Ultrasound assessment of gastric contents and volume in patients before and after endoscopic endonasal transsphenoidal surgery: a prospective observational study

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Article

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Abstract

Surgical procedures may affect the changes in gastric contents and volume, resulting in a potential risk of pulmonary aspiration. We aimed to assess the differences in preoperative and postoperative gastric contents and volume in patients undergoing endoscopic endonasal transsphenoidal surgery using ultrasound and determine the potential factors associated with intraoperative volume changes. This prospective study enrolled 71 adult patients diagnosed with pituitary adenoma. Semi-quantitative (Perlas score: grade 0, 1, or 2) and quantitative (cross-sectional area, CSA) ultrasound scans of the gastric antrum were performed before anaesthetic induction and postoperatively in semirecumbent and semirecumbent-right lateral positions. The postoperative median (interquartile [range]) antral CSA in both positions were 3.5 cm$^2$ (3.3–3.7 [2.9–12.1]) and 3.7 cm$^2$ (3.4–4.6 [2.9–26.6]), significantly higher than the preoperative values of 3.3 cm$^2$ (3.1–3.4 [2.7–3.9]) and 3.4 cm$^2$ (3.2–3.7 [2.8–5.7]), respectively ($P=0.001$). The postoperative estimated gastric volume was 20.2 ml (2.2–42.7 [0–316.7]), significantly larger than the preoperative value of 14.5 ml (0–32.6 [0–66.4]) ($P=0.001$). Seven (9.9%) patients showed significant volume changes, from preoperative grade 0 to postoperative grade 2 (estimated volume > 1.5 ml.kg$^{-1}$) ($P=0.02$). Logistic regression analysis revealed that gastroesophageal reflux, intraoperative irrigation volume, and anaesthesia duration were independent risk factors for significant intraoperative volume changes ($P<0.05$). Our results show that significant change in gastric volume was presented in some patients because of the special surgical procedures and comorbidities. Anesthesiologists could use antral ultrasonography to prevent this potential risk of aspiration in patients after transsphenoidal procedures.

1. Introduction

Regurgitation and aspiration of gastric contents are serious perioperative complications [1, 2]. Currently, aspiration pneumonitis and pneumonia remain the primary causes of death in anesthesia airway management accidents, with a significant mortality rate of approximately 5–9% [3–5]. The three major factors that affect morbidity and mortality include the aspiration of solid particulate matter, aspirate volumes > 0.8 ml.kg$^{-1}$, and lower pH (< 2.5) of the aspirated contents [1, 6, 7].

Present a large volume of gastric contents is the most important risk factor for pulmonary aspiration during anesthesia management. The practice guidelines for preoperative fasting ensure gastric emptying before anesthesia induction to reduce the risk of aspiration and are suitable for healthy patients undergoing elective surgery [8]. However, they are not applicable for patients undergoing urgent or emergency surgery and those with critical comorbidities. Moreover, some surgical procedures may affect the changes in gastric content and volume, resulting in a potential risk of pulmonary aspiration during recovery from anesthesia.

Endoscopic endonasal transsphenoidal surgery is a neurosurgical procedure used extensively to resect pituitary tumours. In clinical practice, the patients undergoing this procedure often had a high incidence of postoperative nausea and vomiting [9]. The large volume of vomit significantly increased the
postoperative risk of aspiration. However, there is limited objective information regarding the gastric contents and volume in these neurosurgical populations during postoperative period.

Ultrasound, as a point-of-care diagnostic tool, can rapidly and reliably assess gastric contents using qualitative and quantitative analyses [10, 11]. The antral cross-sectional area (CSA) is positively correlated with the volume of gastric contents [11]. Several studies conducted on adults and children have focused on preoperative ultrasonography to determine the gastric contents and volume, which could minimise the aspiration risk in anesthesia induction and improve patient outcomes [12–14]. In this prospective observational study, we aimed to use ultrasonography to assess the gastric contents and volume in patients immediately before and after endoscopic endonasal transsphenoidal surgery and report the incidence and factors associated with significant changes in gastric volume during this procedure.

We hypothesized that significant changes in gastric volumes occur in some patients during transsphenoidal surgical procedures. The primary outcomes were the antral CSA before and after transsphenoidal surgery. The secondary outcomes included antral grade, gastric volume distribution, and the incidence and factors associated with significant intraoperative volume changes.

2. Materials And Methods

2.1. Study design and approval

This prospective observational study was registered at http://www.chictr.org.cn (ChiCTR2100045110) on 7 April 2021 and approved by the Institutional Ethics Committee of Lanzhou University Second Hospital (Lanzhou, China) on 11 May 2021 (protocol number 2021A-381). Informed consent was obtained from each participant before initiating the study. This study was designed and conducted according to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines [15].

This study was conducted at a tertiary-level teaching hospital between May 2021 and March 2022. The inclusion criteria were: (i) patients aged 18–80 years, (ii) American Society of Anesthesiologists (ASA) physical status I–III, (iii) patients diagnosed with pituitary adenoma, and (iv) scheduled for elective endoscopic endonasal transsphenoidal surgery for pituitary tumour excision. The exclusion criteria were: (i) patients with a body mass index (BMI) ≥ 35 kg.m$^{-1}$, (ii) patients with preoperative nasogastric tube, (iii) patients with altered states of consciousness, (iv) pregnant women, (v) patients with abnormal anatomy of the upper gastrointestinal tract, (vi) history of previous oesophageal or gastric surgery, (vii) gastric cancer, (viii) failure to follow preoperative fasting guidelines, (ix) hemodynamic instability, (x) declined participation, and (xi) transfer to the intensive care unit after surgery. According to the standard institutional practice of our hospital, all patients fasted for at least 8 h for solid foods (bread, rice, and noodles) and 2 h for clear fluids (carbohydrate beverage, tea, and fruit juice) before the elective surgery. No antacids were administered prophylactically.

2.2. Gastric ultrasonography
After arriving in the operating room, the participants were successively positioned in semirecumbent and semirecumbent-right lateral positions, with the head of the bed elevated 30° for preoperative ultrasound scanning. We used a portable ultrasound device with a curved low-frequency (2–5 MHz) probe and a high-resolution transducer (FUJIFILM SonoSite Bothell, Washington, USA). We followed the standardized ultrasound scanning protocol as previously described [10]. Briefly, the ultrasound probe was placed on the epigastria to obtain the sagittal scanning planes. To locate the gastric antrum, we used the left lobe of the liver and the posterior pancreas as the internal anatomical landmarks at the plane of the inferior vena cava.

We qualitatively assessed the nature (nil, fluid, or solid particles) of the gastric contents in semirecumbent and semirecumbent-right lateral positions. An empty stomach appeared as the antrum walls juxtaposed with a "flat" appearance. Clear fluid appeared as "homogeneously hypoechoic" liquid contents without residues. Solid contents appeared as a "frosted glass," accompanied by acoustic shading, which impaired the visualization of the posterior wall [10]. The antral grade was classified according to the existing three-point grading system (Perlas score) for semi-quantitative assessment: grade 0 corresponded to no appeared any contents in both positions (completely empty stomach); grade 1 corresponded to visualisation of liquid contents only in the semirecumbent-right lateral position (low volume status); grade 2 corresponded to visualisation of liquid contents in both positions (high volume status) [12].

Quantitative assessment of the gastric contents was performed only in the semirecumbent-right lateral position. The antral CSA (cm²) was obtained using the free tracing caliper of the ultrasound machine and included the entire serous layer. We used the mean of three consecutive measurements of this area during the interval of peristaltic contractions for the final analysis. The estimated gastric volumes were calculated according to a previously validated formula: gastric volume (ml) = 27.0 + (14.6 × CSA) – (1.28 × Age) [16]. Risk stomach was defined as Perlas grade 2 or estimated gastric volumes ≥ 1.5ml.kg⁻¹, while non-risk stomach was defined as estimated gastric volumes < 1.5ml.kg⁻¹.

Following preoperative ultrasonography, all participants were placed in a supine position and continuously monitored with electrocardiography, peripheral oxygen saturation, and non-invasive blood pressure. They were premedicated with intravenous midazolam (0.05 mg.kg⁻¹) and penehyclidine hydrochloride (0.5–1 mg). General anesthesia was intravenously induced with etomidate (2 mg.kg⁻¹) and sufentanil (0.5 µg.kg⁻¹), followed by a tracheal intubation with rocuronium (0.6 mg.kg⁻¹). Anesthesia was maintained by the intravenous administration of propofol (4–6 mg.kg⁻¹.h⁻¹) or inhalation anesthesia (2% sevoflurane in 50% oxygen and air mixtures), and continuous intravenous administration of remifentanil (0.2–0.3 µg.kg⁻¹.min⁻¹). We continuously monitored the depth of anesthesia using a bi-spectral index and targeted the range of 40–60. All patients received 4 mg ondansetron intravenously following anesthesia induction to prevent postoperative nausea and vomiting.

An experienced neurosurgical team performed endoscopic endonasal transsphenoidal surgery for pituitary tumours resection using standard surgical procedures [17]. The patients were positioned in a semirecumbent position with the head of the bed elevated to 15–20° and their heads slightly turned...
toward the surgeon. After applying a nasal decongestant, an endoscope was introduced through the chosen nostril. The nasal cavity was enlarged, and the anatomical landmarks adjacent to the sphenoid sinus were identified. Subsequently, the sellar floor was dissected to expose the pituitary fossa, the dura was incised, and the tumour was curetted. The sellar cavity was packed with gelatin sponges for hemostasis and laid over with dural substitutes. Following revision hemostasis, intranasal anatomy was restored without nasal packing. The endoscope lens and operating field were cleaned continuously throughout the surgical procedures using an irrigation sheath connected to an automated irrigation system. The irrigation fluid (0.9% saline) was suctioned intermittently using a negative pressure suction device.

After surgery, the patients immediately underwent postoperative gastric ultrasonography, similar to the protocol for preoperative scanning positions for semi-quantitative and quantitative evaluation. The patients were then transferred to the postanesthesia care unit for recovery from anesthesia and tracheal extubation. If necessary, 30 mg ketorolac was administered intravenously for postoperative pain management. We recorded the incidence of regurgitation or vomiting and pulmonary aspiration within 2 hours of emergence from anesthesia.

2.3. Data collected

Preoperative ultrasonography was performed by an attending anesthesiologist (HT.J) and postoperative ultrasonography by another anesthesiologist (ET.H) blinded to the preoperative findings and surgical procedures. Each had performed at least 80 gastric ultrasound examinations on adult patients. The correlation coefficient of intra- and inter-performer reliability of the antral measurements was > 0.92 in our pilot trial. The third anaesthesiologist collected and analysed the data.

The following demographic characteristics and surgical variables were collected: age, sex, weight, height, body mass index, ASA physical status classification, fasting duration for solids and liquids, classification of pituitary tumours, the status of the co-morbid conditions (hypertension, diabetes mellitus, oesophageal motility disorders, gastroesophageal reflux, hiatal hernia, etc.), duration of anesthesia and surgery, intraoperative volumes of irrigation fluid, and blood loss.

2.4. Statistical analysis

We calculated the required sample size using PASS software, version 11 (NCSS Statistical Software, Kaysville, Utah). According to previous reports of $2.8 \pm 1.15 \text{ cm}^2$ for antral CSA in elective fasted patients and $>3.4 \text{ cm}^2$ for risk stomach [11], we required 71 participants to detect a $0.6 \pm 2 \text{ cm}^2$ differences between preoperative and postoperative antral CSA, with a significance level of 0.05 and a power of 0.8.

We performed the Kolmogorov–Smirnov test to assess continuous variables with normal distribution. Normally distributed continuous variables were expressed as mean ± standard deviation (SD) and compared using the Student’s $t$-test. If the data were not normally distributed, they were expressed as medians (interquartile [range]) and compared using the Wilcoxon signed-rank test. Categorical variables were expressed as frequencies (percentage) or ratios and compared using Pearson’s chi-square test or
Fisher’s exact test, as appropriate. Moreover, we used univariate and multivariate binary logistic regression analysis to identify patients and/or surgical factors associated with postoperative risk stomach (≥ 1.5 ml kg\(^{-1}\)). All significant variables (\(P<0.10\)) associated with postoperative risk stomach in the univariate logistic regression analysis were subjected to multivariate analysis in a stepwise method. The Hosmer–Lemeshow test was used to identify the goodness of fit of the multivariate logistic regression analysis models with \(P>0.05\). The results are presented as odds ratios (OR) with 95% confidence intervals (CI). Statistical analyses were performed using SPSS version 19.0 (IBM, Armonk, New York, USA). The differences were considered statistically significant at \(P<0.05\) with a two-tailed test.

3. Results

Ninety-six patients were enrolled consecutively. We excluded four patients with a history of upper gastrointestinal surgery, four with altered states of consciousness, seven with hemodynamic instability, and three unwilling to participate during the process of eligibility assessment. Following preoperative gastric ultrasound screening, five (6.4%) patients underwent delayed surgery due to the presence of solid particles, while the antrum could not be clearly visualized in two (2.6%) patients. The 71 remaining patients completed preoperative and postoperative ultrasound examinations and were included in the final analysis (Fig. 1). Table 1 presents their demographic characteristics. The mean ± SD of fasting duration was 8.6 ± 1.9 h and 3.6 ± 1.3 h for solid foods and clear liquids, respectively. The most common type of pituitary adenoma in our cohort was non-functioning (56%), followed by lactotrophs (17%), corticotrophs (11%), somatotrophs (10%), and thyrotrophs (6%). Forty-one (57.7%) and 30 (42.3%) patients received total intravenous anesthesia and inhalation anesthesia, respectively.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male:female</td>
<td>32:39</td>
</tr>
<tr>
<td>Age (years)</td>
<td>50 ± 14</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>66.8 ± 7.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.8 ± 8.8</td>
</tr>
<tr>
<td>Body mass index (kg.m(^{-2}))</td>
<td>24.7 ± 3.7</td>
</tr>
<tr>
<td>ASA physical status I:II:III</td>
<td>29:31:11</td>
</tr>
<tr>
<td>Fasting duration for solids (h)</td>
<td>8.6 ± 1.9</td>
</tr>
<tr>
<td>Fasting duration for liquids (h)</td>
<td>3.6 ± 1.3</td>
</tr>
</tbody>
</table>

Values are presented as mean ± SD or ratios
Table 2 summarises the results of the semi-quantitative and quantitative ultrasound assessment of the gastric contents before and after endoscopic endonasal transsphenoidal surgery. Sixty-four (90.1%) patients did not display any gastric contents in both semirecumbent and semirecumbent-right lateral positions in the preoperative examination (grade 0), 52 (73.2%) among them did not demonstrate any change in the postoperative examination, and five (7%) patients showed a change of only one grade (from preoperative grade 0 to postoperative grade 1). Seven (9.9%) patients had a small volume of gastric liquid in the preoperative semirecumbent-right lateral position (grade 1) and no significant change in the postoperative examination. Another seven (9.9%) patients showed an empty stomach (grade 0) in preoperative examinations but presented a larger volume of liquid content in the postoperative examination (grade 2) \( (P = 0.02) \). Figure 2 depicts a gastric ultrasound image of the same patient that shows an empty stomach (flat antrum) preoperatively (A) and a larger volume of liquid content (homogeneously hypoechoic) postoperatively (B).

Table 2
Antral grades, antral cross-sectional areas, and estimated gastric volumes before and after transsphenoidal surgery

<table>
<thead>
<tr>
<th></th>
<th>Preoperative ((n=71))</th>
<th>Postoperative ((n=71))</th>
<th>(P)-value</th>
<th>(\chi^2 / Z)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antral grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>64 (90.1%)</td>
<td>52 (73.2%)</td>
<td>0.009</td>
<td>6.78</td>
</tr>
<tr>
<td>Grade 1</td>
<td>7 (9.9%)</td>
<td>12 (16.9%)</td>
<td>0.218</td>
<td>1.52</td>
</tr>
<tr>
<td>Grade 2</td>
<td>0</td>
<td>7 (9.9%)</td>
<td>0.020</td>
<td>5.41</td>
</tr>
<tr>
<td>Semirecumbent position</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antral cross-sectional area ((cm^2))</td>
<td>3.3 (3.1–3.4 [2.7–3.9])</td>
<td>3.5 (3.3–3.7 [2.9–12.1])</td>
<td>0.001</td>
<td>-6.397</td>
</tr>
<tr>
<td>Semirecumbent-right lateral position</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antral cross-sectional area ((cm^2))</td>
<td>3.4 (3.2–3.7 [2.8–5.7])</td>
<td>3.7 (3.4–4.6 [2.9–26.6])</td>
<td>0.001</td>
<td>-4.556</td>
</tr>
<tr>
<td>Estimated gastric volume ((ml))</td>
<td>14.5 (0–32.6 [0–66.4])</td>
<td>20.2 (2.2–42.7 [0–316.7])</td>
<td>0.001</td>
<td>-4.034</td>
</tr>
<tr>
<td>Estimated gastric volume ((ml.kg^{-1}))</td>
<td>0.2 (0–0.5 [0–0.9])</td>
<td>0.3 (0.1–0.6 [0–4.6])</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are presented as frequency (percentage) or median (interquartile [range]).

For the entire cohort, the postoperative median (interquartile [range]) antral CSA in the semirecumbent position and semirecumbent-right lateral position were 3.5 cm\(^2\) (3.3–3.7 [2.9–12.1]) and 3.7 cm\(^2\) (3.4–4.6 [2.9–26.6]), which were significantly higher than their corresponding preoperative values of 3.3 cm\(^2\) (3.1–3.4 [2.7–3.9]) and 3.4 cm\(^2\) (3.2–3.7 [2.8–5.7]), respectively \( (P = 0.001) \). The postoperative median...
interquartile range) estimated gastric volume in the semirecumbent-right lateral position was 20.2 ml (2.2–42.7 [0–316.7]), which was also significantly higher than the preoperative estimated volume of 14.5 ml (0–32.6 [0–66.4]) \((P=0.001)\) (Table 2). The patients (seven cases) who showed a significant intraoperative volume changes (from preoperative grade 0 to postoperative grade 2) had postoperative median antral CSA of 18.55 cm\(^2\) (range 9.86–26.59 cm\(^2\)) and estimated gastric volume of > 1.5 ml.kg\(^{-1}\) (median 3.1, range 1.6–4.6 ml.kg\(^{-1}\)); while the remaining 64 patients (postoperative grade 0 and 1) had median antral CSA of 3.58 cm\(^2\) (range 2.9–6.9 cm\(^2\)) and estimated volume of < 1.5 ml.kg\(^{-1}\) (median 0.3, range 0–1.2 ml.kg\(^{-1}\)) \((P<0.05, \text{respectively})\). Supplementary file 1 (Supplementary Fig. 1) shows the frequency distribution of the preoperative and postoperative estimated gastric volumes.

To identify the risk factors for intraoperative volume changes, we further categorized the patients as risk stomach group (≥ 1.5 ml.kg\(^{-1}\)) and non-risk stomach group (< 1.5 ml.kg\(^{-1}\)), based on the postoperative ultrasound estimated gastric volume. In this subgroup analysis (Supplementary file 2: Supplementary Table 1), we found that the patients’ characteristics (age, sex, body mass index, and ASA physical status), preoperative fasting duration for solids and fluids, anesthesia type, and pituitary adenomas classification showed no significant difference between the subgroups \((P>0.05)\). Conversely, the anesthesia and operation durations were longer, and the intraoperative irrigation volumes were larger in the risk stomach group \((P<0.05)\). The rate of comorbidities showed no significant difference between the subgroups except the gastroesophageal reflux was higher in the risk stomach group \((P=0.004)\). In addition, the results of logistic regression analysis revealed that gastroesophageal reflux, large intraoperative irrigation volume, and long anaesthesia duration were independent risk factors for postoperative risk stomach and associated with significant intraoperative volume changes \((P<0.05)\) (Table 3).
Table 3

Logistic regression analyses of the risk factors for postoperative risk stomach ($\geq 1.5 \text{ ml.kg}^{-1}$) with patients' and surgical variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate analysis</th>
<th>Multivariate analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P$-value</td>
<td>Odds ratio (95% CI)</td>
</tr>
<tr>
<td>Age</td>
<td>0.556</td>
<td>1.017 (0.962–1.074)</td>
</tr>
<tr>
<td>Sex</td>
<td>0.365</td>
<td>0.453 (0.082–2.511)</td>
</tr>
<tr>
<td>Body mass index</td>
<td>0.307</td>
<td>1.112 (0.907–1.362)</td>
</tr>
<tr>
<td>ASA physical status classification</td>
<td>0.052</td>
<td>5.250 (0.988–27.895)</td>
</tr>
<tr>
<td>Type of anaesthesia</td>
<td>0.363</td>
<td>2.080 (0.429–10.087)</td>
</tr>
<tr>
<td>Anaesthesia duration</td>
<td>0.004</td>
<td>1.021 (1.007–1.035)</td>
</tr>
<tr>
<td>Operation duration</td>
<td>0.135</td>
<td>1.009 (0.997–1.020)</td>
</tr>
<tr>
<td>Volume of irrigation fluid</td>
<td>0.015</td>
<td>1.001 (1.000–1.002)</td>
</tr>
<tr>
<td>Total blood loss</td>
<td>0.630</td>
<td>1.001 (0.996–1.006)</td>
</tr>
<tr>
<td>Oesophageal motility disorders</td>
<td>0.068</td>
<td>6.000 (0.873–41.214)</td>
</tr>
<tr>
<td>Gastrooesophageal reflux</td>
<td>0.002</td>
<td>15.733 (2.725–90.843)</td>
</tr>
<tr>
<td>Hiatal hernia</td>
<td>0.206</td>
<td>5.167 (0.406–65.677)</td>
</tr>
<tr>
<td>Preoperative hypertension</td>
<td>0.326</td>
<td>2.444 (0.410–14.566)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>0.123</td>
<td>3.614 (0.707–18.476)</td>
</tr>
<tr>
<td>Fasting duration for solids</td>
<td>0.227</td>
<td>1.266 (0.864–1.855)</td>
</tr>
<tr>
<td>Fasting duration for liquids</td>
<td>0.305</td>
<td>1.342 (0.765–2.354)</td>
</tr>
<tr>
<td>Pituitary adenoma classification</td>
<td>0.454</td>
<td>1.827 (0.377–8.844)</td>
</tr>
</tbody>
</table>

Data are expressed as the odds ratio (95% CI)

Three patients had vomiting after tracheal extubation, while none experienced aspiration after oropharyngeal suctioning.
4. Discussion

In this prospective observational study, we used ultrasound to assess the gastric contents and volume in adult patients immediately before and after elective endoscopic endonasal transsphenoidal surgery to evaluate the perioperative risk of aspiration. Previously, evaluation of the perioperative risk of aspiration depended exclusively on the preoperative fasting duration. The current practice guidelines suggest that fasting for at least 6 h after a light meal and 2 h after clear fluids before the induction of anesthesia is adequate to empty the gastric contents and minimise the aspiration risk in adult patients undergoing elective surgeries [8]. However, in clinical context, despite following the recommended instructions for fasting, up to 5% of elective surgical patients presented with a full stomach or risk stomach during anesthesia induction [14]. During the initial screening process of our study, five (6.4%) patients presented with solid particles during the preoperative ultrasound examination, which was similar to a previous report [14].

Patients undergoing transsphenoidal surgery frequently experience significant vomiting, regurgitation, and aspiration during postoperative extubation or anesthesia recovery [9, 18]. The preoperative fasting guidelines cannot predict the changes in the gastric contents and volume during this neurosurgical procedure or the rate of postoperative risk stomach. Therefore, ultrasound assessment of the gastric contents and volume is an appropriate and essential non-invasive technique in these cohort patients to evaluate the postoperative aspiration risk and improve outcomes. Our most important finding was that although no significant postoperative aspiration risk was observed in the majority of patients, there were seven (9.9%) patients with significant changes in the gastric volume during transsphenoidal surgery, from the preoperative empty stomach (grade 0) to postoperative risk stomach (grade 2). Meanwhile, the postoperative estimated gastric fluid volume (>1.5 ml.kg$^{-1}$) was significantly larger than that expected in fasted patients who underwent elective surgical procedures, which significantly increased the postoperative risk of aspiration.

These results could be attributed to several factors. First, during this special neurosurgical procedure, the head of the bed was elevated 15–20° to reduce bleeding and cerebrospinal fluid leakage. However, this position potentially allows the downward flow of blood, cerebrospinal fluid, and irrigation fluid (used to clean the endoscope lens and operating field) from the oropharynx to the oesophagus and stomach due to gravity [17, 19]. Second, the upper and lower oesophageal sphincter tone, barrier pressure between the oesophagus and stomach, and intragastric pressure were significantly lower in patients receiving general anesthesia [1, 20–22]. Moreover, the oesophageal sphincter tone was also decreased in patients with critical comorbidities such as esophageal motility disorders, gastroesophageal reflux disease, or hiatal hernia [23]. These complex factors promoted the downward flow of a large volume of liquids from the oropharynx to the oesophagus and stomach during longer anaesthesia and operation duration, thereby resulting in significant changes in the intraoperative gastric volume. The logistic regression analysis confirmed these correlations (Table 3). However, we did not find a significant relationship between the ASA physical status or diabetes mellitus and postoperative risk stomach, although these variables are the
main risk factors for delayed gastric emptying and increased perioperative pulmonary aspiration of gastric contents in elective surgical patients [14, 24].

Our findings emphasize that more precautions are needed during postoperative extubation in patients undergoing transsphenoidal surgery. The use of throat packing may effectively prevent the downward flow of irrigation fluid and blood from the oropharynx to the oesophagus and stomach. Moreover, perfect hemostasis, intraoperative suctioning, prophylactic antiemetic drugs, maintaining hemodynamic stability, smooth emergence from anaesthesia, and orogastric suctioning to remove ingested blood from the stomach could be useful in reducing the rate of postoperative nausea and vomiting [1, 18, 19, 25]. In addition, delayed extubation is mandatory in patients with a compromised level of consciousness. In our study, none of the patients with significant intraoperative volume changes experienced pulmonary aspiration after gastric ultrasound guidance.

This study has several limitations. Our results may not reflect the actual incidence of changes in gastric volume during transsphenoidal surgical procedures as the gastric emptying occurred continuously during the long surgical duration. Moreover, we did not determine the baseline volume of gastric secretions in the postoperative gastric contents. Furthermore, we did not include and analyse patients with obesity (BMI ≥ 35kg.m⁻¹), who accounted for a high proportion in this cohort and had a larger antral size and baseline gastric volume [26]. Lastly, our findings only reflect the local patterns related to intraoperative procedures (e.g. no throat packing) and the experience of the surgical teams. Therefore, the power is insufficient to generalize our results since our patients had relatively a low incidence rate of critical comorbidities. Large sample size and multicentre studies are required to further assess the prevalence of risk stomach associated with transsphenoidal or other relative surgical procedures.

In conclusion, our results show that significant change in gastric volume was presented in some patients because of the special surgical procedures and comorbidities. Anesthesiologists should be alert to this potential risk of aspiration in patients after transsphenoidal procedures. Perioperative point-of-care ultrasound assessment of gastric contents and volume, could facilitate prevent the aspiration risk and aid decision-making regarding tracheal extubation in patients undergone transsphenoidal surgery.

**Declarations**

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**Authors' contributions**

HT.J: study conception, design and execution, manuscript drafting. ET.H: study design and execution, data interpretation. W.H: data acquisition and revision of the manuscript. YL.L: patient recruitment and data acquisition. W.L: patient recruitment. XX.C: patient follow-up. YF.J: surgical execution and follow-up. YB.W: supervision and revision of the manuscript. All authors read and approved the final manuscript.
Data availability statement

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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Competing interests

The author(s) declare no competing interests.

References


**Figures**
Assessed for eligibility (n=96)

Excluded (n=18)
- History of upper gastrointestinal surgery (n=4)
- Altered state of consciousness (n=4)
- Hemodynamic instability (n=7)
- Declined to participate (n=3)

Ultrasound screening (n=78)

Excluded (n=7)
- Surgery delayed due to the presence of solid particles (n=5)
- Antrum cannot be visualized (n=2)

Preoperative scanning (n=71)

Excluded (n=0)

Final analysis (n=71)

Postoperative scanning (n=71)

Excluded (n=0)

Final analysis (n=71)

Figure 1

Patient flow chart
Figure 2

Antral ultrasound views from the same patient in the semirecumbent-right lateral position (A) before and (B) after endoscopic endonasal transsphenoidal surgery. L: liver; P: pancreas; SMV: superior mesenteric vein; IVC: inferior vena cava. Dotted circle: gastric antrum

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryFig.1.doc
- SupplementaryTable1.doc