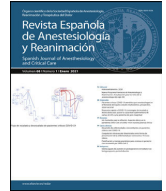




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Brief Report

Inter-observer reliability of gastric ultrasound and level of agreement with clinical evaluation in adult patients requiring emergency surgery



Fiabilidad interobservador de la ecografía gástrica y nivel de acuerdo con la evaluación clínica en pacientes adultos que requieren cirugía de urgencia

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ABSTRACT

Introduction: Pulmonary aspiration of gastric contents is a major perioperative complication with a mortality rate of 75% and severe morbidity of 14%. The risk increases in emergency surgeries and gastric ultrasound may be useful to establish gastric content and inform aspiration risk assessment. In this study we describe the degree of agreement between pre-surgical clinical evaluation and gastric ultrasound, in the identification of full stomach in adult patients requiring emergency surgery.

Materials and methods: Descriptive observational cross-sectional study of diagnostic tests. The analysis included all adult patients with pathologies requiring emergency surgeries between August 2023 and May 2024 at Hospital Universitario Hernando Moncaleano Perdomo, Neiva, Colombia. The Kappa index was calculated between the two tests (Clinical evaluation vs. Gastric ultrasound), and the level of agreement between them was determined.

Results: A total of 57 patients were included in the study. Age, median (range): 51 (18–83), of whom 64.9% were male. The main types of surgeries were general surgery (80.7%), followed by trauma (19.3%). The majority of the population was classified as ASA 3. The most common comorbidities were Arterial Hypertension and type 2 Diabetes Mellitus. Fasting time ranged from 12 to 24 hours. There was a high level of agreement among the examiners for determining a full stomach using point-of-care (POCUS) gastric ultrasound, with a concordance level of 0.88 ($p < 0.001$). In contrast, there was a low level of agreement between the clinical and sonographic evaluation for gastric content assessment, with a concordance level of -0.03 ($p 0.768$).

Conclusion: Our results suggest that gastric ultrasound has a high level of reproducibility in the emergency surgical setting and can provide information beyond the clinical assessment.

RESUMEN

Introducción: La aspiración pulmonar del contenido gástrico es una complicación perioperatoria mayor, con una tasa de mortalidad del 75% y morbilidad grave del 14%. El riesgo se incrementa en las cirugías de urgencia, pudiendo ser útil la ecografía gástrica para establecer el contenido gástrico e informar de la evaluación del riesgo de aspiración. En este estudio describimos el grado de acuerdo entre la evaluación clínica prequirúrgica y la ecografía gástrica en la identificación del estómago lleno en pacientes adultos que requieren cirugía de urgencia.

Materiales y métodos: Estudio transversal observacional descriptivo de pruebas diagnósticas. El análisis incluyó a todos los pacientes adultos con patologías que requirieron cirugías de urgencia entre agosto de 2023 y mayo de 2024 en el Hospital Universitario Hernando Moncaleano Perdomo de Neiva, Colombia. Se calculó el índice Kappa entre las dos pruebas (evaluación clínica vs. ecografía gástrica), y el nivel de acuerdo entre ellas.

Palabras clave:

Ecografía en el punto de atención
 Aspiración gástrica
 Volumen gástrico
 Urgencia
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 Colombia

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Resultados: Se incluyó un total de 57 pacientes en el estudio con media (rango) de edad: 51 (18–83), de los cuales el 64,9% eran varones. Los tipos principales de cirugías fueron cirugía general (80,7%), seguida de traumatismo (19,3%). La mayoría de la población tuvo clasificación ASA 3. Las comorbilidades más comunes fueron hipertensión arterial y Diabetes Mellitus de tipo 2. El tiempo de ayuno fluctuó de 12 a 24 horas. Existió un alto nivel de acuerdo entre los examinadores a la hora de determinar el estómago lleno utilizando ecografía gástrica en el punto de cuidado (POCUS), con un nivel de concordancia de 0,88 ($p < 0,001$). Por contra, existió un bajo nivel de acuerdo entre la evaluación clínica y ecográfica para la determinación del contenido gástrico, con un nivel de concordancia de -0,03 ($p 0,768$).

Conclusión: Nuestros resultados sugieren que la ecografía gástrica tiene un alto nivel de reproducibilidad en el contexto de la cirugía de urgencia, pudiendo aportar información más allá de la evaluación clínica.

Introduction

Pulmonary aspiration of gastric content is a major perioperative complication. It has a mortality rate of 75%, causes severe anaesthesia-related morbidity, including permanent neurological injury, in 14% of patients, and has been described as the most common cause of death in anaesthesia-related events.^{1,2} For this reason, following the international fasting guidelines of the American Society of Anaesthesiologists (ASA), patients undergoing elective surgery are required to fast for a period of time.³ However, it is difficult to ensure an empty stomach in urgent or emergency surgery situations, and these are therefore associated with a higher risk of pulmonary aspiration of gastric contents.⁴ Patients requiring emergency surgery or those with serious co-morbidities may present a full stomach despite prolonged fasting.

The diagnostic accuracy of clinical criteria (fasting time and type of last intake) used to establish a full stomach in patients undergoing emergency surgery has a sensitivity of only 45.3%, a specificity of 77%, a positive predictive value of 42% and a negative predictive value of 79%; the prevalence of full stomach is 29%.⁵ Gastric point-of-care ultrasound (POCUS) has emerged as a promising method of obtaining an accurate assessment of gastric content, and has greater sensitivity and specificity than clinical evaluation.⁶ Gastric ultrasound provides qualitative and quantitative information on gastric content, and has been recommended when prandial status is unclear based on a clinical assessment.⁷ Nevertheless, most of the data available are derived from scheduled surgery, and there is scant evidence of its use in emergency scenarios where aspiration risk may be higher.

This study aims to evaluate the degree of inter-observer agreement in gastric ultrasound and the level of agreement with clinical evaluation in adult patients requiring emergency surgery.

Materials and Methods

Study design

This cross-sectional observational study of diagnostic tests was approved by our local Research Ethics Board (REB) (Record number 04-01-20/04/2023) and patients gave their written informed consent to participate. Inclusion criteria were based on a study that validated a mathematical model for ultrasound assessment of gastric volume by gastroscopic examination,⁸ and were a) age 18-85 years, b) requiring emergency surgery at Hospital Universitario Hernando Moncaleano Perdomo, Neiva, Colombia during the study period, c) ASA class I-IV, d) weight < 120 kg, e) height > 145 cm f) BMI < 40 kg/m², and g) ability to provide written informed consent. Exclusion criteria were: a) pregnancy, b) history of lower oesophageal or gastric surgery (gastric bypass), c) known abnormal upper gastrointestinal anatomy, d) hiatal hernia, e) gastroesophageal reflux disease, f) zenker's diverticulum, g) achalasia, h) oesophageal stenosis, i) gastric tumour, j) gastrointestinal obstruction, k) administration of prokinetics 6 hour prior to surgery, and l) impossibility of placement in right lateral decubitus.

The presence of full stomach was determined by a pre-anaesthesia clinical evaluation (fasting time and type of pre-surgical intake), We

defined "full stomach" as the presence of > 1.5 mL/kg solids and/or clear liquid estimated in the RLD position using the indicated formula.

³ The assessment was performed by the attending anaesthesiologist and independently confirmed by gastric ultrasound performed by 3 evaluators, each with a minimum experience of ≥ 33 gastric ultrasound examinations, which is the minimum training requirement for technical competence. All 3 evaluators were blinded to clinical data and to each other's findings. Patients were recruited through convenience sampling limited to shifts when the resident trained in gastric ultrasound was present in the hospital, which may introduce a potential selection bias.

Data were collected using a report form based on the "I-AIM framework for point of care gastric ultrasound" adapted for the purpose of this research. The form included general data from the tests performed, patient socio-demographic variables, the technique used to collect ultrasound images, and lastly, a summary and interpretation of findings.⁹

Gastric ultrasound

To standardise reporting of findings, the following procedure was implemented in all patients undergoing gastric ultrasound¹⁰:

- 1 Patient preparation: the patient was placed supine in a right lateral decubitus (RLD) position exposing the upper abdomen, and conductive gel was applied to the epigastrium.
- 2 Probe settings: A low-frequency curved matrix probe (2-5 MHz) was placed on a sagittal plane and the abdominal parameters were set on the ultrasound machine, including a depth of 10-15 cm, focal zone and gain settings.
- 3 Scanning: the operator performed a wide left to right sweep of the sub-costal margin to systematically identify the stomach as a hollow organ located superficially between the left hepatic lobe and the pancreas, with a prominent muscular layer within its wall.
- 4 Image capture: the probe was tilted and slid to positively identify the antrum at the level of the aorta. Colour Doppler was used to confirm vessel identification, if necessary. Then the image was captured at rest, especially between peristalses.
- 5 Evaluation of gastric content. Qualitative evaluation: the gastric content was classified as a) no content, empty; b) clear fluid or c) solid content. Volume assessment: if clear fluid was present in the stomach, the antral cross-sectional area (CSA) was measured using the free-tracing tool of the ultrasound equipment, including the total thickness of the gastric wall (from serosa to serosa) in RLD with 3 readings taken between peristaltic contractions. The gastric volume was then calculated using the following formula: (volume (mL) = $27.0 + 14.6 \times \text{CSA}_{\text{RLD}} - 1.28 \times \text{age}$).¹¹

The initial ultrasound evaluation was performed by examiner 1, an anaesthesiology resident with an expert level of training in ultrasound techniques. The ultrasound was stored in the equipment for further review by a second examiner, a cardiovascular anaesthesiologist with experience in ultrasound, and subsequently by a third examiner, a radiologist with experience in ultrasound.

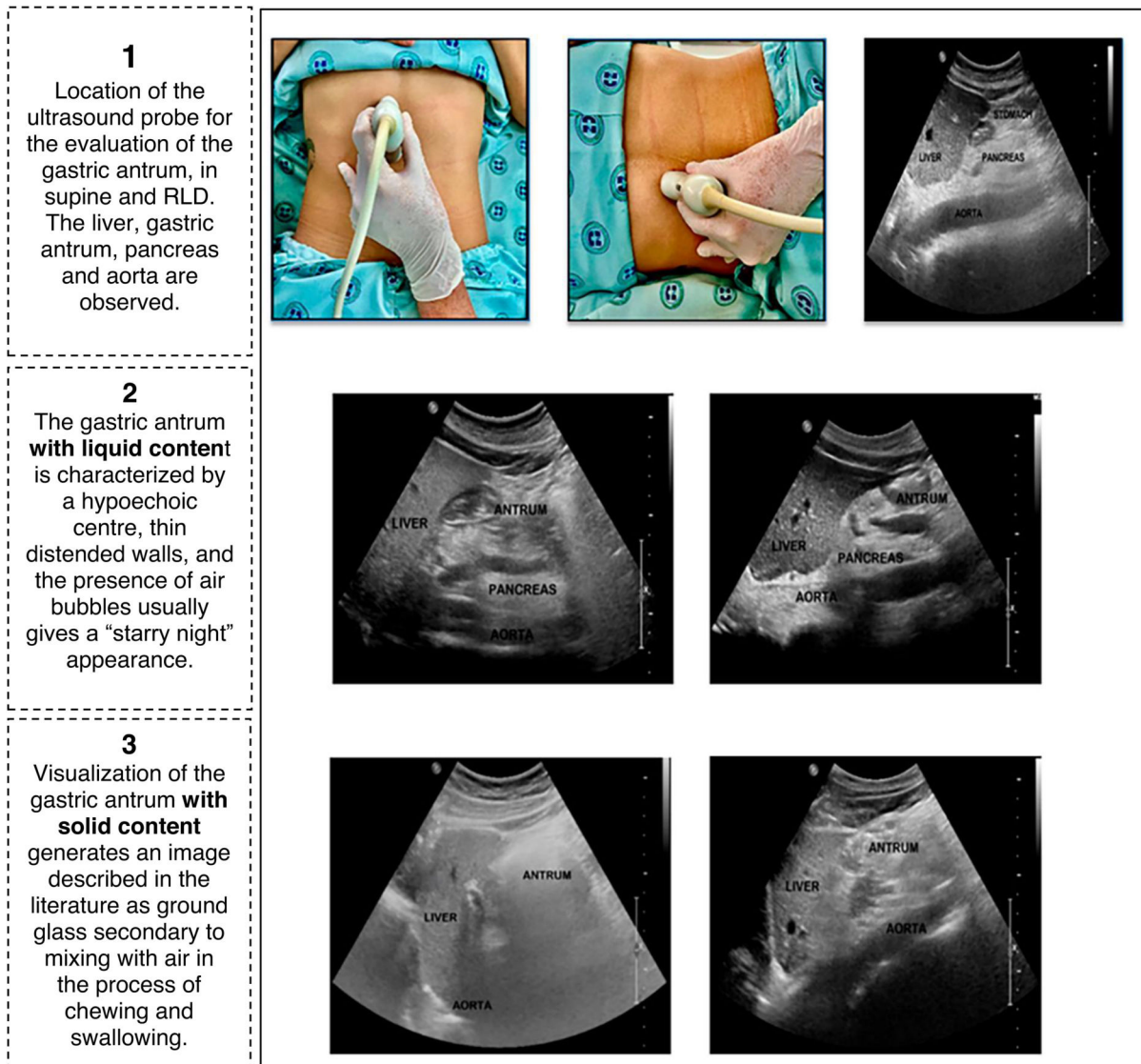


Fig. 1. Visualization of the gastric antrum by gastric ultrasound, with different gastric contents. Abbreviations: RLD, right lateral decubitus.

Qualitative evaluation

The following 3-point classification system has been shown to correlate well with gastric volume (Fig. 1):

- Grade 0 corresponds to the visualization of the empty gastric antrum in both supine and RLD positions.
- Grade 1 refers to the lack of content observed in the supine position; however, clear fluid (anechoic content) is observed in the RLD position, suggesting a residual gastric volume, typically < 1.5 ml/kg.
- Grade 2 shows clear fluid in both supine and right lateral decubitus positions, corresponding to a larger gastric volume > 1.5 ml/kg.¹¹

Quantitative evaluation

Performed by means of CSA measurement in the RLD position. The gastric volume of clear fluid was then calculated using the mathematical model validated by Perlas et al., as previously described. This model estimates gastric volume based on age and CSA, and can also be used as a reference table for various combinations of these parameters.^{11,12}

Sample size estimate and statistical analysis

The sample size was calculated to detect differences between proportions. In this formula, p_1 and p_2 represent the expected proportion of the event of interest in each group, $Z\alpha$ corresponds to the type I error, and $Z\beta$ to the desired power. Based on previously published data, we estimated that full stomach in the emergency surgery context has a prevalence of 56%⁶ when assessed by ultrasound, and 29%⁵ when assessed by clinical criteria. Accepting a 95% confidence level and a power of 80%, the required sample size was calculated using Epidat v4.2, resulting in a minimum of 55 patients.

For statistical analysis, IBM SPSS Statistics® version 24.0 was used. The normality of continuous variables was assessed using the Kolmogorov–Smirnov test. The **McNemar test** was applied to compare the difference in proportions of dichotomous qualitative variables within the same sample evaluated at 2 different time points, and **95% confidence intervals (CI 95%)** for those differences were reported.

The **Kappa statistic** was calculated to assess inter-observer agreement among the 3 evaluators performing gastric ultrasound, and agreement was interpreted using the **Landis and Koch scale**. Additionally, **Kappa values with 95% CI** were calculated to assess concordance between clinical evaluation and gastric ultrasound findings.

Table 1
Demographic and clinical characteristics.

Variable	N	(%)
Age (median, IQR, years)	51	(18-83)
Sex		
Male	37	64.90%
Female	20	35.10%
BMI (kg/m ²)		
Mean	25.87	
SD	4.511	
Type of surgery		
General surgery	46	80.70%
Trauma	11	19.30%
ASA Classification		
1	11	19.30%
2	18	31.60%
3	25	43.90%
4	3	5.30%
Co-morbidities		
None	21	36.8%
Arterial hypertension	18	31.6%
Diabetes mellitus type 2	13	22.8%
Chronic kidney disease	10	17.5%
Hypothyroidism	7	12.3%
Non-gastric cancer	7	12.3%
Peripheral arterial disease	6	10.5%
Obesity	4	7%
Benign prostatic hyperplasia	4	7%
Diabetes mellitus type 1	1	1.8%
Alzheimer	1	1.8%
Ischemic heart disease	1	1.8%
Venous insufficiency	1	1.8%
Gastritis	1	1.8%
COPD	1	1.8%

ASA: American Society of Anesthesiologists; BMI: Body mass index; IQR: Interquartile range; SD: Standard deviation.

All statistical tests were 2-tailed, and $p \leq 0.05$ was considered statistically significant.

Results

A total of 57 patients provided written informed consent and were included in the study between August 2023 and May 2024. Patient demographics and clinical characteristics are summarized in **Table 1**. General surgery (80.7%) was the main indication for emergency surgery, followed by trauma (19.3%). The most frequent comorbidities were arterial hypertension (31.6%) and type 2 diabetes mellitus (22.8%). Only 10 participants (17.5%) had received pre-operative opioids. Antihypertensives (29.8%) and hypoglycaemic agents (14%) were the most common background medication, followed by statins (17.5%) and thyroid supplementation (7%) (**Table 1**).

The clinical evaluation of full stomach was based on pre-surgical fasting time: 70.2% of patients had fasted for between 12 and 24 hours. The type of intake was also evaluated, with solids being the most prevalent (80.7%), followed by thick fluid (10.5%), clear fluid or water (3.5%) and unknown in 5.3% of patients. The prevalence of full stomach by clinical evaluation was 26.3%.

The ultrasound evaluation of examiner 1 found that 50.9% of patients presented solid content, 19.3% clear fluid, and 29.8% empty stomach. In patients with liquid gastric content, 12.3% were considered full stomach due to gastric volume > 1.5 ml/kg. The prevalence of full stomach was 63.2%. The ultrasound performed by examiners 2 and 3 showed full stomach in 61.4% in both cases, with similar results among all 3 examiners (**Table 2**).

Table 2
Results.

Variable	N	(%)
Pre-surgical fasting time 6 – 7.9 hours	5	8.80%
8 – 11.9 hours	5	8.80%
12 - 24 hours	40	70.20%
More than 24 hours	4	7.00%
Unknown	3	5.30%
Last Intake type		
Unknown	3	5.30%
Clear fluid / water	2	3.50%
Thick fluid	6	10.50%
Solid	46	80.70%
Full stomach determined by clinical criteria*	15	26.30%
Full stomach determined by gastric ultrasound Examiner 1		
Empty	21	36.80%
Full	36	63.20%
Examiner 2		
Empty	22	38.60%
Full	35	61.40%
Examiner 3		
Empty	22	38.60%
Full	35	61.40%
Examiner 1 Qualitative ultrasound evaluation		
Liquid	11	19.30%
Solid	29	50.90%
Empty	17	29.80%
Quantitative ultrasound evaluation (for clear fluid only)		
> 1.5 ml/kg	7	
0 - 1.5 ml/kg	3	
Not Performed	1	

* Clinical criteria (fasting time and type of pre-surgical intake).

The difference in proportions between clinical evaluation and gastric POCUS was - 0.368 ($p < 0.001$). Agreement on full stomach between examiners 1 and 2 was substantial ($\kappa = 0.88$; 95% CI: 0.75 to 1.00; $p < 0.001$). Agreement between examiners 1 and 3 was moderate ($\kappa = 0.66$; 95% CI: 0.45 to 0.85; $p < 0.001$), and agreement between examiners 2 and 3 was also moderate ($\kappa = 0.63$; 95% CI: 0.39 to 0.82; $p < 0.001$). Finally, concordance between clinical evaluation and gastric ultrasound performed by examiner 1 was poor ($\kappa = -0.03$; 95% CI: -0.25 to 0.17; $p = 0.768$) according to the Landis and Koch classification (**Table 3**).

Discussion

Gastric ultrasound is a useful, safe, and reliable exam for the diagnosis of full stomach and can guide safe airway management in patients with unknown or questionable *per os* intake.⁹ This emerging application of point-of-care ultrasound is defined as a limited focused exam performed at the bedside by the treating team to answer a specific binary question (full or empty stomach) for the purpose of guiding clinical care and ultimately improving patient outcomes.¹² The technique has been well described elsewhere, and a study on learning curves suggested that a minimum of 33 exams is required to obtain an accuracy of 90%.¹³

In our study, 77.2% of patients had fasted for more than 12 hours; however, 63.2% presented full stomach, suggesting that emergency surgery patients may have delayed gastric emptying and present with a full stomach despite otherwise “adequate” fasting.

Table 3
Comparative proportions test results.

Variable	N	p-value
Clinical evaluation vs. gastric POCUS*	-0.368	<0.001
Gastric POCUS performed by examiner 1 vs examiner 2	0.88	<0.001
Gastric POCUS performed by examiner 1 vs examiner 3	0.66	<0.001
Gastric POCUS performed by examiner 2 vs examiner 3	0.63	<0.001
Clinical evaluation vs. gastric POCUS performed by examiner 1 [†]	-0.03	0.768

* McNemar method.

[†] Cross tables and simple kappa index method.

In this study, the prevalence of full stomach determined by clinical evaluation was 26.3%. This is similar to the findings of Delamarre et al. in a study performed in 2021 with 196 patients. Using clinical criteria, the authors found that 29% presented full stomach, compared to findings from gastric ultrasound performed in 10 patients undergoing emergency surgery.⁶ The prevalence of full stomach, defined as solid content or clear fluid > 1.5 mL/kg, using gastric POCUS was 63.2% according to the Perlas et al. scale. This is similar to the results of a prospective study performed in 2017 in a cohort of patients undergoing scheduled and emergency surgery, in which full stomach was identified in 56% of cases using gastric ultrasound.¹⁴ Concordance between the observations of the 3 examiners showed an almost perfect score according to the Landis and Koch classification ($p < 0.001$), indicating that the probability of bias and chance is minimal in determining full stomach through gastric ultrasound, with little inter-observer variability.

There was no agreement between the two diagnostic tests (Kappa index = -0.030 [p 0.768]), indicating that agreement between clinical criteria and pre-surgical gastric ultrasound is low when evaluating full stomach in adult patients requiring emergency surgery. The results of our comparison of these diagnostic tests support the findings of Delamarre et al.

The diagnostic performance of clinical assessment was found to be very low in comparison to gastric ultrasound, a finding that underlines the accuracy of gastric POCUS in the diagnosis of full stomach. This tool is a useful alternative for anaesthesiologists in patients with questionable *per os* intake, and can prevent pulmonary aspiration in patients requiring emergency surgery⁵.

Limitations

- Small sample size, single-centre design, and potential selection bias.

This study was conducted at a single centre and included a relatively small sample size, which may limit the generalizability of the findings. In addition, the patient selection process may have introduced bias, as the inclusion criteria were based on the availability of the resident performing the ultrasounds during specific shifts.

- Lack of an objective gold standard

As with other pioneering studies in gastric ultrasound, this study lacks a reference gold standard based on invasive methods such as gastroscopy or gastric aspiration. While this does not invalidate the findings, it is a clear limitation.

- Image acquisition vs. image interpretation.

Evaluator 1 was solely responsible for image acquisition and measurements, while evaluators 2 and 3 assessed the stored images. This methodological approach limits the assessment of interobserver reproducibility, as it does not capture variability in image acquisition (e.g., probe positioning, anatomical plane selection), but only in the interpretation of static clips or images. This should be acknowledged as a limitation, and future studies should consider evaluating both acquisition and interpretation phases to more accurately assess reproducibility.

- Variability of interobserver agreement.

The results show a significantly lower interobserver agreement between the radiologist (evaluator 3) and the other 2 examiners (resident and attending physician with POCUS expertise) compared to the high concordance observed between the latter two. Possible contributing factors include differences in training, specific experience with gastric POCUS, and the use of static images versus dynamic scanning. Future studies may benefit from implementing calibration sessions prior to data collection, cross-training between radiologists and anaesthesiologists, and interobserver reliability assessments to better isolate sources of variability.

In summary, this study was conducted in a single centre using convenience sampling, lacked an objective gold standard for gastric content validation, and used a methodological approach in which image acquisition and interpretation were performed by different examiners. These factors should be acknowledged as limitations when interpreting the findings and highlight the need for future multicentre studies with standardized protocols.

Implications for clinical practice and future directions

Gastric POCUS shows promise as a practical bedside tool for improving perioperative risk stratification in emergency surgical patients, particularly when fasting status is uncertain. Integration into emergency and anaesthesia care could enhance patient safety by reducing the risk of pulmonary aspiration. However, successful integration will depend on the introduction of structured training programs, widespread availability of equipment, and incorporation of the exam into the workflow. Future multicentre studies with larger sample sizes, formal cost-effectiveness analyses, and standardized training pathways are warranted to consolidate the role of gastric POCUS in clinical practice.

Conclusions

Our results suggest that gastric ultrasound has a high level of reproducibility in the emergency surgical setting, and can provide information beyond the clinical assessment. Given that aspiration of gastric content is uncommon but potentially life-threatening, the addition of gastric POCUS to clinical assessment may be beneficial for adult patients requiring emergency surgery.

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