±SD	15.48±11.18	-9.77±18.56	2.85±19.83	<.0001*

*Independent *t*-test, Group D - Diabetic, Group ND - Non-diabetic, AP - anteroposterior, CC - craniocaudal, CSA – cross-sectional area, SD - standard deviation

In SS position, the mean anteroposterior diameter, caudocranial diameter, CSA, and gastric volume in diabetic patients were 15.8 ± 3.51 (mm), 25.19 ± 4.08 (mm), 318.23 ± 97.14 (mm^2), and -161.26 ± 8.56 (ml), respectively, while in non-diabetic patients 10.1 ± 2.53 (mm), 16.38 ± 3.31 (mm), 133.12 ± 58.56 (mm^2), and -177.6 ± 13.28 (ml), respectively, with both groups having statistical significance (p <.0001). Similarly Rabab Sabry *et al*.[10] measured cross-section and calculated gastric volume with ultrasonography and found diabetic patients have significantly higher median cross-section area and calculated gastric volume compared to non-diabetic patients.

In RLD position, the mean anteroposterior diameter, caudocranial diameter, CSA, and gastric volume in diabetic patients were 1.81 ± 0.39 (cm), 2.78 ± 0.4 (cm), 4 ± 1.1 (cm^2), and 15.48 ± 11.18 (ml), respectively, while in non-diabetic patients 1.19 ± 0.34 (cm), 1.91 ± 0.38 (cm), 1.83 ± 0.83 (cm^2), and -9.77 ± 18.56 (ml), respectively, showing diabetic patients had statistically significant ($p < 0.0001$) higher gastric volume than non-diabetics. Our findings correlated with an observational study by Heena Garg *et al*.[12] which showed more fasting gastric volume in diabetic patients. Heena Garg *et al*.[12] observed the CSA in RLD was 2.30 ± 1.18 cm^2 and 3.73 ± 1.61 cm^2 in non-diabetic and diabetic patients, respectively. The mean residual gastric volumes were 4.20 ± 22.26 ml and 9.15 ± 25.70 ml in non-diabetic and diabetic patients, showing statistically significant more fasting residual gastric volume in diabetic patients.

In our study, observed residual gastric volumes were lower compared to the findings of Rebab Sabrey *et al*.[10] The higher values in their study may be because of the higher BMI of the studied population or different racial characteristics. Also the comparable observations and results of our study with a study by Heena Garg *et al*.[12] may be due to a similar demographic profile and Indian subcontinental study population.

In our study, the mean gastric tube aspirate in the diabetic group was 1.24 ± 1.46 ml and 0.3 ± 0.78 ml in the non-diabetic group, and the difference was found to be statistically significant between the two groups ($p = 0.0006$). These results were similar to the study by Rabab Sabry *et al*.[10] but they reported higher gastric tube aspirate in diabetic (mean value of 150 ml) and non-diabetic patients (mean value of 75 ml). These higher volumes might be because these study group patients had a higher BMI and different racial characteristics when compared with our study population. Our study population was not at higher risk of aspiration as all the patients had a calculated residual gastric volume of less than 1.5 ml/kg as per the risk stratification by Van de Putte *et al*.[2]

In our study, the RLD position residual gastric volume was 15.48 ± 11.18 ml while in the semi-sitting position the calculated volume was negative, i.e., 0 ml and this finding is statistically significant with a *p* value of <0.0001. This might be a result of equal distribution of volume in the semi-sitting position when compared with the right lateral position where residual gastric volume is accumulated in the dependent antrum as a result of the gravitational shift.

A small study of 25 patients done by Gustafsson *et al*.[14] recommend safe administration of carbohydrate-rich drink 180 min before anesthesia in type II diabetes patients without elevated risk of hyperglycemia or aspiration but results need

to be reproduced in a larger group of studies to generalize their results.

The post-operative complications like sore throat, nausea, and vomiting were comparable among both diabetic and non-diabetic groups. There were no respiratory complications in either group.

Strengths of the study

1. The study was carried out by a single sonography investigator and the inter-observer bias in ultrasonography is prevented.
2. Many of our results corroborated with existing literature. Thus, adding to the already existing knowledge about delayed gastric emptying in diabetic patients.

Limitations of the study

In our study, only type 2 DM patients were included; the duration of diabetes was not further stratified to assess the effect of different duration of diabetes and gastric emptying. The control group had a younger population compared to the diabetic group. Also, the effect of various diets was not evaluated. The mean fasting interval was around 10 h. In daily clinical practice, it is difficult to exactly control the fasting interval in the preoperative period. Also, an already published reference standard was chosen for quantitative analysis. Further studies are required in diabetic patients to correctly stratify the fasting volumes.

Conclusion

This observational comparative study of 80 patients suggests that long-standing diabetic patients have a higher residual gastric volume and antral CSA when compared with the non-diabetic patients after fasting for elective surgery when observed by ultrasonography. This signifies that diabetic patients have delayed gastric emptying. Further studies are required to stratify fasting volume in diabetic patients so that a preoperative protocol for avoiding aspiration can be done in diabetic patients.

Consent to participate

Taken from all participants.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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