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Preoperative Ultrasound Assessment of Residual Gastric Volume in Patients with Delayed Gastric Emptying Compared with Normal Adult Patients Undergoing Elective Surgeries

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Abstract

Background: Perioperative A substantial risk factor for pulmonary aspiration, an uncommon but serious anaesthetic event, is leftover stomach fluid upon induction. The use of bedside ultrasonography to measure stomach contents has recently demonstrated encouraging results, especially in those with abnormal gastric emptying. People in emergency circumstances or with disorders that impede stomach function may not fully benefit from the current fasting recommendations. The purpose of this research was to evaluate the appearance and volume of the gastric antrum using ultrasonography before surgery in individuals having elective surgery and fasting patients with delayed gastric emptying. On the basis of ultrasonography findings, a gastric antrum grading system was suggested. Methods: The 90 participants in this descriptive cross-sectional research were divided into three groups: those with normal gastric emptying (e.g., chronic renal failure, diabetes with autonomic neuropathy) after an eight-hour fast with water consumption, and those without this condition. Gastric volumes were estimated and compared between groups using ultrasound evaluations. Conclusion: Older patients tended to have delayed stomach emptying. The delayed emptying group had substantially larger stomach antrum diameters and projected volumes as measured by ultrasound compared to people who fasted normally. The delayed emptying group had much larger stomach volumes as measured by ultrasonography and nasogastric tube aspirate. In contrast, the delayed emptying group showed inconsistent agreement between ultrasonography and tube measures. In this group, delayed stomach emptying was more common. Conclusions: Patients having gastric bypass surgery face the significant risk of delayed stomach emptying. Furthermore, in healthy individuals, there is a strong link between ultrasound evaluation of the stomach capacity and the volume assessed by NGT; however, in patients undergoing gastric emptying, this correlation is not present.

Elective surgeries, ultrasound evaluation, delayed gastric emptying, residual gastric volume, and related terms.

1. Introduction

Perioperative Anaesthesia side effects, including as aspiration of stomach contents, are uncommon but potentially life-threatening [1]. Depending on patient and operative circumstances, the overall incidence in a mixed surgical population might vary from less than 0.1% to over 19%. There is a risk of death of up to 5% and a large deal of morbidity, such as the need for extended mechanical ventilation, linked with aspiration pneumonia [2].

Up to 9% of all fatalities caused by anaesthesia include pulmonary aspiration. If there is any remaining stomach fluid while the anaesthesia is being administered, it increases the likelihood of aspiration [3].

For the diagnosis of risk stomach, which is defined as the presence of solid particles and/or a gastric volume of 0.4-0.8 ml/kg, bedside ultrasonography can reliably give quantitative and qualitative information on the type (fluid or solid) and volume of gastric content [4].

On the basis of qualitative evaluation alone, antral sonography may distinguish between an empty stomach and one with fluid or solid contents. The entire amount of gastric fluid may be predicted by measuring the cross-sectional area (CSA) of the antrum in the right lateral decubitus when the stomach is filled with fluid [5]. The physiological systems that prevent aspiration, such as the tone of the lower esophageal sphincter and upper airway reflexes, are suppressed or impaired by sedation and general anaesthesia [6].

In order to ensure the safety of their patients, anesthesiology associations have established standards for preoperative fasting, which include limiting fluid and food consumption [7].

Clear fluids should be consumed at least 2 hours after fasting, 6 hours after a light meal (toast and clear drinks), and 8 hours after a big meal with a lot of calories or fat, according to ASA standards. Elective surgery patients who are otherwise healthy are the only ones who should follow these recommendations; patients with other conditions that impact gastric emptying or volume, those for whom airway management could be challenging, and patients experiencing emergencies should not rely on them [8].

By suggesting a gastric antrum grading system, this research sought to provide a qualitative description of the sonographic appearance of the gastric antrum in normal adult patients having elective surgery and fasting individuals with delayed stomach emptying.

2. Methods

Patients:

The cross-sectional This descriptive research was carried out at several surgical units at Benha University Hospitals in Benha, Egypt, and included 90 patients who were having elective surgery. An whole year, beginning in May 2022 and ending in April 2023, was devoted to the research.

In this investigation, 90 individuals who were already scheduled for surgical procedures were included. Three groups were formed from them; Group A consisted of 30 healthy adults who had elective surgery, fasted for 8 hours before eating solid meal, and had 200 ml of water 2 hours before to the ultrasounds. Group B consisted of 30 healthy adults who had elective surgery, fasted for 8 hours before eating solid meal, and had 200 cc of water one hour before ultrasounds. In Group (C), thirty patients undergoing elective surgery for delayed gastric emptying (chronic renal failure, long-standing diabetes, autonomic neuropathy) were included. Prior to the ultrasound examinations, the patients were instructed to fast for eight hours before eating solid food and to consume 200 ml of water.

Patients were eligible for inclusion if they were at least 21 years old, had a body mass index (BMI) of less than 40 kg/m2, and followed the ASA recommendations for fasting. patients scheduled for elective surgeries, patients with delayed gastric emptying (diabetics, renal, patients with autonomic neuropathies) (Group C), and normal adult patients without a history of gastric emptying complaints; 2 hours after consuming clear fluids; 6 hours after a light meal; 8 hours after a full meal with high calorie or fat content (Groups A and B).

Patients who did not meet the inclusion criteria were those who were under the age of 21, had a body mass index (BMI) greater than 40 kg/m2, had a history of abnormalities in the upper gastrointestinal tract, such as a hiatus hernia, cancer, or esophageal or gastric surgery, were pregnant or had recently been pregnant (within the past three months), or refused to participate in the study.

The standard preoperative evaluation for all patients included taking their medical history, performing a physical examination, and running a battery of tests to determine the patient's overall health and risk for complications. These tests included a complete blood count (CBC), serum albumin, bilirubin, hepatic transaminases, and international normalised ratio (INR), as well as serum creatinine, random blood glucose, and serum electrolytes (Na and K).

Before each patient had the surgery, the anaesthesia team evaluated their medical history. When necessary, further investigations were mandated (like echocardiography). The American Society of Anesthesiologists (ASA) classification system was used for all patients [9].

Get ready for the procedure: As soon as the patient reached the recovery room, a 20-gauge intravenous (IV) cannula was placed in the upper limb on the opposite side. The patient underwent common monitoring procedures, such as electrocardiogram (ECG), non-invasive blood pressure (NIBP), and peripheral oxygen saturation (SpO2) (SpO2).

Evaluation by ultrasound: this is carried out with the use of low-frequency, ultrasonic curvilinear arrays (2- 5 MHz).

Techniques Used in the Study: A transducer-specific focused ultrasound scan of the stomach was performed prior to the administration of anaesthesia. Scanners placed the patient on their right side while they were laying down. The purpose of the ultrasonography was to see what was within the stomach and determine if it was empty, full with fluid, or solid. The antrum, which is a section of the stomach, was looked at and its contents were recorded. When fluid was present, it appeared as a hollow with less dense content, but an empty appearance indicated flattened walls. The solid substance looked like frosted glass or pictures of liver. Grading of patients was done according to these results. The antrum's volume was estimated statistically based on its size, which was determined by ultrasound [10]. A stomach tube was placed after intubation; the contents were aspirated and recorded for a minimum of fifteen minutes while the patient's posture was changed. This allowed for a better match between the ultrasound-predicted volume and the actual contents of the stomach.

Research methods including statistics:

The data was examined with the help of IBM SPSS 22.0. Quantitative data was summarised using the median (min-max) for non-standard data and the mean with standard deviation for standard data once normality was confirmed. Counts and percentages were utilised for qualitative data. One-Way ANOVA and Kruskal-Wallis evaluated quantitative data across groups, whereas Monte Carlo and chi-square tests compared groups qualitatively. The Kappa coefficients were used to quantify the level of agreement between the evaluations, which ranged from weak to strong. From all analyses, p-values more than 0.05 were deemed non-significant, ⩽0.05 were regarded significant, and less than 0.001 were considered highly significant, according to the significance level given using two-tailed probability.

3. Findings

Cases in group C had a much older mean age than those in groups A and B. When comparing the three groups according to gender and body mass index, no statistically significant difference was found. There was a very significant difference between the three groups ($P < 0.001$), as seen in Table 1, where no patients in group A had ASA III and 30% in group C did. In terms of operating time, anaesthetic duration, and intravenous fluid volume received, no statistically significant difference was seen among the three groups. Listing 1

When it came to the preoperative evaluation of vital signs including heart rate, oxygen saturation, and mean arterial pressure (MAP), there was no statistically significant difference among the three groups. One Table

Table 1: Comparison of the three groups' demographic, operational, and critical data sets.

		Group A (n= 30)	Group B (n= 30)	Group C (n= 30)	P value
Age (years)		52.10 ± 9.27 A	50.57 ± 8.02 A	59.77 ± 6.15 B	< 0.001*
Gender	**Male**	15 (50%)	19 (63.3%)	16 (53.3%)	0.785
	Female	15 (50%)	11 (36.7%)	14 (46.7%)	
BMI (Kg/m^2)		27.22 ± 3.45	28.43 ± 3.84	26.82 ± 3.96	0.228
ASA	**ASA I**	19 (63.3%)	16 (53.3%)	0 (0%)	< 0.001*
	ASA II	11 (36.7%)	14 (46.7%)	21 (70%)	
	ASA III	0 (0%)	0 (0%)	9 (30%)	
Operative time (min)		56.91 ± 11.48	58.53 ± 7.72	60.71 ± 6.81	0.348
Duration of anaesthesia (min)		184.50 ± 9.68	183.03 ± 10.83	190.26 ± 13.09	0.059
Intravenous fluid volume (min)		1468.94 ± 306.61	1464.68 ± 267.97	1450.44 ± 218.98	0.994
Vital signs					
HR		74.74 ± 10.58	73.26±11.42	75.41 ± 8.62	0.356
MAP		89.88 ± 7.69	87.89±9.92	88.44±16.59	0.216
SO2		97.60 ± 1	97.50 ± 0.82	97.53 ± 0.90	0.911

A, B, and C: Results that are similar show no significant difference between the adjacent groups; results that are different show no significant difference between the adjacent groups; *: Statistically significant (P < 0.05).

The Group C had a considerably greater rate of CSA supine posture compared to groups A and B. Also, when comparing groups A and B, the CSA supine position was much higher in group B. In comparison to groups A and B, group C had a much greater predicted volume supine posture. Also, when comparing groups A and B, the predicted volume in the supine position was much larger in group B. Part 2 of the table

Group C had a considerably greater CSA right lateral position compared to groups A and B. Group B also had a statistically significant greater CSA right lateral location than group A. When comparing groups A and B, group C had a much higher predicted right lateral position. Also, when comparing groups A and B, the predicted right lateral position was much greater in group B. Second Table (1)

A, B, and C: Results that are similar show no significant difference between the adjacent groups; results that are different show no significant difference between the adjacent groups; *: Statistically significant (P < 0.05).

The Group C had a considerably bigger stomach capacity (by US) than groups A and B. Additionally, there was a statistically significant difference between groups A and B with respect to stomach volume (as measured by US). In comparison to groups A and B, group C had a considerably greater stomach capacity (as measured by NGT). In addition, group B had a considerably bigger stomach capacity (as measured by NGT) than group A. While there was no statistically significant difference between groups A and B, group C had a much larger percentage of stomach volume difference between US and NGT. Table (3)

Table (2) Measurements taken by ultrasound in each of the three groups.

Ultrasound measurements	Group A (n= 30)	Group B (n= 30)	Group C (n= 30)	P value
CSA supine position (mm2)	8.30 ± 1.58 A	10.49 ± 2.17 B	14.72 ± 3.01 C	< 0.001*
Predicted volume supine position (mL)	84.20 ± 22.15 A	130.97 ± 24.47 B	182.73 ±56.36 C	< 0.001*
CSA right lateral position (mm^2)	8.67 ± 1.38 A	11.27 ± 2 B	16.55 ± 4.53 C	< 0.001*
Predicted right lateral position (mL)	90.60 ± 18.67 A	126.73 ± 20.28 B	222.13 ±49.81 C	< 0.001*
Gastric Volume (mL)	61.60 ± 16.08 A	79 ± 20.02 B	138.70 ±32.11 C	< 0.001*

Table (3) shows the gastric capacity in each group as evaluated by NGT and ultrasound.

Ultrasound measurements	Group A (n= 30)	Group B (n= 30)	Group C (n= 30)	P value
Gastric Volume (mL)	61.60 ± 16.08 A	79 ± 20.02 B	138.70 ±32.11 C	< 0.001*
Gastric Volume (mL) by NGT	39.50 ± 9.04 A	50.67 ± 15.96 B	79 ± 17.29 C	< 0.001*
Percent of difference between the two volumes	35.09 ± 5.72 A	36.82 ± 6.90 A	42.66 ± 5.56 B	< 0.001*

A, B, and C: Results that are similar show no significant difference between the adjacent groups; results that are different show no significant difference between the adjacent groups; *: Statistically significant (P < 0.05).

The In groups A and B, the interclass agreement coefficient between NGT and ultrasonography for stomach volume detection was extremely significant (p= 0.005 and 0.008, respectively), whereas in group C, there was no statistically significant agreement (p= 0.085). Chapter 4

Table (4) Comparison of GV detection methods using ultrasonography and NGT, including agreement analysis (interclass correlation).

	Agreement coefficient (Interclass correlation)	95% CI	P
Group A	0.797	0.617-0.864	0.005*
Group B	0.780	0.594-0.848	0.008*
Group C	0.526	0.386-0.672	0.085

CI: Confidence interval, *: Statistically significant (p< 0.05)

Regarding the grading of gastric emptying in the study groups, there was higher incidence of delayed gastric emptying in the cases of group C. **Table 5**

Table (5) Analysis of grading of gastric emptying in the study groups.

	Group A (n= 30)	Group B (n= 30)	Group C (n= 30)	p
Grade 0	12 (40%)	9 (30%)	6 (20%)	
Grade 1	15 (50%)	17 (56.7%)	12 (40%)	**0.032***
Grade 2	3 (10%)	4 (13.3%)	12 (40%)	

4. Discussion

The In order to provide a qualitative description of the stomach antrum's sonographic appearance in both normal adult patients having elective surgery and fasting individuals with delayed gastric emptying, this research proposed a grading system. This research breaks new ground by comparing the effects of delayed stomach emptying to those of two consecutive bouts of absolute fasting in otherwise healthy people.

There was a statistically significant difference in the mean ages of groups A and B and C in this investigation.

This was in line with the findings of Valero Castañer et al., who included 53 patients; 23 of them had delayed gastric emptying predisposing factors (DGEF), and 30 did not. Their results demonstrated that the DGEF group's patients were much older than the NDGEF group's patients [11].

Perlas et al. also noted this pattern, drawing the conclusion that, for a given stomach capacity, older patients tend to have a greater CSA than younger ones [12]. One possible explanation is that the stomach walls of elderly people are more flexible than those of younger ones [13].

Group C scored considerably higher than groups A and B on measures of CSA supine position, projected volume supine position, CSA right lateral position, and predicted right lateral position in the present investigation. In addition, group B had much higher values for the same parameters as group A.

Sabry et al. found the same result when they studied 25 individuals with diabetes and 25 healthy controls who had elective procedures. Patients with diabetes had a greater Antral CSA in the semi-sitting and right lateral positions compared to those without diabetes. Diabetic individuals had a greater predicted stomach volume in both locations compared to non-diabetic patients. In addition, those with diabetes had a larger amount of fluid aspirate from the nasogastric tube [14].

Nevertheless, the present findings contradict those of Valero Castañer et al., who demonstrated that neither the area measured by the FTM in the DGEF (6.54 ± 2.58 cm2) nor the NDGEF (5.60 ± 2.30 cm2) groups (p = 0.24) nor when the TDM method was employed (5.11 ± 2.68 cm2 vs. 5.43 ± 2.72 cm2, respectively; p = 0.67) [11].

They attributed the disparity to the fact that the DGEF group's patients' comorbidities were in their acute rather than chronic stages (i.e. the evolution of diabetes was not long enough to have had any gastric repercussion).

Group A had a stomach volume (measured by US) of 61.60 ± 16.08 ml, group B had 79 ± 20.02 ml, and group C had 138.70 ± 32.11 ml. The stomach capacity measured by NGT in groups A, B, and C was 39.50 ± 9.04 ml, 50.67 ± 15.96 ml, and 79 ± 17.29 ml, respectively.

According to Sharma's study, 42 out of 100 individuals with a fasting duration of 6 hours or more had GRV levels ranging from 40 to 80 mL [15]. Bisinotto measured GRV in 80 participants; all groups had a median GRV of 60 mL, regardless of whether they were fasting or had consumed 200 or 500 mL of isotonic fluid two hours before [16].

Patients were permitted to consume clear liquids up to 5 hours before to surgery, and the average GRV measured before surgery varied between 0 and 16 mL, according to Perlas. In patients who had not eaten before surgery, van de Putte discovered a wide range of GRV, from 18 to 138 mL [13]. Differences in the patient population, the type of last meal consumed, the duration of fasting, and inter-individual variations in gastric emptying are likely to blame for the variations in gastric re-fill volumes (GRV) across studies. For instance, van de Putte discovered that certain patients with high GRV had symptoms of dyspepsia, prolonged fasting, and eating a high-fat meal just before fasting [13].

An increased risk of aspiration has been associated with GRV levels over 1.5 mL per kg of body weight, rather than with absolute GRV values [17, 18].

Our findings corroborated those of Sabry et al., who found that fasting diabetes patients had a greater residual stomach volume than non-diabetic patients, when it came to gastric volume (as assessed by US or gathered by NGT). The risk of aspiration was increased for a greater number of individuals in the diabetes group when contrasted with the non-diabetic patients [14].

According to the same source, Reissell et al. found that stomach residual volumes were larger in diabetes uremic patients than in non-diabetic uremic patients [19].

In fact, Valero Castañer proved that individuals with or without comorbidities that postpone gastric emptying did not exhibit any notable gastric content during their planned operation. The stomach volumes of the two groups were identical. With a p-value of just 0.08, the mean stomach capacity in DGEF was 35.21 ± 32.69 mL, whereas in NDGEF it was 53.50 ± 30.72 mL. Out of all the patients, the average computed volume per kilogramme was 0.61 ± 0.46 mL/kg. Out of the DGEF group, only one patient had an estimated volume that was deemed high risk, measuring 1.57 mL/kg [11].

Alternatively, in studies comparing diabetic and non-diabetic individuals, it was shown that neither the delayed stomach emptying [20] nor the increased gastric residual volume [21, 22] seen in diabetes patients were explained by autonomic neuropathy.

Gastric emptying of 75 g glucose was shown to be comparable between normal people and type I diabetes patients, according to Jones et al. [23]. In a study of individuals with type I diabetes, Lydon et al. found that autonomic function and serum glycosylated haemoglobin levels were not predictive of gastroparesis [24].

We found results that were somewhat in line with those of Doctor et al., who randomised 90 adult patients without risk factors for delayed gastric emptying to receive 200 mL of water, clear apple juice, or apple-flavored ORS after overnight fasting in order to detect the gastric volume using ultrasound and NGT. A lack of agreement between the radiologist's and anesthesiologist's readings was shown. There was a strong association between the two groups (0.3 intra-class correlation, 95% CI 0.09 to0.48, p 0.004) [25].

Gastric ultrasonography is not strongly advised as a bedside technique for evaluating the stomach contents before surgery, according to the Indian Society of Anaesthesiologists' recently released fasting guidelines [26].

The research by Arzola, which relied on qualitative evaluation rather than volume measurements, found that 33 ultrasound exams were sufficient to get 95% competency [27, 28].

Although another research had anesthesiologists train under a radiologist's supervision for 20 cases before doing USG-based GRV evaluations, this study did not compare the anesthesiologists' and radiologist's measures side by side to see how well they agreed [15].

While participating anesthesiologists had performed at least 50 stomach exams before to the research, Kruisselbrink discovered that inter-rater concordance between sonographers and anesthesiologists was 0.96 to 0.99.

In a recent study, Kruisselbrink and colleagues found that bedside USG can accurately distinguish between an empty stomach, solid, liquid, and gastric reflux volume (GRV) greater than or equal to 1.5 mL per kg. The anesthesiologist in this study had performed over 100 gastric ultrasound examinations [30]. Similarly, the evaluator in Kaydu's research had over 50 stomach exams under their belt [31].

Having said that, the authors used a different method for GRV computation and conducted the evaluation when the subject was lying down. Since there is substantial support for both qualitative and quantitative evaluation of stomach volume only when conducted in the RLD posture, the accuracy of their results may be in question [26].

In regards to stomach emptying, our study aligns with Muresan et al., who indicated that 30–50% of individuals with type 1 and 2 diabetes mellitus have delayed gastric emptying, which is accompanied by esophageal and gastric-related symptoms [32].

Contrarily, research conducted by Valero Castañer et al. found that out of the patients in the DGEF group, 14 (66.7% of the total) were determined to have an empty stomach and 7 (33%) to have a non-empty stomach. In contrast, the NDGEF group yielded findings of 17 (62.3%) and 10 (37% of the total). There were no discernible variations between the two sets of data. Within the DGEF group, fourteen patients were classified as grade 0, six as grade 1, and one as grade 2. In contrast, the NDGEF group had seventeen patients classified as grade 0, ten as grade 1, and zero as grade 2 [11].

The current evidence does not support this attitude due to larger stomach capacity, which might expose patients to aspiration, and there is no prior data about the delayed use of fluids preoperatively (maximum of one hour).

5. Last Thoughts

Patients having gastric bypass surgery face the significant risk of delayed stomach emptying. Furthermore, in healthy individuals, there is a strong link between ultrasound evaluation of the stomach capacity and the volume assessed by NGT; however, in patients undergoing gastric emptying, this correlation is not present.

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