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## SCIENTIFIC ARTICLE

# Ultrasound assessment of gastric antrum in term pregnant women before elective cesarean section



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### KEYWORDS

Ultrasound;  
Gastric antrum;  
Pregnant women;  
Cesarean section;  
Aspiration pneumonia

### Abstract

**Background and objectives:** Pregnant women are considered patients at risk for pulmonary aspiration of gastric contents. The study aim was to evaluate the gastric antral cross-sectional area using ultrasound.

**Method:** In this prospective study, 85 scheduled term pregnant women underwent gastric ultrasound. The outcomes were the measurement of the gastric antral cross-sectional area (main outcome), the estimated gastric volume, the incidence of pregnant women at risk for pulmonary aspiration, and the association between gastric antral cross-sectional area and clinical-demographic characteristics. Gastric antral cross-sectional area and gastric volume were compared according to body mass index  $<30$  or  $\geq 30$ .

**Results:** The median (IQR) for gastric antral cross-sectional area was  $4\text{cm}^2$  (2.8–6.3), for the estimated gastric volume it was 49.8 mL (33.7–87.2), and for the gastric volume estimated in  $\text{mL.kg}^{-1}$  it was  $0.62\text{mL.kg}^{-1}$  (0.39–0.95). The 95<sup>th</sup> percentile [95% confidence interval (CI)] of the gastric antral cross-sectional area and the estimated gastric volume were  $\leq 10.3\text{cm}^2$  (95% CI: 7.6–15.6) and  $1.42\text{mL.kg}^{-1}$  (95% CI: 1.20–2.64), respectively. The incidence of pregnant women at risk for pulmonary aspiration was 3.5% (CI: 3.5 (1.2–9.8)). There was a positive correlation between gastric antral cross-sectional area and weight,  $p < 0.001$  and body mass index  $< 0.001$ . Patients with a body mass index  $\geq 30$  had a gastric antral cross-sectional area and an estimated gastric volume greater than those with a body mass index  $< 30$ , respectively,  $p < 0.01$  and  $p < 0.02$ .

**Conclusion:** Measuring the gastric antral cross-sectional area of pregnant women is feasible and easy. There was positive correlation between gastric antral cross-sectional area, body weight

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and body mass index. The estimation of gastric volume by measuring the gastric antral cross-sectional area can identify patients at risk for pulmonary aspiration. Obese patients had a gastric antral cross-sectional area and an estimated gastric volume greater than non-obese patients. © 2019 Sociedade Brasileira de Anestesiologia. Published by Elsevier Editora Ltda. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## PALAVRAS-CHAVE

Ultrassonografia;  
Antro gástrico;  
Gestante;  
Cesariana;  
Pneumonia aspirativa

## Ultrassom de antro gástrico em gestantes a termo antes de cesariana eletiva

### Resumo

**Justificativa e objetivos:** As gestantes são consideradas pacientes de risco para aspiração pulmonar do conteúdo gástrico. O objetivo foi avaliar a área transversal do antro gástrico por meio de ultrassonografia.

**Método:** Neste estudo prospectivo, 85 gestantes a termo agendadas foram submetidas à ultrassonografia do antro gástrico. Os desfechos foram a mensuração da área transversal do antro gástrico (desfecho principal), a estimativa do volume gástrico, a incidência de gestantes sob risco de aspiração pulmonar, a associação entre a área transversal do antro gástrico e características clínico-demográficas. A área transversal do antro gástrico e do volume gástrico foi comparada de acordo com o índice de massa corporal  $<30$  ou  $\geq 30$ .

**Resultados:** A mediana (IIQ) da área transversal do antro gástrico foi  $4\text{ cm}^2$  (2,8-6,3), do volume gástrico estimado  $49,8\text{ mL}$  (33,7-87,2) e do volume gástrico estimado em  $\text{mL.kg}^{-1}$  de  $0,62\text{ mL.kg}^{-1}$  (0,39-0,95). O percentil 95 [intervalo de confiança (IC) 95%] da área transversal do antro gástrico e do volume gástrico estimado foi  $\leq 10,3\text{ cm}^2$  (IC 95%: 7,6-15,6) e  $1,42\text{ mL.kg}^{-1}$  (IC 95%: 1,20-2,64), respectivamente. A incidência de gestantes sob risco de aspiração pulmonar foi de 3,5% (IC: 3,5 (1,2-9,8)). Houve correlação positiva entre a área transversal do antro gástrico e peso,  $p < 0,001$  e índice de massa corporal  $p < 0,001$ . As pacientes com índice de massa corporal  $\geq 30$  apresentaram maior área transversal do antro gástrico, e do volume gástrico estimado, do que as com índice de massa corporal  $< 30$ , respectivamente  $p < 0,01$  e  $p < 0,02$ .

**Conclusão:** A mensuração da área transversal do antro gástrico de gestantes é factível e fácil. A área transversal do antro gástrico correlacionou-se positivamente com peso e índice de massa corporal. A estimativa do volume gástrico através da mensuração da área transversal do antro gástrico pode identificar pacientes sob risco de aspiração pulmonar. As pacientes obesas apresentaram área transversal do antro gástrico e volume gástrico estimado maior do que as não obesas.

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## Introduction

Perioperative pulmonary aspiration (PA) of gastric contents (GC) is a rare event, but represents a serious complication related to anesthesia. A recent research in the UK reported that aspiration pneumonia was the most common cause of death from airway management incidents, accounting for 50% of all incidents. Of these incidents, 28% occurred during elective procedures.<sup>1</sup>

The gastrointestinal tract during pregnancy undergoes significant anatomical and physiological changes that may increase the risk of PA of GC,<sup>2</sup> mainly when pregnant women undergo general anesthesia.<sup>3</sup> As this complication has remained one of the main causes of morbidity and mortality in parturients,<sup>4,5</sup> it is important to find methods that adequately evaluate both the contents and gastric emptying of these patients.

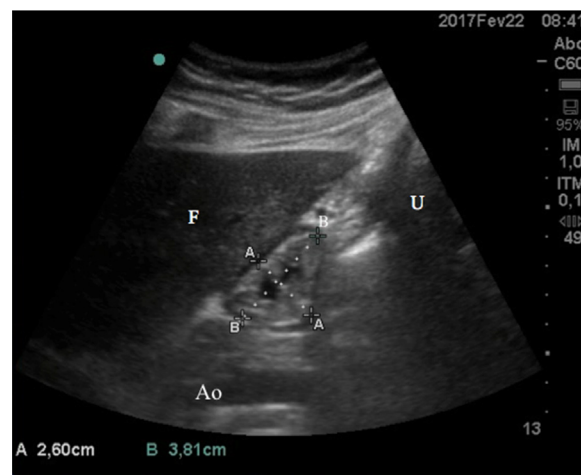
Most of the methods to evaluate GC are expensive or have little clinical applicability in the preoperative period, such as the techniques of polyethylene glycol dilution, acetaminophen absorption, computed tomography, and magnetic resonance imaging.<sup>6-8</sup> The ultrasonographic assessment of GC for both the qualitative analyses of the antrum (if empty or with presence of liquid or solid) and measurement of the gastric antral cross-sectional area (ACSA) emerges as an easy, bedside noninvasive method, which allows reassessment in real time as the patient's condition changes. Several studies have confirmed the good linear correlation between gastric ACSA and gastric volume (GV),<sup>9-13</sup> including in the obstetric population.<sup>14,15</sup> Moreover, the gastric ACSA measurement can indirectly differentiate small gastric volumes  $\leq 1.5\text{ mL.kg}^{-1}$ , consistent with baseline gastric secretions, from larger volumes that may be related to increased risk of PA.<sup>16,17</sup> Arzola et al.<sup>18</sup>

showed that 95% of pregnant women with gestational age >36 weeks fasted for Cesarean section (C-section) under neuraxial blockade presented gastric ACSA  $\leq 9.6 \text{ cm}^2$  measured in right lateral decubitus (RLD), which corresponded to an estimated gastric volume (EGV)  $\leq 1.5 \text{ mL.kg}^{-1}$ . They suggested that these values could describe the upper limits of the normal findings in full-term pregnant woman. The objective of the study was to perform ultrasonographic measurements of the gastric ACSA, estimate the GV, identify pregnant women who are at risk for PA, evaluate the association between ACSA and clinical-demographic variables, and compare ACSA and GV between obese and non-obese patients.

## Methods

After approval by the Ethics and Research Committee of the institution (CAAE no. 68533816.4.0000.5156), a prospective cohort study was performed between July and October 2017. Pregnant women at term out of labor and scheduled for C-section were evaluated. Written informed consent was obtained from each pregnant woman. The inclusion criteria were pregnant women with gestational age  $\geq 36$  weeks, aged  $\geq 18$  years, American Society of Anesthesiologists (ASA) physical status classification II–III. The exclusion criteria were twinning, upper gastrointestinal tract abnormal anatomy, previous surgical procedures of the esophagus or upper abdomen, use of medication that affects gastrointestinal motility, and obstetric urgency. Patients were asked to follow fasting instructions (8 h after solid foods and 2 h after clear liquids). Clear liquids included water, fruit juice, maltodextrin, carbonated liquids, tea or coffee. In the institution where this study was performed there is no routine for pharmacological prophylaxis against PA before elective C-section, unless requested by the responsible anesthesiologist. A questionnaire was applied to identify demographic and clinical characteristics, such as age, weight, body mass index (BMI), gestational age, parity, previous C-section, fasting time, and type of last diet. Ultrasound examination was performed by a single anesthesiologist (CKA) at the time of admission in the Department of Obstetrics, through a standardized scanning technique using a portable device equipped with a curvilinear probe of 2–5 MHz (S-Nerve® Ultrasound System, SonoSite, Inc., Bothel, WA, USA). Parturients were placed with head elevation at  $45^\circ$  in right lateral decubitus (RLD)—in this position the liquid or semi-liquid content gravitates preferentially to the antrum and the air or gas is displaced proximally to the body or fundus, which facilitates ultrasound scan of the gastric antrum (GA). GA was visualized in a sagittal plane in the epigastrium, along the border of the left hepatic lobe and at the aorta level. The ACSA was calculated using the formula  $(A \times B \times \pi)/4$ , where A (the anteroposterior diameter) and B (the craniocaudal diameter) of the antrum (Fig. 1) were considered an ellipse; each ACSA was determined by an average of three consecutive measurements.<sup>15</sup> The GV in mL was estimated using a mathematical model previously validated in non-pregnant adults as follows:  $27 + 14.6 \times \text{ACSA} (\text{cm}^2) - 1.28 \times \text{age} (\text{years})$ .<sup>11</sup>

The primary endpoint was the ACSA measurement. The secondary outcomes included GV estimation,



**Figure 1** Ultrasonographic image showing the measurement of the gastric antral cross-sectional area of a pregnant woman (F, liver; U, uterus; Ao, aorta). A and B are the antrum largest perpendicular diameters.

incidence of pregnant women at risk for PA (EGV  $\leq 1.5 \text{ mL.kg}^{-1}$  was adopted as a borderline normal value),<sup>17–19</sup> and the association between ACSA and demographic and clinical characteristics of pregnant women. In addition, ACSA and EGV were compared according to BMI < 30 or  $\geq 30$ .

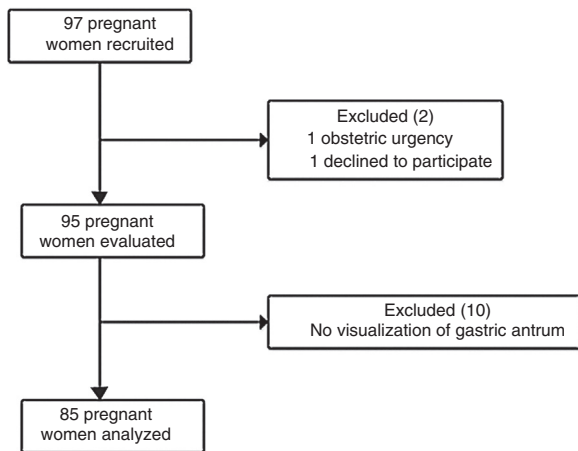
The sample calculation assumed a ACSA mean (SD) of  $4.83 (4.50) \text{ cm}^2$ ,<sup>15</sup> allowing a margin of error of 20%, a 95% confidence level, and an alpha error of 0.05. Thus, it was necessary to include 84 pregnant women. To this number we added 15% to compensate for possible losses, making up a final sample of 97 pregnant women.

After applying the Shapiro–Wilk test for normal data distribution, the values were presented as mean  $\pm$  standard deviation (SD) or median and interquartile range (IQR). Categorical or discrete data were presented as number and percentage with 95% CI. The 95<sup>th</sup> percentiles (CI) of ACSA and gastric volume were calculated using a binomial method. For ACSA and EGV comparison in the two BMI strata (<30 or  $\geq 30$ ), the Mann–Whitney test was used. The null hypothesis rejection criterion was  $p < 0.05$ . Analyses were performed using the Statistical Package for Social Sciences for Windows 21.

## Results

A total of 97 pregnant women were recruited for the study. In one pregnant woman, the ACSA was not measured due to the anticipation of urgent C-section and another parturient refused to participate in the study. In 10 pregnant women, the gastric antrum was not adequately visualized and 10.5% of inconclusive exams were excluded from the analysis. A total of 85 pregnant women were analyzed (Fig. 2). The demographic and clinical characteristics of the patients are described in Table 1.

Four patients did not meet the fasting recommendation for solid diet. In three of these it was necessary to postpone the operation until the minimum fasting time had elapsed (in one of them there was presence of solid food in the antrum) and in the fourth patient it was not possible to wait



**Figure 2** Flowchart of the study patients.

**Table 1** Demographic and clinical characteristics of patients.

	n = 85
Age (years)	28.1 ± 5
Weight (kg)	82 (72–93)
BMI (kg.m <sup>-2</sup> )	30.2 (26.9–34.4)
BMI < 30	43 (50.6)
BMI ≥ 30	42 (49.4)
Gestational age (weeks)	39.1 ± 1.3
No. of pregnancies	
1	23 (27)
2	24 (28.2)
≥ 3	38 (44.7)
No. of C-sections	
1	60 (70.5)
≥ 2	25 (29.4)
Comorbidities	
None	70 (82.3)
Preeclampsia	9 (10.5)
Gestational diabetes	3 (3.5)
Urinary tract Infection	2 (2.3)
Fasting time for solids (h)	10.6 (7.0–14.8)
Fasting time for clear liquids (h)	6.5 (3.7–12)

Data presented as mean ± standard deviation, median (interquartile range) and n (%).

the minimum fasting time, the C-section was performed due to suspected fetal distress. Twelve patients were fasted for more than 12 h. The median and IQR of fasting time for solid diet was 10.6 h (7.0–14.8).

Three patients did not meet the fasting recommendation for clear liquids, it was also necessary to postpone the operation. Twenty-one patients were fasted for more than 6 h for clear liquids. The fasting time median (IQR) for clear liquids was 6.5 h (3.7–12). The demographic and clinical characteristics of the patients are described in [Table 1](#).

The median (IQR) of ACSA was 4.0 cm<sup>2</sup> (2.8–6.3) and its 95% percentile was 10.3 cm<sup>2</sup> (95% CI: 7.6–15.6).

**Table 2** Gastric antral cross-sectional area (ACSA) and estimated gastric volume of patients.

	n = 85
ACSA (cm <sup>2</sup> )	
Median (IQR)	4.0 (2.8–6.3)
Percentile 95 (95% CI)	10.3 (7.62–15.67)
Gastric volume (mL)	
Median (IQR)	49.9 (34.6–85.6)
Percentile 95 (CI)	144.4 (112.5–219.6)
Gastric volume (mL.kg <sup>-1</sup> )	
Median (IQR)	0.62 (0.39–0.95)
Percentile 95 (95% CI)	1.42 (1.20–2.64)
Gastric volume > 1.5 mL.kg <sup>-1</sup> n [% (95% CI)]	3 [3.5 (1.2–9.8)]

CI, confidence interval; IQR, interquartile range.

**Table 3** Spearman correlation between gastric antral cross-sectional area (cm<sup>2</sup>) and demographic and clinical characteristics of the patients.

	ACSA correlation coefficient	p-value
Age (years)	–0.138	0.206
Weight (kg)	0.339	0.001
Body mass index (kg.m <sup>-2</sup> )	0.374	0.001
Gestational age (weeks)	0.020	0.837
Fasting for clear liquids (h)	0.032	0.818
Fasting for solids (h)	–0.266	0.161

The values represent Spearman’s rho correlation coefficients and their corresponding p values. Level of significance at p < 0.05.

The median (IQR) of EGV in mL and in mL.kg<sup>-1</sup> were 49.8 mL (33.7–87.2) and 0.62 mL.kg<sup>-1</sup> (0.39–0.95), respectively. The 95th percentile of EGV in mL and EGV in mL.kg<sup>-1</sup> were 144.4 mL (95% CI: 112.5–219.6) and 1.42 mL.kg<sup>-1</sup> (95% CI: 1.20–2.64), respectively.

The incidence of pregnant women at risk for PA (EGV > 1.5 mL.kg<sup>-1</sup>) was 3.5% (95% CI: 1.2–9.8). Of these, one had an EGV of 4.24 mL.kg<sup>-1</sup>, ACSA of 18.7 cm<sup>2</sup>, and gastroesophageal reflux disease; another had an EGV of 2 mL.kg<sup>-1</sup>, ACSA of 14.4 cm<sup>2</sup>, BMI = 41.2 kg.m<sup>-2</sup>, gestational diabetes; another had EGV of 2 mL.kg<sup>-1</sup>, ACSA of 11.4 cm<sup>2</sup>, and a 7-h fast for solids. ACSA and the estimated gastric volume of the patients are described in [Table 2](#).

All C-sections were uneventful. There was no incidence of vomiting in any patient.

Continuous demographic and clinical variables did not show normal distribution, except for the age variable. In the Spearman correlation analysis between ACSA and these variables, we found a positive correlation between ACSA with weight = 0.339 (p < 0.001) and BMI = 0.374 (p < 0.001) ([Table 3](#)).

ACSA and EGV of patients with BMI ≥ 30 were higher than those with BMI < 30. The median (IQR) ACSA of patients with BMI < 30 was 3.6 (2.5–5.0) and of those with BMI ≥ 30 was 4.6 (3.3–7.1); p = 0.01. While the median (IQR) EGV of patients with BMI < 30 was 49.0 (23.3–66.3) and of those with BMI ≥ 30 was 57.6 (40.9–99.3); p = 0.02 ([Table 4](#)).

**Table 4** Gastric antral cross-sectional area (ACSA) and estimated gastric volume (EGV) according to the patients' body mass index (BMI).

	BMI < 30 <i>n</i> = 43	BMI ≥ 30 <i>n</i> = 42	<i>p</i> -value
ACSA (cm <sup>2</sup> )	3.6 (2.5–5.0)	4.6 (3.3–7.1)	0.01
EGV (mL)	49.0 (23.3–66.3)	57.6 (40.9–99.3)	0.02

Data presented as median (interquartile range).

Mann–Whitney test. Level of significance at  $p < 0.05$ .

## Discussion

Studies have performed ultrasound-guided GC assessments in the early preoperative period of pregnant women scheduled for elective C-section.<sup>18,20–24</sup> Our study was designed to be performed in a scenario that reflects the day-to-day of the institution's obstetrical service and for prompt decision-making based on these subsidies regarding the potential risk of PA of GC in each patient. It was also decided to measure the ACSA only in the RLD, as the ACSA measured in this position seems to correlate more strongly with the GV.<sup>16</sup>

Gastric ultrasound may be challenging in parturients as a result of uterine compression that changes commonly used landmarks previously described in non-pregnant adult patients. Moreover, many patients in this study were on prolonged fasting, which may hinder the gastric antrum identification. However, the rate of inconclusive exams was 10.5%, which is similar to that of previous reports (2%–17.4%).<sup>14,15,18,21</sup>

About 50% of the pregnant women in the present study were obese, reflecting the trend of increasing prevalence of obesity in the world.<sup>25</sup> When we stratified the pregnant women according to the BMI (<30 or ≥30), we found that the ACSA and RGV values of pregnant women with BMI ≥ 30 were higher than those with BMI < 30 ( $p = 0.01$  and  $p = 0.02$ ). This result suggests that these obese pregnant women may be under a higher risk for PA of GC. The ASA guideline<sup>26</sup> for obstetric anesthesia recommends that a pregnant woman scheduled for elective C-section should have a fasting period of 6–8 h, depending on the type of food ingested (e.g., 8 h for fat content); however, it does not provide a specific recommendation regarding oral intake for obese pregnant women. Wong et al.<sup>27</sup> demonstrated that the ACSA of obese pregnant women (BMI ≥ 35 kg·m<sup>-2</sup>) 60 minutes after ingestion of 300 mL of water was similar to the ACSA evaluated in fasting. However, when comparing the gastric antrum of these fasting obese pregnant women with those of non-obese pregnant women in a study previously conducted by the same authors,<sup>20</sup> the ACSA mean (standard deviation) was higher in the former, 5.18 ± 2.13 cm<sup>2</sup> vs. 4.07 ± 2.5 cm<sup>2</sup> ( $p = 0.02$ ).

The fasting time for solid (10.6 h) and clear liquid diet (6.5 h) does not differ much from that of other studies.<sup>15,18,21</sup> A low adherence was observed with regard to maintenance orientation, especially the fasting time of 2 h for clear liquids (extrapolated three-fold as recommended), and the difficulty of implementing fasting recommendations of 6–8 h

for solids and 2 h for liquids was observed in healthy and out of labor pregnant women.<sup>26</sup>

The results of this study are in agreement with those of other studies regarding ACSA and EGV evaluated in women in the third trimester of pregnancy positioned in right lateral decubitus. The median ACSA in our study was 4.0 cm<sup>2</sup>; while in three other studies it ranged from 4.0 to 4.8 cm<sup>2</sup>.<sup>15,18,20</sup> While the median EGV of 49.8 mL was very close to the result of the study by Arzola et al.,<sup>18</sup> which was 48.1 mL.

The correlation study between ACSA and weight and BMI showed a positive but weak correlation. There was also no correlation of ACSA with fasting time, a result similar to that found in the study by Arzola et al.<sup>18</sup>

The ACSA 95th percentile value in this study differs slightly from that found by Arzola et al. (≤10.3 vs. ≤9.6 cm<sup>2</sup>).<sup>18</sup> It should be noted that in a recent study, Arzola et al.<sup>28</sup> reinforced the recommendation to use the cutoff point of 9.6 cm<sup>2</sup> for ACSA, which corresponded to the area under the curve of 82 (95% CI 0.72–0.93) to discriminate a low from a high GV. In this study, 3.5% of our patients were at risk for PA, very different from the study by Hakak et al., who reported that approximately one third of their patients had EGV > 1.5 mL·kg<sup>-1</sup>; however, their patients were on solid food fasting (light solid diet) for 6 h. These authors suggested that a 6-h fast for this type of food may not be sufficient to ensure residual gastric volumes considered low risk for PA.

In the light of the results of our study, some patients were at risk for pulmonary aspiration, so it would be important to follow the guidance proposed by the ASA, which advocates the use of H<sub>2</sub> receptor antagonists, non-particulate antacids, and metoclopramide before C-section in order to prevent PA.

The present study has some limitations. First, it was decided not to exclude obese pregnant women, those with gastroesophageal reflux disease, diabetes, hypertensive gestation disease, and gestation with polyhydramnios, but this decision may hinder the external validation of our results. Second, a mathematical model was used to estimate the validated GV in non-pregnant subjects with BMI < 40 kg·m<sup>-2</sup>. This was due to the fact that when we developed the research project of this study there was no validated mathematical model in pregnant women. However, a model for this purpose has recently been described. And this model showed a good Pearson correlation coefficient between ACSA and GV of 0.73,<sup>28</sup> which contrasted with the coefficient of 0.86 of the model used in this study.<sup>11</sup> Third, the results were based on the comparison of data provided by a single technique (ACSA ultrasonographic examination) and the actual GV of each parturient was not confirmed by other

non-invasive methods. Fourth, many participants had fasting intervals longer than the minimum recommended by current guidelines, and the results may not apply to patients who more closely follow the minimum guidelines for fasting before surgery.

In conclusion, this study showed that the ACSA was 4 cm<sup>2</sup> and correlated with weight and BMI. The GV was estimated to be 49.8 mL. Of the patients, 95% had ACSA values  $\leq 10.3$  cm<sup>2</sup>; EGV of  $\leq 144.4$  mL, which corresponded to a GV of  $\leq 1.43$  mL.kg<sup>-1</sup>. The incidence of patients at risk for PA was 3.5%. Therefore, we emphasize the need for ACSA evaluation, especially in those cases whose fasting state is unclear or unknown and also in obese patients, and the use of preventive measures to reduce the risk of PA of GC as those recommended by ASA.<sup>26</sup> Thus, the use of ultrasound for GC evaluation has proved to be a useful and promising tool. However, more studies are needed for its validation in our population.

## Conflicts of interest

The authors declare no conflicts of interest.

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