



Gastric emptying time after breakfast in healthy adult volunteers using ultrasonography

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Abstract

There is little evidence of gastric excretion after ingestion of solids. We examined gastric emptying times after ingesting normal breakfast in healthy adult volunteer using ultrasonography. Eight adult volunteers fasted for 8 h, and we examined the gastric antral area in the right lateral decubitus position using ultrasonography. Sixteen adult volunteers ingested normal breakfast. We evaluated the gastric antral area in the same manner at two consecutive time points before lunch. Gastric volume was calculated by using an approximation formula based on the antral area. Correlation coefficients between gastric volume and fasting time were calculated. The calculated gastric volume from the gastric antral area after 8 h fasting was 53.1 ml. The gastric volume correlated significantly with fasting time ($r = -0.811$, $P < 0.001$). The time when the attenuation line obtained from two measurements between breakfast to lunch in each subject overlapped the fasting stomach volume (53.1 ml) was taken as gastric empty time. The calculated gastric emptying time was 276.4 ± 58.9 min. This result shows that gastric emptying time was lower than 5 h average after a typical breakfast that contains various food in healthy adult volunteers. However, further research is necessary to establish the clinical safety implications of these findings.

Keywords Gastric ultrasonography · Breakfast · Gastric content

Introduction

The purpose of preoperative fasting is to prevent regurgitation and pulmonary aspiration of gastric contents during anesthesia. In the American Society of Anesthesiologists (ASA) guidelines for preoperative fasting, 6 h of fasting for light meals and 8 or more hours for fatty food are recommended to prevent pulmonary aspiration during anesthesia [1]. However, there is little evidence regarding preoperative gastric content after consuming various types of solid meals; making it difficult to evaluate and confirm safety. Ultrasonography has recently been introduced to evaluate gastric volumes during the preanesthetic period [2, 3]. Therefore, in this study, we studied gastric emptying times after a normal Japanese breakfast including various types of foods in healthy adult volunteers using ultrasonography.

Methods

This study was approved by the Ethics Committee of Kumamoto University School of Medicine (protocol number: 546) on Nov 9, 2016 and was registered in the UMIN Clinical Trials Registry (UMIN 000013557) on Mar 27, 2014. This study was conducted according to the recommendations of the current Helsinki Declaration. Written informed consent was obtained from each volunteer. This study took place between October and November 2017. Recruitment was supported by authors' colleagues and friends. We enrolled healthy adult volunteers. Exclusion criteria included gastrointestinal disease and/or functional disorder, and those who had undergone previous surgical procedures on the esophagus or upper abdomen.

The amount of gastric contents was evaluated using ultrasonography. Subjects were scanned in the right lateral position on a bed using a standard convex ultrasound probe (C60 2–5 MHz SonoSite S-Nerve ultrasound device, SonoSite, Inc., Bothell, USA). The antral cross-sectional area (CSA) was identified in a parasagittal plane of the epigastric region using the left lobe of the liver, abdominal aorta, and superior mesenteric artery as internal landmarks

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[3]. The antral CSA was calculated using the two diameters as follows:

$$\text{Antral CSA} = \text{AP} \times \text{CC} \times \pi/4$$

where AP is the anteroposterior diameter and CC is the craniocaudal diameter [4]. Both diameters were included the gastric 5-layer walls (Fig. 1). Two anesthesiologists who had experienced of performing at least 50 gastric ultrasounds performed the measurements and the average of their measured values was calculated. Gastric volume (GV) was obtained using an existing model validated in adults as follows: $\text{GV (ml)} = 27.0 + 146 \times \text{CSA (cm}^2) - 1.28 \times \text{age (year)}$ [3].

After 8 h fasting of meal and 2 h fasting of clear fluids, healthy adult volunteers had a typical breakfast in the morning as they wished that was not limited in volume or contents. We performed ultrasonographic measurement of the gastric antral area with the subject in the right lateral decubitus position at two consecutive time points before lunch. Another day, we examined gastric volume under fasting condition, after 8 h of fasting. Correlation coefficients between gastric volume and fasting time were calculated and the linear regression equation explaining their relationship was calculated.

The time when the attenuation line obtained from two measurements between breakfast to lunch in each subject overlapped the fasting stomach volume (53.1 ml) was taken as gastric empty time. The average value and standard deviation were calculated.

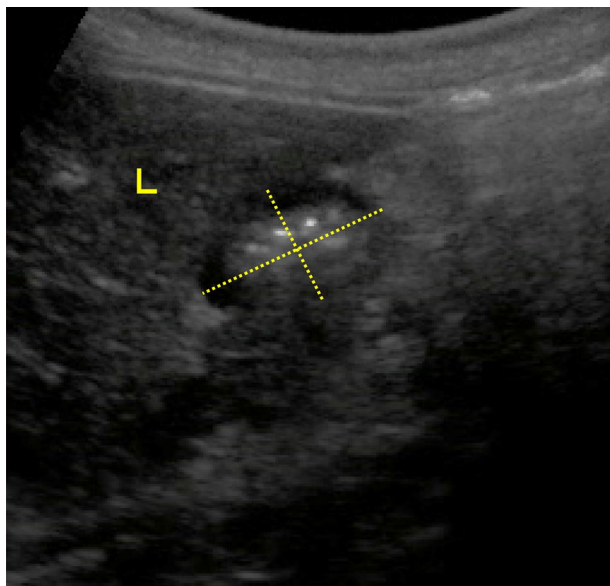


Fig. 1 Ultrasonographic image of the antral cross-sectional area. Two dashed lines indicate anteroposterior and craniocaudal diameter, respectively, including the full thickness of the gastric wall. *L* liver

Statistical analysis

Statistical analysis was performed using *R* software, version 2.15.3 (R development Core Team, 2013). The sample size was based on a previous study in children [5]. The correlation coefficient for the children's study was 0.69. Based on $\alpha = 0.05$ and $\beta = 0.8$, 16 subjects were required. Data are presented as mean \pm standard deviation or range. Spearman's correlation coefficient and linear regression analysis were performed to detect the relationship between gastric volume, fasting time, and calculated mean gastric emptying time. A paired *t* test was used to compare GV after breakfast and before lunch. Values of $P < 0.05$ were considered statistically significant.

Results

Fasting GV: Eight healthy adult volunteers (M/F, 5/3) aged 30.1 ± 2.4 (22 to 54) years were included. Participants' body weight and height were 58.9 ± 10.1 kg and 167.6 ± 0.1 cm, respectively. After 8 h of fasting, the calculated GV from the gastric antral area was 53.1 ml.

Gastric emptying time after breakfast: Sixteen healthy adult volunteers (M/F 6/10) aged 31.5 ± 4.9 (24 to 54) years were included. The participants' body weight and height were 56.6 ± 7.8 kg and 165.9 ± 7.6 cm, respectively. The breakfast contents are shown in Table 1. After having breakfast, the first measured gastric volume was significantly higher than the second measured gastric volume before lunch (179.0 ± 129.0 vs 63.6 ± 30.4 $P < 0.001$). The calculated gastric volume correlated significantly with fasting time ((regression equation: $\text{GV} = -0.78 \times \text{fasting time} + 263.7$, $r = -0.811$, $P < 0.001$) (Fig. 2).

The gastric empty time was defined as the time that the attenuation line obtained from two consecutive measurements in each subject overlapped with fasting stomach volume (53.1 ml). The mean gastric emptying time was 276.4 ± 58.9 min.

Discussion

The main findings of this study are that after ingesting a typical Japanese breakfast, GV correlated with fasting time, and the mean gastric emptying time was lower than 5 h in

Table 1 Contents of breakfast

Solid	Bread, rice, Fried egg, Fried fish Cereal, Cake Chocolate, Yogurt
Fluid	Water, Juice (fruits, vegetable) Tea, Coffee, Milk Total volume 100~500 ml

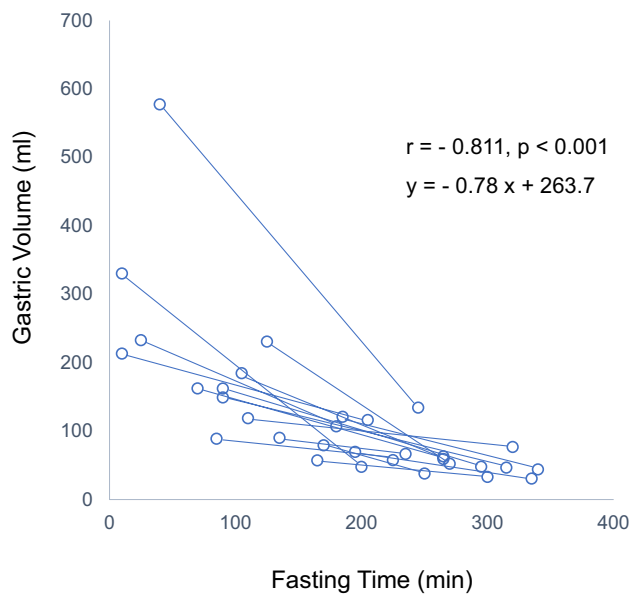


Fig.2 Relationship between the gastric volume and fasting time from breakfast. Scatter plot was revealed gastric volume measured by ultrasonography and fasting time from breakfast. The line showed the attenuation of two values measured under consecutive time between breakfast to lunch in each volunteer. The time to the empty stomach after taking breakfast was defined overlaps the measured fasting stomach volume 53.1 ml and the average value and standard deviation were calculated to obtain gastric emptying time. Time 0=immediately after breakfast

healthy adult volunteer based on ultrasonographic measurements. The consumed breakfasts contained various kinds of foods in this study. There is little evidence regarding the preoperative fasting period after the consumption of solid foods. Miller et al. reported that there were no significant differences between a group of adult patients who fasted overnight and a group allowed a light breakfast with respect to the volume of gastric contents aspirated [6]. This report is based on the ASA guideline that there should be 6 h of fasting after a light meal. In the fasting guideline, a vague explanation was provided for what constitutes a light meal. An actual meal is typically larger and contains various foods.

In measurements of preschool children, gastric antral area correlated with fasting time, and the mean gastric emptying time was less than 4 h after breakfast [5]. Beck et al. also reported a mean gastric emptying time of less than 4 h after a standard light breakfast in children [7]. A recent meta-analysis of 49 studies including 1457 individuals from neonates to adults revealed that meal type not but age was the significant covariate for gastric emptying [8]. The mean gastric residence time which is meaning similar to gastric emptying time of semisolid food such as yogurt and cereal were 87 min, while that of solid foods like eggs and sandwiches was 98 min [8]. Okabe et al. [9] examined the gastric emptying time after ingesting soluble solid diets with water. They mentioned when the energy content and

total volume of the ingested material are equal, gastric emptying times may be the same independent of compositional differences [9]. Because typical meals contain, however, insoluble or hard materials, we believe that further investigation is necessary. In this study, the meals consumed contained various kind of foods as listed in Table 1. Traditional Japanese ingredients were also included. Diet contents across the world are diverse, and it is expected that the contents of breakfast differ between each country as well. From such a point of view, it is convincing that such research has utility. On the other hand, recent retrospective cohort study suggests that a small proportion of elective surgical patients may present a full stomach despite recommended fasting [10]. The inclusion of such cases must also be considered.

This study has some limitations. The ultrasonography examination was not blinded to the study protocol or fasting time. Another limitation is that participants were healthy young adult volunteers and not surgical patients. In this regard, research with surgical patients will be necessary.

In conclusion, the current study shows that gastric emptying time was lower than 5 h average after a typical breakfast that contains various food in healthy adult volunteers. However, further research is necessary to establish the clinical safety implications of these findings.

Compliance with ethical standards

Conflicts of interest All authors declare that they have no conflicts of interest.

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