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Evaluation of the Effectiveness of Ultrasound Training for Emergency Medicine Residents

Acil Tıp Asistanları İçin Ultrason Eğitiminin Etkinliğinin Değerlendirilmesi

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Abstract

Aim: The assessment of gastric content using bedside ultrasound is a critical skill for emergency physicians, particularly in determining aspiration risk during procedural sedation or emergency intubation. This pilot study aimed to evaluate the effectiveness of a structured ultrasound training program for emergency medicine residents in assessing gastric content and volume.

Materials and Methods: A six-hour structured theoretical and practical training session was conducted for emergency medicine residents. Following the training, participants performed gastric antrum ultrasound measurements on eight healthy volunteers in both fasting and postprandial states. Measurements included anteroposterior (AP) and craniocaudal (CC) diameters in both the supine and right lateral decubitus (RLD) positions. Intraclass correlation coefficients (ICC) were calculated to assess interobserver reliability.

Results: Emergency medicine residents demonstrated high interobserver reliability in gastric antrum ultrasound measurements following a structured training program. In the supine position, the ICC was 98% for AP diameter and 91% for CC diameter, while in the RLD position, ICC values were 95% for AP diameter and 96% for CC diameter. Postprandial measurements exhibited comparable reliability, with ICC values of 98% for supine AP, 97% for supine CC, 95% for RLD AP, and 98% for RLD CC, all of which were statistically significant ($p < 0.001$).

Conclusion: Our study indicates that a short, focused ultrasound training session can effectively equip emergency medicine residents with the necessary skills to perform reliable gastric ultrasound assessments in clinical settings, facilitating improved aspiration risk evaluation and airway management decision-making.

Keywords: Ultrasonography; gastric antrum, emergency medicine

Öz

Amaç: Yatak başı ultrason kullanarak gastrik içeriğin değerlendirilmesi, özellikle prosedürel sedasyon veya acil entübasyon sırasında aspirasyon riskini belirlemede acil tıp hekimleri için kritik bir beceridir. Bu pilot çalışma, acil tıp asistanları için yapılandırılmış bir ultrason eğitim programının gastrik içeriği ve hacmi değerlendirmedeki etkinliğini incelemeyi amaçlamaktadır.

Gereç ve Yöntemler: Acil tıp asistanlarına altı saatlik teorik ve pratik eğitim verilmiştir. Eğitim sonrasında asistanlar, sekiz sağlıklı gönüllü üzerinde açlık ve tokluk durumlarında mide antrum ultrason ölçümleri gerçekleştirmiştir. Ölçümler, sırtüstü ve sağ lateral dekübit (RLD) pozisyonlarında anteroposterior (AP) ve kraniokaudal (CC) çapları içermektedir. Gözlemciler arası güvenilirliği değerlendirmek için sınıf içi korelasyon katsayısı (ICC) hesaplanmıştır.

Bulgular: Acil tıp asistanları, yapılandırılmış bir eğitim programının ardından mide antrum ultrason ölçümlerinde yüksek gözlemciler arası güvenilirlik göstermiştir. Sırtüstü pozisyonda ICC AP çapı için %98, CC çapı için %91 olarak hesaplanırken, RLD pozisyonunda AP çapı için %95, CC çapı için %96 bulunmuştur. Postprandiyal ölçümler benzer güvenilirlik göstermiş, sırtüstü pozisyonda AP çapı için %98, CC çapı için %97, RLD pozisyonunda AP çapı için %95, CC çapı için %98 olarak ölçülmüştür ($p < 0,001$).

Sonuç: Çalışmamız, kısa ve odaklanmış bir ultrason eğitiminin acil tıp asistanlarını gastrik ultrason değerlendirmeleri yapmaya etkili bir şekilde hazırlayabileceğini ve klinik uygulamalarda aspirasyon risk değerlendirmesi ile hava yolu yönetimi kararlarını iyileştirebileceğini göstermektedir.

Anahtar sözcükler: Ultrasonografi; mide antrumu; acil tıp

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INTRODUCTION

Airway management in the emergency department (ED) is a high-risk procedure, and aspiration of gastric contents is one of the most feared complications during rapid sequence intubation (RSI) and procedural sedation. The incidence of morbidity and mortality associated with aspiration varies, and studies estimate that aspiration contributes to up to 9% of all anesthesia-related deaths (1). Critically ill patients presenting to the ED often experience delayed gastric emptying due to factors such as sepsis, trauma, opioid use, and metabolic disorders, which increases the risk of gastric content retention and subsequent aspiration (2). Current practice primarily relies on fasting guidelines to minimize aspiration risk; however, these recommendations are often impractical in emergency situations (3).

Traditional methods for assessing gastric contents, such as clinical history and nasogastric tube aspiration, have significant limitations and are not reliable bedside tools (4). Gastric ultrasound (GUS) has emerged as a promising, non-invasive modality for evaluating gastric volume and contents, enabling real-time decision-making regarding aspiration risk in both elective and emergency settings (5). Recent studies have demonstrated that point-of-care ultrasound (POCUS) can accurately distinguish an empty stomach from one containing liquid or solid contents, and that antral cross-sectional area (CSA) measurements correlate with gastric volume (1). The supine and right lateral decubitus (RLD) positions have been shown to optimize antral imaging, thereby aiding in the assessment of aspiration risk (6).

Despite its potential benefits, gastric ultrasound training among emergency medicine (EM) physicians remains underdeveloped compared to other POCUS applications. Studies in anesthesiology and critical care have demonstrated that a structured training program significantly improves accuracy and reliability in identifying gastric contents (7). However, data on the feasibility and effectiveness of formal gastric ultrasound training within EM residency programs remain limited (3). Previous research has shown that anesthesiologists achieve proficiency in gastric ultrasound after approximately 30–40 supervised examinations, but a clear learning curve has not yet been established for EM residents (4).

This study aims to evaluate the effectiveness of a structured gastric ultrasound training program for EM residents by assessing their ability to perform and interpret gastric ultrasonography following a dedicated training session. By examining interobserver reliability and measurement accuracy after training, we seek to determine whether gastric ultrasound can be effectively integrated into the EM curriculum as a standardized tool for aspiration risk assessment.

MATERIALS and METHODS

Study Design and Setting: The study adhered to the STARD and CONSORT guidelines for diagnostic accuracy studies. Ethical approval was obtained from the local ethics committee (21.09.2020-631). Written informed consent was obtained from all participants prior to enrollment.

This study was designed as a single-center, prospective, blinded diagnostic accuracy study evaluating the effectiveness of a structured POCUS training program for EM residents. The study was conducted between October 1, 2020, and October 31, 2020, at the emergency medicine department in collaboration with a multidisciplinary team comprising the departments of emergency medicine, radiology, and anesthesiology and reanimation.

Participants

Emergency medicine residents: A total of five EM residents who had previously completed both basic and advanced ultrasound training were included in the study. The inclusion criteria for EM residents were as follows.

- Being a resident physician in the emergency medicine department, completion of basic and advanced ultrasound courses in accordance with the guidelines of the American College of Emergency Physicians
- No prior formal training in gastric US.
- Residents with prior clinical experience in gastric ultrasound or participation in gastric aspiration risk assessment studies were excluded to ensure an unbiased evaluation of the training program.

Healthy volunteers: Eight final-year medical students rotating in the emergency department were recruited as healthy volunteers for standard gastric ultrasound measurements. All participants signed a written informed consent form prior to participation. The inclusion criteria for healthy volunteers were as follows.

- Age over 18 years
- No history of gastrointestinal diseases (e.g., GERD, hiatal hernia, gastroparesis)
- No history of prior abdominal surgery
- Normal BMI (18.5–24.9 kg/m²)

The exclusion criteria for healthy volunteers were as follows.

- Any metabolic disorder affecting gastric motility (e.g. diabetes, hypothyroidism)
- Use of prokinetic or anticholinergic medications
- Pregnancy or suspicion of pregnancy

Structured Training Program: A six-hour structured training session was developed to teach gastric ultrasound techniques to emergency medicine residents.

The training was organized by a senior radiology professor, a radiology resident, an anesthesiology professor who specializes in gastric ultrasound and has authored a book chapter on the subject, and two

members of the emergency medicine department. The program was designed based on the existing literature on competency-based ultrasound education and included the following components:

1. Theoretical Training

- Fundamentals of ultrasound physics and probe orientation
- Gastric anatomy and antral CSA measurement techniques
- Correlation between antral CSA and gastric volume
- Imaging protocols for supine and RLD positions
- Aspiration risk assessment algorithms

2. Practical Hands-On Training

- Live demonstrations using standardized ultrasound protocols
- Probe positioning techniques with a curvilinear (2–5 MHz) transducer
- Image acquisition and interpretation exercises
- Blinded gastric ultrasound assessments on healthy volunteers

Ultrasonographic Measurements: After the training, each resident performed gastric ultrasound examinations on all eight volunteers and obtained the following measurements:

Supine Position: Antral anteroposterior (AP) and craniocaudal (CC) diameters

Right Lateral Decubitus Position: Antral AP and CC diameters

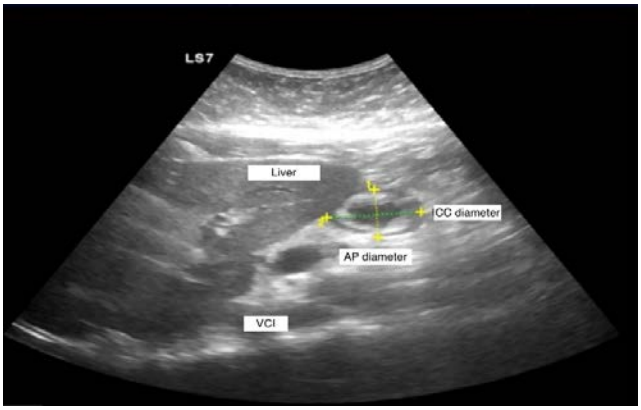
In this study, the evaluation of gastric volume and contents was performed using the antral region of the stomach, as it has been previously identified as the most reliable anatomical site for quantitative gastric volume estimation. (1) Gastric antrum imaging was performed in both the supine and RLD positions, as previous research has demonstrated that the RLD position optimizes visualization of gastric contents and facilitates more accurate volume estimation. (2) However, considering that critically ill patients may not always tolerate the RLD position, an alternative supine position was also utilized to ensure a comprehensive assessment.(3)

Each volunteer was scanned under two conditions. Fasting state (10 hours of fasting) and postprandial state (1 hour after a standard meal). A total of 32 gastric ultrasound measurements were obtained per participant (4 measurements per volunteer × 8 volunteers).

Ultrasound Equipment and Image Acquisition: The scanning protocol followed previously validated antral measurement techniques (7). Gastric measurements were performed using the General Electrics S7 Ultrasonography® device in the Emergency Department. A convex, low-frequency (2–5 MHz) transducer probe was used for the measurements.

Measurement Procedure and Anatomical Landmarks: The pyloric antrum was identified as the primary reference point for ultrasound measurements. To ensure precise localization, the following anatomical landmarks were used (Figure 1).

Figure 1. Gastric ultrasound antrum imaging and measurement



Sagittal Plane Identification: To establish anatomical orientation, the left lobe of the liver and the inferior vena cava (IVC) were first visualized.

Probe Repositioning: The transducer was adjusted in the parasagittal plane to obtain the cross-sectional image of the pyloric antrum at its smallest diameter. This ensured accurate and reproducible measurement of antral dimensions (6).

- The antral region was identified in the parasagittal plane using the left lobe of the liver, the IVC, and the superior mesenteric vein (SMV) as anatomical landmarks. (6)
- Measurements were obtained between peristaltic contractions, and the average of three consecutive scans was recorded for each reading.
- For each scan, AP and CC diameters were measured.

Interobserver and Intraobserver Agreement

All ultrasound scans were reviewed by a blinded expert radiologist to assess measurement reliability. Interobserver agreement between emergency medicine residents and the expert radiologist was calculated using the Intraclass Correlation Coefficient (ICC).(2) Interobserver agreement was determined through repeated measurements on a subset of volunteers, with the observers blinded to prior readings.

Statistical Analysis: All statistical analyses were performed using SPSS 23.0 (IBM, Armonk, NY, USA). Descriptive statistics were used to summarize continuous variables, which were presented as mean ± standard deviation (SD). To evaluate the reliability of the ultrasound measurements, interobserver and intraobserver agreement were assessed using the Intraclass Correlation Coefficient. A p-value < 0.05 was considered statistically signifAll statistical analyses were performed using SPSS 23.0 (IBM, Armonk, NY, USA).

RESULTS

The analysis of fasting-state gastric antrum dimensions revealed considerable interindividual variability in both AP and CC diameters. In the supine position, the mean AP diameter ranged from 0.90 cm to 3.17 cm, while the CC diameter varied between 2.27 cm and 3.70 cm. In the RLD position, the AP diameter exhibited a wider distribution, spanning 0.90 cm to 3.17 cm, whereas the CC diameter ranged from 2.27 cm to 3.70 cm.

These findings underscore the inherent variability in gastric antrum dimensions in fasting individuals. Gastric antrum measurements in the fasting state are shown in table 1.

Measurements represent mean values and standard deviations of gastric antrum diameters in both supine and right lateral decubitus positions. Following oral uptake, significant increases were observed in both AP and CC diameters, reflecting expected gastric distension.

Table 1. General characteristics and gastric antrum measurements in the fasting state (supine and right lateral decubitus positions)

Volunteer	Supine AP Diameter (Mean)	Supine AP Diameter (SD)	Supine CC Diameter (Mean)	Supine CC Diameter (SD)	RLD AP Diameter (Mean)	RLD AP Diameter (SD)	RLD CC Diameter (Mean)	RLD CC Diameter (SD)
A	0.90	.00	2.27	.31	1.30	.17	.90	.00
B	1.13	.06	2.30	.20	1.80	.17	1.13	.06
C	1.43	.21	2.73	.21	1.73	.15	1.43	.21
D	1.63	.15	2.70	.20	1.60	.10	1.63	.15
E	1.83	.15	2.67	.21	2.20	.26	1.83	.15
F	3.17	.21	3.70	.26	3.13	.29	3.17	.21
G	1.30	.20	2.80	.10	2.30	.26	1.30	.20
H	2.00	.10	2.67	.21	2.63	.29	2.00	.10

AP: Anteroposterior diameter, CC: Craniocaudal diameter, SD: Standard deviation, RLD: Right lateral decubitus.

In the supine position, the AP diameter expanded to a range of 0.97 cm to 3.77 cm, while the CC diameter increased to a maximum of 5.57 cm. In the RLD position, the AP diameter extended from 2.67 cm to 3.73 cm, whereas the CC diameter reached up to 7.83 cm. These findings confirm gastric antral expansion postprandially. Gastric antrum measurements are shown in table 2.

Table 2. General characteristics and gastric antrum measurements in the postprandial states (supine and right lateral decubitus positions)

Volunteer	Supine AP Diameter (Mean)	Supine AP Diameter (SD)	Supine CC Diameter (Mean)	Supine CC Diameter (SD)	RLD AP Diameter (Mean)	RLD AP Diameter (SD)	RLD CC Diameter (Mean)	RLD CC Diameter (SD)
A	.97	.21	5.00	.30	3.23	.06	6.57	.21
B	1.63	.15	4.83	.25	2.67	.15	6.50	.50
C	1.77	.21	2.87	.21	2.93	.21	4.97	.29
D	1.50	.10	3.47	.25	2.17	.21	4.37	.25
E	3.70	.20	3.73	.35	3.70	.30	7.07	.15
F	3.77	.25	4.67	.21	3.73	.15	6.30	.20
G	1.90	.26	5.27	.25	3.33	.25	6.00	.17
H	2.73	.15	5.57	.31	3.27	.15	7.83	.21

AP: Anteroposterior diameter, CC: Craniocaudal diameter, SD: Standard deviation, RLD: Right lateral decubitus.

Measurements represent mean values and standard deviations of gastric antrum diameters in both supine and right lateral decubitus positions. Interobserver reliability analysis demonstrated high concordance in gastric antrum ultrasound measurements across different examiners. In the fasting state, intraclass correlation coefficients (ICC) were 98% for supine AP diameter, 91% for supine CC diameter, 95% for RLD AP diameter, and 96% for RLD CC diameter. Postprandial measurements exhibited similarly high agreement, with ICC values of 98% for supine AP, 97% for supine CC, 95% for RLD AP, and 98% for RLD CC, all of which were statistically significant ($p < 0.001$). Interobserver agreement in fasting and postprandial states are shown in table 3. Measurements represent intraclass correlation coefficient (ICC) values for gastric antrum diameters obtained in both fasting and postprandial states, across supine and right lateral decubitus positions. All measurements were statistically significant ($p < 0.001$).

Table 3. Interobserver agreement in fasting and postprandial state

		Average Measures	**p-value**
Fasting State	Supine AP Diameter	%98	<0.001
	Supine CC Diameter	%91	<0.001
	RLD AP Diameter	%95	<0.001
	RLD CC Diameter	%96	<0.001
Postprandial State	Supine AP Diameter	%98	<0.001
	Supine CC Diameter	%97	<0.001
	RLD AP Diameter	%95	<0.001
	RLD CC Diameter	%98	<0.001

AP: Anteroposterior diameter, CC: Craniocaudal diameter, SD: Standard deviation, RLD: Right lateral decubitus.

DISCUSSION

Rapid sequence intubation and procedural sedation in the emergency department carry a significant risk of pulmonary aspiration of gastric contents, particularly in patients with delayed gastric emptying, metabolic disorders, or critical illness (1). Despite established fasting guidelines, emergency physicians frequently encounter patients who have not undergone adequate pre-procedural fasting, making real-time assessment of gastric contents crucial (2). This study demonstrates that emergency medicine residents can reliably perform gastric ultrasound measurements following structured training.

Several studies have validated GUS as a reliable tool for assessing gastric volume and content, particularly in perioperative and emergency settings (1, 3). Consistent with previous findings, our study demonstrated significant postprandial increases in antral dimensions, reinforcing the role of ultrasound in dynamic gastric content assessment(2, 8). Notably, the RLD position yielded larger antral diameters compared to the supine position, a phenomenon attributed to gravity-induced redistribution of gastric contents, as previously reported(5). This positional effect is particularly relevant in aspiration risk assessment, where accurate volume estimation is crucial for airway management decisions(7). Additionally, the observed interindividual variability in fasting antral diameters highlights the limitations of standardized fasting guidelines, further supporting the need for bedside ultrasonography as a patient-specific risk stratification tool(9). These findings reinforce the clinical utility of structured GUS training, ensuring that emergency physicians can reliably integrate gastric ultrasound into airway safety protocols.

Previous studies have extensively investigated the application of gastric ultrasound (GUS) in aspiration risk assessment, particularly in anesthesiology and perioperative medicine (10). These studies primarily focused on evaluating gastric contents in preoperative fasting patients using antral CSA measurements to establish thresholds for aspiration risk.

Several studies have highlighted the limitations of fasting guidelines, demonstrating that a significant proportion of patients retain gastric contents even after prolonged fasting periods, posing a persistent aspiration risk (11). However, while most of these studies have been conducted in controlled surgical settings, our study evaluates the effectiveness of a structured GUS training program for emergency medicine residents. Unlike previous research, our findings highlight that emergency physicians can achieve expert-level interobserver agreement

following a targeted, structured training regimen, emphasizing the feasibility of integrating GUS into emergency airway management protocols. This distinction arises from our focused training approach, which is designed to facilitate rapid skill acquisition in high-risk emergency scenarios, in contrast to traditional anesthesia-based training models.

The high interobserver reliability observed in our study is comparable to findings reported in anesthesia-based training models but was achieved through a shorter and more focused educational intervention. Previously demonstrated that anesthesiologists required extensive training and experience to attain proficiency in GUS assessments, with learning curves often exceeding 30–40 supervised scans to achieve diagnostic accuracy (8, 12).

In contrast, our study indicates that emergency medicine residents can develop comparable competency within a structured, time-efficient training framework, emphasizing the adaptability of targeted ultrasound education for high-acuity emergency settings. Furthermore, the use of both supine and RLD positions for gastric content evaluation aligns with prior literature and reinforces the robustness and external validity of our findings. Bouvet et al. and Hamada et al. highlighted that the RLD position consistently yields larger antral diameters, improving sensitivity for detecting residual gastric content, particularly in patients with delayed gastric emptying. (2, 3) However, Cubillos et al. noted that supine positioning remains an essential adjunct, especially in critically ill or immobilized patients where repositioning may not be feasible (5).

Our results support this dual-positioning approach, demonstrating strong interobserver agreement across both fasting and postprandial states, which further substantiates the clinical applicability of GUS as a standardized risk stratification tool in emergency airway management.

The interobserver agreement observed in this study was consistently high, particularly for the AP diameter in the supine position (98%) and the CC diameter in the RLD position (98%) in the postprandial state. All measurements achieved statistical significance ($p < 0.001$). These values are comparable to, or even exceed, the interobserver reliability reported among trained anesthesiologists and intensivists in previous studies (3,6). Perlas et al. demonstrated that experienced anesthesiologists achieved ICC values ranging from 0.89 to 0.94 for antral cross-sectional area measurements in both fasting and postprandial states, underscoring the reproducibility of gastric ultrasound in controlled settings (6). Similarly, Bouvet et al. reported that antral CSA measurements were highly correlated with aspirated gastric volumes, further validating the reliability of this technique for assessing gastric contents (3).

Our findings suggest that structured, targeted training can enable emergency medicine residents to achieve interobserver reliability comparable to that of experienced clinicians, highlighting the potential of gastric ultrasound to become an integral tool for aspiration risk assessment in emergency and critical care environments.

Integrating GUS into emergency care offers a valuable method for real-time assessment of aspiration risk, particularly in situations where fasting status is uncertain. Evidence from prior research underscores the effectiveness of GUS in clinical practice, highlighting its capability to provide rapid, noninvasive, and reliable guidance for airway management in high-risk scenarios (13).

The strong interobserver reliability demonstrated in our study further confirms that focused, time-efficient training programs can equip emergency physicians with the necessary skills to perform gastric ultrasound with a high degree of accuracy. These findings address an important need in clinical practice, establishing GUS as a critical tool in point-of-care diagnostics and a pivotal addition to emergency medicine protocols.

Limitations: One of the major strengths of this study is its prospective, blinded design, which minimizes bias and ensures the reliability of results. Additionally, the study utilized a standardized training curriculum, reducing variability in skill acquisition among participants.

However, certain limitations should be acknowledged. The study included only five emergency medicine residents and eight volunteers, limiting the generalizability of findings. Larger, multicenter studies are needed to validate these results. While we demonstrated high interobserver agreement, we did not correlate antral measurements with actual aspiration events or clinical outcomes. Future studies should assess the predictive value of antral measurements in peri-intubation risk stratification.

The study assessed measurement accuracy immediately post-training but did not evaluate skill retention over time. Previous literature suggests that ongoing practice and periodic refresher training may be necessary to maintain proficiency.

To address this gap, we recommend a longitudinal study evaluating skill retention over a 6–12-month period following training. Alternatively, a randomized controlled trial comparing GUS-trained and non-GUS-trained emergency physicians in a

real-world rapid sequence intubation (RSI) setting could be conducted to measure aspiration-related complications and intubation success rates. Such studies would provide further insight into the long-term clinical utility of GUS training and its impact on patient outcomes.

CONCLUSION

This study provides strong evidence that emergency medicine residents can achieve high interobserver agreement in gastric ultrasound measurements following a structured training program. These findings support the incorporation of gastric ultrasound into emergency medicine ultrasound curricula to improve airway management, enhance sedation safety, and refine aspiration risk assessment. However, further research is necessary to evaluate long-term skill retention, assess its clinical utility in real-world settings, and determine its impact on patient outcomes.

Author's Contribution

The authors declare no conflict of interest.

The authors disclose that no grants or support resources were used.

All authors declared their contribution to the study at all stages and approved the final version of the manuscript.

All authors declared that this manuscript has not been published before and is not currently being considered for publication elsewhere.

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