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HUMAN RESEARCH **ANESTHESIA**

Ultrasonographic estimation of gastric volume in patients after overnight fasting and after ingestion of clear fluids two hours before surgery

Manjunath C. Patil[1], Pavan V. Dhulkhed[2], B. Prajwal[3]

1-Professor; 2-Assistant Professor; 3-Senior Resident,

Department of Anesthesiology, Jawaharlal Nehru medical college, KLE University, Belgavi-590010, Karnataka, India.

Correspondence: Dr. Manjunath C. Patil, Professor, Department of Anesthesiology, Jawaharlal Nehru medical college, KLE University, Belgavi-590010, Karnataka. India.

Abstract

Introduction: Pre-operative fasting aims to decrease the volume and increase the pH of gastric contents, hence reducing the risk of aspiration. According to the past literature gastric contents of 25 ml (0.4 ml/kg) and with pH ≤ 2.5 predisposes the patient to pulmonary aspiration hence pre-operative fasting was recommended. Use of two-dimensional ultrasonography is an accurate non-invasive tool to determine gastric volume. We compared the gastric volume using ultrasonography and pH of gastric aspirate by pH strip in patients after overnight fasting and after ingestion of 200 ml clear fluids (water) 2 h prior to surgery.

Methodology: The study was conducted in 60 ASA I patients undergoing elective surgery after obtaining institutional ethical committee clearance & written informed consent from all the patients. Patients were randomized based on computer generated randomization table into one of the two groups; Group A - patients with overnight fasting, and Group B - patients with overnight fasting, but receiving 200 ml of clear fluids (water) 2 h before surgery. Gastric antral dimensions were noted and gastric volume was calculated. Gastric aspirate pH was measured by pH strips.

Results: Age and gender distribution was comparable between the two groups. The mean gastric volume by USG was 29.7 ± 8.0 ml and 19.2 ± 4.9 ml in Group A and B respectively. The reduced gastric volume in Group B was statistically significant (< 0.00001). The mean pH of gastric aspirate in Group A was 1.4 and Group B was 2.63. The results reveal that Group B has a better result in terms of pH of the gastric contents and was statistically significant ($p < 0.00001$).

Conclusion: We conclude that the surgical patients who fasted overnight may be allowed 200 ml of clear fluids 2 h prior to surgery as it results in lesser residual gastric fluid volume and higher mean pH at the time of surgery, resulting in a reduced risk of aspiration.

Key words: Gastric volume; Ultrasound; Fasting

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1. Introduction

Aspiration of gastric contents in the peri-operative period is a serious complication. The overall incidence of aspiration pneumonia ranges from 0.1% to 19% in the patients undergoing surgical procedures.[1-6] Aspiration pneumonia is associated with significant morbidity, including prolonged mechanical ventilation, and carries a risk of mortality as great as 5%. Pulmonary aspiration is the cause of around 9% of all anesthesia related deaths.[1,7,8] In particular, aspiration of particulate material, volumes more than 25 ml with low pH is associated with high morbidity. The physiological protective reflexes that prevent aspiration (tone of lower esophageal sphincter and

upper airway reflexes) are inhibited by sedation and general anesthesia.[9,10]

Some of the interventions to reduce the risk of aspiration include optimizing the time of anesthesia and surgery, regional vs. general anesthesia, method of induction, airway management technique and pre-operative fasting. Preoperative fasting aims to reduce the volume and acidity of the gastric contents, hence reducing the risk of aspiration. Inspite of the recommendations as per the recent guidelines[11,12] to allow the intake of clear fluids upto 2 h before surgery,[13] it is a common practice to restrict oral intake after mid-night for liquids as well as solids.

Previous studies have shown that the aspiration risk is more in patients with gastric volume of ≥ 25 ml (0.4 ml/kg). However, Cochrane database has reviewed several studies and concluded that avoiding the intake of clear fluids will not increase the pH of the gastric contents and also that the gastric volume increases with the increase in the hour of fasting.[14] Prolonged fasting before surgery is uncomfortable to the patient.[14]

The volume of gastric contents can be assessed by various methods like aspiration through a nasogastric tube, absorption of paracetamol, electrical impedance tomography, dilution of polyethylene glycol, diet containing radio-active labelled substances, etc. which are all invasive methods to determine gastric volume and gastric emptying time.[15-19]

The size of viscera have been assessed using ultrasonography (USG), so is the gastric volume. Two dimensional USG can be a non-invasive tool to determine the gastric volume.[20]

Primary Objective: To compare the gastric volume using ultrasonography in patients after overnight fasting and after intake of clear fluids (water) 200 ml 2 h before surgery.

Secondary Objective: To assess pH of gastric aspirate.

2. Methodology

Following approval by institutional ethical committee, a written informed consent was obtained from all patients. Adults aged between 18 to 50 y, of ASA physical status 1, posted for elective surgery under general surgery were included in the study. Patients with body mass index (BMI) >30 kg/m^2, gastro esophageal reflex disorders and pregnant women were not included in the study. Patients were randomized based on computer generated randomization table into one of the two groups; Group A: patients with overnight fasting, and Group B: patients with overnight fasting, but receiving 200 ml of clear fluids (water) 2 h before surgery.

Preoperatively the patient's intravenous (IV) line was secured with 18 or 20G IV cannula and infusion was started at 5 ml/kg/h. Patient was positioned in right-lateral position and using USG probe 3-5 MHz, the gastric antrum was visualized by placing the probe in sagittal plane which was seen as round to ovoid and has been compared with a 'target' or 'bulls eye' pattern. Then antral cross-sectional area (CSA) was measured by using two perpendicular diameters and the formula of the area of an ellipse, e.g., CSA = (AP×CC×π)/4

AP = Antero-posterior diameter (in cm)

CC = Craniocaudal diameter (in cm)

And gastric volume (GV) was calculated using the formula;

GV = 27+14.6×rt-latCSA (in cm^2)-1.28×age (in years)

Then the patient was shifted to the operation theatre and routine monitors including electrocardiograph (ECG), pulse oximeter and non-invasive blood pressure were attached and baseline readings recorded. The patient was preoxygenated for 3 min and premedicated with glycopyrrolate, midazolam, fentanyl and induced with thiopentone and vecuronium. The airway was secured with an appropriately sized endotracheal tube. Patients were maintained with oxygen, nitrous oxide and vecuronium. Gastric aspirate was obtained via a 16G or 14G nasogastric tube while the upper abdomen was massaged by an assistant to facilitate the aspiration of the gastric contents. The volume of the gastric aspirate was noted and the pH was recorded using the standardized pH strip. The parameters noted include: sex, age, gastric volume by ultrasonography, gastric aspirate volume, duration of fasting and interval between ingestion of water and surgery.

Using the formula,

$$\text{Sample size (n)} = \frac{2\,(Z\alpha_{/2} + Z_{1-\beta})^2\,(SD^2)}{d^2}$$

Level of significance was taken as 5%; power of the test used was taken as 80%; type I error rate $\alpha = 0.05$ and type II error rate $\beta = 0.2$

Taking the level of significance at 5% (α=0.05),

Power of the test as 90% (β=0.2), and using two-tailed test we get

$Z\alpha$=1.96

$Z_{1-\beta}$=0.84

SD= Standard deviation of mean gastric volume of overnight fasted patients.

d = effect size = 1.65 (6% of the mean gastric volume value of 27.48 in fasted patients)

The clinical significance of the effect size value was that any difference of mean value upto 1.65 between the fasting and 2 h 200 ml clear fluid group this study will be able to detect.

The study result was expecting to find a mean gastric volume value less than 27.48 ± 2

Hence,

$Z\alpha = 1.96$

$Z\beta = 1.28$

Mean gastric volume for fasted patients = 27.48

SD = 1.98 =2

d =1.65

Hence sample size (n) = $\frac{2\,(1.96 + 0.84)^2\,(2^2)}{(1.65)^2}$

n = 22.94

For ease of calculations and sake of consistent result, sample size was taken as 30. There were two groups of 30 patients each.

The results are mentioned as mean ± standard deviation (SD) Data collected was analyzed using Student's t-test. Difference was considered significant if $p < 0.05$

3. Results

The age, weight and sex ratio of the groups were comparable.

Table 2 shows that the mean gastric volume by USG in Group A was 29.7 ± 8.0 ml and Group B was 19.2 ± 4.9 ml. The reduced gastric volume in Group B was statistically significant ($p < 0.00001$).

The mean pH of gastric aspirate in Group A was 1.4 and Group B was 2.63. Which shows that Group B has a better outcome in terms of gastric pH and was statistically significant ($p < 0.00001$).

Gender	Group A	Group B
Male	33 ± 11.1	32.08 ± 11.4
Female	36.16 ± 8.76	27.61 ± 7.7
Overall	35.43 ± 9.57	29.4 ± 9.45

Table 1: Age distribution according to gender in the two study groups (Mean ± SD)

4. Discussion

Fasting is considered a mandatory prerequisite for elective surgery. It has been widely believed that the goals of pre-operative fasting are (a) to increase the alkalinity of gastric juice and (b) to reduce the volume of gastric contents and thereby reducing the likelihood of pulmonary aspiration.[33] The concept of empty stomach has been universally followed to safeguard against vomiting, regurgitation and aspiration during anesthesia.[40] However stomach can never be completely empty even after a midnight fast since it continues to secrete gastric fluid. On the contrary, studies have shown that prolonged fasting has been associated with reduced gastric pH and increase in gastric volume, placing the patients at risk category for aspiration. Current guidelines[11,12] recommend clear liquids upto 2 h before surgery, which was a compromise between comfort, cooperation and hydration, on the one hand and safety on the other.[55]

Gastric emptying is affected by many factors like obesity,[56] gastrointestinal disorders and systemic diseases.[29] The rate of gastric emptying depends on several variables including the volume of oral fluids.[33] Previous investigations in adults demonstrated different emptying rates for different fluids, with caloric load,[57] carbonation, carbohydrate levels[58] and nutrient composition.[59]

The volume of gastric contents can be assessed by various invasive methods to determine gastric volume and gastric emptying time.[15-19] Many of these are not applicable in perioperative period.[52,60-63] Gamma scintigraphy was a noninvasive method considered a gold standard.[64,65] It has the drawbacks of cost, use of radiation, and was not a practical examination tool.

Variables	Group A (Mean ± SD)	Group B (Mean ± SD)	Calculated Unpaired t-test value	p value
Mean pH of gastric aspirate during intra-operative period	1.4 ± 0.50	2.63 ± 0.61	9.69	< 0.00001*
Mean gastric volume by gastric aspiration during intra-operative period	26.7 ± 7.5	13.47 ± 4.8	9.70	< 0.00001
Mean Gastric volume by USG	29.7 ± 8.0	19.2 ± 4.9	6.07	< 0.00001**

Table 2: Showing the values of Gastric volume and pH of the gastric contents in the two groups.

**The mean pH of gastric aspirate in Group A is 1.4 and Group B is 2.63. Which shows that Group B has a better outcome in terms of gastric pH and is statistically significant (p<0.00001)*

***The mean gastric volume by USG in Group A is 29.7 ± 8.0ml and Group B is 19.2 ± 4.9 ml. The reduced gastric volume in Group B is statistically significant (<0.00001).*

Measurement of residual gastric volume by an aspiration using a nasogastric tube usually underestimates the gastric volume. MRI was used by Schmitz et al.[38] to study the effects of different quantities of sugared clear fluids on gastric emptying and residual volume in children aged 6 - 14 y. Gastric fluid volume decreased rapidly with a median half-life of < 30 min after drinking 7 ml/kg of standardized clear fluids. Body weight corrected gastric air volume (GAV_w) continued to increase until 30 -90 min post syrup in most children, but declined below initial value after 120 min ($p < 0.008$).

Previous MRI studies in adults have shown the following elimination half-lives: 38 min for 500 ml of glucose 10%,[66] 100- 130 min for several meals and liquid nutrients,[67,68] 21 min for water, 31 for non-carbonated carbohydrates, 47 for carbonated carbohydrates and 107 min for carbonated cola.[69]

It has been shown that a pH < 2.5 and volume of gastric aspirate > 25 ml (0.4 ml/kg) predisposes patients to pulmonary aspiration.[14]

Until recently there was a lack of a non-invasive diagnostic method that could promptly assess gastric content and be applied perioperatively. Ultrasound has been the first non-invasive technique that provides both quantitative and qualitatively validated information of gastric contents at bedside,[20,41] Studies have revealed that gastric antrum was the region which will be easily accessible to ultrasonographic examination.[56-58]It can be identified in 98-100% of cases[20,22,50].Several mathematical models were developed for gastric volume calculation using the gastric antrum image and calculating its cross-sectional area[20,22,41].

A Perlas et al.[41] reported accurate linear model based on gastroscopic fluid assessment with a mean difference of 6 ml between the predicted and measured volumes. This study had 108 patients. It was applicable to adult, non-pregnant subjects with BMI up to 40 kg/m^2. It can predict volumes up to 500 ml.

In our study ultrasound was used and gastric volume was determined using the above mentioned formula, 60 patients posted for elective surgery were examined. 30 each belonging to overnight fasting group and 30 patients after 2 h of intake of 200 ml clear fluids. There were no incidence of vomiting or aspiration in both the groups.

In our study the distribution of sexes and ages were comparable in both groups. The majority of them between 26-41 years old.

The differences in mean gastric volume by ultrasonography and in mean pH were statistically significant in favor of Group B ($p < 0.00001$).

Malcolm Scar and J Roger Maltby[28] studied the effect of oral fluids on residual gastric volume and acidity before elective surgery in 211 healthy patients. Patients were allowed to have 150 ml of tea or coffee or apple juice or water until 3 h before surgery. The differences between the groups was statistically insignificant. Effects of fasting interval on gastric volume and pH was also studied by Riaz hussain[29] in 65 patients aged

15-50 years undergoing elective surgery under general anesthesia. Both the gastric volume (p = 0.998) and pH (p = 0.408) changes between the groups were insignificant. This study concluded that prolonged fasting had no added benefits but added to patient discomfort.

Flora margarida et al.[55] used ultrasound for gastric volume evaluation after consuming different volumes of isotonic saline solution in 80 healthy volunteers. The volunteers were scanned 3 times. Gastric volume were estimated by scan after overnight fast, overnight fast followed by 200 ml saline or 500 ml saline after 2 h of ingestion of liquid. The scans were graded as grade 0-antrum was empty in both supine and right lateral decubitus (RLD) position, grade 1- presence of liquid in RLD only, grade 2- presence of liquid in both RLD and supine. Grade 2 suggested increased gastric volume. Their results were not statistically significant (p = 0.07).

5. Limitations

Our study has some limitations;

1. As with all ultrasound techniques, which was dependent on the equipment quality and also the operator, the antrum was not identifiable in all patients and multiple attempts needed to be performed to obtain reliable results in some of them.
2. The present study was conducted on healthy volunteers and, thus, the results may not be extrapolated to patients with chronic diseases or who are on medications that alter the digestive system motility.

6. Conclusion

The results of our study reflect better outcome as regards to both pH and residual gastric juice volume in patients who consumed 200 ml of clear fluids 2 h prior to surgery. This result supports the present NPO guidelines for clear fluids as 2 h, which helps in reducing the preoperative discomfort of prolonged fasting and dehydration of patients.

7. Conflict of interest

None declared by the authors

8. Authors' contribution

Both authors contributed in conduct of study, literature search and manuscript writing.

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