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Brief Report

Test performance of point-of-care ultrasound for gastric content☆

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ABSTRACT

Objective: We sought to determine test performance characteristics of emergency physician ultrasound for the identification of gastric contents.
Methods: Subjects were randomized to fast for at least 10 h or to consume food and water. A sonologist blinded to the patient's status performed an ultrasound of the stomach 10 min after randomization and oral intake, if applicable. The sonologist recorded their interpretation of the study using three sonographic windows. Subsequently 2 emergency physicians reviewed images of each study and provided an interpretation of the examination. Test performance characteristics and inter-rater agreement were calculated.
Results: 45 gastric ultrasounds were performed. The sonologist had excellent sensitivity (92%; 95% CI 73%–99%) and specificity (85%; 95% CI 62%–92%). Expert review demonstrated excellent sensitivity but lower specificity. Inter-rater agreement was very good ($\kappa = 0.64$, 95%CI 0.5–0.78).
Conclusion: Emergency physician sonologists were sensitive but less specific at detecting stomach contents using gastric ultrasound.

1. Introduction

Identification of stomach contents may help identify patients at high risk of aspiration prior to procedural sedation or intubation. Point-of-care ultrasound may allow a clinician to detect or exclude the presence of gastric content. Direct visualization or exclusion of gastric content could inform a clinician's sedation plan or demonstrate patients at low risk of aspiration. We sought to determine the test performance characteristics of point-of-care ultrasound by emergency physicians for stomach content.

2. Methods

We prospectively enrolled a convenience sample of healthy volunteer adults greater than 18 years old. To avoid recruiting subjects with potentially abnormal gastric emptying, we excluded potential subjects with a history of gastric or esophageal surgery, current or recent (less than three months ago) pregnancy, hiatal hernia, or diabetes. The institutional review board approved the study.

Subjects were instructed for a minimum of 10 h prior to participation in the study. They were then randomized to remain fasting or consume 50 g of carbohydrates and 300 mL of water. Subjects were randomized in a 1:1 ratio to remain fasting or consume oral intake by selecting a token indicating their group assignment.

A study investigator blinded to the subject's intake performed a point-of-care ultrasound examination of the stomach within 10 min of randomization and oral intake, if applicable. The sonologist had fellowship training in emergency ultrasound. Images were obtained using a curvilinear transducer (Sonosite, Bothell, WA). Images of the subject's stomach were obtained using a subxiphoid approach in both the supine and right lateral decubitus position, and in the left upper quadrant with the subject left lateral decubitus position. The sonologist recorded an interpretation for each of the three windows as stomach content present or absent, or stomach not visualized. Based on a composite of all sonographic windows, the sonologist recorded their overall impression of the study as stomach content present or absent. Representative video and still images were saved. The primary outcome of the study was to describe the test performance characteristics for the identification of gastric content. We used the sonologist's overall interpretation to calculate the primary outcome. Secondary outcomes included a calculation of the test performance characteristics for each of the three windows.

Subsequently, two emergency physicians with advanced training in emergency ultrasound reviewed the images obtained by the sonologist. They were blinded to whether the subject was fasted or had consumed

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Table 1
Subject characteristics.

Male	67
Age (y)	32
Time fasted (h)	10
Height (cm)	173
Weight (kg)	70
BMI	23

Data are median or percent.

Table 2
Test performance of the sonologist with 95% confidence intervals.

	Overall	Subxiphoid	Right lateral decubitus	Left upper quadrant
Sensitivity	92 (73, 99)	87 (68, 97)	92 (73, 99)	69 (48, 86)
Specificity	85 (62, 97)	90 (68, 99)	75 (51, 91)	74 (52, 94)
PPV	88 (72, 95)	91 (74, 98)	82 (67, 90)	82 (65, 92)
NPV	90 (69, 97)	86 (67, 94)	88 (66, 97)	63 (48, 77)
LR+	6.1 (2.1, 17.5)	8.8 (2.3, 32.9)	3.7 (1.7, 7.9)	3.1 (1.3, 7.7)
LR−	0.09 (0.02, 0.36)	0.13 (0.05, 0.39)	0.11 (0.03, 0.41)	0.38 (0.21, 0.72)

oral intake. They recorded their interpretation for each window as stomach content present, absent, or stomach not visualized, and made an overall conclusion for the study as positive or negative for content. Test performance characteristics for each investigator and inter-rater agreement were calculated.

3. Results

The sonologist performed 45 gastric ultrasounds. Table 1 depicts the characteristics of study subjects. Representative appearance of the stomach ultrasound findings is depicted in Fig. 1. The accuracy of the overall interpretation was 89%. The sensitivity of the overall interpretation of stomach ultrasound was 92% (95% CI 73%–99%) was specificity 85% (95% CI 62%–92%). Test performance characteristics are depicted in Table 2. Test performance was similar between the overall impression and isolated interpretation using the subxiphoid and right lateral decubitus windows (Table 2). Sensitivity was highest using the overall interpretation based on all three gastric windows. Specificity for stomach content was highest in the supine subxiphoid window.

In 14 (32%) subjects, one of the stomach window interpretations was discordant with that of the other two windows. This was most frequently the left upper quadrant window (n = 10, 23%). The discordant interpretation was predominantly inaccurate relative to subject condition of being fasted or having consumed oral intake (n = 12, 86%), including nine of the discordant left upper quadrant interpretations.

In the follow up image review by two emergency ultrasound experts, the sensitivity of the overall interpretation was excellent, but specificity was poor (Table 3). Sensitivity was similar between the three sonographic windows; specificity was lowest using the left upper quadrant view. Fig. 2 depicts agreement between each interpreter graphically. Inter-rater agreement was very good for the overall interpretation ($\kappa = 0.64$, 95% CI 0.5–0.78), right lateral decubitus ($\kappa = 0.91$, 95% CI 0.72–1), and subxiphoid windows ($\kappa = 0.72$, 95% CI 0.5–0.94), but only fair for the left upper quadrant approach ($\kappa = 0.4$, 95% CI 0.1–0.67).

4. Discussion

Aspiration is an important potential consequence of an emergent or semi-elective procedure that requires sedation [1]. Common emergency department procedures such as intubation or procedural sedation for cardioversion or management of orthopedic injuries carry a risk of iatrogenic injury due to aspiration. The guidelines for emergency medicine

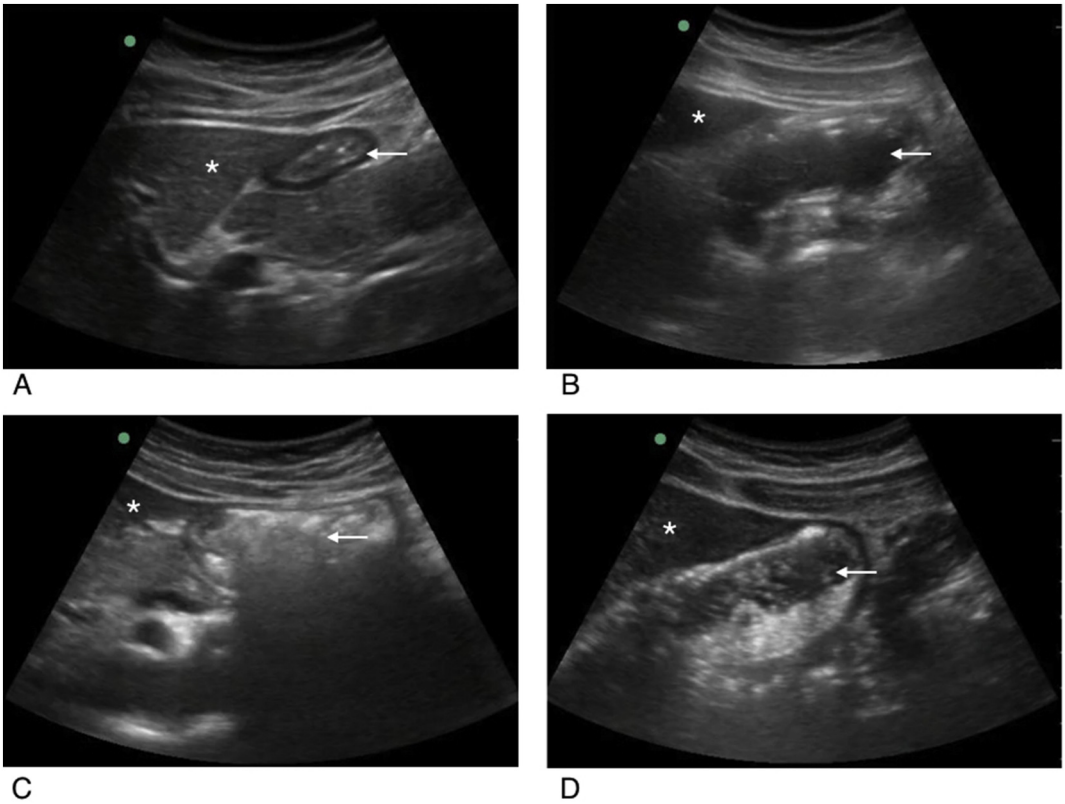

Fig. 1. Ultrasound images of the stomach. Arrowheads indicate the stomach. The liver is shown with an asterisk. A) Empty stomach with collapsed pylorus. B) Fluid filled stomach. C) Air-filled stomach with dependent shadowing. D) Stomach with layering fluid and solid content.

Table 3
Test performance characteristics of image reviewers with 95% confidence intervals.

	Overall		Subxiphoid		Right lateral decubitus		Left upper quadrant	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Reviewer 1	96 (80–100)	35 (15–59)	96 (79–100)	48 (26–70)	96 (80–100)	37 (16–62)	85 (65–96)	37 (16–62)
Reviewer 2	100 (86–100)	35 (15–59)	100 (87–100)	58 (34–80)	100 (86–100)	35 (15–59)	84 (60–97)	58 (37–77)

Fig. 2. Interpretation of gastric ultrasound images.

societies do not recommend that patients be fasted prior to semi-elective procedures [2]. In contrast, anesthesia society guidelines for procedural sedation recommend that patients remain fasting for at least two (from liquids) to six (from solids) hours prior to sedation [1,3,4]. Emergency medicine specialty societies recommend proceeding with procedural sedation regardless of time since last oral intake. However, some emergency clinicians practice in settings that adhere to anesthesia guidelines, leading to potential delays in care and disruption to emergency department flow.

The ability to non-invasively evaluate the stomach for the presence or absence of contents with ultrasound could help emergency physicians gauge the risk of aspiration. Knowledge of stomach content might affect sedation or induction strategy, change the timing of a procedure, or in practice settings with requirements that patients be fast prior to sedation, provide a visual demonstration that proceeding with the procedure is low risk. Emerging evidence from the anesthesia literature has suggested a role for gastric ultrasound in peri-operative assessment [5-9]. Gastric ultrasound may have a related role in emergency medicine.

Our data demonstrate that an emergency physician sonologist with experience in point-of-care ultrasound was able to accurately evaluate the stomach for the absence of content with excellent test performance characteristics. Accurate detection of stomach content was lower. Additional experience with gastric ultrasound might also lead to improved specificity [10]. Test performance might also be higher in practice, when the sonologist will approach the study with knowledge of the patient's last reported oral intake, and an associated pre-test probability.

In this study, the image reviewers identified an empty stomach with high sensitivity, but had lower specificity for detecting stomach content. They demonstrated excellent overall agreement. The principal source of false positive studies were ones in which air was visualized in the stomach (Fig. 1); both reviewers interpreted the presence of air as a positive study. Air can be entrained in the stomach with food or with swallowing, and interpreting the presence of air as a marker of content is reasonable for a conservative approach to a blinded observer. A clinician who visualized air with a relatively low pre-test probability might interpret the result as negative, and feel more comfortable proceeding with the planned procedure. However, it is essential to note that these data do not support delaying a critical procedure such as intubation on the basis of a gastric ultrasound.

We used three sonographic windows to examine the stomach. Using a combination of all three views to evaluate for stomach content provided the best performance. Isolated use of the left upper quadrant had the weakest test characteristics. This may be due to the orientation of the stomach, as this window would be suited to show content in the body and fundus of the stomach. An image that depicts the pylorus, as in the supine and subxiphoid windows, may provide favorable windows and allow greater accuracy.

Limitations of our study include the small number of operators who interpreted the studies, and their high level of experience with emergency ultrasound, which constrains the generalizability of our results. We also assumed that fasted subjects would have empty stomachs. The study population was not obese, which may have affected the ability of the sonologist to obtain adequate images of the stomach. As a preliminary study, we did not evaluate the effect of gastric ultrasound on patient outcomes, measures of care processes, or clinical decision making. Future studies to evaluate the role of gastric ultrasound in the emergency department are needed to address these questions, and our data do not support withholding sedation or a critical procedure solely based on a gastric ultrasound.

5. Conclusions

Emergency physician sonologists were sensitive but less specific at detecting stomach contents using gastric ultrasound. Sensitivity of each of the gastric ultrasound windows was similar; specificity was lower using the left upper quadrant window. Image interpretation agreement between the subxiphoid and right lateral decubitus approaches was similar. Gastric ultrasound may be interpreted more accurately using these windows.

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Conflicts of interest

None to disclose.

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