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REVIEW

Ultrasound Assessment of Preoperative Gastric Contents for Predicting Aspiration Risk in Surgical Patients: A Scoping Review and Future Directions

Yuzhou Li[1,2], Li Tang[1,2], Shuying Zou[2,3], Xiangnan Zhu[1], Bo Zhang[2], Caixia Xie[2]

[1]School of Medicine, University of Electronic Science and Technology of China, Chengdu, People's Republic of China; [2]Department of Nursing, Sichuan Provincial People's Hospital, University of Electronic Science and Technology of China, Chengdu, People's Republic of China; [3]College of Nursing, Chengdu University of Traditional Chinese Medicine, Chengdu, People's Republic of China

Correspondence: Caixia Xie, Department of Nursing, Sichuan Provincial People's Hospital, University of Electronic Science and Technology of China, Chengdu, People's Republic of China, Email caixiaxie@uestc.edu.cn

Introduction: This scoping review aims to summarise studies evaluating gastric contents in surgical patients using preoperative ultrasound, discuss current challenges, and propose future directions.

Methods: The system retrieved data from 8 databases, including PubMed, with a search period spanning from the inception to May 11, 2025. The scoping review follows the JBI scoping review framework and the PRISMA-ScR reporting guidelines.

Results: A total of 44 studies were included. The research involved various perioperative populations and surgical procedures, with a "full stomach" rate ranging from 0% to 57.7%. Ultrasound operators included anesthesiologists, sonographers, and medical consultants. Assessment methods comprised qualitative, quantitative, or combined approaches. Evaluation metrics included gastric contents nature, Perlas 3-point grading system, gastric antral cross-sectional area (CSA), and gastric volume.

Conclusion: Preoperative gastric ultrasound can provide information about gastric contents, thereby aiding in the identification of aspiration risk and enabling the adoption of appropriate anaesthesia strategies. However, existing studies still face limitations, including restricted study populations and sample sizes, variations in operator training, a lack of consensus on an evaluation metric threshold value, and diverse gastric volume calculation models. Future studies should expand their scale, enhance training for clinicians in gastric ultrasound, and standardise assessment positions, threshold values, and selection criteria for calculation models. Furthermore, we believe that integrating artificial intelligence with gastric ultrasound can overcome the limitations of manual measurement, offering a direction for precise and convenient preoperative assessment of gastric contents.

Keywords: gastric ultrasound, gastric contents, aspiration, gastric antral cross-sectional area, anesthesia

Introduction

Patients undergoing surgery with inadequate fasting or delayed gastric emptying may harbour gastric contents exceeding safe thresholds, increasing aspiration risk during anaesthesia induction.[1] Even when following American Society of Anesthesiologists (ASA) fasting guidelines, 9–11.5% of elective surgery patients still have a "full stomach" (indicating a high risk of aspiration).[2,3] In diabetic patients with delayed gastric emptying, this proportion can reach 52.3%.[4] Pulmonary aspiration of gastric contents may cause acute airway obstruction, chemical pneumonitis, and respiratory failure, leading to patient death and increasing the burden on healthcare resources.[5] Studies indicate that the incidence of aspiration during anaesthesia ranges from 0.03% to 14%, with an aspiration-related mortality rate of 5%, which accounts for 9% of anaesthesia-related deaths.[1,6]

Currently, the clinical standard for assessing low aspiration risk is based on patients meeting the minimum fasting periods recommended by the ASA (2 hours of fluid restriction and 6–8 hours of fasting preoperatively), failure to meet these indicates high aspiration risk.[7] However, this standard is for healthy individuals and has limited applicability to special patient populations like those at risk of delayed gastric emptying.[8] Point-of-care ultrasound, an essential tool for

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anesthesiologists, is widely applied in vascular puncture, nerve blocks, and cardiac function assessment. In recent years, it has also been recommended for evaluating preoperative gastric contents to predict aspiration risk.[9] It can identify gastric contents nature through echogenicity, perform Perlas 3-point grading, and rapidly measure gastric antral cross-sectional area (CSA), which can be combined with formulas to quantify gastric volume, providing a basis for preoperative assessment.[10] Compared to other methods for assessing gastric contents, such as endoscopy, acetaminophen absorption testing, radionuclide scanning, and electrical impedance tomography, point-of-care gastric ultrasound offers the advantages of being noninvasive, repeatable, time-efficient, and portable Studies have demonstrated that ultrasound-guided preoperative gastric content assessment can modify anaesthesia management strategies, thereby reducing the risk of aspiration.[10] However, the current system for assessing gastric contents via ultrasound has limitations, including controversial gastric volume thresholds for high aspiration risk, inconsistent CSA thresholds for "full stomach", inconsistent gastric volume calculation formulas, and lack of accuracy and reliability in execution, which compromise the assessment's scientific rigour and standardisation.

Up to now, several narrative reviews and two systematic reviews have been published on this topic.[10–15] However, narrative reviews lack systematic search strategies, may introduce selective reporting bias, and cannot synthesise quantitative data. Moreover, they mainly describe ultrasound technology principles and evaluation methods, lacking critical discussion and future research directions. Therefore, this study summarises existing evidence on ultrasound assessment of preoperative gastric contents based on the Joanna Briggs Institute (JBI) scoping review framework. To analyze the controversies and limitations of existing studies, and propose recommendations for enhancing assessment accuracy and standardization to facilitate future high-quality randomized controlled trials in this field.

Materials and Methods

This scoping review was conducted with the Joanna Briggs Institute (JBI) scoping review framework. Reporting was performed with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR).

Review Questions

Figure 1 lists the review questions.

Search Strategy

PubMed, Embase, Web of Science, Cochrane Library, CINAHL, CNKI, Wanfang, and VIP databases were systematically searched from inception to May 11, 2025. The search strategy employed a combination of Medical Subject Headings

- Who is eligible for ultrasound assessment of gastric contents, and what is the range of "full stomach" incidence across different populations?
- Who performs the preoperative assessment of gastric contents?
- What are the qualitative assessment metrics for gastric contents?
- What are the quantitative assessment metrics for gastric contents?
- What is the gastric volume threshold associated with high aspiration risk?
- What are the cutoff values for gastric antral cross-sectional area associated with high aspiration risk?
- What formulas are available for calculating gastric volume based on ultrasonographic gastric antral cross-sectional area?
- Were anesthesia intervention strategies modified after high aspiration risk was identified through gastric content assessment, and were aspiration events reported?

Figure 1 Review questions.

(MeSH), free-text terms, wildcards, and Boolean operators, and reference lists of included studies were also screened. Search terms were adapted for each database. (Appendix supplementary data 1).

Inclusion and Exclusion Criteria

The inclusion criteria were established using the Population, Context, and Concept (PCC) framework. The population comprised adult patients undergoing preoperative ultrasound assessment of gastric contents. The context was defined as the operating room or hospital ward during the preoperative phase. The core concept of the study was the application of preoperative ultrasound to assess gastric contents in surgical patients. Eligible studies were required to report the incidence of a "full stomach" or provide data enabling its calculation, and to include a clear definition of high aspiration risk. Eligible study types included randomised controlled trials and observational studies (case–control, cohort, and cross-sectional designs). Studies published in English or Chinese were included. Exclusion criteria were as follows: non-human studies; studies without available full text; duplicate publications; case reports, dissertations or theses, study protocols, editorials, reviews, and conference abstracts.

Study Selection and Data Extraction

Import the obtained literature into EndNote X9 for deduplication. According to the inclusion and exclusion criteria, two researchers read the titles and abstracts for the initial screening, and read the full texts of the literature that met the requirements for the re-screening. If there were any differences, they discussed them with the third researcher.

According to the research questions, the two researchers mentioned above extracted the relevant information from the included literature and verified it. In case of any disagreement, they discussed and negotiated with the third researcher. Data extraction was conducted using Excel 2021.Extracted information included: author and year, country, study design, sample size, type of surgery, "full stomach" incidence, operator, operator training, methods to ensure accuracy and reliability, assessment methods, assessment metrics, gastric volume calculation formula, CSA measurement, definition of aspiration risk, changes in anaesthetic management, and aspiration incident. Findings are presented in both tabular and narrative formats.

Results

Study Selection

The primary search yielded 2,345 studies, and an additional 3 were identified through reference tracing. Ultimately, 44 studies that met the inclusion criteria were included. (Figure 2).

Characteristics of Included Studies

A total of 44 studies were included.The studies originated from 16 countries, including China (n=14),[16–29] India (n=7),[30–36] France (n=5),[8,37–40] USA (n=3),[41–43] Brazil (n=2),[44,45] Turkey (n=2),[4,46] Canada (n=2),[3,47] South Korea (n=1),[48] Switzerland (n=1),[49] Belgium (n=1),[50] Israel (n=1),[51] Indonesia (n=1),[52] Norway (n=1),[53] Australia (n=1),[54] Egypt (n=1),[55] and Spain (n=1).[2] Of these, 34 articles were published in English[2–4,8,26–55] and 10 in Chinese.[16–25] The study designs included randomized controlled trials (n=6),[16–18,22,27,51] cross-sectional studies (n=4),[3,26,43,46] retrospective observational study (n=1),[50] and prospective observational studies (n=33).[2,4,8,19–21,23–25,28–42,44,45,47–49,52–55]

The 44 publications spanned 2011 to 2024, with 12 articles published between 2011 and 2019,[16,21,29,33,34,37,39,45–47,50,54] and 32 published between 2020 and 2024.[2–4,8,17–20,22–28,30–32,35,36,38,40–44,48,49,51–53,55] Over the past five years, the number of studies has risen markedly. (Appendix supplementary data 2).

Study Population

Target Group

The study populations included pregnant women (n=8),[19,20,22,26,38,45,51,55] patients with diabetes (n=8),[2–4,17,24,29,36,40] patients with kidney disease (n=2),[32,35] patients with gallbladder disease (n=2),[27,48] patients with gastrointestinal tumors

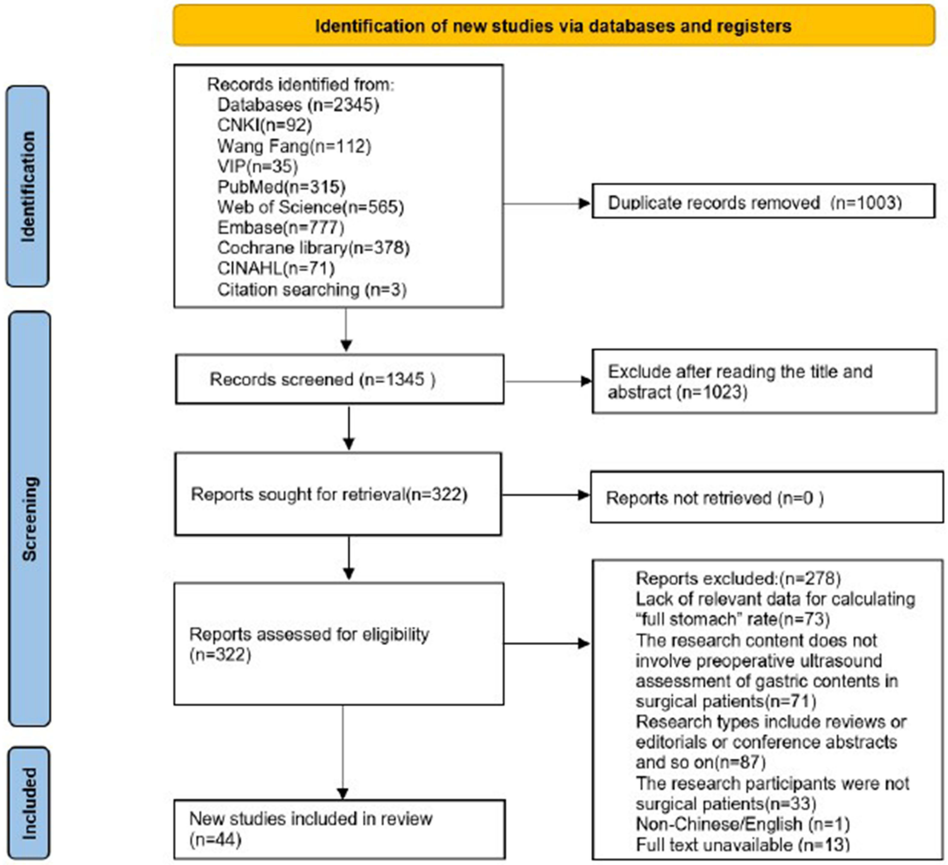

Figure 2 PRISMA flowchart of identified studies via the database.

(n=2),[28,30] patients treated with Glucagon-like peptide-1 receptor agonists (GLP-1RA) (n=2),[43,44] and other patients (n=30).[2,3,8,16–18,21,23–25,29,31,33–37,39–44,46,47,49,50,52–54]

Types of Surgery

Surgical procedures included cesarean section (n=8),[19,20,22,26,38,45,51,55] gastrointestinal surgery (n=2),[28,30] cholecystectomy (n=2),[27,48] endoscopy (n=1),[41] arteriovenous grafting or fistulasurgery (n=1),[32] gynecological surgery (n=1),[18] emergency surgery (n=9),[8,20,21,23,25,34,37,39,49] and other elective surgeries (n=23).[2–4,16,17,24,29,31,33,35–37,40,42–44,46,47,49,50,52–54]

"Full Stomach" Rate

Data are presented as median (IQR). The incidence of "full stomach" among pregnant women was 7.7% (2.4%-28.8%), among patients with diabetes was 16.7% (13.8%-38.6%), among patients with kidney disease was 53.6% (range 49.6%-57.7%), among patients with gallbladder disease was 13% (7.7%-21.8%), among patients with gastrointestinal tumors was 12.5% (range 3.9%-21%), among patients receiving GLP-1RA was 48% (range 40%-56%), among emergency surgery patients was 27.9% (22.4%-35%), among other elective surgery patients was 8% (3%-19.5%).

Sample Size

Sample sizes varied considerably. Data is presented as median (minimum, maximum). Pregnant women 65 (39–297), patients with diabetes 70 (42–110), among patients with kidney disease 148 (115–182), patients with gallbladder disease 76 (45–138), patients with gastrointestinal tumors 201 (102–300), GLP-1RA users 84 (62–107), endoscopy 83, emergency patients 250 (73–757), and elective surgeries 105 (30–1246). Nearly half (48%) of studies included fewer than 100 participants. (Appendix supplementary data 2).

Operator Assessing Gastric Contents

2 studies[44,47] indicate that sonographers perform evaluations, 24 reports[8,17,18,20–24,28,31–35,39–43,45,48–50,52] documented assessments conducted by anesthesiologists under supervision or independently, 2 additional reports[30,36] mentioned that medical consultants conducted the assessment. Operator requirements varied, 8 studies[17,26,32,37,38,40,41,53] required a minimum of 50 prior experiences in gastric ultrasound assessment. Additionally, some studies[2,18,24,33–35,39] have different training requirements for operators. During the assessment, to reduce errors and ensure the accuracy and reliability of ultrasound assessments, the strategies included taking multiple measurements and calculating the average CSA (n=17),[2,4,8,17,19,21,22,24,34,35,38–40,45,47,51,52] an experienced gastric ultrasound specialist will guide the initial scanning phase until the operator can perform the procedure independently (n=2),[30,49] or measurements may first be performed by one researcher, followed by image review by another experienced researcher (n=6).[31,33,36,42–44] (Table 1).

Assessment of Gastric Contents

7 studies[16,18,20,22,29,37,42] used qualitative ultrasound examination of gastric contents. 13 studies[17,19,21,23,24,30,31,39,45,46,51,52,54] examined gastric contents quantitatively. The remaining 24 studies[2–4,8,25–28,32–36,38,40,41,43,44,47–50,53,55] combined both. (Table 2).

Table 1 Operators, Operator Training, and Methods to Ensure the Accuracy and Reliability of Ultrasound

		No. of Study [Reference]
Operator	Sonographer	2[44,47]
	Anesthesiologists	24[8,17,18,20–24,28,31–35,39–43,45,48–50,52]
	Medical consultants	2[30,36]
	Not defined	16[2–4,16,19,25–27,29,37,38,46,51,53–55]
Operator Training	At least 20–40 gastric ultrasound procedures performed	5[33–35,39,49]
	At least 50 gastric ultrasound procedures performed	8[17,26,32,37,38,40,41,53]
	At least 100 gastric ultrasound procedures performed	1[2]
	At least 3 months of training	1[23]
	At least 6 months of training	1[24]
	2 years of experience in performing gastric ultrasounds	2[18,48]
	5 years in the medical profession	1[50]
	10 years in the medical profession	1[19]
	Experienced	10[4,8,20,22,28,30,31,36,46,51]
	Not defined	14[3,16,21,25,27,29,42–45,47,52,54,55]
Methods to ensure the accuracy and reliability of ultrasound	Taking multiple measurements and calculating the average CSA	17[2,4,8,17,19,21,22,24,34,35,38–40,45,47,51,52]
	The initial scanning phase is guided by an experienced gastric ultrasound specialist until the operator can perform the procedure independently.	2[30,49]
	Dual or multiple checks	6[31,33,36,42–44]
	Not defined	19[3,16,18,20,23,25–29,32,37,41,46,48,50,53–55]

Note: Not defined, not reported.
Abbreviation: CSA, gastric antral cross-sectional area.

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Table 2 Assessment Methods, Indicators, Gastric Volume Calculation Formula, CSA Measurement, and Aspiration Definition

			No. of Study [Reference]
Assessment methods	Qualitative assessment		7[16,18,20,22,29,37,42]
	Quantitative assessment		13[17,19,21,23,24,30,31,39,45,46,51,52,54]
	Combining qualitative and quantitative methods		24[2–4,8,25–28,32–36,38,40,41,43,44,47–50,53,55]
Assessment metrics	Nature of gastric contents		21[3,4,8,25,27,28,32–36,38,41–44,48–50,53,55]
	Perlas 3-point grading system		14[2,16,18,20,22,25,26,29,32,36,37,40,47,55]
	CSA		7[19,21,39,40,46,51,55]
	GV		33[2–4,8,17,21,23–28,30–36,38,39,41,43–45,47–50,52–55]
Gastric Volume Calculation Formula	GV (mL)=27+14.6×right lateral CSA (cm^2)−1.28×age(yr)	This formula applies to non-pregnant adults with BMI ≤40 kg/m^2 and can predict volumes up to 500 mL, with gastroscopy as the reference standard and R=0.86.	27[2–4,8,17,24,25,27,28,30–36,41,43–45,48–50,52–55]
	GV (mL)=0.18×right lateral CSA (mm^2)+0.11×supine CSA (mm^2)−62.4	This model applies to pregnant women, with MRI as the reference standard and adjusted R^2=0.76.	3[26,38,55]
	GV (mL)=−215+57×log(semi-recumbent CSA (mm^2))−0.78×age (yr)−0.16× Height(cm)−0.25×weight (kg)−0.80×ASA+16mL	This model applies to non-pregnant adults with BMI≤31 kg/m^2, predicting a volume of 250mL with R=0.72 against nasogastric tube aspiration reference standards.	3[21,23,39]
	GV (mL)=0.24×right lateral CSA (mm^2)−54.9	This model applies to pregnant women, with MRI as the reference standard and adjusted R^2=0.73.	1[38]
	GV (mL)=0.28×supine CSA (mm^2)−21.5	This model applies to pregnant women, with MRI as the reference standard, adjusted R^2=0.61.	1[38]
	GV (mL)=−372.54+282.49×log(right lateral CSA (cm^2))−1.68×weight	Using ingested water volume as the reference standard, this model can predict gastric fluid volume within 300 mL.R=0.86	1[47]
CSA measurement	Double-diameter method		26[2,4,8,17,18,21,23–25,27–31,37–40,45–48,51,52,54,55]
	Ultrasound built-in free-tracing measurement		11[3,19,22,26,32,33,36,41,43,49,54]
	Not defined		8[16,20,34,35,42,44,50,53]
Definition of aspiration risk	Presence of solids in the stomach		13[3,27,28,32,35,36,41,42,44,48,50,53,55]
	Presence of either solid or thick fluid contents in the stomach		8[4,8,25,33,34,38,43,49]
	Perlas Grade 2		14[2,16,18,20,22,25,26,29,32,36,37,40,47,55]
	Perlas Grade 1 with GV/W ≥ 1.5 mL/kg		1[26]
	Perlas Grade 1 with a CSA ≥ 505 mm^2		1[55]
	Semi-recumbent CSA > 410 mm^2		2[21,39]
	Semi-recumbent CSA>340 mm^2		2[40,46]
	Semi-recumbent CSA > 381 mm^2		1[51]
	Right lateral CSA > 10.3 cm^2		1[19]
	GV/W >1.5 mL/kg		30[3,4,8,17,21,23–28,30–35,38,41,43–45,47–50,52–55]
	GV/W >0.8 mL/kg		3[2,36,39]

Notes: Not defined—not reported; Perlas 3-point grading system—Grade 0 shows an empty gastric antrum in both supine and right lateral positions/Grade 1 shows gastric fluid only in the right lateral position, indicating a small volume of fluid/Grade 2 shows fluid in the gastric antrum in both supine and right lateral positions, indicating a larger volume of fluid.

Abbreviations: CSA, gastric antral cross-sectional area; GV, gastric volume; GV/W, gastric Volume/weight ratio; MRI, magnetic resonance imaging; BMI, body mass index; R, pearson correlation coefficient.

Qualitative Assessment of Gastric Contents

A total of 21 studies using gastric contents nature as an assessment metric,[3,4,8,25,27,28,32–36,38,41–44,48–50,53,55] 13 studies[3,27,28,32,35,36,41,42,44,48,50,53,55] concluded that the presence of solids in the stomach alone constitutes a high risk of aspiration. Additionally, 8 studies[4,8,25,33,34,38,43,49] suggest that the presence of either solid or thick fluid contents in the stomach constitutes a high risk of aspiration.

14 studies used the Perlas 3-point grading system.[2,16,18,20,22,25,26,29,32,36,37,40,47,55] All 14 studies concluded that Perlas Grade 2 indicates a high risk of aspiration. Specifically, 1 study[26] of pregnant women proposed that Perlas Grade 1 with a gastric volume-to-weight ratio (GV/W) $\geq$ 1.5 mL/kg should be classified as high risk for aspiration. Another study[55] of pregnant women suggested that Perlas Grade 1 with a CSA $\geq$ 505 mm^2 should also be considered high risk for aspiration.

Quantitative Assessment of Gastric Contents

Among the studies included in this review, 7 articles used CSA as a metric.[19,21,39,40,46,51,55] 2 studies[21,39] concluded that semi-recumbent CSA > 410 mm^2 indicates a high risk of aspiration. 2 studies[40,46] suggested that semi-recumbent CSA>340 mm^2 indicates high aspiration risk. Regarding pregnant women, 1 study[51] identified semi-recumbent CSA > 381 mm^2 as high risk, while another[19] indicated that right lateral CSA > 10.3 cm^2 carries high aspiration risk. Furthermore, 1 study[55] of pregnant women indicated that Perlas Grade 1 with semi-recumbent CSA > 505 mm^2 carries a high aspiration risk. For CSA measurement, most studies (n=26)[2,4,8,17,18,21,23–25,27–31,37–40,45–48,51,52,54,55] used the double-diameter method to calculate CSA, while a minority of studies (n=11)[3,19,22,26,32,33,36,41,43,49,54] utilised the ultrasound built-in free-tracing measurement for identification.

Ultrasound-based gastric antral CSA has been demonstrated to correlate linearly with gastric volume, which can be indirectly calculated using the formula.[56] Among the included studies, 27 studies[2–4,8,17,24,25,27,28,30–36,41,43–45,48–50,52–55] using the formula GV (mL)=27+14.6×right lateral CSA (cm^2)−1.28×age (yr); 3 studies[26,38,55] used GV (mL)=0.18×right lateral CSA (mm^2)+0.11×supine CSA (mm^2)−62.4; 3 studies[21,23,39] employed the formula: GV (mL)=−215+57×log (semi-recumbent CSA (mm^2))−0.78×age (yr)−0.16×height (cm)−0.25×weight(kg)−0.80×ASA+16mL. 1 study[38] used GV (mL)=0.24×right lateral CSA (mm^2)−54.9. 1 study[38] employed the formula GV (mL)=0.28×supine CSA (mm^2)−21.5. Additionally, 1 study[47] employed GV (mL)=−372.54+282.49×log(right lateral CSA(cm^2))−1.68×weight(kg).

Among the 33 studies[2–4,8,17,21,23–28,30–36,38,39,41,43–45,47–50,52–55] used gastric volume (GV) as an assessment metric, 30 studies[3,4,8,17,21,23–28,30–35,38,41,43–45,47–50,52–55] suggested that a GV/W>1.5 mL/kg indicates high aspiration risk, while 3 studies[2,36,39] proposed that a GV/W >0.8 mL/kg signifies high aspiration risk.

Changes in Perioperative Intervention Strategies Following Identification of High Aspiration Risk Through Gastric Contents Assessment

12 studies[18,21,24,25,27,28,37,39,41,42,48,50] employed rapid sequence induction after identifying aspiration risk in patients; 2 studies[37,50] canceled the surgery; 4 studies[16,25,44,50] delayed surgery; 1 study[16] conducted gastric suction of stomach contents;4 studies[24,25,37,50] employed local or regional anesthesia; 5 studies[25,37,42,48,50] performed tracheal intubation. Additionally, 1 study[36] indicated that self-determination of anaesthesia protocols. Another study[49] demonstrated that treatment strategies were appropriately adjusted based on the level of aspiration risk. Among the included studies, only 2[39,47] reported aspiration events, each involving a single case; the remaining studies either did not experience aspiration events or did not report them. (Table 3).

Discussion

In recent years, the use of ultrasound to assess gastric contents preoperatively for predicting aspiration risk has garnered increasing attention and become a hot topic. This study determined the value of ultrasound in evaluating gastric contents in surgical patients before surgery, identified some limitations, and based on these findings, proposed some suggestions for future research.

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Table 3 Changes in Anaesthetic Strategy and Aspiration Incidents

		No. of Study [REFERENCE]
Changes in anaesthetic strategies	Rapid sequence induction	12[18,21,24,25,27,28,37,39,41,42,48,50]
	Cancelled the surgery	2[37,50]
	Delayed surgery	4[16,25,44,50]
	Gastric suction of stomach contents	1[16]
	Local or regional anaesthesia	4[24,25,37,50]
	Tracheal intubation	5[25,37,42,48,50]
	Other	2[36,49]
	Not defined	28[2–4,8,17,19,20,22,23,26,29–35,38,40,43,45–47,51–55]
Aspiration incident	No aspiration occurred.	16[3,16,24,25,27,28,30,34–37,40,41,44,48,50]
	Aspiration occurred, with only one case reported.	2[39,47]
	Not defined	26[2,4,8,17–23,26,29,31–33,38,42,43,45,46,49,51–55]

Notes: Not defined—not reported; Other—such as determining the anaesthesia strategy independently.

Ultrasound Assessment of Preoperative Gastric Contents Necessitates Expanding the Sample Size and Increasing Disease Diversity

The preoperative gastric content assessments included in the study primarily focused on pregnant women, patients with diabetes, patients with kidney disease, patients with gallbladder disease, patients with gastrointestinal tumours, patients treated with GLP-1RA, and endoscopy patients. However, these studies exhibited significant limitations, including substantial variations in sample sizes and generally small sample sizes.

Research indicates that gastric emptying time measured using radiopaque X-ray markers is significantly longer in patients with liver cirrhosis compared to healthy individuals.[57] Anxiety and high-stress groups experience altered gastrointestinal function mechanisms due to psychological stress changes, thereby inhibiting gastrointestinal motility and leading to delayed gastric emptying.[58] In older patients, gastric emptying half-life is significantly prolonged due to sarcopenia and physiological decline in gastrointestinal motility.[59] Preoperative oral carbohydrate intake is generally considered safe, however, in actual clinical practice, the assessment of gastric status via gastric ultrasound following oral carbohydrate administration has not been sufficiently explored.[60] This population constitutes a large proportion of surgical patients, yet there is a lack of research based on gastric ultrasound assessment.

Therefore, future clinical studies should be conducted with larger sample sizes and more diverse patient populations. In particular, gastric ultrasound assessment should be extended to include more patients at risk of delayed gastric emptying or with unclear preoperative gastric contents status, such as those with comorbid conditions causing delayed gastric emptying, preoperative oral carbohydrates, or those taking medications affecting gastric emptying time. This will provide a more comprehensive validation of the applicability and value of gastric ultrasound in preoperative gastric content assessment.

There is No Consensus on the Threshold Values for Various Metrics in the Ultrasound Assessment of Gastric Contents

The CSA of the gastric antrum can be directly used to predict aspiration risk. The commonly predicted CSA for a gastric volume of 0.8 mL/kg includes Non-pregnant adults: 340 mm^2 (semi-recumbent), 410 mm^2 (semi-recumbent); Pregnant women: 381 mm^2 (semi-recumbent), 505 mm^2 (semi-recumbent), 588 mm^2 (right lateral). Predicted CSA for a gastric volume of 1.5 mL/kg includes 608 mm^2 (semi-recumbent) and 719 mm^2 (right lateral) for pregnant women.[61–63] However, Arzola[64] proposed that the right lateral semi-recumbent CSA of 9.6 cm^2 more accurately represents the upper limit of gastric volume in fasting pregnant women. In 2024, Perlas[65] analysed a large sample of 1,203 individuals, demonstrating that a right lateral CSA of 10 cm^2 corresponds to an upper limit of 1.5 mL/kg for normal fasting gastric volume in adults. Subsequent studies have continued to explore the CSA corresponding to the upper limit of gastric volume in preoperatively fasting individuals, including critically ill patients, endoscopy patients, and patients with dyspepsia.[66–68] Due to variations in the threshold for predicting gastric volume, body position, and reference standards, differences exist in the resulting threshold value for CSA and the resulting AUC (Refers to the area under the receiver operating characteristic ROC curve. The value closer to 1 indicates better performance of the classifier), sensitivity, and specificity. Therefore, it is recommended that future studies comprehensively consider factors such as predicted gastric volume, population variability, and predictive efficacy when selecting CSA values.

In addition to the CSA threshold values, gastric volume serves as a more precise indicator for quantifying gastric contents. Initially, the developed gastric volume calculation formula was just applicable to non-pregnant adult patients.[15,61] In recent years, in addition to the formulas mentioned above, multiple gastric volume prediction models have been developed for different populations. For example, Tan[68] constructed predictive models for gastric volume in functional dyspepsia and organic dyspepsia. Tacken[69] noted that previous models were limited to clear liquids, thus proposing a gastric volume prediction formula for thick liquids, which may be more suitable for critically ill patients receiving enteral nutrition. Jacob[70] updated the gastric volume formula to achieve higher accuracy in patients with a history of sleeve gastrectomy. There are also specialised formulas for specific populations, such as children and pregnant women. Particularly for pregnant women, multiple calculation models coexist due to differences in included variables or variations in assessment postures.[64,71–73] The diversification and personalisation of gastric volume calculation formulas have also led to confusion in selection and inconsistencies in standards. Due to the enlargement of the uterus during pregnancy, which compresses the stomach, the size and position of the antrum of the stomach change. Therefore, the volume assessment models previously designed for non-pregnant patients cannot be directly applied to pregnant women.[74] In the studies included in this paper, computational models designed exclusively for non-pregnant patients were applied to pregnant women, making it difficult to compare the research findings across studies.[45] In addition, some calculation formulas use ingested contents as the reference standard, disregarding the body's own gastric acid secretion, thus lacking comparison and validation against the gold standard.[69] Future studies should focus on rigorous experimental design and conduct large-scale trials across diverse populations to evaluate the formula's accuracy, while laying the groundwork for developing new models. When encountering inconsistent gastric volume calculation formulas, it is recommended to select newer computational models validated by gold standards with high AUC, sensitivity, and specificity, considering research conditions. For specific populations, unique equations with higher accuracy may be considered. We strongly advise establishing formula selection criteria early to enhance the comparability of research results and the generalizability of clinical applications while preserving the advantages of individualisation.

Additionally, we note that current studies exhibit differences in the specification of the choice of body position during assessment. For instance, some studies conducted Perlas grading in the supine position, while others performed it in the semi-recumbent position.[16,37] Other studies measured CSA in the supine position when the semi-recumbent position should have been used, or mistakenly applied CSA results obtained from other positions when calculating gastric volume. These errors may reduce the accuracy of the findings.[30,46] Additionally, while some research methods specify measuring in a supine position with the head elevated at 45°, sections such as abstracts or conclusions describe it as simply a supine position.[63] Therefore, we recommend that future research and clinical practice standardise the terminology for patient positioning while strictly adhering to the standard positions corresponding to each assessment metric. If an alternative position must be used due to special circumstances, it should be clearly established whether the diagnostic accuracy of that position has been validated. For example, existing evidence indicates that the Perlas 3-point grading system can still distinguish between high and low gastric fluid levels when the supine position is elevated to 45°, and it demonstrates higher sensitivity compared to the standard supine position.[75] In addition, future research should further explore feasible ultrasound assessment protocols for populations unable to adopt standard positioning.

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Enhance Operator Training and Integrate Artificial Intelligence to Ensure the Accuracy and Reliability of Ultrasound Assessments

As demonstrated in this paper, preoperative gastric content assessment primarily involves multiple professionals, including anesthesiologists, sonographers, and medical consultants, with anesthesiologists constituting the largest proportion. As the basic principles, technical specifications, and operational procedures of gastric ultrasound have been relatively well-established, non-sonography specialists such as nurses and anesthesiologists can rapidly master and apply these techniques through systematic training.

Under ultrasound imaging, different gastric contents exhibit distinct echogenicity characteristics.[76] For non-ultrasound professionals, distinguishing between different echo characteristics and determining the nature of gastric contents poses a challenge. Achieving accurate and reliable image interpretation requires systematic training and extensive hands-on experience. Arzola emphasised that with proper training and supervision, anesthesiologists achieved a 95% success rate in qualitatively identifying gastric contents via ultrasound after 33 examinations, however, quantifying gastric volume proved more complex and required additional training.[77] Most included studies emphasised that operators require substantial experience in gastric ultrasound assessment. However, the variation in training standards reflects inconsistent requirements for operator technical and professional competence. Furthermore, no inter-rater reliability was reported in studies involving multiple evaluators. Moving forward, we suggest promoting gastric ultrasound technology among surgical staff, with attention given to standardised training and certification for operators, and establishing training protocols for operating room personnel to perform qualitative and quantitative ultrasound assessments of gastric contents. This will enhance the reliability of evaluation outcomes.

To ensure the accuracy and reliability of ultrasound assessments and reduce measurement errors, studies have incorporated multiple measurements of the mean CSA or employed multi-operator measurement and review protocols. However, it is known that ultrasound measurements of the gastric antrum inherently exhibit inter-individual variability. Additionally, gastric peristaltic contractions and changes in patient positioning contribute to CSA variability, often leading to measurement bias. Currently, research has established training and validation datasets based on extensive point-of-care ultrasound videos and images, developing an artificial intelligence system capable of automatically identifying CSA and motility patterns.[78] This system has been demonstrated to deliver recognition results comparable to those of experienced clinicians. This system is currently applied in enteral nutrition management for critically ill patients, if it is extended to perioperative patients, it could overcome the limitations of traditional ultrasound assessments that rely heavily on operator experience and technical skill, thereby enhancing efficiency and standardisation. More importantly, this system introduces gastric antral motility rhythm as a novel dimension, enabling direct differentiation between fasting and postprandial states. This approach may transform current preoperative assessment practices for predicting aspiration risk based on gastric contents, shifting from static cutoff point judgments toward AI-driven dynamic physiological evaluation. Machine learning, as a vital branch of artificial intelligence, is currently widely applied in the medical field. Jin[79] constructed a gastric ultrasound machine learning model to distinguish between fasting and full stomachs in gastrointestinal endoscopy patients, achieving a high AUC of 0.903. Liu[6] developed a novel ultrasound-based machine learning model using patient age, Perlas 3-point grading system, and right-lateral CSA to accurately predict gastric volume, better than previous linear models. Advancements in AI for preoperative gastric content assessment provide a direction for precise and rapid gastric volume identification. Future efforts should focus on integrating AI into clinical practice and promoting its standardised application.

Optimising Anaesthesia Strategies Reduces Aspiration Risk, Making Preoperative Assessment of Gastric Contents Particularly Crucial

In clinical practice, symptomatic aspiration that can be observed is inherently a rare occurrence. The low incidence of aspiration may be attributable to various optimised intervention strategies employed in real-world clinical practice, underscoring the critical importance of preoperative assessment.[80] For the high-risk patients identified in this study, researchers adopted more cautious anaesthetic strategies, such as gastric aspiration and rapid sequence intubation, thereby reducing the incidence of aspiration. This might explains why of the 18 studies included in this paper that focused on aspiration incidence, only 2 reported actual aspiration events. In settings with limited medical resources or inadequate anaesthesia protocols, accurately assessing gastric contents remains the primary step and fundamental prerequisite for preventing aspiration. Particularly during gastrointestinal endoscopy examinations and procedures, preoperative evaluation can prevent reduced surgical field visibility caused by residual gastric contents, thereby enhancing diagnostic accuracy and reducing the risk of surgical complications.[81]

Limitations

(1) Although a systematic retrieval strategy was employed, some valuable studies were excluded because they focused on non-perioperative patients; (2) Our focus was on synthesizing existing evidence and identifying future research directions rather than assessing the quality of included studies, so methodological rigor may vary among them; (3) Due to high methodological heterogeneity (such as population, indicators, and threshold value), we could not perform quantitative synthesis (meta-analysis) of the data, limiting the possibility of statistical comparisons of results; (4) Regarding the accuracy and reliability of ultrasound operators, we retrospectively identified that some studies lacked relevant data, necessitating cautious interpretation of “full stomach” rates; (5) Among the 44 included studies, 14 originated from China, potentially introducing population bias; (6) Only English and Chinese studies were included.

Conclusion

This review concludes that preoperative ultrasound can provide information on the nature and volume of gastric contents, enabling surgical teams to implement measures to reduce the risk of aspiration of gastric contents during the perioperative period. However, these studies face challenges, including limitations in the diversity and size of study populations, inconsistent assessment protocols and training variations, controversial threshold values, and diverse gastric volume calculation models. The above highlights the necessity for further research. We recommend conducting future cohort studies with larger sample sizes and more diverse populations to further evaluate this application. Concurrently, establishing standardised preoperative gastric content assessment and training criteria will help regulate clinical practice, particularly regarding threshold value and computational model selection criteria, thereby facilitating broader implementation in clinical settings. Additionally, we suggest that future research increasingly integrate artificial intelligence and machine learning into preoperative gastric ultrasound assessments of gastric contents to overcome the limitations of manual measurement and enhance the accuracy and reliability of results.

Data Sharing Statement

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

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict.

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