

# Validity of ultrasonographic measurement of gastric volume in fasted pediatric patients without sedation

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Received: 1 August 2015 / Accepted: 8 June 2016 / Published online: 22 June 2016  
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**Abstract** Recently, gastric ultrasonography has been used as a noninvasive portable tool for evaluating gastric content and volume in adults and children. Pediatric patients are not always cooperative, especially younger ones, and it may be difficult to keep them in the appropriate scanning position without sedation. Hence, we modified the scanning method and position, and evaluated the efficacy of this alternative scanning technique in pediatric cases. We evaluated the gastric contents of 44 pediatric patients aged 4–14 years who were about to undergo elective surgery. Solid food and fluids were prohibited 8 and 2 h before anesthesia, respectively. Before anesthetic induction, we used gastric ultrasonography to measure the antral cross-sectional area in the supine position (supine CSA), irrespective of peristaltic contractions. The gastric volume was then aspirated using a multi-orifice catheter under general anesthesia. Supine CSA measured via this gastric ultrasonography method was positively correlated with gastric volume ( $r = 0.56$ ,  $p < 0.0001$ ). We concluded that our alternative method of measuring antral CSA may be applicable for children minimal gastric contents.

**Keywords** Gastric ultrasonography · Pediatric patients · Without sedation

## Introduction

It is especially important to estimate gastric contents before anesthesia induction in pediatric cases, as the incidence of pulmonary aspiration in children is reportedly higher than in adults [1–3]. Gastric contents and volume have recently been evaluated using noninvasive portable gastric ultrasonography in adults [4–8], and in children [9, 10]. The validity of gastric ultrasonography to estimate gastric content and volume in pediatric patients before anesthetic induction has not yet been established. The current recommended method is measurement of the antral cross-sectional area (CSA) in the right lateral decubitus (RLD) position, with measurements taken while the gastric antrum is at rest between peristaltic contractions [11]. It can be difficult for unsedated pediatric patients to remain in the RLD position during gastric ultrasonography. In this study, we assessed a technically simpler alternative scanning method of measuring antral CSA in the supine position (supine CSA) without having to consider gastric peristaltic contractions. The aim of this study was to evaluate the usefulness of this simple gastric ultrasonography method for determining gastric volume in pediatric patients undergoing elective surgery.

## Case series

## Ethics approval

This study was approved by the Ethics Committee of Kumamoto University Hospital (protocol number: 1434) on April 9, 2012, and was registered with UMIN Clinical Trials Registry (UMIN 00000778) on April 17, 2012. This study was conducted according to the recommendations of

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the current Helsinki Declaration. Pediatric patients were enrolled in this study after oral informed consent was obtained from pediatric patients, and written informed consent was provided by their parents.

### Inclusion and exclusion criteria

We enrolled 50 pediatric patients aged 4–14 years with ASA physical status I or II who were scheduled for elective surgery under general anesthesia. We excluded pediatric patients with any gastrointestinal disease and/or functional disorder, and those who had undergone previous surgical procedures on the esophagus or upper abdomen.

### Gastric ultrasonography

Gastric ultrasonography was performed using a Venue 40™ ultrasound machine (convex array, 4C-SC, 3.32 MHz; GE Healthcare, Milwaukee, WI, USA) with the patient on the operating bed in the supine position. The gastric antrum was identified in a parasagittal plane of the epigastric region using the left lobe of the liver, the inferior vena cava, and the superior mesenteric vein as internal landmarks. Once these vessels were identified, the transducer was rotated slightly to obtain the supine CSA [4]. Supine CSA was measured once, without waiting for the gastric antrum to be at rest between peristaltic contractions. Supine CSA was calculated using the following equation:

$$\text{Supine CSA} = \text{AP (cm)} \times \text{CC (cm)} \times \pi/4$$

where AP was the anteroposterior diameter and CC was the craniocaudal diameter [12].

### Study protocol

No pediatric patients received sedative premedication. Following institutional guidelines, the pediatric patients were prohibited from eating solid foods for 8 h and from drinking clear fluids for 2 h before the scheduled induction time of anesthesia; the volume of clear fluids consumed was not restricted. An anesthesiologist with no specific pediatric ultrasound training performed gastric ultrasonography before general anesthesia induction. After tracheal intubation, a multi-orifice catheter (10–16 French Salem Sump Tube, Covidien, Japan) was inserted into the stomach from the mouth, and its position was verified by auscultation of the epigastrium after inflation with air. The volume of gastric contents was measured by aspirating the contents slowly into a 20 ml syringe for 5 min while moving the tube back and forth between the following three positions: supine, left lateral tilt, and right lateral tilt [13].

### Sample size calculation and statistical analysis

The values of  $\alpha$ ,  $1 - \beta$ , and correlation coefficient are required to determine the appropriate sample size of this study. The null hypothesis is expressed there is no relationship between supine CSA and gastric volume. A type I error occurs when the null hypothesis is rejected although it is true; this value is denoted by  $\alpha$  and is also called a significant level. A type II error occurs when the null hypothesis is not rejected although it is false; this value is denoted by  $\beta$ . We set  $\alpha$  at 0.05 and  $\beta$  at 0.1. The correlation coefficient for adult patients undergoing elective and emergency surgery is 0.72 [6]; as the correlation coefficient for pediatric patients has not yet been established, it was arbitrarily set at 0.5. Using these figures, we calculated that a minimum sample size of 38 subjects was needed. To meet the sample size requirement, a total of 50 children were included in our study.

The Pearson's correlation coefficient was calculated to determine whether there was a correlation between supine CSA and gastric volume.

All statistical analyses were performed using R software, version 2.15.3 (R Development Core Team, 2013). Data were presented as mean  $\pm$  standard deviation or range. Values of  $p < 0.05$  were considered statistically significant.

Gastric ultrasonography was performed in 44 of the 50 enrolled pediatric patients. Six pediatric patients aged 4–6 years were excluded as they cried on entering the operation room and during the measurement. The patient demographics are summarized in Table 1. No pediatric patient experienced regurgitation or pulmonary aspiration of gastric contents during the induction of anesthesia. No solid particles were found in aspirated gastric contents. Supine CSA was  $1.7 \pm 0.6 \text{ cm}^2$  (range, 0.7–3.1  $\text{cm}^2$ ), gastric volume was  $20.7 \pm 14.4 \text{ ml}$  (range, 0–50 ml), and gastric volume per weight was  $0.6 \pm 0.4 \text{ ml/kg}$  (0–2 ml/kg). Supine CSA and gastric volume had a positive linear correlation ( $r = 0.56$ ,  $p < 0.0001$ ; Fig. 1).

### Discussion

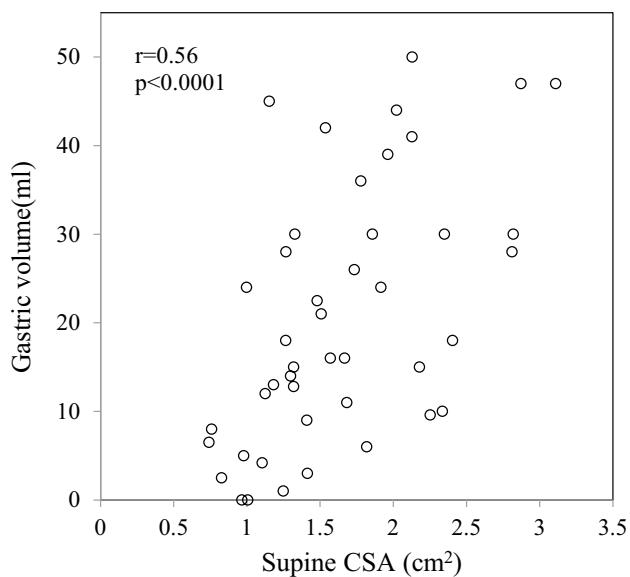
Antral CSA measured via this alternative method of gastric ultrasonography was positively correlated with gastric volume aspirated by a gastric catheter in fasted pediatric patients before anesthetic induction.

It is potentially difficult to perform gastric ultrasonography in the RLD position and identify peristaltic gastric contractions in conscious pediatric subjects [14]; hence, we evaluated a simpler alternative scanning method in conscious pediatric patients. Recently, two studies validated gastric ultrasonography in pediatric subjects. Schmitz et al.

**Table 1** Demographic data of pediatric patients ( $n = 44$ )

	Mean $\pm$ SD	Range (min–max)	Number (%)
Gender			
Male			32 (72.3)
Female			12 (27.3)
Age (years)	9.4 $\pm$ 3	4–14.9	
The number of children			
<7 (years)			9 (20.5)
7–10 (years)			20 (45.5)
10< (years)			15 (34.1)
Height (cm)	133 $\pm$ 19.3	92.4–169	
Weight (kg)	31 $\pm$ 12.8	13.6–60	
Body mass index	17 $\pm$ 3.2	13.2–25.6	
ASA			
1			37 (84.1)
2			7 (15.9)
The type of surgery			
Otolaryngology			11 (25)
Urology			9 (20.5)
Orthopedics			9 (20.5)
Dental			6 (13.6)
Ophthalmology			3 (6.8)
Dermatology			2 (4.5)
The others			4 (9)

ASA American Society of Anesthesiologists physical status



**Fig. 1** Relationship between supine CSA and gastric volume. Supine CSA: antral cross-sectional area measured with the patient in the supine position

showed that antral CSA was positively correlated with gastric volume; the correlation coefficients were 0.62 in the supine position and 0.73 in the RLD position in conscious healthy volunteers aged 6–12 years. Gastric volume was measured by magnetic resonance imaging [9]. However, this previous study did not include younger children, so it is likely that positioning during scanning was relatively easier. Spencer et al. reported correlation coefficients of 0.63 in the supine position and 0.67 in the RLD position in pediatric patients with gastrointestinal complaints aged 0–18 years under general anesthesia; gastric volume was measured by endoscope [10]. Spencer et al. included infant cases, but they performed scanning under general anesthesia; therefore, the methodology was impractical and unsuitable for use in clinical practice.

We simplified the method for measuring gastric contents and assessed its validity. Although six of 50 cases (12 %) were excluded owing to crying, we are confident that our technique facilitates gastric ultrasonography in pediatric cases. The RLD scan position is reportedly better for estimation of gastric volume [9, 10]. Even in the supine position, the correlation coefficient of our data was slightly lower than the data of the two abovementioned previous studies [9, 10]. This may be due to the following reasons. First, the investigators in the previous studies had some experience with pediatric ultrasonography; in contrast, the anesthesiologist who performed the scanning in our study had not undergone special pediatric ultrasonography training. Second, the subjects in our study were fasted elective surgery patients, so their gastric volume was expected to be small; the subjects of the two previous studies had varying gastric volumes.

In the present study, we measured gastric volume according to the technique proposed by Cook-Sather et al. They reported that this technique could aspirate approximately 97 % of gastric contents [13]. Hence, we are confident that the aspirated volume measured in our study accurately reflected the actual gastric contents.

Our study had a limitation. This study was not blinded; gastric ultrasonography and gastric volume aspiration were performed by the same anesthesiologist.

In conclusion, antral CSA measured via gastric ultrasonography with the pediatric patient in the supine position was positively correlated with gastric volume aspirated via gastric catheter. This alternative method of measuring antral CSA may be applicable for children minimal gastric contents.

**Acknowledgments** The authors thank Wataru Ishizuka for helpful comments on data analysis.

### Compliance with ethical standards

**Conflict of interest** All authors declare that they have no conflicts of interest.

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