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Comparative ultrasound-guided assessment of gastric volume between diabetic and non-diabetic patients posted for elective surgery—a prospective, observational, correlation study

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Abstract

Background Perioperative aspiration of gastric contents is a serious complication and its severity depends upon the gastric volume and nature of the aspirate. Diabetic patients are more prone for aspiration because of delayed gastric emptying. USG-guided gastric examination can help in aspiration risk assessment by identifying the nature and volume of the gastric contents. This prospective observational study compared, USG-guided gastric contents and volume in fasting diabetic and non-diabetic patients posted for elective surgery under general anesthesia. Based on the history of diabetes mellitus (DM), 50 patients were divided into two groups, i.e., group A (diabetic for > 5 years, $n = 25$) and group B (non-diabetic, $n = 25$). After standard fasting period of 8 h, bedside ultrasound was conducted to assess gastric antral cross-sectional area, gastric volume and contents.

Results The mean gastric antral cross-sectional area (3.96 ± 2.07 versus 2.96 ± 1.88, *P* value 0.08), mean gastric volume (17.88 ± 19.48 versus 9.72 ± 12.29, *P* value 0.083) and the mean gastric volume per kg body weight (0.16 ± 0.374 versus 0.04 ± 0.20, *P* value 0.164) after 8 h fasting were higher in diabetics as compared to non-diabetics, but were statistically insignificant.

Conclusions Diabetic patients had comparatively slower gastric emptying and hence higher mean effecting gastric volume and gastric volume/kg body weight, after fixed hours of fasting. However, no patient had gastric volume/kg body weight > 1.5 ml/kg or presence of any solid food was visualized in any of the groups. Hence, the fixed 8 h fasting guarantees the safety from the risk of aspiration in diabetic and non-diabetic adult population.

Keywords Aspiration, Diabetes, Diabetic gastroparesis, Gastric emptying, Point of care anesthesia, POCUS

Background

Perioperative aspiration of gastric contents is a serious complication and is associated with high morbidity and mortality (Robinson and Davidson 2013). General anaesthesia tends to decrease both lower esophageal sphincter tone and upper airway reflexes, making anesthetized patients susceptible to pulmonary aspiration. Further, diabetic patients tend to show delayed gastric emptying because of gastroparesis, predisposing them to increased risk of aspiration as compared to non-diabetic patients (Vinik et al. 2003; Koch 1999; Ajumobi and Griffin 2008; Jones et al. 1995).

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Pre-operative fasting guidelines are beneficial in prevention of aspiration in elective cases, but there is dilemma over the adequate duration of fasting for diabetic patients (Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: an updated report by the American Society of Anesthesiologists Task Force on preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration 2017; Smith et al. 2011).

With the advent of portable ultrasound machines, performing point-of-care ultrasound has become relatively easy and feasible. Gastric ultrasound examination is finding a place as a point-of-care tool for aspiration risk assessment. It can identify the nature of the gastric content, i.e., empty, clear fluid and solid and when clear fluid is present, its volume can be quantified (Bouvet et al. 2011; Cubillos et al. 2012). This study examined and compared the fasting gastric contents and volume in diabetic and non-diabetic individuals undergoing elective surgery.

Methods

This single-center, prospective, observational study was conducted between March 2020 and July 2020, at a tertiary care center, after obtaining Institutional Ethics Committee approval (BH/CEO/2020/276A).

After obtaining written informed consent, adult patients (18–80 years) undergoing elective surgery and belonging to American Society of Anesthesiologist grade 1–3 were included in the study. Based on the history of diabetes mellitus (DM), the patients were divided into two groups i.e., group A (diabetic for > 5 years) and group B (non-diabetic).

Patient not willing to participate in the study, pregnant patients, patients taking opioids or prokinetic drugs via any route, patients with prior gastro-duodenal surgeries or bariatric surgeries, patients with body mass index (BMI) outside the range of 19–40 (kg/m^2), and patients with chronic kidney disease with or without renal replacement therapy (RRT) were excluded.

After adequate standard fasting period of 8 h, the bedside ultrasound was conducted using Sonosite M-turbo; low-frequency, curved array probe (2–5 MHz) in right lateral decubitus position to assess the gastric antrum cross sectional area (GA-CSA) in both the study groups. The GA-CSA was calculated by assessing the antero-posterior diameter and cephalo-caudal diameter of stomach (Putte and Perlas 2014).

$$\mathrm{CSA} = (\mathrm{AP} \times \mathrm{CC} \times \pi)/4$$

CSA—cross-sectional area, AP—antero-posterior diameter of stomach, CC—cephalo-caudal diameter of stomach.

The CSA was assessed utilizing the still images of the sagittal section of the antrum during aperistalsis stage of the stomach (Fig. 1). The qualitative assessment of the gastric contents was also done for presence of any clear fluid or solid food particles. The effective gastric volume was calculated later based on data observed on each participant by the formula: (Perlas et al. 2013).

$$\mathrm{GVe\ (gastric\ volume\ in\ ml)} = 27.0 + [14.6 \times \mathrm{right-lateral\ CSA\ (cm^2)}] - (1.28 \times \mathrm{age})$$

Fig. 1 Still image of the sagittal section of the Antrum during aperistalsis stage of the stomach for cross-sectional area calculation

The primary outcome of this study was to compare the mean antral cross-sectional area of stomach after 8 h of fasting in diabetic and non-diabetic patients undergoing elective surgery. Secondary outcomes were to compare the mean calculated gastric volume and mean gastric volume per kilogram weight after 8 h of fasting between the two study groups.

The sample size was calculated using statistic and sample size pro software version 1.0. Based on the median antral right lateral CSA (16 cm^2), range (3–29 cm^2) with 95% of confidence interval and 80% of power, the minimum required sample size 25 patients in each group were needed.

The patient biodata, time since last solid meal, duration of DM, presence of any other co-morbidities, ultrasonographic values, and calculations were assessed and analyzed using SPSS software version 21.0. Continuous variables were expressed using mean ± standard deviation and categorical variables were expressed using frequency and percentage. Comparison of all continuous variables in a group was done by independent sample t test and for categorical variables Pearson chi-square test was used. P value < 0.05 was considered as statistically significant.

Results

A total of 50 patients were included include in the data analysis, with 25 patients in each group (Fig. 2). The two groups were comparable in terms of age (58.16 ± 7.26 years in group A vs. 56.24 ± 8.52 years in group B, $P = 0.396$), gender (male: female = 13:12 in group A and B, $P = 1$), and body-mass index (24.88 ± 2.20 in group A vs. 24.72 ± 1.86 in group B, $P = 0.783$) (Table 1).

The mean antral cross-sectional area (3.96 ± 2.07 versus 2.96 ± 1.88) and mean calculated gastric volume (17.88 ± 19.48 versus 9.72 ± 12.29) were found to be higher in group A as compared to group B, but were statistically insignificant (P value 0.08 and 0.083 respectively) (Fig. 3). The mean gastric volume per kilogram was also found to be insignificantly higher in group A (0.16 ± 0.37 mL/kg) as compared to group B (0.04 ± 0.20 mL/kg) (Table 2).

Discussion

Perioperative gastric aspiration is a major and dreaded complication. Mortality due to severe aspiration pneumonia represents up to 9% of all anesthesia-related deaths (Robinson and Davidson 2013). As compared to

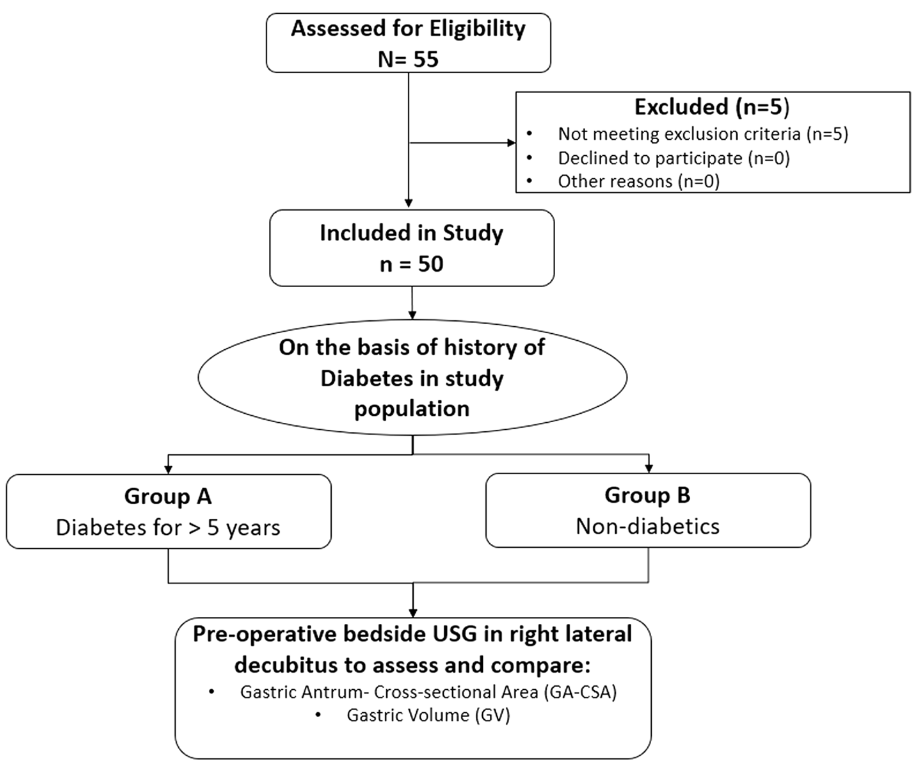

Fig. 2 CONSORT Flow Diagram for the study

Table 1 Demographic parameters of included in study

Parameters assessed	Group A (diabetic)	Group B (non-diabetic)	*P* value
Mean age (years ± SD)	58.16 ± 7.26	56.24 ± 8.52	0.396
Gender (male/female)	13/12	13/12	1
BMI (mean ± SD)	24.88 ± 2.20	24.72 ± 1.86	0.783
ASA status			
1	0	15	0.001
2	24	10	
3	1	0	

non-diabetic patients, diabetic patients are predisposed to an increased risk of perioperative aspiration due to autonomic gastropathy (Vinik et al. 2003; Jones 1995).

With the advent of portable ultrasound machines, gastric ultrasound examination can be utilized as a point-of-care tool for aspiration risk assessment. It can identify the nature of the gastric content, i.e., empty, clear fluid and solid and when clear fluid is present, its volume can be quantified (Bouvet et al. 2011; Cubillos et al. 2012). Thus, bedside ultrasound can be used to assess the gastric volume and contents, and help in prevention of aspiration in diabetic patients, independent of the fasting interval.

After adequate standard fasting period of 8 h, the bedside ultrasound was conducted in study participants to assess the gastric antrum cross sectional area (CSA) and gastric volume. The mean antral cross-sectional area (CSA) and mean calculated gastric volume (GV) were found to be higher in diabetic patients as compared to non-diabetic patients, but were statistically insignificant. Similarly, the mean gastric volume per kilogram bodyweight was also found to be insignificantly higher in diabetic patients as compared to non-diabetics.

Gustafsson et al. (2008) conducted a study in diabetic and non-diabetic volunteers to assess the gastric emptying rate after ingestion of semi-solid meals, using ultrasound, and found that diabetic patients had a significantly wider median values of post-prandial antral area after 90 min as compared to non-diabetic individuals. These findings are similar to our present study.

Chiu et al. (2014) compared the gastric antral area in type 2 diabetic and healthy individuals after a meal, and found that the gastric antral area was more in diabetics with a significantly slower gastric emptying. These results are in accordance to our study.

Perlas et al. (2013) suggested that an ultrasound of the stomach when done in right lateral decubitus position gives the best sensitivity results in observing and measuring the antral cross-sectional area and subsequently calculating the effective gastric volume (indirectly) by the formula gastric volume (ml) $= 27.0 + 14.6 \times$ Right lateral Antral Cross-Sectional Area (cm^2) $- 1.28 \times$ Age (years). In our study, we have used the same technique and tool for our computation and analysis. In this study, it was observed that the mean antral cross-sectional area in group of diabetic adults was non-significantly higher as compared with the mean antral cross-sectional area of non-diabetic adults ($P > 0.05$). It was observed that the mean effective gastric volume in diabetic adults was

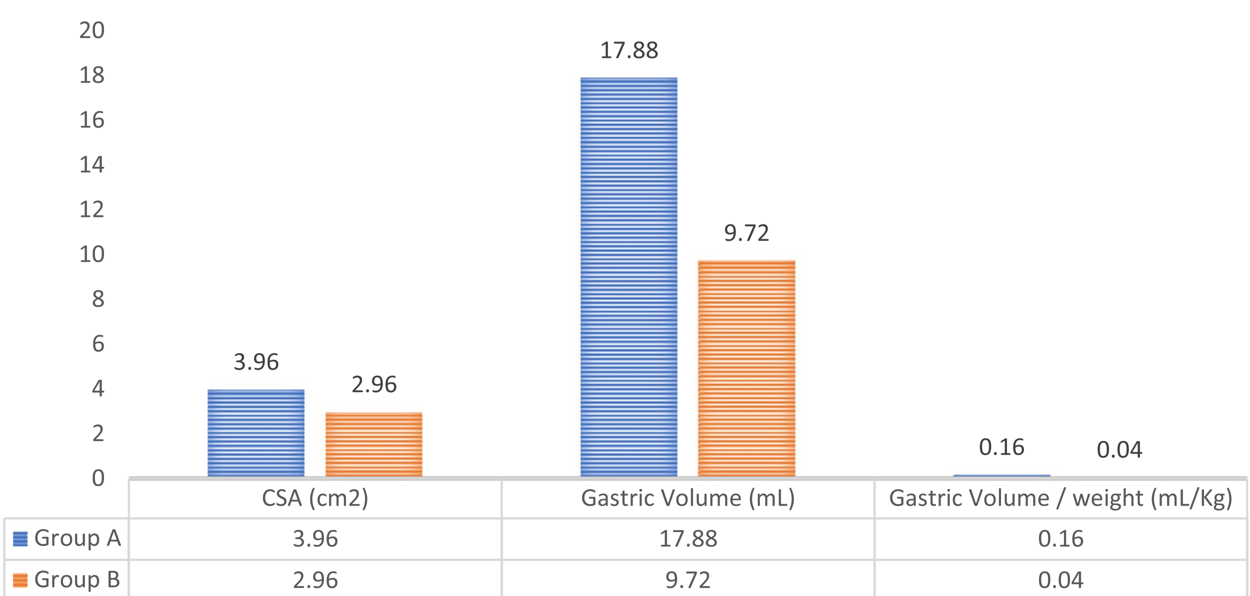

Fig. 3 Comparison of cross-sectional area (CSA), gastric volume (GV) and gastric volume per-kg body weight in diabetic and non-diabetic patients

Table 2 Comparison of antral cross-sectional area (CSA), gastric volume (GV), and gastric volume per kg weight between the study groups

USG parameters	Group A	Group B	P value
Antral cross-sectional area (cm^2)	3.96 ± 2.07	2.96 ± 1.88	0.08
Calculated gastric volume (mL)	17.88 ± 19.48	9.72 ± 12.29	0.083
Gastric volume/weight (mL/kg)	0.16 ± 0.374	0.04 ± 0.20	0.164

non-significantly higher as compared to the non-diabetic adults ($P > 0.05$). It was also observed that the ratio of gastric volume (ml) per kilogram of patient body weight (kgs) in diabetic adults was non-significantly higher as compared with non-diabetic adults ($P > 0.05$). In this study, out of total 25 participants in diabetic group, 6 patients had 0 mL of calculated effective gastric volume. Whereas, in non-diabetic group, out of total 25 participants, 11 patients had the calculated effective gastric volume of 0 (zero) ml. In both the groups none of patients had gastric volume per kg body weight to be above or equal to the critical value 1.5 ml/kg and none of the patients were found to be having solid food particles in the stomach albeit gastric antrum. No critical airway or anesthesia related events were noted in any of study participants.

Based on our study findings we can verily state that, DM is associated with a non-significant delay in gastric emptying and increase gastric volume at a given time as compared to the population of non-diabetic individuals in health. However, this delay in gastric emptying does not pose any increased risk of aspiration of gastric contents after fixed adequate period of fasting. The fixed 8 h of fasting do guarantee decreased risk of aspiration in diabetic population as per our study results and observation.

There was a limitation to our study, that this study was a single-centered study with a small sample size. A multi-centered randomized controlled trial, with a large sample size is required to make any affirmative conclusions regarding the safety from aspiration of gastric contents in diabetic population.

Conclusions

Diabetic patients had comparatively slower gastric emptying and hence higher mean effecting gastric volume and gastric volume/kg body weight, after fixed hours of fasting. However, no patient had gastric volume/kg body weight > 1.5 ml/kg or presence of any solid food was visualized in any of the groups. Hence, the fixed 8 h fasting guarantees the safety from the risk of aspiration in diabetic and non-diabetic adult population.

Abbreviations

AP	Anterio-posterior diameter of stomach
ASA	American Society of Anaesthesiology
BMI	Body mass index
CC	Cranio-caudal diameter of stomach
DM	Diabetes mellitus
GA-CSA	Gastric antrum cross-sectional area
GV	Gastric volume
POCUS	Point of care ultrasound
SPSS	Statistical Package for Social Sciences

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Nil.

Authors' contributions
Concept and design of study was made by SAK. SAK, TKS, and ST were involved in defining intellectual content, literature search, data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing, and manuscript review of the article. All authors have read and approved the final manuscript.

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Availability of data and materials
Available with author.

Declarations

Ethics approval and consent to participate
Ethical approval was taken from Institutional Ethics Committee & Scientific Research Committee of Bansal Hospital Bhopal, M.P, India, via reference number-BH/CEO/2020/276A, dated 1st June 2020. Written informed consent for participation was obtained from the patient. A copy of consent form is available for review by the Editor of this journal.

Consent for publication
Written informed consent for publication of the clinical details and /or clinical images was obtained from the patient. A copy of consent form is available for review by the Editor of this journal.

Competing interests
The authors declare that they have no competing interests.

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