ASRA pain medicine narrative review and expert practice recommendations for gastric point-of-care ultrasound to assess aspiration risk in medically complex patients undergoing regional anesthesia and pain procedures

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ABSTRACT

Gastric point-of-care ultrasound (POCUS) may offer clinical value in assessing aspiration risk among medically complex patients undergoing regional anesthesia and pain procedures. While the American Society of Anesthesiologists (ASA) preoperative fasting guidelines primarily apply to healthy individuals, medically complex populations often present with differing gastric emptying and aspiration risk. This narrative review, conducted by the American Society of Regional Anesthesia and Pain Medicine (ASRA-PM), adhered to PRISMA guidelines and was registered with PROSPERO. It focused on seven medically complex patient groups: those who are pregnant, obese, diabetic, have gastroesophageal reflux disease (GERD), are receiving emergency care, are enterally fed, or are taking GLP-1 receptor agonists (GLP-1RA). Study quality was assessed using the Mixed Methods Appraisal Tool (MMAT). Practice recommendations were developed using an iterative expert consensus process, with final recommendations based on evidence strength, clinical relevance, and expert agreement. Findings support the use of gastric POCUS in patients in active labor, those undergoing urgent cesarean sections, and those with diabetes. Conditional support is given for obesity, emergency care, enteral feeding, and GLP-1RA use. Routine use is not recommended in non-laboring pregnancies, elective cesarean delivery, or GERD. While gastric POCUS may aid with aspiration risk evaluation, its use should complement clinical judgment. Implementation may be limited by practical and training constraints, requiring individualized decision-making. These recommendations serve as a foundation for future research and potential clinical guideline development. PROSPERO registration number: CRD42023445927.

INTRODUCTION

The American Society of Anesthesiologists (ASA) practice guidelines for preoperative fasting published in 2017 applied to a limited patient population, namely healthy, that is, patients with minimal aspiration risk, for elective surgical procedures. Specifically, 'the guidelines may not apply to or may need to be modified for patients with coexisting diseases or conditions that can affect gastric emptying or fluid volume (eg, pregnancy, obesity, diabetes, hiatal hernia, gastroesophageal reflux disease (GERD), ileus or bowel obstruction, emergency care, or enteral tube feeding).'[1] The ASA practice guidelines for preoperative fasting were updated in 2023; however, they primarily addressed carbohydrate-containing clear liquids, chewing gum, and pediatric fasting in otherwise healthy patients.[2] Although there is no need to change or dispute these fasting guidelines for healthy patients, regional anesthesiologists and pain management physicians often provide sedation or care for medically complex patients that fall outside the limited scope of the ASA fasting guidelines. Therefore, these American Society of Regional Anesthesia and Pain Medicine (ASRA-PM)-specific evidence-based clinical practice guidelines describe the role of gastric point-of-care ultrasound (POCUS) in the clinical management of these medically complex patients in whom gastric content and aspiration risk may be uncertain based on clinical assessment alone.

The following is a narrative review of studies on the use of gastric POCUS on patients with the following conditions: pregnancy, obesity, diabetes, GERD, emergency care, enteral tube feeding, and those taking glucagon-like peptide-1 receptor agonists (GLP-1RA). Hiatal hernia and ileus/bowel obstruction were not included because gastric POCUS may not be accurate in these patient populations. GLP-1RAs were added as they have been demonstrated to delay gastric emptying[3] and, therefore, are a new medically complex patient population that has led to guidance from governing bodies such as the ASA[4] to adjust standard fasting guidelines. The narrative review will provide an overview of the evidence available for each of these medically complex patient populations, and based on the overall level of evidence, the authors will offer evidence-based clinical practice guidelines on the role of gastric POCUS. Given that gastric POCUS has been validated and demonstrated to be an accurate

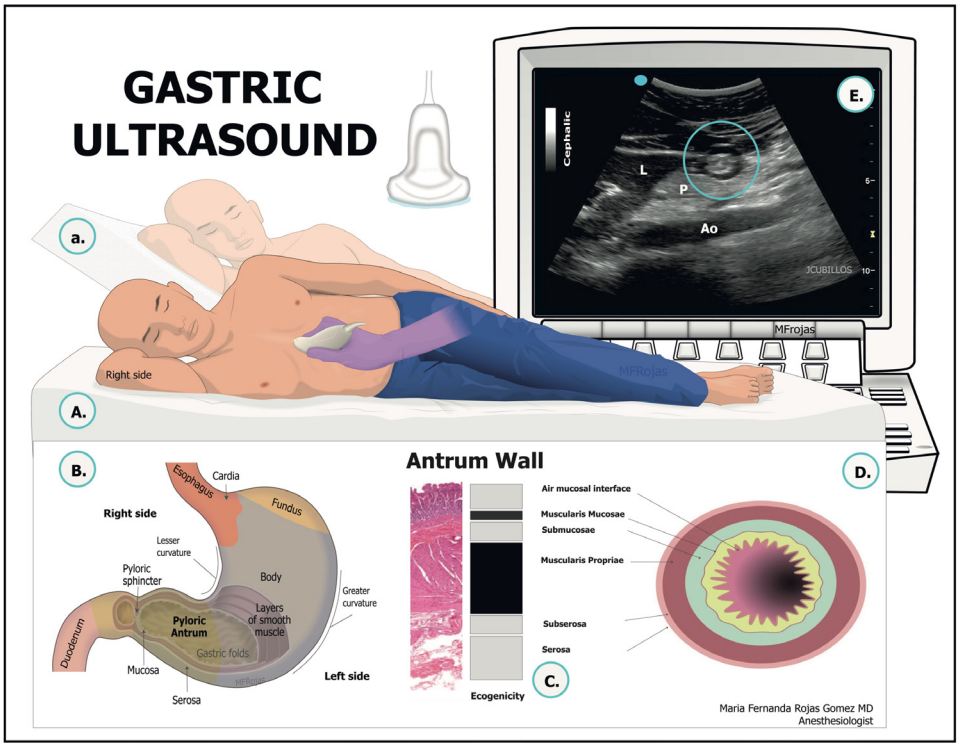

Figure 1 Gastric ultrasound image acquisition pearls: illustration of patient positioning, probe placement and orientation, key anatomical landmarks, and sonographic representation of the gastric anatomy. (A) Probe placement for gastric ultrasound with the patient positioned in the right lateral decubitus position at 0 degrees inclination (flat), the validated posture for gastric volume estimation. (a) Alternative patient positioning at 45 degrees inclination (semi-recumbent) to enhance the gravitational effect, facilitating gastric content movement toward the antrum. (B) Basic anatomical structures of the stomach. (C) Sonographic representation of the gastric wall layers at the level of the gastric antrum. (D) Anatomical illustration of the gastric antrum and its corresponding wall layers. (E) Gastric ultrasound image of an empty stomach, demonstrating the characteristic 'bull's eye' appearance when contracted, with key anatomical landmarks highlighted. Note: when using a low-resolution curvilinear transducer, only the muscularis propria layer is typically visualized as a hypoechoic structure, serving as a useful reference for identifying the gastric antrum. Ao, aorta; L, liver (left lobe); P, pancreas.

diagnostic test in both healthy and medically complex patient populations,[5–19] these guidelines do not re-examine the diagnostic accuracy of gastric POCUS but rather assess and provide guidance regarding the evidence-based support for its use in clinical decision-making for medically complex patient populations.

Following approval by the ASRA-PM guidelines committee, the coauthors of the narrative review were assembled based on their expertise in gastric POCUS. The coauthors performed the narrative review and provided guidance on this document. The ASRA-PM Board of Directors has reviewed and endorsed this document. This document does not establish a standard of care or replace clinical judgment. It does not intend to limit or deny care, affect the rights of patients or providers, or define the standard of care. It is not intended to replace clinical judgment. In the imperfect setting of heterogeneous data, limited data, controversial topics, and bias inherent to expert opinion, compliance with the recommendations may not result in improved outcomes, that is, reduction in aspiration, compared with personalized medicine. We hope these practice recommendations will help further mitigate risk for an already low-risk complication. Ultimately, our suggestions aim to provide a structured approach to risk assessment and guide clinicians on the role of gastric POCUS in assessing gastric content for various clinical scenarios and patient acuity.

Fundamentals of gastric POCUS for assessing aspiration risk

To assist clinicians in understanding the principles of gastric ultrasound, we have included key figures (figures 1 and 2) that illustrate probe placement, anatomy, and the sonographic appearance of the gastric antrum under various conditions. These figures are designed to serve as a rapid reference for practitioners. For greater detail and depth, please refer to other RAPM publications.[8 20] Additionally, table 1 summarizes the Perlas qualitative grading system for fluid and solid-gastric content to assess aspiration risk. The grading system evaluates for fluid within the gastric antrum in both the supine and right lateral decubitus (RLD) positions without performing a quantitative assessment based on the cross-sectional area (CSA), which is summarized in table 1. A grade 0 antrum appears empty in both supine and RLD positions, indicating a low risk of aspiration. A grade 1 antrum is empty in the supine position but contains fluid in the RLD position, representing an intermediate risk. A grade 2 antrum contains fluid in both positions, suggesting a higher aspiration risk. A grade 3 antrum indicates a full stomach with solid contents or thick fluid, appearing hyperechoic and either homogeneous (eg, milk/dairy) or heterogeneous (eg, food) on ultrasound, and is associated with an increased aspiration risk.

METHODS

This review was registered in PROSPERO on July 31, 2023 (CRD42023445927).

Design

This work is a narrative review. It was carried out using the Cochrane Handbook for Systematic Reviews of Interventions[21]

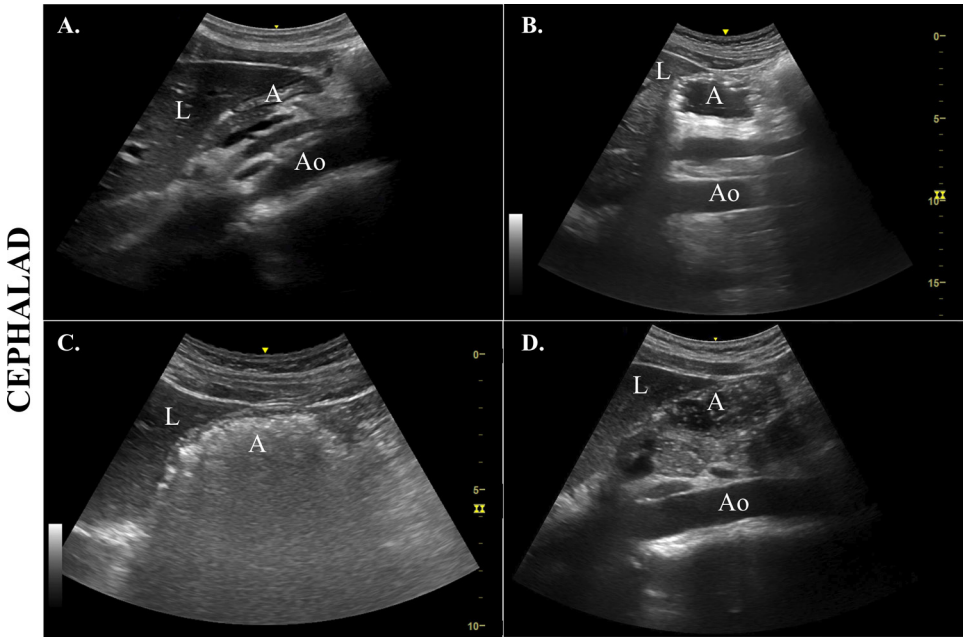

Figure 2 Gastric ultrasound sonoanatomy. (A) Sonographic appearance of the antrum in an empty stomach. (B) Appearance with clear fluid. (C) Appearance soon after a solid meal (early stage solid) with significant air content. (D) Appearance with mixed solid and fluid content (late-stage solid). A, antrum; Ao, aorta; L, liver.

and was reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement.[22]

Information sources

The databases searched included MEDLINE (PubMed), Embase (Elsevier), Web of Science (Clarivate), and ProQuest Dissertations and Theses Global (PQDTGlobal).

Search strategy

A professional medical librarian, LL, developed and conducted the search in consultation with the author team. It included a mix of keywords and subject headings representing ultrasound, stomach, and aspiration/anesthesia. The searches were independently peer-reviewed by a librarian using a modified Peer Review Electronic Search Strategies Checklist[23] and validated against a set of preselected articles.

Search hedges or database filters were used to remove publication types such as editorials, case reports, comments, conference abstracts, and animal-only studies as was appropriate for each database. The search was conducted on April 3, 2023, and updated on January 9, 2024, for a total of 6196 citations. Complete reproducible database search strategies, including date ranges and search filters, are detailed in the online supplemental appendix.

Table 1 Perlas gastric POCUS grading system to assess aspiration risk

Grade	Supine	Right lateral decubitus
0	Empty	Empty
1	Empty	Fluid
2	Fluid	Fluid
3	Thick fluid/solid content	Thick fluid/solid content

POCUS, point-of-care ultrasound.

Eligibility criteria

The inclusion criteria for the search focused on human studies using gastric ultrasound in medically complex patients scheduled for surgery. Medically complex was defined as patients with coexisting diseases or conditions that could affect gastric emptying or fluid volume, such as pregnancy, obesity, diabetes, GERD, emergency care, enteral tube feeding, or the use of GLP-1RAs. Animal studies, reviews, editorials, letters, case reports, comments, congress proceedings, and validation studies were excluded. Patients with hiatal hernia, ileus, or bowel obstruction were excluded as these conditions either render gastric POCUS potentially inaccurate (eg, hiatal hernia) or the findings of the gastric POCUS exam do not significantly alter the risk of aspiration due to distal gastrointestinal pathology. Gastric POCUS studies reporting both qualitative and quantitative outcomes were included. A 'qualitative assessment' using gastric POCUS refers to identifying the *type* of gastric contents (solid, liquid, or empty) based solely on imaging, without using measurement software on the ultrasound machine. In contrast, a 'quantitative assessment' involves estimating the *volume* of gastric contents by measuring the CSA of the gastric antrum and using a mathematical model to estimate total gastric fluid volume.

Selection process

After the search, all identified studies were uploaded into Covidence,[24] a software system for managing reviews, and duplicates were removed by the software (n=2046). A final set of 4151 citations remained to be screened during the title/abstract phase. Study selection was carried out independently by two authors.

Studies were excluded if they did not meet inclusion criteria based on title and/or abstract review. All disagreements were resolved by adjudication by a third reviewer. A total of 6,197 records were identified across four databases:

Embase (n=2,624), Web of Science (n=2,182), PubMed (n=1,358), and an unspecified source (n=33). After the removal of 2,046 duplicates using Covidence and manual review, 4,151 titles and abstracts were screened. Of these, 220 full-text articles were assessed for eligibility. Following the application of inclusion and exclusion criteria, 155 articles were excluded for reasons including wrong study design (n=38), pediatric population (n=31), wrong patient population (n=34), non-English language without available translation funding (n=8), and others. Ultimately, 65 studies met all criteria and were included in the final narrative review.

For the full-text screening stage, articles were divided into subgroups according to the patient population studied as follows: pregnancy (30 studies), obesity (five studies), diabetes (13 studies), GERD (two studies), emergency care (eight studies), enteral tube feeding (four studies), and GLP-1RA (three studies). Papers were then reviewed in detail by two independent reviewers who were subject specialists and were excluded if they did not meet the inclusion criteria. A third reviewer resolved any conflicts between the two independent reviewers at each stage of the selection process. The article selection is presented in a flow chart per PRISMA guidelines (figure 3).

For papers not published in English that met the inclusion criteria during the title/abstract screening, the abstracts were reviewed for usable data. Due to restrictions in funding for translation services, these articles were excluded at the full-text screening phase.

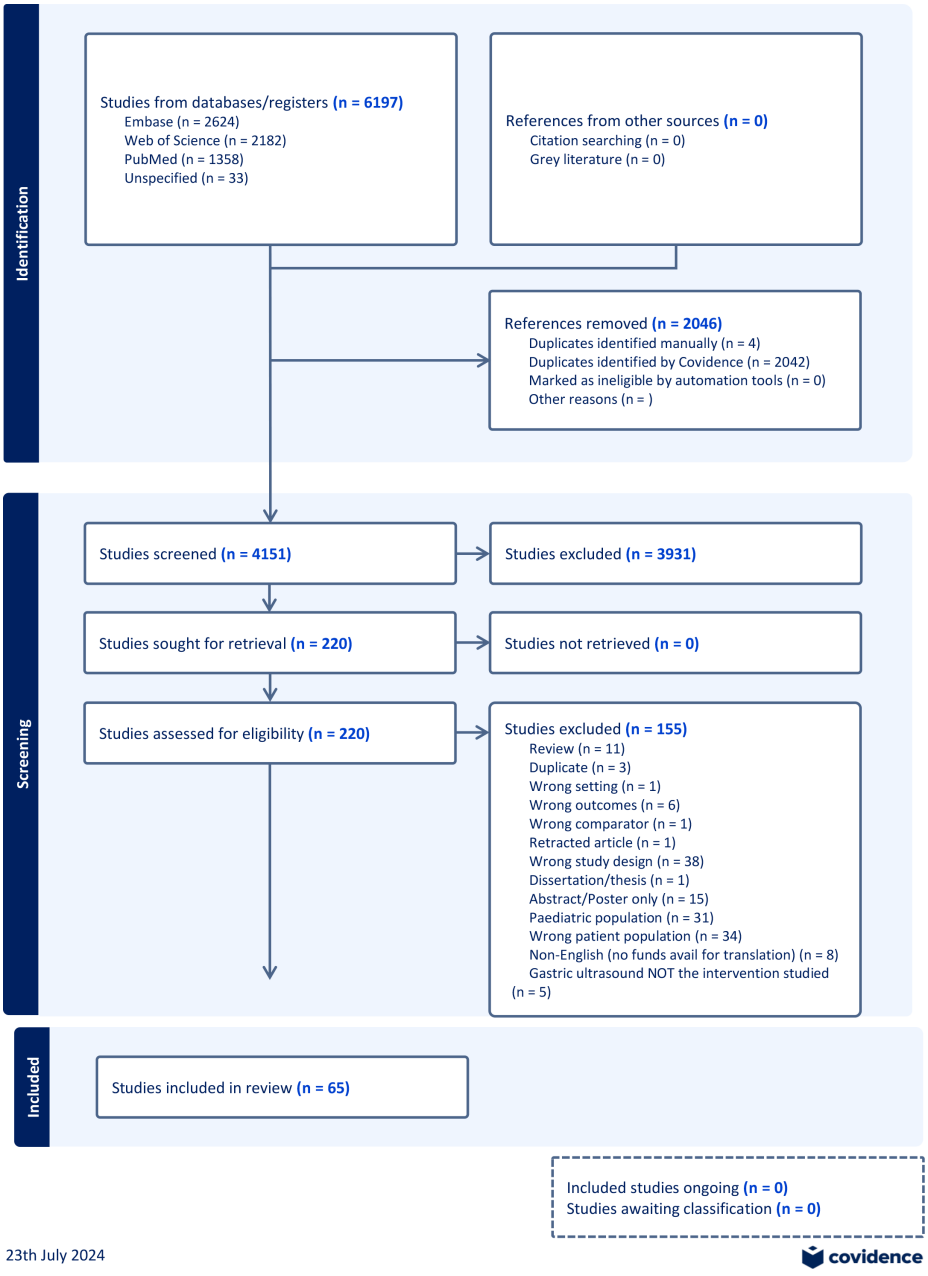

Figure 3 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)—gastric point-of-care ultrasound review. This figure illustrates the PRISMA flow diagram, detailing the identification, screening, and inclusion process of studies for this review. It outlines the number of records retrieved from databases, duplicates removed, studies excluded at various stages, and the final number of studies included in the narrative review.

Quality assessment

The Mixed Methods Appraisal Tool (MMAT), V.2018,[25] was used to assess the methodological strengths, weaknesses, and risk of bias at the individual study level, ensuring a standardized assessment across diverse quantitative study designs. Given that all included gastric POCUS studies were quantitative, MMAT was *not* applied to qualitative reports (eg, patient experiences, surveys) or mixed-methods studies. Two reviewers independently assessed each study with evaluations based on five core criteria specific to the study type. Randomized controlled trials (RCTs) were evaluated for appropriate randomization, baseline group comparability, completeness of outcome data, blinded outcome assessment, and participant adherence to the assigned intervention. Non-randomized quantitative studies were assessed for representativeness of the target population, appropriate measurement of both exposure and outcome, completeness of outcome data, control for confounders in design and analysis, and whether the intervention was administered as intended. Quantitative descriptive studies were evaluated based on the relevance of the sampling strategy, representativeness of the sample, appropriateness of measurement methods, risk of non-response bias, and appropriateness of statistical analysis. These criteria ensured a standardized and rigorous assessment of study quality across diverse methodologies. Each study received a final MMAT score ranging from 0% (none of the criteria met) to 100% (all criteria met) to ensure a standardized and transparent quality assessment.

MMAT was chosen because it evaluates multiple study types without penalizing non-randomized designs, making it more suitable than the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool, designed to assess diagnostic accuracy in randomized trials. Since our goal was to evaluate gastric POCUS's impact on perioperative patient management—not to validate it as a diagnostic tool—QUADAS-2 was not appropriate. Most of the included studies were prospective observational, which do not fit within randomized diagnostic trial frameworks. MMAT allowed for a robust assessment of study methodology and bias without automatically downgrading studies due to a lack of randomization—a key factor when evaluating real-world applications of gastric POCUS in complex patient populations.

Before selecting MMAT, coauthor (LL), a medical librarian, was consulted to ensure its appropriateness. By using MMAT, we ensured a rigorous and clinically relevant evaluation of the literature. The individual MMAT scores for each study included in this narrative are available in the online supplemental materials.

Consensus process

Our consensus process used a structured approach to ensure methodological rigor and transparency. The process involved:

1. Proposal of recommendations: the lead author evaluated each medically complex patient population based on the methodological quality of the included studies using the MMAT. All included studies scored at least 80% (four out of five criteria), indicating a low risk of bias across the body of evidence. This overall low risk of bias allowed the authors to focus primarily on the number of studies, the consistency and strength of their outcomes, and their relevance to clinical management. There was no prespecified threshold for the number of studies or specific outcomes required to determine levels of support. Instead, each medically complex patient population was assessed on its merits, and consensus shaped the expert recommendations.
2. Expert review and feedback: preliminary recommendations were then circulated among all coauthors, each with expertise in gastric POCUS. coauthors independently reviewed the evidence, MMAT-based quality assessments, and proposed recommendations, offering agreement or constructive feedback.
3. Integration of feedback: the lead author collated all feedback and revised the recommendations where needed to address any concerns or suggestions.
4. Finalization of recommendations: the revised recommendations were recirculated for final review and approval, ensuring that all authors were in agreement before inclusion in the manuscript.

This structured, iterative process—guided by evidence quality, outcomes, and clinical relevance—follows established models such as those used by the National Institute for Health and Care Excellence, emphasizing multidisciplinary input and real-world applicability.[26]

RESULTS

Pregnancy

A total of 30 pregnancy-related studies were identified.[27–56] Two were published in the 1990s,[27 28] one in 2007,[29] and all the remainder between 2014 and 2024. Quality assessment scores using the MMAT[25] ranged from 80% (four criteria met) for 11 studies,[28 30–39] while the remaining 19 studies scored 100%.[27 29 30 40–55] The quality assessment for each study is presented in online supplemental table 1). A summary of the study findings is provided in table 2. The majority of recent studies report a 0%–15.1% rate of indeterminate ultrasound examinations, except for one study, which reported a higher incidence of indeterminate examinations (36%).[31] The most frequent study designs were prospective observational (21 studies), interventional non-randomized (three studies),[51 55 56] and randomized controlled trials (six studies).[28 38 39 49 50 52]

Randomized controlled trials

Scrutton *et al*[40] compared eating versus non-eating during labor, finding higher plasma β-hydroxybutyrate in the non-eating group by the end of labor, while the eating group had a higher gastric antral CSA and more vomiting episodes, with no differences in maternal plasma lactate or neonatal outcomes. Irwin *et al*[44] examined the gastric emptying of tea with milk versus water in non-laboring pregnant women. They noted no significant difference in gastric antrum CSA or total gastric fluid volume between the groups after 120 min, suggesting that fasting guidelines could allow tea with milk up to 2 hours before elective surgery.

Rousset *et al*[33] compared gastric antral CSA in fasting parturients with those allowed to drink up to 400 mL for 90 min after randomization, showing no change in the percentage of women with an 'empty stomach' at full cervical dilatation. Similarly, Ni *et al*[50] compared the gastric antral CSA over time between a high-energy semifluid solid beverage (HESSB) and a carbohydrate (CHO) solution, finding similar decreases in CSA at 120 min. Ijiri et al. (2023)[56] demonstrated that oral rehydration solution (ORS) decreased the need for vasopressors without increasing gastric content volume (GCV), indicating stabilized circulatory dynamics preoperatively.

Hamed *et al*[55] evaluated metoclopramide's effects on gastric volume and antral CSA in cesarean section patients, finding significant reductions in both and decreased nausea and vomiting.

Table 2 Summary of studies—pregnancy

Study	Study design	MMAT quality grade	Gastric POCUS performed (qualitative, quantitative, or both)	Primary outcome	Number of patients enrolled	Number (percentage) of indeterminate examinations	Was gold standard of gastric suctioning used?	Was there a change in anesthetic management? (Yes, no, or not reported)—number of patients (%)	Relevant findings
Carp *et al* [37]	Prospective observational study	100%	Qualitative	Assess stomach contents in laboring patients and volunteers after solid food intake at varying intervals.	73	29 (40)	No	Not reported	Visualizing an empty antrum with gastric POCUS was challenging but improved after clear fluid ingestion. Solid food remained visible in the stomach for hours after labor began.
Scrutton *et al* [40]	Randomized controlled trial	80%	Quantitative	Plasma β-hydroxybutyrate during labor (eating vs non-eating) and gastric CSA 1 hour postdelivery.	88	50 (43.2)	No	Not reported	By the end of labor, plasma β-hydroxybutyrate was significantly higher in the non-eating group. Gastric antral CSAs were significantly higher in the eating group.
Wong *et al* [38]	Prospective observational cross-over study	100%	Quantitative	Compare gastric emptying in obese term pregnant volunteers: ultrasound and acetaminophen absorption after 50 mL vs 300 mL water.	10	0	No	Not reported	Gastric emptying in obese, term pregnant volunteers did not differ.
Bataille *et al*[27]	Cohort study, prospective observational study	100%	Quantitative	Feasibility of antral CSA assessment and gastric volume changes in laboring women under epidural analgesia.	58	5 (4.54)	No	Not reported	Gastric POCUS shows feasible antral CSA assessment in laboring women. Gastric motility persists with epidural analgesia, as evidenced by a significant antral CSA decrease from labor onset to full dilation, lowering aspiration risk from 50% to 13%.
Arzola *et al*[41]	Cohort study, prospective observational study	100%	Both	Incidence of grade 2 antrum in fasting term pregnant women.	103	1 (0.97)	No	Not reported	Most term pregnant women had an empty stomach (grade 0 or 1); only 1/103 had a grade 2 antrum. CSA in RLD matches non-pregnant adults.
Zieleskiewicz *et al*[29]	Cohort study, prospective observational study	80%	Both	Establishing CSA cut-offs in supine and RLD to diagnose gastric fluid volumes of 0.4, 0.8, and 1.5 mL/kg.	78	28(36)	No	Not reported	During labor, optimized CSA cut-offs for 0.4, 0.8, and 1.5 mL/kg were 387, 505, and 608 mm^2 (supine) and 570, 588, and 719 mm^2 (RLD).
Rouget *et al* [28]	Cohort study, prospective observational study	80%	Both	Compare the antral CSA before and after cesarean section	50	7 (14)	No	Not reported	Median antral CSA decreases postcesarean in supine but not in RLD, with significant antral position changes in both positions.
Barboni *et al* [42]	Quantitative non-randomized experimental study	100%	Quantitative	Evaluate gastric emptying after a full meal in healthy non-pregnant and pregnant women undergoing elective cesarean.	20	0 (0)	No	Not reported	Antral CSA measured postmeal showed pregnant women had a larger antrum at 4 hours than non-pregnant controls, indicating delayed gastric emptying and increased aspiration risk.
Vial *et al* [31]	Prospective observational study	100%	Quantitative	Percentage of full stomach in post partum	100	10 (10)	No	Not reported	48% of postpartum parturients had antral CSA ≥381 mm^2, requiring re-assessment before peripartum anesthesia or sedation. No risk factors were linked to a full stomach postdelivery.
Jay *et al* [30]	Prospective cohort study	80%	Both	Calculate the supine antral CSA cut-off for rapid diagnosis of an 'empty' stomach (grade 0), indicating a full stomach if exceeded.	86	13 (15.1)	No	Not reported	A supine CSA cut-off of 381 mm^2 was identified for diagnosing an empty stomach (grade 0), enabling rapid aspiration risk assessment during emergency anesthesia in laboring parturients.
Roukhomovsky *et al*[32]	Prospective cohort study	100%	Both	Develop a model to predict gastric volume in third-trimester pregnancy and evaluate POCUS grading for clear fluid volumes >0.8 and >1.5 mL/kg.	34	0 (0)	No	Not reported	Two CSA-based models were developed with R^2 values of 0.73 (RLD) and 0.76 (RLD and supine) without additional covariates.

Continued

Table 2 Continued

Study	Study design	MMAT quality grade	Gastric POCUS performed (qualitative, quantitative, or both)	Primary outcome	Number of patients enrolled	Number (percentage) of indeterminate examinations	Was gold standard of gastric suctioning used?	Was there a change in anesthetic management? (Yes, no, or not reported)—number of patients (%)	Relevant findings
Hakak *et al* [43]	Prospective observational study	100%	Both	Solid food present in the antrum 6 hours after fasting following a standardized light meal.	51	5 (9.8)	No	Not reported	No solid food was visible in the antrum, but 37.5% showed gastric volumes >1.5 mL/kg, indicating aspiration risk.
Riveros-Perez *et al*[39]	Prospective cross-sectional observational study	100%	Both	Correlation between CSA (POCUS gastric volume surrogate) and BMI in term pregnant women undergoing elective cesarean.	42	0 (0%)	No	Not reported	BMI significantly correlated with gastric antral area (p=0.001) and longitudinal diameter (p<0.001), independent of gravidity and parity, highlighting increased aspiration risk with higher BMI in pregnancy.
Van de Putte et al[47]	Prospective cohort study	100%	Both	Characterize gastric fluid volume range in fasting, non-laboring, term pregnant patients.	59	4 (6.8%)	No	Not reported	Total gastric fluid volume and volume per body weight showed no significant differences between cohorts.
Gal *et al* [46]	Prospective non-randomized experimental study	100%	Quantitative	Compare gastric volume and content pre-anesthesia: term-pregnant cesarean versus non-pregnant/first-trimester gynecological surgery.	50	0 (0%)	No	Not reported	Despite shorter fasting times, gastric volumes in cesarean patients were similar to non-pregnant and early pregnant women.
Irwin *et al* [44]	Randomized controlled trial	100%	Quantitative assessment	Compare gastric emptying of tea with milk versus water in pregnant women.	50	0 (0%)	No	Not reported	Gastric antrum CSA change after tea with milk is similar to an equivalent volume of water in fasted term women.
Rousset *et al*[33]	Randomized controlled trial	100%	Quantitative	Incidence of 'empty stomach' (gastric CSA <300 mm²) at full cervical dilation in pregnant women.	162	16 (9.9)	No	Not reported	In laboring women, PO intake up to 400 mL did not alter the incidence of 'empty stomach' (antral CSA <300 mm²) compared with strict fasting.
Bouvet, *et al*[34 57]	Prospective observational study	100%	Both	Antral CSA measured 15 and 90 min postlight meal during labor.	43	Not reported	No	Not reported	Laboring women showed delayed gastric emptying after a light meal compared with non-pregnant and non-laboring term pregnant women, with epidural analgesia improving emptying.
Sarhan, *et al* [54]	Prospective observational study	80%	Both	Proportion of patients with gastric residual volume >1.5 mL/kg 8 hours poststandardized meal.	56	1 (1.8)	No	Not reported	Full-term non-laboring pregnant women have a 2.4% incidence of gastric volume >1.5 mL/kg after 8 hours of fasting poststandardized meal.
Dhanger, *et al* [52]	Prospective cross-sectional study	80%	Both	Incidence of grade 2 antrum in parturients scheduled for elective cesarean.	236	2 (0.8)	No	Not reported	99.6% of parturients had an empty stomach (grade 0 or 1) after ASA fasting; one had a grade 2 antrum, and none had solids.
Desgranges *et al*[35]	Prospective cohort study	80%	Both	Changes in gastric contents during vaginal delivery and prevalence of aspiration risk stomach in the immediate postpartum period before placental delivery.	30	3 (5.2)	No	Not reported	Gastric antral CSA and solid contents decreased after vaginal birth, indicating partial preservation of gastric emptying, but nearly 25% had a high-risk stomach post partum.
Chang *et al* [48]	Prospective cross-sectional study	80%	Both	Prevalence of risk stomach in term non-fasted laboring women versus fasted non-laboring women.	117	17 (14.5)	No	Not reported	Non-fasting laboring women had a higher incidence of grade 2 antrum than fasted non-laboring women.
Rousset *et al* [36]	Prospective observational study	80%	Both	Comparison of gastric antral CSA in third-trimester pregnant women scheduled for cesarean versus non-pregnant women scheduled for hysteroscopy.	66	3 (4.5)	No	Not reported	Pregnant women have increased antral CSA, which should not be used solely to guide decisions, especially with discordant indicators (CSA, gastric fluid volume, and Perlas score).
Hamed *et al* [55]	Randomized double-blind study	100%	Both	Effect of metoclopramide on gastric volume and contents in parturients undergoing cesarean section.	111	0 (0)	No	Not reported	Metoclopramide significantly reduced antral CSA, gastric volume (p<0.001), nausea/vomiting (p=0.003), and high-risk grade antrum (p<0.001) in parturients.

Continued

Table 2 Continued

Study	Study design	MMAT quality grade	Gastric POCUS performed (qualitative, quantitative, or both)	Primary outcome	Number of patients enrolled	Number (percentage) of indeterminate examinations	Was gold standard of gastric suctioning used?	Was there a change in anesthetic management? (Yes, no, or not reported)—number of patients (%)	Relevant findings
Zhou *et al* [51]	Observer-blinded, prospective interventional study	100%	Both	Effect of 20 min high flow nasal oxygen on gastric volume in non-laboring pregnant women scheduled for elective cesarean under neuraxial anesthesia.	60	0 (0)	No	Not reported	High flow nasal oxygen at 50 L/min for 20 min had no significant effect on gastric volume, antral CSA, or distension.
Ijiri *et al* [56]	Prospective randomized study	80%	Quantitative	Vasopressor doses in parturients undergoing elective cesarean were compared across: (1) group O: 500 mL ORS pre-anesthesia, (2) group M: 500 mL mineral water, (3) group C: No fluid intake >8 hours.	51	0 (0)	No	Not reported	Group O (ORS) required fewer vasopressor boluses and a lower phenylephrine dose ($p<0.05$) vs controls. Neither ORS nor mineral water increased gastric volume or antral CSA. Preoperative ORS stabilized circulatory dynamics without increasing gastric content.
Liu *et al* [49]	Prospective controlled observational study	100%	Quantitative	Gastric emptying rates: epidural analgesia vs pharmacological/ non-pharmacological interventions.	120	Unclear	No	Not reported	Epidural and other labor analgesia minimally affect gastric emptying. Antral ultrasound effectively monitors maternal gastric volume.
Ni *et al*[50]	Randomized controlled trial	80%	Quantitative	Gastric antral CSA at 120 min for parturients given high-energy semifluid solid beverage (HESSB) vs carbohydrate (CHO) solution.	40	2 (5)	No	Not reported	Parturients given HESSB versus CHO showed similar decreases in antral CSA over time, with comparable CSA at 120 min (2.73 cm^2 vs 2.55 cm^2, $p=0.061$).
Bellapukonda *et al*[53]	Cohort study, prospective observational study	100%	Both	Compare gastric volume before elective cesarean with non-pregnant females before elective surgery.	33	12 (36.4)	no	Not applicable	Pregnant and non-pregnant patients show similar CSA before surgery, although the gravid uterus may hinder antrum visualization in pregnancy.
Harnett *et al* [45]	Paired cohort prospective observational study	100%	Both	The difference in antral CSA between the fully fasted group and the 'Sip Til Send' group	58	0 (0)	No	Not reported	No significant difference in antral CSA, gastric volume, or high gastric volume (>1.5 mL/kg) between fasted and 'Sip Til Send' groups. Perlas score was higher in the fasted group but not significant.

Summary of published studies using gastric ultrasound for pregnant women. Not reported for the change in management indicates that the study did not explore the impact of gastric ultrasound findings on anesthetic management.
ASA, American Society of Anesthesiologists; BMI, body mass index; CHO, carbohydrate solution; CSA, cross-sectional area; HESSB, high-energy semifluid solid beverage; MMAT, Mixed Methods Appraisal Tool; ORS, oral rehydration solution; POCUS, point-of-care ultrasound; RLD, right lateral decubitus.

Interventional non-randomized studies

Barboni *et al*[42] compared gastric emptying of a full meal between healthy female volunteers (n=10) and pregnant women before elective cesarean delivery (n=10) over 4 hours. The meal included 600 mL of water, pasta, meat, and salad (450 kcal). Pregnant patients showed delayed initial CSA increase and subsequent CSA reduction compared with healthy volunteers.

Zhou *et al*,[51] in an observer-blinded prospective study with 60 participants, showed that high flow nasal oxygen therapy did not significantly affect gastric volume or cause gastric distension in non-laboring pregnant women.

Bouvet *et al*,[34 57] in a prospective observational study with 43 women, tested the effect of a light meal (125 g yogurt; 120 kcal) on gastric emptying in parturients receiving epidural analgesia compared with those with no labor analgesia and non-pregnant women. Gastric emptying was delayed in laboring women compared with both non-pregnant and non-laboring term pregnant women. Epidural analgesia improved gastric emptying in parturients.

Prospective observational study

Carp *et al*[37] conducted one of the first documented ultrasound examinations in laboring and postpartum women in anesthesia literature. In a prospective observational study of 73 women at term for elective cesarean delivery, intrapartum, and postpartum, gastric POCUS identified the stomach but could only confirm the empty state after ingesting clear fluids. Solid food remained for many hours after labor onset, and the ultrasound technology had a 40% failure rate in identifying the stomach.

Wong *et al*,[38] in a prospective observational cross-over study with 10 full-term pregnant women with obesity, demonstrated that gastric emptying determined by serial gastric POCUS and acetaminophen absorption did not differ after ingesting 50 mL or 300 mL up to 60 min.

Bataille *et al*[27] and Vial *et al*[31] presented prospective cohorts of 58 and 100 spontaneous laboring parturients under epidural analgesia, respectively. Both cohorts used similar CSA cut-off values for an empty stomach (320 and 381 mm^2). They observed a 'full stomach' around epidural insertion time and at full dilation or immediately after delivery in 50% and 13% (Bataille *et al*),[27] or 65% and 48% (Vial *et al*).[31] Median fasting times were 6 and 14 hours for clear fluids and solids and 3 and almost 5 hours, respectively. Despite preserved gastric motility and emptying, the studies caution about the risk of a 'full stomach' based on the percentage of patients above CSA cut-off limits.

Arzola *et al*[58] and Rouget *et al*[28] conducted studies in prospective cohorts of elective cesarean patients. While Arzola *et al*[58] showed only 1/103 (0.9%) with grade 2 antrum, Rouget *et al*[28]

noted 5/43 (12%). Both cohorts followed fasting guidelines of at least 6 hours for solids and 2 hours for clear fluids. The CSA measurements postsurgery were consistent, supporting the fasting guidelines.

Zieleskiewicz *et al*[31] reported optimized cut-off CSA values for estimated water intake volume during labor using sensitivity and specificity analysis. Suggested cut-offs were 387, 505, and 608 mm² in the supine position and 570, 588, and 719 mm² in the RLD position.

Jay *et al*,[33] in a prospective cohort study of 73 laboring women (97% under epidural analgesia), optimized the sensitivity and specificity of the CSA cut-off limit of 381 mm² in the supine position for the fast diagnosis of an empty stomach. Mean fasting times were 5 hours for clear fluids and 10 hours for solids, with CSA measurements taken within the first 2 hours of labor.

Roukhomovsky *et al*,[44] in a prospective cohort study of 34 third-trimester pregnant women, developed a mathematical model to predict GCV using gastric POCUS CSA compared with MRI-measured GCV, with high R^2 values of 0.73 and 0.76, showing strong correlation.

Hakak *et al*,[45] in a prospective observational study of 51 non-laboring term pregnant women after a 6-hour fast of a standard light meal, demonstrated that 37.5% had a residual volume >1.5 mL/kg, suggesting a revision is needed of current fasting guidelines for pregnancy.

Riveros-Perez *et al*,[46] in a prospective cross-sectional study of 42 full-term pregnant women scheduled for elective cesarean delivery, observed a significant positive correlation between body mass index (BMI) and antral CSA and gastric longitudinal diameter, suggesting BMI as an independent variable to predict gastric volume and risk for aspiration, warranting adjustments in fasting guidelines for pregnancy.

Van de Putte *et al*[47] studied non-laboring term pregnant patients and fasted non-pregnant female surgical patients, finding no significant difference in estimated total gastric fluid volume and volume per body weight, supporting the relatively low risk of aspiration in pregnant non-laboring patients.

Gal *et al*[48] conducted a prospective non-randomized study comparing fasting gastric volume in 50 term-pregnant women undergoing elective cesarean section with 45 non-pregnant or first-trimester pregnant women undergoing minor gynecological procedures, finding no significant differences.

Sarhan *et al*,[34] in a prospective observational study of 56 parturients, demonstrated a low incidence (2.4%) of gastric volume >1.5 mL/kg after an 8-hour fast of a standardized meal, suggesting the adequacy of current fasting guidelines.

Dhanger *et al*,[35] in a prospective cross-sectional study of 236 term parturients scheduled for elective cesarean section, found that 99.6% had an empty stomach (grade 0 or 1 antrum) after following ASA fasting guidelines, with only one having a grade 2 antrum and none with solids.

Desgranges *et al*,[36] in a prospective observational study of 30 full-term pregnant women, observed a decrease in gastric antral CSA and the proportion of patients with solid gastric contents after vaginal birth, suggesting partial preservation of gastric emptying during vaginal delivery, although almost one in four had a high-risk stomach immediately postpartum.

Chang *et al*,[37] in a prospective cross-sectional study of 117 women, demonstrated a higher incidence of grade 2 antrum in non-fasting laboring women compared with fasted non-laboring women.

Rousset *et al*,[58] in a prospective observational study of 66 women, found an increased antral CSA in third-trimester pregnant women scheduled for cesarean section compared with non-pregnant women scheduled for hysteroscopy, suggesting antral CSA should not be used alone in decision-making, especially with discordant results.

Liu *et al*[53] observed that neither epidural nor other labor analgesia significantly impacted gastric emptying in 120 parturients. Although no significant differences were observed, the study demonstrated that gastric POCUS could effectively monitor changes in maternal gastric volume during labor.

Bellapukonda *et al*[30] compared gastric volume before elective cesarean delivery in term pregnant patients and non-pregnant female patients, finding similar CSA measurements.

Harnett *et al*[54] noted no significant difference in gastric volume or antral CSA between fully fasted parturients and those allowed to sip fluids until anesthesia induction in a study of 58 participants.

Summary

As demonstrated, significant heterogeneity exists in the gastric POCUS studies on the pregnant population. The 30 studies focus on gastric volumes in laboring and non-laboring pregnant women and highlight differences based on factors such as BMI, fasting state, and interventions during labor. These studies collectively emphasize the role of gastric POCUS in safely monitoring and managing gastric volume in pregnant women under various clinical interventions without any reported need for gastric suctioning or changes in anesthetic management.

The selected pregnancy-related studies characterize the antral CSA and/or gastric volume. They can be grouped into several topics: gastric emptying, cesarean delivery, labor and post partum, and mathematical models to estimate gastric volume. Studies before elective cesarean delivery assess gastric emptying after standard fasting conditions (liquids: 2 hours; solids: 6 or 8 hours) and compare it with non-pregnant surgical populations.[30 32 35 41 48 58] Some studies use a controlled meal and follow-up for 4 hours,[56] 6 hours,[45] or 8 hours[34] before cesarean delivery. Two studies provide high-energy fluids[38] or allow oral intake until spinal anesthesia ('Sip Til Send').[54] Most studies show favorable conditions before cesarean delivery, except three: Barboni *et al*[56] noted solids in the stomach after 4 hours of a standard meal and Hakak *et al*[45] showed gastric volume >1.5 mL/kg after 6 hours despite no solids. An 8-hour fasting period remains the most conservative and 'safe' approach.[34]

Research during active labor, with or without epidural analgesia, and in the postpartum period attempts to demonstrate that gastric emptying is preserved when only clear liquids or small amounts of fluids are ingested in a time-restricted protocol.[50] While epidural anesthesia appears to preserve gastric emptying during labor, it may not ensure a completely safe gastric status at delivery or post partum.[36] Some protocols do not allow oral intake during labor,[33 40 43] questioning the generalizability of the results. Any study involving solids during labor shows remaining gastric contents.[27 28 37 51] Two interventional studies before cesarean delivery suggest metoclopramide enhances gastric emptying,[52] and oral hydration solutions help maintain stable circulatory dynamics.[39]

Studies in non-laboring women and volunteers show a significant correlation between CSA and BMI,[46] although no changes in gastric emptying of water are observed in patients with BMI >35.[29] Fasted non-laboring women are generally comparable with non-pregnant women,[47] except for Rousset *et al*, which showed increased CSA in the pregnant population.[58] Irwin *et al* demonstrated no changes in gastric emptying when milk is added to tea.[49] High-flow nasal oxygenation does not significantly

affect or distend the stomach, making it a valuable adjunct in airway management.[55]

Finally, Perlas *et al* developed a mathematical model to estimate gastric volume from CSA measurements using gastroscopy as the reference standard, with an $R^2=0.73$.[59] Although validated only in non-pregnant[59] and adults with obesity,[17] this model remains widely used in pregnancy. Three models described in pregnancy correlate highly with the Perlas model. Arzola *et al*[5] used ingested clear fluids as the reference standard ($R^2=0.44$). Roukhomovsky *et al* developed two models and used MRI as a standard reference ($R^2=0.73$ and $R^2=0.76$).[44] These three models in pregnancy highly correlate with the model by Perlas *et al*[59] and suggest cut-off limits for CSA and gastric volumes per body weight in the fasted state. The gastric volume of 1.5 mL/kg is also accepted in adult populations during pregnancy, which appears to correspond to an upper CSA cut-off limit of 10 cm^2, as suggested in a recent meta-analysis in adults, including pregnant women. Other suggested cut-off limits in pregnancy relate to an ultrasound image of a 'completely empty' stomach (antrum grade 0). However, these may not account for normal residual gastric secretions (antrum grade 1), which are very common and present in around 50% of all fasting individuals, whether pregnant or not. These studies, conducted by a French group dedicated to gastric POCUS research, derive some cut-off limits from sensitivity and specificity performance in receiver operating characteristic curve analysis. However, they do not always consider the upper 95th percentile of fasted patients.[33 36 40 57 60]

Expert practice recommendation

The authors *support* the use of gastric POCUS to assess gastric content and volume in pregnant patients for assessment and management of aspiration risk in the following high-risk clinical scenarios: active labor, urgent cesarean section where nil per os (NPO) status is unclear, and in pregnant patients experiencing delayed gastric emptying due to medications or medical conditions such as hyperemesis gravidarum, pre-eclampsia/eclampsia, or gestational diabetes.

In non-laboring pregnant patients, the authors *do not support* routine gastric POCUS as the current evidence suggests that their gastric contents are comparable with non-pregnant patients. We consider non-laboring patients clinically equivalent to non-laboring patients presenting for 'elective' cesarean section, and therefore, they also fall under these same recommendations.

The authors acknowledge the heterogeneity of study designs and the predominance of moderate-quality studies. While this cohort has not consistently shown changes in perioperative management based on gastric POCUS findings in pregnancy, expert consensus supports its use due to the well-documented increased aspiration risk of this medically complex patient population. Although no interventions were reported in the study settings, gastric ultrasound effectively confirmed an empty stomach, highlighting its risk-stratification value—especially in laboring or high-risk pregnancies where an unexpected full stomach may occasionally be detected. Given the ability of gastric POCUS to individualize risk assessment and potentially avoid unnecessary fasting delays or airway management precautions, its clinical value is considered higher in pregnancy compared with other populations with similarly inconclusive data.

Ultimately, gastric POCUS is one tool for clinical decision-making, alongside bedside assessments and patient history. Practitioners should feel comfortable implementing aspiration risk precautions based on clinical acumen and the complete clinical picture rather than relying solely on ultrasound findings. Additionally, given the evidence of unique challenges associated with scanning due to a gravid uterus, there is a potential for an increased risk of error, particularly among non-experts.

Obesity

For this review, obesity was defined by the WHO definition of a BMI >30. Five studies were identified with publication years ranging from 2016 to 2023.[17 61–64] Quality assessment scores using the MMAT[25] ranged from 80% (four criteria met)[17] to 100% (five criteria met).[61–64] The quality assessment for each study is presented in online supplemental table 2. A summary of the study findings is provided in table 3.

Three of the five studies were prospective observational studies,[17 63] one was retrospective,[61] and one was a randomized, blinded study.[64] Kruisselbrink *et al*[64] conducted a randomized, blinded study to validate a previously described mathematical model to estimate gastric volume based on a two-dimensional assessment of the antral area in subjects with severe obesity with a BMI >40 kg/m^2. The study involved 40 participants, and the results suggested that the existing model accurately predicted gastric volume in subjects with severe obesity (BMI >40 kg/m^2).

Sharma *et al*,[63] Khalil *et al*,[17] and Schwisow *et al*[62] conducted prospective observational studies using gastric POCUS to identify risk factors for aspiration in patients with obesity. Sharma *et al*[63] used both qualitative and quantitative gastric POCUS, finding that out of 38 patients with obesity, 27.8% had an average gastric volume of 1.9 mL/kg, with a higher risk of aspiration compared with patients without obesity. Khalil *et al*[17] assessed residual gastric volume in 50 patients, noting that one patient with obesity had an increased gastric volume without solid content, and patients with obesity had an increased CSA but <1.5 mL/kg by gastric POCUS, suggesting a low aspiration risk with >8 hours of fasting. Schwisow *et al*[62] used only qualitative gastric POCUS in 40 high-risk patients, including 32 individuals with obesity. They showed solid food in five patients, four of whom had obesity, resulting in changes in anesthetic management in two cases (5%).

Lastly, Baettig *et al*[61] reported on a retrospective study using both gastric POCUS types to investigate the potential impact of routine preoperative gastric POCUS on the perioperative management of adult patients undergoing elective or emergency surgery. Of the 2003 patients in the study, 244 had obesity. The study reported a change in anesthetic management in 379 patients (18.9%). The gastric POCUS led to a more liberal approach in 14% of elective surgery patients and 18% of emergency surgery patients, with a more conservative approach in 4% and 3% of elective and emergency patients, respectively.

Summary

The overall findings indicate that gastric POCUS is feasible and accurate in individuals with obesity, enabling clinical differentiation between 'low-risk' and 'high-risk' stomachs for anesthetic management. Although patients with a 'high-risk' stomach may have a higher aspiration risk, studies on aspiration are scarce, and there is no clear link established. While data conflict regarding obesity as a risk factor for a full stomach despite fasting, the largest study (Baettig *et al*,[61] including 244 patients with obesity) showed that the use of gastric POCUS changed management in 18%–21% of cases, highlighting its potential impact in obesity compared with clinical assessment alone.

Table 3 Summary of studies—obesity

Study	Study design	MMAT quality grade	Gastric POCUS performed (qualitative, quantitative, or both)	Primary outcome	Number of patients enrolled	Number (percentage) of indeterminate examinations	Was gold standard of gastric suctioning used?	Change in anesthetic management based on findings? (Yes or not applicable)—number of patients (%)	Relevant findings
Kruisselbrink *et al* [17]	Randomized blinded study	100%	Both	Evaluate gastric volume in subjects with severe obesity (BMI >35 kg/m^2).	40	1	Yes	Not applicable	A mathematical model to determine gastric fluid volume based on sonographic assessment performs well in individuals with severe obesity.
Sharma *et al* [61]	Prospective observational study	100%	Both	Identify risk factors for aspiration through both qualitative and quantitative assessment of residual gastric volume.	246; 38 patients with obesity (BMI >30 kg/m^2)	Unclear	No	Not applicable	Average gastric volume in the obese group (1.9 mL/kg). 27.8% of patients with obesity were at risk of aspiration (p<0.007) compared with 11.4% of patients without obesity. Elevated BMI was 1.07 times the risk for aspiration.
Mohammad Khalil *et al*[62]	Prospective observational study	80%	Both	Assess residual gastric volume in normal-weight patients and patients with obesity scheduled for elective surgery.	50	0	Yes	Not applicable	One of 50 patients with obesity (2%) had increased gastric volume. No solid content was seen. Patients with obesity had increased CSA but <1.5 mL/kg via gastric POCUS and gastric suctioning. Both groups had low aspiration risk with >8 hours fasting.
Schwisow *et al*[63]	Prospective observational study	100%	Qualitative	Use a gastric POCUS protocol checklist to screen for gastroparesis and possible aspiration risk. Gastric POCUS was performed on high-risk patients.	40 total; 32 patients with obesity (BMI >30 kg/m^2)	Unclear	No	Yes—2 (5%)	Gastric POCUS revealed solid food on examination in five out of 40 patients (12.5%). Four of the five patients (80%) had obesity. All patients with solid food gastric contents were >ASA 3 and had two or more risk factors for gastroparesis.
Baettig *et al*[64]	Retrospective study	100%	Both	Potential impact of routine pre-operative gastric POCUS on peri-operative management of adult patients undergoing elective or emergency surgery.	2003 total; 244 patients with obesity (BMI >35 kg/m^2)	34 total; Unclear for obese	No	Yes—379 total (18.9%). Unclear for obese.	Gastric POCUS for elective surgery: ► More 'liberal approach' 14% of patients. ► More 'conservative' approach 4%. Gastric POCUS for emergency surgery: ► More 'liberal approach' 18% of patients. ► More 'conservative' approach 3%.

Summary of published studies using gastric ultrasound for the population with obesity based on the WHO definition of BMI >30 kg/m^2.
BMI, body mass index; CSA, cross-sectional area; MMAT, Mixed Methods Appraisal Tool; POCUS, point-of-care ultrasound.

Expert practice recommendation

The authors *conditionally support* the use of gastric POCUS to assess gastric content and volume in patients with obesity undergoing regional anesthesia to tailor anesthetic and airway management. The limited number of publications, the heterogeneity in study designs and patient populations, and the reliance on only a few moderate-quality studies reduce the overall confidence in the findings. Future research should focus on large population-based studies with advanced statistical methods to clarify obesity's role as an aspiration risk factor.

Diabetes

For this review, gastric POCUS studies that included diabetes, either type 1 or type 2, were included. 13 studies were identified with publication dates ranging from 2018 to 2024. Quality assessment scores using the MMAT[25] ranged from 80% (four criteria met)[65–75] to 100% (five criteria met).[76–78] The quality assessment for each study is presented in online supplemental table 3.

Of the 13 studies identified, most were prospective observational single-center studies,[65 66 70–73 76–78] and one was a multicenter study.[75] Three of these studies[68 69 79] evaluated the effect of preoperative carbohydrate loading on baseline gastric volume in patients with diabetes scheduled for elective surgery. A summary of the study findings is provided in table 4.

Table 4 Summary of studies—diabetes

Study	Study design	MMAT quality grade	Gastric POCUS performed (qualitative, quantitative, or both)	Primary outcome	Number of patients enrolled	Number (percentage) of indeterminate examinations	Was gold standard of gastric suctioning used?	Was there a change in anesthetic management?(Yes, no, or not reported)—number of patients (%)	Relevant findings
Sabry *et al*[65]	Prospective observational study	80	Both	Residual gastric volumes in semi-sitting position.	25	0	No	Not reported	Higher antral CSA and residual gastric volume in patients with diabetes (both estimated and suctioned).
Zhou *et al*[76]	Prospective, cohort	100	Both	Prevalence of full stomach in elective surgical patients with obesity.	102	6 (5.5%)	No	Not reported	48% of patients with diabetes were found to have full stomachs after standard fasting. Diabetic retinopathy was an independent risk factor for a full stomach.
Reed and Haas[77]	Prospective observational study	100	Both	Assess gastric contents during fasting in patients with type 2 diabetes undergoing elective surgery.	40	0	No	Yes—2 (5%)	There is no association between preoperative stress and gastric contents, but HbA1c >7 is associated with increased gastric volume.
Garg *et al*[66]	Prospective observational study	80	Both	Fasting gastric volumes in patients with and without diabetes.	103	0	No	Not reported	High residual gastric volume in patients with diabetes compared with patients without diabetes in fasting elective surgery patients.
Haramgatti *et al*[70]	Prospective observational study	80	Both	Comparison of residual gastric volumes between patients with and without diabetes scheduled for elective surgery.	40	0	NG aspirates	Not reported	There was higher residual gastric volume and higher CSA in patients with diabetes, but none had a grade 2 antrum.
Rousset *et al*[75]	Prospective multicenter study	80	Both	Percentage of patients in two groups with an average CSA >340 mm^2 or grade 2 antrum.	42	0	No	Not reported	Increased gastric contents in patients with diabetes compared with controls despite following appropriate fasting guidelines. (This study used low thresholds for CSA and volume.) Therefore, it could have an increased number of false-positive results).
Lin *et al*[68]	Prospective observational study; randomized controlled trial	80	Both	Evaluate the impact of preoperative carbohydrate loading on gastric volumes in patients with type 2 diabetes for elective surgery.	80	2 (2.5%)	No	No	Preoperative carbohydrate (14.2%) loading 2 hours before induction of anesthesia did not alter gastric volumes/weight in patients with type 2 diabetes.
Lee *et al*[69]	Prospective observational study	80	Both	Assess the risk of aspiration after carbohydrate loading in patients with type 2 diabetes before elective surgery.	49	0	No	No	Preoperative carbohydrate loading did not increase gastric volumes in patients with type 2 diabetes.
Demirel *et al*[73]	Prospective observational study	80	Both	Antral CSA and gastric volumes in patients with type 2 diabetes.	80	0	No	Not reported	15% had grade 2 antrum with 8.75% solids in patients with type 2 diabetes, even with regular fasting for elective surgery. Duration of more than >8 years of type 2 diabetes and peripheral neuropathy is associated with high-risk antral grade.
Hakak *et al*[72]	Prospective observational study	80	Both	Fasting gastric volumes in patients with and without diabetes.	60	0	No	Not reported	High residual gastric volumes in patients with type 2 diabetes compared with patients without type 2 diabetes in fasting elective surgery patients.
Khan *et al*[71]	Prospective observational study	80	Both	Compare mean antral CSA after 8 hours of fasting in patients with and without diabetes undergoing elective surgery.	25	0	No	Not reported	There was an insignificant increase in CSA and gastric volumes in patients with diabetes over patients without diabetes who fasted for 8 hours scheduled for elective surgery.
Vishak *et al*[74]	Prospective observational study; randomized controlled trial	80	Both	Effect on gastric volumes after carbohydrate and non-carbohydrate loading in patients with and without diabetes for elective surgery.	120	0	No	Yes One patient had surgery postponed due to a grade 2 antrum. After 2 hours, it was a grade 1 antrum.	Carbohydrate or non-carbohydrate loading two 2 hours before surgery did not affect gastric volumes in patients with and without diabetes.
Perlas *et al*[78]	Prospective observational study; cross-sectional study	100	Both	Determine if current preoperative fasting guidelines consistently ensure an empty stomach in patients with diabetes	91	7 (7.7%)	No	No	Fasting gastric volumes were not higher in patients with diabetes. The 95th percentile for gastric volumes was similar in both groups.

Summary of published gastric POCUS studies for the population with diabetes. Not applicable for the change in management indicates that the study did not explore the impact of gastric ultrasound findings on anesthetic management.
CSA, cross-sectional area (cm^2); HbA1c, hemoglobin A1c; MMAT, Mixed Methods Appraisal Tool; POCUS, point-of-care ultrasound.

Baseline gastric volumes in fasting patients with and without diabetes

In nine out of the 10 studies looking at baseline gastric volume, patients with diabetes exhibited higher baseline gastric volumes and larger antral CSA compared with patients without diabetes. Sabry *et al*[65] demonstrated that patients with diabetes had higher antral CSA and residual gastric volumes in both semi-sitting and RLD positions, with 60% of patients with diabetes having residual gastric volumes >1.5 mL/kg vs 20% of patients without diabetes. Similarly, Zhou *et al*[76] showed that 48% of patients with diabetes had a full stomach, with a longer time to attain an empty stomach state for clear liquids and light meals compared with patients without diabetes, and identified diabetic retinopathy as an independent risk factor for a full stomach.

Reed and Haas[77] reported no association between preoperative stress and gastric contents in patients with type 2 diabetes. Still, they noted that a hemoglobin A1c (HbA1c) level >7 was linked to increased gastric fluid volume, with 5% of patients having solid contents. Garg *et al*[66] demonstrated a higher incidence of grade 2 antrum in patients with diabetes (35%) compared with patients without diabetes (20%), along with higher fasting gastric volume and antral CSA. Haramgatti *et al*[70] observed higher residual gastric volumes and CSA in patients with type 2 diabetes, but these increases were clinically insignificant as all patients had low-grade antrums (0–1).

In a multicenter study, Rousset *et al*[75] reported that a greater proportion of patients with diabetes (42.9%) had an antral CSA >340 mm^2 compared with the control group (22.2%). The study showed that the duration of diabetes was the only independent risk factor for higher gastric volume, although the clinical significance of an antral area >340 mm^2 remains questionable. Demirel *et al*[73] showed that 15% of patients with type 2 diabetes had high-risk antral grades, with solid contents in 8.75% of patients despite adequate fasting. The duration of diabetes and peripheral neuropathy was associated with grade 2 antrum.

Hakak *et al*[45] compared fasting gastric volumes in patients with type 2 diabetes and patients without type 2 diabetes, finding a higher incidence of grade 2 antrum, higher RLD CSA, and residual gastric volume in patients with diabetes. Khan *et al*[71] noted a clinically insignificant increase in CSA and gastric volume in patients with diabetes compared with patients without diabetes who fasted for 8 hours, with no high-risk gastric volumes or solid contents recorded.

Alternatively, Perlas *et al*,[78] in a study on 180 fasting elective surgical patients, noted fasting gastric volumess were not higher in patients with diabetes than patients without diabetes. The 95th percentile distribution of gastric volume values was similar in both groups, but no solid contents were seen in either group. There was a weak correlation between gastric volume and HbA1c.

Effects of preoperative carbohydrate loading

Preoperative carbohydrate loading appears safe in patients with diabetes, resulting in similar baseline gastric volumes to standard care. Lin *et al*[68] reported that up to 300 mL of oral carbohydrate loading did not significantly affect gastric volume per unit of weight in patients with type 2 diabetes, supporting its use in enhanced recovery after surgery (ERAS) programs for improved nutrition and prehabilitation. Similarly, Lee *et al*[69] demonstrated that preoperative carbohydrate loading did not increase gastric volumes in patients with type 2 diabetes undergoing elective cholecystectomy and video-assisted thoracoscopic surgery procedures, with all patients exhibiting either grade 0 or grade 1 antrum and no cases of regurgitation or aspiration.

In an RCT, Vishak *et al*[74] observed no significant increase in gastric volumes with carbohydrate loading 2 hours before induction of anesthesia. Only one patient out of 240 had a grade 2 antrum, indicating that preoperative carbohydrate loading is safe and does not increase the risk of aspiration.

Summary

The above studies indicate that gastric POCUS can differentiate between low-risk and high-risk gastric content based on qualitative assessment (antral grades) and quantitative (estimated volume) assessments in patients with diabetes. While we have mixed results overall, most of these studies[65 66 73 76] showed higher residual gastric volumes and antral CSA in patients with diabetes than patients without diabetes. In contrast, a few of these studies[77 78] showed no significant difference between patients with diabetes and patients without diabetes. Garg *et al*[66] assessed 53 patients with diabetic mellitus vs 50 patients without diabetes and reported higher mean gastric volumes (9 mL) in patients with diabetes compared with 2 mL in patients without diabetes. Reed and Haas,[77] with a study of 40 patients with type 2 diabetes mellitus (DM), reported a mean gastric volume of ~23.7 mL in patients with type 2 diabetes, which falls within the normal fasting range. However, they noted an HbA1c >7 was associated with higher volumes. Zhou *et al*,[76] a study of 52 patients with diabetes vs 50 patients without diabetes, reported a higher incidence of a full stomach (48%) in patients with diabetes compared with patients without diabetes (8%).

Similarly, Rousset *et al*[75] observed a high incidence of a full stomach. The incidence of solid contents after adequate fasting is infrequent in patients with diabetes, as shown by Demirel *et al*,[73] who reported an incidence of 8.75% (7/80), and Reed *et al*,[77] who found 5% (2/40). In contrast, Khan *et al*[71] and Perlas *et al*[78] showed no solid content. The major limitation of some studies is what constitutes a high-risk stomach, the variations in normal values taken as thresholds, and a lack of quantitative examinations to determine volume. Although some have statistical significance, their clinical relevance is lacking as the follow-up on the aspiration events, or change in anesthesia or airway management, is not documented well.

The major limitation of these studies is that most patients had type 2 DM, and very few had type 1 DM. These studies demonstrate successful evaluation of gastric contents with gastric POCUS in patients with diabetes, which can be used for risk stratification. It was also challenging to specifically look into causative factors for high residual gastric volume and gastric content in patients with diabetes. At the same time, few of the studies have associated diabetic eye disease, duration of diabetes of >8 years, HbA1c of >7, and peripheral neuropathy.

The multicenter study by Rousset *et al*[75] used lower CSA and volume thresholds to define a 'full stomach,' which falls below the 95th percentile values identified in a recent meta-analysis by Perlas *et al*[80] (9.9 cm^2 and 2.3 mL/kg in fasting adults). These lower cutoffs may increase false positives, whereas higher, evidence-based thresholds may better support safe ERAS implementation in patients with diabetes using gastric POCUS.

Expert practice recommendation

The authors support using gastric POCUS to assess gastric content and volume in patients with diabetes, particularly those with type 2 diabetes, due to their typically higher baseline gastric volumes and larger antral CSA compared with patients without

Table 5 Summary of studies—GERD

Study	Study design	MMAT quality grade	Gastric POCUS performed (qualitative, quantitative, or both)	Primary outcome	Number of patients enrolled	Number (percentage) of indeterminate examinations	Was gold standard of gastric suctioning used?	Was there a change in anesthetic management?(Yes, no, or not reported)—number of patients (%)	Relevant findings
Valero Castañer *et al*[67]	Prospective observational study	80%	Both	To determine if any differences exist in gastric volume between patients with and without comorbidities for delayed gastric emptying (DM, Parkinson's, GERD, or opioids)	23	2 (8.6%)	No	Not reported	The investigators found no difference in gastric content between patients with gastric emptying factors and control subjects.
Tan *et al*[81]	Prospective observational study	80%	Both	Investigate the utility of gastric POCUS, specifically in patients with dyspepsia	120	3 (2.5%)	Yes	Yes Nine patients (7.7%)	Antral CSA cut-off values of 10.0 cm^2 for measuring antral CSA (in the right lateral decubitus) correlate with gastric volumes >0.8 mL/kg in patients with organic dyspepsia.

Summary of published studies using gastric ultrasound for GERD patient population. Not applicable for the change in management indicates that the study did not explore the impact of gastric ultrasound findings on anesthetic management.
CSA, cross-sectional area (cm^2); DM, diabetes mellitus; GERD, gastroesophageal reflux disease; MMAT, Mixed Methods Appraisal Tool; POCUS, point-of-care ultrasound.

diabetes, even when appropriately fasted. Given the heterogeneity of the studies and the variability in findings, gastric POCUS may not be necessary for all patients with diabetes. Still, it is useful for identifying high-risk individuals to tailor anesthesia and airway management strategies. Future research should focus on larger population-based studies, especially including more patients with type 1 diabetes, to further validate these findings and refine the guidance.

Gastroesophageal reflux disease

Two studies assessing the role of gastric POCUS for patients with GERD were identified, with publication years ranging from 2021 to 2022.[67 81] Quality assessment scores using the MMAT[25] for both studies were 80% (four criteria met). The quality assessment for each study is presented in online supplemental table 4. Table 5 summarizes the study findings.

Valero Castañer *et al*[67] performed a prospective observational study using qualitative and quantitative gastric POCUS to assess the antral contents of patients with or without predefined comorbidities believed to slow gastric emptying, including GERD or dyspepsia. The study involved 53 patients, 23 (43.3%) of whom had at least one factor thought to slow gastric emptying (which authors defined as DM, Parkinson's disease, dyspepsia, GERD, or opioid treatment). The investigators noted no difference in gastric content between patients with gastric emptying factors and control subjects.

Tan *et al*[81] performed a prospective observational study of 120 patients with complaints of dyspepsia (a group that included GERD symptoms) scheduled for elective gastroscopy. The authors assessed the utility of gastric ultrasonographic measurements of the CSA and its predictive value in patients suffering from GERD. Despite the patients being appropriately fasted, the investigators demonstrated that the gastric antral CSA was greater in patients with dyspepsia than previously reported values in patients without these symptoms. They suggested that patients with dyspepsia have slower gastric emptying and proposed a model for predicting gastric volume, specifically in patients with these symptoms.

Summary

There is a lack of research investigating the use of gastric POCUS in patients with GERD. The two small studies had conflicting results—Valero Castañer *et al*[67] found no volume difference in patients with presumed delayed-emptying conditions (including GERD) versus controls, while Tan *et al*[81] derived a CSA cut-off (10.0 cm^2 in RLD) for high gastric volume in patients with dyspepsia with no healthy control group, thereby limiting their comparison.

Expert practice recommendation

The authors *do not support* the use of gastric POCUS to assess gastric content and volume in patients with GERD due to the heterogeneity of the studies, the limited patient population, and conflicting findings in the studies. Further large-scale studies are needed to determine if gastric POCUS can detect a difference in gastric content in patients presenting with GERD and if these results can be used clinically to stratify patients for aspiration risk.

Emergency care

For this review, emergency care was defined as urgent or non-elective cases (surgical or medical procedures), with various fasting times not necessarily complying with the ASA NPO guidelines for elective cases. Eight studies were identified with publication years ranging from 2017 to 2023.[82–88] Quality assessment scores using the MMAT[25] ranged from 80% (four criteria met)[31 82] to 100% (five criteria met).[83–88] The quality assessment for each study is presented in online supplemental table 5. A summary of the study findings is provided in table 6.

Six of the eight were prospective observational studies,[82–84 86 88 89] one was a prospective non-randomized clinical trial,[85] and one was a prospective randomized, double-blinded study.[87] Bouvet *et al*[83] conducted a prospective observational cohort study to evaluate the prevalence of full and empty stomach examnations in patients presenting for emergency and elective procedures. The study involved 440 participants using qualitative and quantitative gastric POCUS, assessing gastric antral CSA in the supine, RLD,

Table 6 Summary of studies—emergency care

Study	Study design	MMAT quality grade	Gastric POCUS performed (qualitative, quantitative, or both)	Primary outcome	Number of patients enrolled	Number (percentage) of indeterminate examinations	Was gold standard of gastric suctioning used?	Was there a change in anesthetic management?(Yes, no, or not reported)—number of patients (%)	Relevant findings
Bouvet *et al*[82]	Prospective observational cohort	100%	Both	Prevalence of full and empty stomachs in elective and emergency patients.	440	55 (11%)	No	Yes 10 (5.2%)	Gastric POCUS was feasible in 89% of patients. 5% of elective and 56% of emergency patients had a full stomach despite prolonged fasting. Preoperative morphine consumption, obesity, diabetes mellitus, and emergency surgery were factors independently associated with a full stomach.
Dupont *et al*[83]	Prospective observational cohort	80%	Quantitative	Measurement of gastric antral cross-sectional area to estimate gastric volume in patients before unplanned surgery after at least a 6 hours fast.	300	37 (12%)	No	Not reported	Gastric POCUS was feasible in 88% of patients. 35% of patients fasted for a median of 16 hours before surgery had a measured gastric antral area exceeding 410 mm^2, a value that categorizes a full stomach.
Nasr-Esfahani *et al*[85]	Prospective observational study; cross-sectional study	100%	Quantitative	Measurement of gastric antral cross-sectional area in adult patients requiring emergency procedural sedation for extremity trauma.	100	20 (16.7%)	No	Not reported	Gastric POCUS was feasible in 83.3% of patients and can be used as a diagnostic tool for assessing the risk of vomiting in patients undergoing procedural sedation; CSA correlated with the incidence of vomiting ($p<0.0001$). The mean CSA in patients who vomited was 10.3 cm^2 vs 3.5 cm^2 in non-vomiting patients ($p<0.0001$). Age, sex, and BMI were not independent risk factors for vomiting.
Sayyadi *et al*[86]	Prospective; non-randomized, parallel clinical trial	100%	Both	The effect of metoclopramide on reducing gastric contents in patients requiring urgent surgery with incomplete fasting before the induction of general anesthesia.	60	None reported	No	Not reported	Metoclopramide can accelerate gastric emptying compared with placebo in patients with incomplete fasting before induction of general anesthesia. Mean CSA reduced by 4.3 cm^2 ($p<0.001$) compared with placebo. Prevalence of Perlas grade 2 stomach reduced from 56.7% to 6.9% after treatment.
Okada *et al*[87]	Prospective observational study; cross-sectional study	100%	Quantitative	To determine the antral-CSA threshold of the 'high-risk stomach,' defined as the presence of solid/thick fluid and/or gastric content volume >1.5 mL/kg in patients undergoing emergency abdominal surgery.	39	19 (12%)	Yes	Not reported	The cut-off value of antral CSA for diagnosing 'high-risk stomach' was 3.01 cm^2 in the supine position. This value had a sensitivity of 85%, a specificity of 53%, and an accuracy of 69%. Notably, 51% of patients requiring emergency abdominal surgery had a high-risk stomach despite long fasting times (median solid and liquid fasting times of 16 and 6 hours, respectively).
Delamarre *et al*[84]	Prospective observational study	80%	Both	To assess the diagnostic performance of clinical judgment for the preoperative assessment of full stomach in urgent patients compared with gastric POCUS.	196	8 (4.1%)	No	Not reported	Clinical judgment showed poor-to-moderate performance in urgent surgical patients to diagnose full stomach. PPV 42.1, NPV 79.4, accuracy 68.7%. Patients with gastric POCUS full stomach were misdiagnosed by clinical judgment in 55% of the cases. Abdominal and gynecologic-obstetric surgery were independently associated with gastric POCUS full stomach.
Lin *et al*[88]	Prospective; randomized double-blind parallel controlled trial	100%	Both	To evaluate the effects of metoclopramide on gastric motility in patients being treated for trauma in the emergency department.	50	None reported	No	Yes 23 (46%)	When metoclopramide was used in satiated emergency trauma patients, it accelerated gastric emptying within 30 min, up to 120 min ($p<0.001$). Calculated gastric volume at 120 min was 1.4 mL/kg in the treatment group vs 2.2 mL/kg in the control group, although both groups had measured CSA >3.4 cm^2 and did not meet the fasting standard CSA.

Continued

Table 6 Continued

Study	Study design	MMAT quality grade	Gastric POCUS performed (qualitative, quantitative, or both)	Primary outcome	Number of patients enrolled	Number (percentage) of indeterminate examinations	Was gold standard of gastric suctioning used?	Was there a change in anesthetic management?(Yes, no, or not reported)—number of patients (%)	Relevant findings
Asokan *et al*[89]	Prospective observational study	100%	Both	Measurement of gastric antrum CSA and calculation of gastric volume in patients requiring urgent emergency intubation in the emergency department.	100	None reported	No	Not reported	Measured CSA cutoff ≥9.27 cm^2 (RLD) (sensitivity 100%, specificity 87%) and calculated (Perlas formula) gastric volume ≥111.594 mL (sensitivity 100%, specificity 92%) predicts aspiration. Aspiration is defined as observable gastric contents in the hypopharynx during intubation (progression to clinical or radiographic evidence of aspiration not studied).

Summary of published studies using gastric ultrasound for the emergency care patient population based on patients not receiving elective surgery or procedures. Not applicable for the change in management indicates that the study did not explore the impact of gastric ultrasound findings on anesthetic management.
ASA, American Society of Anesthesiologists; BMI, body mass index (kg/m^2); CSA, cross-sectional area (cm^2); MMAT, Mixed Methods Appraisal Tool; NPV, negative predictive value; POCUS, point-of-care ultrasound; PPV, positive predictive value; RLD, right lateral decubitus position.

and semi-recumbent positions. A mathematical model was used to calculate gastric CSA measurements from two cross-sectional gastric antrum diameters (anterior-posterior and cranio-caudad). Gastric POCUS was feasible in 89% of patients studied, with a full stomach observed in 56% of emergency patients (Perlas *et al*[16] gastric antral grade 2), compared with 5% of elective patients despite prolonged fasting. These findings led to a change in airway management in 5.2% of patients in the study. Other pertinent findings were the identification of multiple risk factors for a full stomach, including preoperative morphine consumption, obesity, diabetes, and emergency surgery.

Dupont *et al*[82] conducted a prospective observational study in 300 patients using quantitative gastric POCUS to measure gastric CSA and estimate gastric volume in patients presenting for emergency surgery after at least a 6-hour fast. Gastric CSA measurements were successfully obtained in the semi-recumbent position in 88% of patients, with gastric CSA calculated using the method referenced in the study by Bouvet *et al*.[83] They demonstrated that 35% of patients had a gastric CSA value consistent with a full stomach despite fasting for a median of 16 hours before surgery. Gastric CSA was associated with BMI and morphine consumption but not fasting time.

Nasr-Esfahani *et al*[84] executed a prospective cross-sectional observational study with 100 patients to determine the relationship between measured gastric CSA (and inferred gastric volume) for extremity trauma, using quantitative gastric POCUS. Measurements were feasible in 83.3% of patients, and the authors observed a reduced incidence of vomiting with lower gastric volumes ($p<0.0001$). The mean gastric CSA in patients who vomited was 10.3 cm^2 compared with 3.5 cm^2 in non-vomiting patients. Age, sex, and BMI were not determined to be independent risk factors for vomiting. Limitations of the study include a lack of identification of the type and dose of pharmacological agents used. The association between vomiting and aspiration was not studied.

Sayyadi *et al*[85] conducted a prospective non-randomized parallel clinical trial involving 60 patients, using quantitative and qualitative gastric POCUS, to assess the efficacy of metoclopramide in accelerating gastric emptying in patients presenting for urgent surgery with insufficient NPO time (2.5 hours mean fasting time). Gastric CSA was calculated using the Bouvet *et al*[83] method in control and treatment groups and measured again 30 min after administration of 10 mg of intravenous metoclopramide. The mean reduction in CSA in the treatment compared with the control group was 4.3 cm^2 ($p<0.001$), while the prevalence of Perlas gastric antral grade 2 stomach was reduced from 56.7% to 6.9% after treatment.

Okada *et al*[86] compared gastric POCUS CSA with CT-measured gastric volumes in a prospective cross-sectional observational study with 39 patients presenting for emergency abdominal surgery. Gastric POCUS was feasible in 88% of patients. CT and gastric POCUS measurements were obtained supine, with gastric CSA calculated from the previously described two-diameter method. This study demonstrated that the cut-off value for a high-risk stomach (>1.5 mL/kg fluid content) was equivalent to a CSA of 3.01 cm^2, with a sensitivity of 85%, a specificity of 53%, and an accuracy of 69%. Notably, 51% of patients undergoing emergency abdominal surgery had high-risk stomachs despite prolonged fasting times (median solid and liquid fasting times of 16 hours and 6 hours, respectively).

Delamarre *et al*[89] investigated the validity of clinician assessments of full and empty stomachs to gastric POCUS determinations of gastric CSA and estimated gastric volumes in a prospective observational study using 196 patients presenting for emergency surgery or procedures. Gastric POCUS examinations were feasible in 95.9% of patients, using quantitative and qualitative methods, with CSA calculated by the previously described two-diameter method. Gastric volume estimated using the Perlas *et al* formula.[16] Overall, clinical judgment displayed poor to moderate performance in assessing the gastric status of patients presenting for emergency or urgent procedures, with a positive predictive value of 42.1%, a negative predictive value of 79.4%, and an accuracy of 68.7%. Importantly, patients with gastric POCUS full stomach were misdiagnosed by clinical judgment in 55% of the cases. Gastric POCUS full stomach was associated with abdominal and obstetrical-gynecological surgery but not with fasting durations. Interestingly, positive solid food intake after the onset of illness was an independent risk factor inversely related to a gastric POCUS-determined full stomach.

Lin *et al*[87] carried out a prospective randomized, double-blinded parallel controlled trial involving 50 patients to evaluate the effects of metoclopramide on gastric motility in patients undergoing extremity trauma-related debridement procedures in the emergency department. Quantitative and qualitative gastric POCUS examination results changed anesthetic management in 46% of patients. Similarly, Sayyadi *et al*[85] demonstrated a reduction in gastric CSA and estimated volume within 30 min of metoclopramide administration. The calculated gastric volume at 120 min after administration was 1.4 mL/kg in the treatment group and 2.2 mL/kg in the control group ($p<0.001$). In

contrast to the results of Sayyadi *et al*,[85] gastric CSA was >3.4 cm^2 for both treatment and control groups throughout the study period (0–120 min) and did not meet the threshold for a fasting empty stomach.

Lastly, Asokan *et al*[88] reported on a prospective observational study with 100 patients using preprocedure quantitative and qualitative gastric POCUS methods to predict aspiration in patients undergoing urgent endotracheal intubation in the emergency department. An observer blinded to the gastric POCUS examination recorded an aspiration event when gastric content was visualized in the oropharynx during the intubation. Neither the development of clinical or radiological evidence of aspiration pneumonia nor the use of muscle relaxants was accounted for in the study. Aspiration was observed in 8% of patients and was more common when propofol or etomidate were used as induction agents than ketamine (p<0.047). The authors determined that gastric POCUS better predicted aspiration risk than fasting status. A CSA >9.27 cm^2 (RLD) was associated with 100% sensitivity and 87% specificity in predicting aspiration risk, while an estimated gastric volume >111.6 mL predicted aspiration with 100% sensitivity and 92% specificity.

Summary

In summary, the findings indicate that gastric POCUS is feasible and accurate in most patients undergoing emergent (ie, nonelective) surgical or medical procedures, enabling clinical stratification between low-aspiration-risk and high-aspiration-risk stomachs and offering the ability to modify anesthetic airway management. Gastric POCUS studies confirm that fasting time in emergency care patients is not a reliable indicator of residual gastric volume. Furthermore, clinical assessment of gastric volume is imperfect, with poor to moderate performance compared with gastric POCUS. Lastly, evidence supports the role of gastric POCUS in evaluating the prokinetic effects of medications that can reduce residual gastric volume in an emergency care setting, along with evidence confirming that vomiting and aspiration may be more likely to occur with progressively larger gastric CSA.

Expert practice recommendation

The authors *conditionally support* the use of gastric POCUS to assess gastric content and volume in emergency care patients undergoing regional anesthesia to tailor anesthetic and airway management due to the limited number of publications, the heterogeneity in study designs and patient populations, and the reliance on only a few moderate-quality studies. Future research should focus on extensive population-based studies with advanced statistical methods to clarify the decision-making role of gastric POCUS in reducing aspiration events in patients presenting for emergency care.

Enteral tube feeding

Four studies assessing gastric content and volume in patients on tube feeding were identified, with publication years ranging from 2021 to 2023.[90–93] Quality assessment scores using the MMAT[25] ranged from 80%[90] (four criteria met) to 100%[91–93] (five criteria met). The quality assessment for each study is presented in online supplemental table 6. A summary of the study findings is provided in table 7.

All four were prospective observational studies in critically ill patients—two of the studies aimed at comparing the measured gastric volume with the gold standard of gastric suctioning. Taskin *et al*[90] conducted a prospective observational trial to assess the correlation between aspirated gastric residual volume (aGRV) and gastric antral CSA in critically ill patients receiving enteral nutrition. The study included 56 patients, each of whom underwent several examinations, with only 2.8% being unreadable. The authors determined the CSA by measuring the anteroposterior and craniocaudal diameters. The CSA correlated well with aGRV.

Additionally, a cut-off value of 922 mm^2 for antral CSA to determine an aGRV of >250 mL had a sensitivity of 100% and a specificity of 91.3%. Brotfain *et al*[92] aimed to correlate calculated gastric residual volume (cGRV) with the aspirated gastric volume in 90 intensive care unit (ICU) patients. Two expert sonographer teams (A and B) looked at 360 examinations. They found a high correlation between the calculated GRV and the aGRV with an intraclass correlation coefficient (ICC) of 0.812 (team A) and 0.85 (team B). In summary, both studies suggest that both antral CSA and cGRV correlate well with the aspirated gastric volume and may be used as a predictor for full stomach in ICU patients.

Two studies looked at the reliability of gastric POCUS performed in ICU patients. In a study by Brotfain *et al*,[92] two teams performed 360 ultrasound examinations to calculate the gastric volume using the Perlas formula and showed a high interobserver agreement in cGRV with an ICC of 0.931 (95% CI 0.9 to 0.98, p>0.001). Similar results were demonstrated in a study including 41 mechanically ventilated ICU patients,[90] with two ultrasound teams reaching a high intra-observer agreement with a concordance correlation coefficient (CCC) of 95 (95% CI 0.940 to 0.977) and 0.94 (95% CI 0.922 to 0.973), respectively for the CSA. Similar to the first study, Ruiz Ávila *et al*[90] also noted a high inter-observer agreement for the CSA (0.84 (95% CI 0.778 to 0.911) and the cGRV (0.84 (95% CI 0.782 to 0.913). These findings suggest that gastric POCUS measurement can be performed in ICU patients with high reliability and accuracy.

Two studies assessed the risk of aspiration in critically ill patients by evaluating quantitative and qualitative gastric content and volume measures. Nguyen *et al*[93] included 100 intubated and tube-fed ICU patients to assess the effect of fasting on gastric content and volume before extubation using the antral CSA. 26% of the intubated patients had a full stomach on ultrasound at the time of extubation, regardless of whether feeds were held. Furthermore, the duration of fasting did not affect the incidence of a full stomach. In the study by Ruiz Ávila,[90] of 41 mechanically ventilated patients with ongoing enteral nutrition at the time of the gastric POCUS examination, the examiners noted only 7.7% of patients to have a low-risk stomach using qualitative measures (grade 0 and grade 1). Similarly, on quantitative evaluation, 75% of the cases had a gastric volume >1.5 mL/kg and were thus at risk of pulmonary aspiration.

Summary

Gastric POCUS measurements of antral CSA correlate well with aGRV, reliably predict full stomachs, and aid in aspiration risk assessment. Gastric POCUS demonstrates high inter-observer and intra-observer reliability, making it suitable for use in ICU settings. The findings indicate that many ICU patients may have full stomachs despite fasting, highlighting the importance of gastric POCUS in guiding clinical decisions to enhance patient safety and reduce the risk of aspiration.

Table 7 Summary of studies—enteral tube feeding

Study	Study design	MMAT quality grade	Gastric POCUS performed (qualitative, quantitative, or both)	Primary outcome	Number of patients enrolled	Number (percentage) of indeterminate examinations	Was gold standard of gastric suctioning used?	Was there a change in anesthetic management?(Yes, no, or not reported)—number of patients (%)	Relevant findings
Taskin *et al*[93]	Prospective observational study	80%	Quantitative	Assess the correlation between aspirated gastric volume and the gastric antral CSA in critically ill patients receiving enteral nutrition.	56	8 (2.82%)	Yes	Not reported	The antral craniocaudal and anterior-posterior diameter and the antral CSA correlated linearly with the aspirated gastric volume. A CSA cut-off value of 922 mm^2 determined a gastric volume >250 mL with a sensitivity of 100% and a specificity of 91.3%.
Nguyen *et al*[91]	Prospective observational study	100%	Both	Assess the effect of fasting on gastric content before extubation of ICU patients receiving enteral nutrition using the antral CSA.	100	12 (10.7%)	No	Not reported	26% of intubated ICU patients had a full stomach on gastric ultrasound. There was no correlation between the duration of fasting (stopping enteral nutrition or not enteral nutrition at all) and the incidence of a full stomach.
Brotfain *et al*[92]	Cross-sectional study; prospective observational study	100%	Both	Correlation of calculated gastric volume and aspirated gastric volume in ICU patients. It also aimed to assess the reliability of gastric ultrasound interpretation for NGT confirmation.	90	No	Yes	Not reported	The authors found a significant correlation between aspirated gastric volume and ultrasound-measured gastric volume(s). There was also good interobserver agreement on ultrasound-measured gastric volume. In more than 70% of patients, the correct placement of the NGT could be verified by both teams via ultrasound.
Ruiz Ávila *et al*[90]	Diagnostic test accuracy study; prospective observational study	100%	Both	Assessing intra-observer and inter-observer agreement in ultrasound assessment of gastric content and volume in critically ill patients receiving enteral nutrition and mechanical ventilation.	41	Unclear	No	Not reported	Only 7.7% had a low risk for aspiration (grade 0 and 1), and 92.3% had a high-risk stomach (grade 2). The enteral nutrition ran for at least 4 hours and was ongoing during the ultrasound examination. There was excellent intra-observer and inter-observer agreement in assessing gastric content and volume in ultrasound.

Summary of published studies using gastric ultrasound for the enteral tube feeding patient population. Not applicable for the change in management indicates that the study did not explore the impact of gastric ultrasound findings on anesthetic management.
BMI, body mass index (kg/m^2); CSA, cross-sectional area (cm^2); ICU, intensive care unit; MMAT, Mixed Methods Appraisal Tool; NGT, nasogastric tube; POCUS, point-of-care ultrasound.

Expert practice recommendation

The authors **conditionally support** the use of gastric POCUS to assess gastric content and volume for patients receiving enteral tube feeding undergoing regional anesthesia to tailor anesthetic and airway management. These studies consistently show that gastric ultrasound correlates well with gastric volumes and that many continuously tube-fed patients have significant gastric content. However, because sample sizes are small, populations are heterogeneous (ICU settings), and the reliance on only a few moderate-quality studies, we advise only conditional support pending further research. Future research should focus on fasting duration and associated gastric volume to develop more practical guidance for managing aspiration risk in this patient population.

Glucagon-like peptide-1 receptor agonists

For this review, GLP-1RA use was identified in three publications from 2023 to 2024.[94–96] Quality assessment scores using the MMAT[25] ranged from 80% (four criteria met)[94 95] to 100% (five criteria met).[96] The quality assessment for each study is presented in online supplemental table 7. A summary of the study findings is provided in table 8. Two were prospective observational studies[94 95] and one was a cross-sectional study.[96]

Sherwin *et al*[94] conducted a prospective observational gastric POCUS study of volunteers using the GLP-1RA semaglutide. Ten volunteers used semaglutide; the other 10 did not use a GLP-1RA. Both groups were asked to follow a standard 8-hour fast before undergoing a gastric POCUS examination. In the semaglutide group, 90% of participants had solid food present on examination in the RLD position after 8 hours compared with 10% in the control group.

Sen *et al*[96] performed a prospective cross-sectional gastric POCUS study in patients using a once-weekly, long-acting GLP-1RA who presented for surgery after following standard institutional fasting guidelines. The study compared the gastric POCUS results of 62 GLP-1RA users with 62 non-users. There was a 56% incidence of residual gastric content (RGC) in GLP-1RA users, defined by the presence of solids, thick liquids, or >1.5 mL/kg of clear liquids on gastric POCUS. In non-users, the incidence of RGC was 19%. After adjustment for confounding (eg, BMI, DM, GERD, etc), GLP-1RA use was associated with a 30.5% higher prevalence of increased RGC.

Nersessian *et al*[95] investigated the relationship between preoperative semaglutide use and RGC assessed via gastric POCUS in 220 elective surgical patients. Patients were divided into semaglutide (n=107) and non-semaglutide (n=113) groups, with semaglutide use defined as administration within 10 days before surgery. The study found a significantly higher incidence of increased RGC in the semaglutide group (40%) compared with the non-semaglutide group (3%) despite adherence to fasting guidelines. Semaglutide use was independently associated with increased gastric content (OR 36.97, 95% CI 16.54 to 99.32). Although gastric POCUS proved useful in perioperative risk assessment and management, the study highlighted

Table 8 Summary of studies—GLP-1RA

Study	Study design	MMAT quality grade	Gastric POCUS performed (qualitative, quantitative, or both)	Primary outcome	Number of patients enrolled	Number (percentage) of indeterminate examinations	Was gold standard of gastric suctioning used?	Change in anesthetic management?(Yes, no, or not reported)—number of patients (%)	Relevant findings
Sherwin *et al*[94]	Prospective observational study	80%	Both	The percentage of volunteers who had solid contents in their stomachs after an overnight fasting period as measured by gastric ultrasonography.	10 control, 10 semaglutide users	0	No	Not reported	90% of semaglutide users vs 10% of controls had solids on gastric ultrasound after 8 hours fasting. This small sample study used volunteers, not surgical patients.
Sen *et al*[95]	Cross-sectional study, prospective observational study	100%	Both	The presence of increased RGC defined by the presence of solids, thick liquids, or >1.5 mL/kg of clear liquids on gastric ultrasonography.	124 participants, 62 semaglutide users	0	No	Not reported	In patients receiving weekly long-acting GLP-1RA injections, 56% had RGC (solids, thick liquids, or >1.5 mL/kg clear liquids), compared with 19% in non-GLP-1RA users. After adjusting for confounders, GLP-1RA use was linked to a 30.5% higher prevalence of increased RGC.
Nersessian *et al*[96]	Prospective observational study	80%	Both	The presence of increased RGC defined as any solid content or >1.5 mL/kg of clear fluids as assessed by gastric ultrasound.	220 participants, 107 in the semaglutide group	Unclear	No	Yes (not stated specifically, but presumed to be 40%)	Semaglutide users had higher RGC (40% vs 3%), with use within 10 days of surgery strongly linked to increased RGC (OR 36.97). No aspiration cases occurred, and gastric POCUS-guided perioperative decisions, avoiding delays or cancelations.

Summary of published studies using gastric POCUS for the patient taking a GLP-1 agonist. Not applicable for the change in management indicates that the study did not explore the impact of gastric ultrasound findings on anesthetic management. BMI, body mass index (kg/m^2); CSA, cross-sectional area (cm^2); GLP-1RA, glucagon-like peptide-1 receptor agonist; MMAT, Mixed Methods Appraisal Tool; POCUS, point-of-care ultrasound; RGC, residual gastric content.

the inadequacy of the current 1-week interruption guideline and recommended a more conservative 2–3 weeks interruption period. No cases of pulmonary aspiration were reported, emphasizing the need for further research to refine semaglutide management in the perioperative setting.

Summary

These findings indicate that gastric POCUS is a beneficial tool for assessing RGC in GLP-1RA users. Most patients on GLP-1RA have an increased incidence of residual solid or a large volume of liquid content on gastric POCUS examination. While the GLP-1RAs are not novel medications, newer, more potent versions, along with a marked increase in their use and popularity, have presented an increased risk of potential full stomach and aspiration. Given concerns about the safety of standard preoperative fasting guidelines in this patient cohort, gastric POCUS has been endorsed by several international and intersocietal guidelines to assist clinicians in guiding management while awaiting further research.[97–99] There is great interest in the role of gastric POCUS in this patient population, and the authors recognize that as more evidence emerges, recommendations may change.

Expert practice recommendation

The authors *conditionally support* the use of gastric POCUS to assess gastric content and volume for patients on GLP-1RAs undergoing regional anesthesia to tailor anesthetic and airway management. Because this is a newer area with only three studies to date (although all showing a significant effect of GLP-1RAs on gastric content), we issue conditional support pending further research due to the overall heterogeneity of the study design and the limited number of studies/subjects. Further larger-scale studies in broader patient populations are needed.

Limitations

Several limitations must be acknowledged in our literature search. First, we did not translate non-English papers, which may have led to the exclusion of relevant studies published in other languages. Additionally, we primarily relied on our search strategy and did not perform citation chasing or hand-searching of references, which could have resulted in missed studies. These factors could potentially affect the comprehensiveness and generalizability of our conclusions.

Another limitation relates to the development of recommendations. While the recommendations were based on expert group consensus, informed by the overall quality of the studies, the number of studies, and the outcomes, as outlined in the 'Consensus process' section, there was no a priori set of rules or predefined thresholds to specifically guide or determine the expert recommendations. This approach was deemed most appropriate given the heterogeneity of the data and the limited number of studies available. The consensus process was conducted thoroughly; however, the lack of predefined criteria introduces the possibility that a different cohort of experts could reach an alternate set of recommendations under similar circumstances. This limitation underscores the need for further research to strengthen the evidence base and provide more definitive guidance in the future.

CONCLUSIONS

Gastric POCUS is reliable for assessing gastric content and volume in pregnant patients before elective cesarean delivery, throughout pregnancy, labor, and post partum. In pregnancy, it aids in understanding gastric emptying, providing safer anesthetic management, and allowing clear fluid consumption during epidural labor. Therefore, we *support* the use of gastric POCUS to assess aspiration risk in active labor, before

Table 9 Summary of expert practice recommendations for medically complex patient populations

Medically complex patient population	Expert practice recommendations	Summary of findings
Pregnancy	*Support* the use of gastric POCUS to assess aspiration risk in: ► Labor ► Pregnant patients experiencing delayed gastric emptying due to medications or medical conditions such as hyperemesis gravidarum, pre-eclampsia/eclampsia, or gestational diabetes *Do not support* routine use in non-laboring pregnant women or before elective cesarean section	Gastric POCUS: effective for assessing antral CSA; most laboring women have an empty stomach. Aspiration risk: increased with higher BMI and non-fasting; reduced by metoclopramide.
Obesity	*Conditionally support* the use of gastric ultrasound	Gastric POCUS: gastric volume accurately measured in patients with severe obesity. Aspiration risk: patients with obesity have higher CSA and aspiration risk, gastroparesis risk factors increase solid content detection, and gastric POCUS supports a more liberal approach in elective and emergency cases.
Diabetes	*Support* the use of gastric POCUS	Gastric POCUS: feasible and patients with diabetes have higher antral CSA and residual gastric volumes despite fasting, with 48% having a full stomach. Aspiration risk: diabetic retinopathy and longer diabetes duration increase the risk of high-risk antral grades; HbA1c >7 is linked to increased gastric volume.
GERD	*Do not support* the routine use of gastric POCUS	Gastric POCUS: feasible and no difference in gastric content between patients with gastric emptying factors and controls. Aspiration risk: antral CSA >10.0 cm^2 (RLD) correlates with increased aspiration risk in patients with organic dyspepsia. Note: the two studies included have conflicting conclusions.
Emergency care	*Conditionally support* for the use of gastric ultrasound	Gastric POCUS: feasible in the vast majority of patients and useful for assessing aspiration risk, vomiting risk, and procedural sedation safety. Aspiration risk: full stomach was found in >50% of emergency cases despite fasting; obesity, diabetes, emergency surgery, and pre-operative morphine use were independent risk factors. CSA ≥9.27 cm^2 (RLD) and gastric volume ≥111.6 mL strongly predict aspiration.
Enteral tube feeding	*Conditionally support* the use of gastric ultrasound	Gastric POCUS: feasible and antral CSA correlates with aspirated gastric volume and reliably verifies NGT placement. Aspiration risk: approximately 25% of intubated ICU patients had a full stomach regardless of fasting duration. >90% had a high-risk stomach with ongoing enteral nutrition.
GLP-1RA	*Conditionally support* the use of gastric ultrasound	Gastric POCUS: feasible to perform. Aspiration risk: GLP-1RA use was linked to a higher prevalence of increased residual gastric content.

CSA, cross-sectional area; GERD, gastroesophageal reflux disease; GLP-1RA, glucagon-like peptide-1 receptor agonists; HbA1c, hemoglobin A1c; ICU, intensive care unit; NGT, nasogastric tube; POCUS, point-of-care ultrasound; RCT, randomized controlled trials; RLD, right lateral decubitus.

urgent cesarean section when NPO status is unclear, and in pregnant patients experiencing delayed gastric emptying, such as concomitant GERD, diabetes, or other conditions that can lead to gastroparesis. However, the current evidence suggests that non-laboring pregnant women have gastric content similar to that of the non-pregnant population. Therefore, we *do not support* routine use in non-laboring pregnant women, including those undergoing elective cesarean sections.

For patients with diabetes, gastric POCUS helps identify high-risk individuals, making it useful for bedside assessments to tailor anesthesia approaches. Future research should include broader populations with diabetes, especially patients with type 1 diabetes. Therefore, we *support* using gastric POCUS in this medically complex patient population.

In the patient population affected by obesity, enteral tube feed patients, patients requiring emergency care, and patients on GLP-1RA, we *conditionally support* the use of gastric POCUS at the bedside to tailor anesthetic and airway management, but further studies are needed to clarify their role as an aspiration risk factor.

There is insufficient and conflicting evidence for patients with GERD; therefore, we *do not support* the use of POCUS in this patient population.

The following is a high-level summary of the expert recommendations by patient population; a more detailed overview, including rationale and levels of support, is provided in table 9.

Brief summary of recommendations

- *Support*: pregnancy (active labor, urgent cesarean) and diabetes.
- *Conditional support*: obesity, emergency care, enteral tube feeding, and GLP-1RA users.
- *Not supported*: non-laboring pregnant patients, elective cesarean sections, and GERD.

The authors acknowledge that aspiration risk is multifactorial, with contributing factors such as GERD, patient history, and the specific surgical or procedural context. Gastric POCUS serves as a helpful adjunct in evaluating gastric content and volume, providing additional information that may not be evident from clinical history or examination alone. While it helps identify patients with higher aspiration risk, such as those with RGC, it is only one component of a broader clinical decision-making process. Clinicians should use it alongside other factors to guide airway management, anesthesia choices, or procedural timing to help minimize aspiration risk.

Additionally, our support for use does not mandate universal practice nor imply that failure to perform gastric POCUS constitutes a deviation from the standard of care. These expert practice recommendations are intended to guide clinicians in situations where gastric POCUS is clinically appropriate and feasible. Given current practice limitations (ie, operator dependence, the steep learning curve, anatomical challenges such as obesity or pregnancy, lack of standardization, equipment availability, time constraints, and limited evidence base), performing gastric POCUS routinely may not always be possible. In such cases, clinical judgment should take precedence.

While these practice recommendations are tailored to regional anesthesia and pain medicine practitioners, we acknowledge their broader relevance to the anesthesia community. ASRA-PM is uniquely positioned to issue recommendations within its scope of practice, which includes

managing diverse and medically complex patient populations. Given the limited body of evidence specific to regional anesthesia and pain medicine, the inclusion of data from broader clinical contexts is necessary to provide meaningful guidance. These recommendations serve to inform our members while also offering a foundation for other anesthesia societies to develop complementary recommendations based on this evidence. This approach ensures the applicability of gastric POCUS in improving safety and decision-making across a wide range of clinical scenarios while staying true to our society's mission and expertise.

Future studies are needed to resolve, among other things, the following unanswered questions about gastric POCUS: (1) Does the finding of a 'high-risk' antrum on gastric POCUS (grade 2 antrum or solids) predict an increased risk of peri-procedural aspiration? (2) Is there an antral size threshold on gastric POCUS below which the risk of aspiration is unlikely, even if a small amount of solids is seen? (3) In patients with a grade 2 antrum on gastric POCUS (ie, a higher volume of clear liquids than is expected for a fasted patient of that age), are there subcategories of excess clear liquid volume that have different aspiration risks (eg, if a patient has 5% more clear fluid than expected for a fasted state, does the patient need to be treated with full stomach precautions peri-procedurally)? However, given that aspiration is a rare clinical event, we as a group recognize the challenges of definitively answering these clinical questions and thereby choose to err on the side of caution and suggest that gastric POCUS findings of solids or anything clinically above what is documented as normal gastric secretions should be considered a higher aspiration risk.

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