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ORIGINAL ARTICLE

Accuracy of point-of-care ultrasonography compared to abdominal X-ray in the diagnosis of small bowel obstruction in emergency patients

Dina Saad Alsufyani[1], Sawan Bagabas[2], Areej Alhamdi[3], Nawaf Basulaib[1], Maha Aleid[4], Ali Hasan Alkhulaif[5]*

ABSTRACT

Background: Small bowel obstruction (SBO) is a common cause of acute abdominal pain. Many diagnostic modalities are used to diagnose or rule out SBO.

Objective: This study aimed to compare the diagnostic accuracy of SBO for point-of-care ultrasound (POCUS) to that of abdominal X-ray (AXR) using computerized tomography (CT) and/or patients' follow-up as the gold standard.

Methods: This was a prospective, cohort study of a convenience sample of adult patients, who presented to the emergency department (ED) with signs and symptoms suggestive of SBO. Emergency medicine residents performed POCUS looking for sonographic signs of SBO. Abdominal X-ray and CT results were based on the radiologist's final report.

Results: A total of 77 patients were enrolled in the study. The mean age was 56 years, and the mean BMI was 28 kg/m^2. Point-of-care ultrasound had a sensitivity of 90%, specificity of 61%, +likelihood ratio (LR) of 2.3, and -LR of 0.159, compared to AXR, which had a sensitivity of 57%, specificity of 62%, +LR of 1.5, and -LR 0.69.

Conclusion: POCUS performed by ED residents for the diagnosis of SBO has high diagnostic accuracy as compared to that of AXR, with a p-value of 0.046. The accuracy is higher if all the sonographic signs are present or absent.

Keywords: Point-of-care ultrasound, small bowel obstruction, emergency ultrasound, bedside ultrasound.

Introduction

Small bowel obstruction (SBO) is a common cause of acute abdominal pain in patients presenting to the emergency department (ED). In the United States, SBO accounts for 15% of hospital admissions for acute abdominal pain and more than 300,000 annual ED visits [1,2]. Many of these patients need early surgical interventions [3]. Delay in diagnosis and treatment is associated with a higher rate of complications, such as bowel ischemia and perforation, leading to morbidity and death [3,4]. Symptoms and signs of SBO include abdominal pain, abdominal distention, vomiting, and inability to pass flatus or stools. Unfortunately, these clinical features are not 100% accurate to confirm or exclude the diagnosis of SBO [3,5].

Many diagnostic modalities are used to diagnose or rule out SBO. For most patients, abdominal X-ray (AXR) with an erect and supine view is commonly used for initial imaging study. However, the diagnostic accuracy is not optimal. In many cases, AXRs are read as equivocal or

Correspondence to: Ali Hasan Alkhulaif
*Consultant of Emergency Medicine, King Abdullah bin Abdulaziz University Hospital, Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia.
Email: ahalkhulaif@kaauh.edu.sa
Full list of author information is available at the end of the article.
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nonspecific [6-8]. Computed tomography (CT) has high diagnostic performance and provides information about the underlying etiology and complications [9,10]. The cost, availability, radiation exposure, and risk of contrast, as well as the need for transfer to a radiology suite, limit its use in day-to-day emergency medicine practice.

Recently, point-of-care ultrasound (POCUS) has emerged for use by emergency physicians for the diagnosis of SBO [11-16]. Ultrasound (US) is quick, portable, readily available, and can be performed for unstable patients. Research studies have shown it to have high sensitivity and moderate specificity [12]. However, these studies were carried out in a radiology suite or were conducted in ED academic centers and performed by fellowship-trained emergency physicians. Its applicability for ED in nonacademic centers is controversial. The aim of this study was to compare the diagnostic accuracy of POCUS with AXR using CT and/or patients' follow-up as the gold standard for final diagnosis. The authors hypothesize that POCUS is a more accurate test than AXR for the diagnosis of SBO in ED patients.

Subjects and Methods

This was a prospective cohort study that was conducted between June 1, 2018, and November 13, 2020. Patients aged ≥14 years, who presented to the Prince Sultan Military Medical City (PSMMC) ED with symptoms and signs suggestive of SBO, were included in the study. These symptoms and signs include abdominal pain, abdominal distention, nausea, vomiting, constipation, and obstipation. Pregnant patients, patients who needed emergency surgery or an invasive procedure, and patients who refused to provide consent were excluded from the study. The convenience sampling technique was used because the study physicians who had finished training to perform the POCUS may not have always been available.

The study was conducted at the PSMMC ED. The department receives more than 130,000 annual ED visits and is considered a training center hosting more than 40 emergency medicine residents.

Patients presenting to the ED with signs or symptoms suggestive of SBO were screened for eligibility for enrolment in the study. When a potential subject was identified, the treating physician would make the initial contact with the study operators to discuss potential participation in the study with the patient. Once the patient agreed to be a participant, the study operators obtained consent and filled in a data collection sheet that included the patient's serial number in the study, medical record number, age, gender, weight, height, nationality, chief complaint(s), past medical history, past surgical history, medications, and vital signs. Following this, POCUS of the abdomen was performed by the study operators who were blind to the result of AXR. US video clips were saved but were not part of the patient's medical record. The study operators were emergency medicine residents [postgraduate year (PGY)-1 to PGY-4]. All operators had finished a brief training session (10-min lecture and 10-min hands-on training) about the use of POCUS to diagnose or exclude SBO.

The ultrasound scans were performed with an HM70 portable ultrasound machine (Samsung Health Care, South Korea) using a low-frequency CA1-74 probe. The study protocol consisted of scanning four regions of the abdomen: the epigastrium, bilateral colic gutters, and suprapubic regions. The examination aimed to look for the presence or absence of sonographic dilated loops of bowel (>2.5 cm) as the main finding of SBO. Other supportive signs of SBO included to-and-fro movement of bowel contents, presence of free fluid between loops of bowel, and edematous small bowel wall >3 mm. Based on the presence or absence of all signs, the POCUS is called positive or negative, respectively. If only the small bowel wall diameter is >2.5 cm and other supportive signs are negative, POCUS is called "suggestive positive."

As part of the standard diagnostic workup, the enrolled patients had erect and supine AXR views, regardless of the results of POCUS. Multiple dilated loops of small bowel in supine film or multiple air-fluid levels in upright film are characteristic plain radiographic findings for SBO. Other suggestive findings are predominantly central dilated loops, visible valvulae conniventes, string-of-beads sign, and gasless abdomen. The decision to perform an abdominal CT scan was at the discretion of the treating physician. The results of the AXR and CT scans are based on the radiologist's final report, while the results of the POCUS are based on the study operator's interpretations. Seven days after the index visit, patients were followed up to record their final diagnosis, current symptoms, return ED visit, CT scan reports, and surgeries, if any.

Statistical analyses were carried out using the software SPSS version 27. Categorical classifications using "frequency table procedures" were used to estimate measures of performances of POCUS and AXR with CT being the gold standard. Five percent as type I error rate for all statistical tests was used.

For screening test to be useful, the overall diagnostic accuracy should be at least 75%. At type I error rate 5% and statistical power 80% a null hypothesis H_0: overall diagnostic accuracy = 0.75, can be tested against a one-sided alternative H_1: overall diagnostic accuracy > 0.75. The estimated sample size was n = 72 subjects, which was rounded up to 77.

Results

A total of 77 patients were recruited in the study (Table 1). The mean age was 56 years and the mean BMI was 28 kg/m^2. Most patients were Saudi (97.4%); 53% (41 patients) were men.

Using CT and/or 7-days follow-up as the gold standard for the final diagnosis, comparison of POCUS and AXR is shown in Table 2.

After excluding the suggestive positive of both tests, POCUS showed higher overall diagnostic accuracy sensitivity of 95% (88%-99%) (Table 3).

Signs of SBO on sonogram are shown in Figure 1.

Figure 2 shows the abdominal X-ray with supine and lateral decubitus views. The patient was not able to stand

Table 1. *Patient characteristics.*

Characteristic	Percentage (*N*)
Age	Mean of 56.8
Gender	Female 47% (36 patients) Male 53% (41 patients) Total of 77
Abdominal pain	87% (67)
Abdominal distention	59% (46)
Vomiting	62% (48)
Constipation	64.9% (50)
Abdominal surgery	64% (50)

Table 2. *Measure of performance of the diagnostic test relative to the gold standard.*

Parameter	AXR	POCUS
Sensitivity	57%	90%
Specificity	62%	61%
PV+	50%	70%
PV-	68%	90%
LR+	1.5	2.3
LR-	0.69	0.256
Accuracy	58%	73%
p-value = 0.046		

LR, Likelihood ratio.

Table 3. *Measure of performance of the diagnostic test relative to the gold standard when the "suggestive" positive and "suggestive" negative categories were removed.*

Parameter	AXR	POCUS
Sensitivity	36%	95%
Specificity	93%	76%
PV+	83%	77%
PV-	61%	95%
LR+	5.14	3.96
LR-	0.73	0.07
Overall accuracy	66%	85%
p-value= 0.007		

up for the erect view. The final report was indeterminate for small bowel obstruction.

Discussion

Small bowel obstruction is a high-risk diagnosis that should be considered in the ED [3,5]. Due to the limitations of history and physical examination to confirm or rule out SBO, emergency physicians need an accurate, reliable, and portable diagnostic tool. When compared to AXR, it was found that POCUS has a higher diagnostic accuracy to diagnose and confirm SBO. The diagnostic accuracy was even higher when all the sonographic signs were present. The presence of these findings may suggest a higher grade of obstruction.

Similar to the present results, multiple studies have shown higher diagnostic performance of departmental ultrasound (US) for diagnosing SBO [11-17]. In 1996, Czechowski et al. [17] reported higher sensitivity of US (91%) as compared to AXR (30%). The sensitivity was high in the strangulated group as compared to the simple SBO group. In 1997, a similar result was shown by Schmutz et al. [14], with US reporting 95% sensitivity. Although both these studies were performed by a trained radiologist, a study by Ünlüer et al. [12] showed that POCUS performed by emergency physicians and ultrasonography performed by radiology residents were not significantly different, with a Cohen's kappa of 0.81. Both emergency residents and radiology residents showed high sensitivity of 97.7% and 88.4%, respectively. Multiple subsequent studies showed high diagnostic performance of emergency physicians performing POCUS to diagnose SBO [11,15,16,18]. Jang et al. [11] prospectively enrolled a convenience sample of 76 patients with suspected SBO. Dilated bowel >2.5 cm on US had a sensitivity of 91% [95% confidence interval (CI) = 75%-98%]and specificity of 84% (95% CI = 69-93%) for SBO, compared to 46.2% (95% CI = 20.4%-73.9%) and specificity of 66.7% (95% CI =

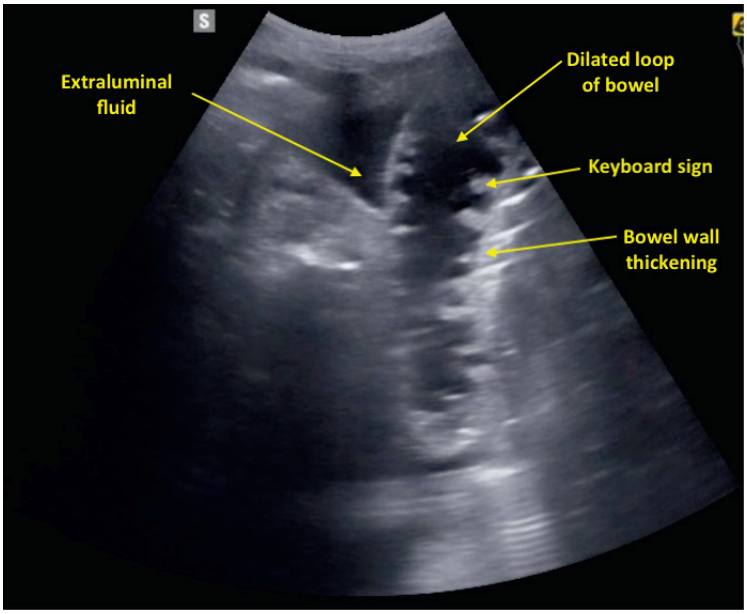

Figure 1. *Sonographic signs of small bowel obstruction.*

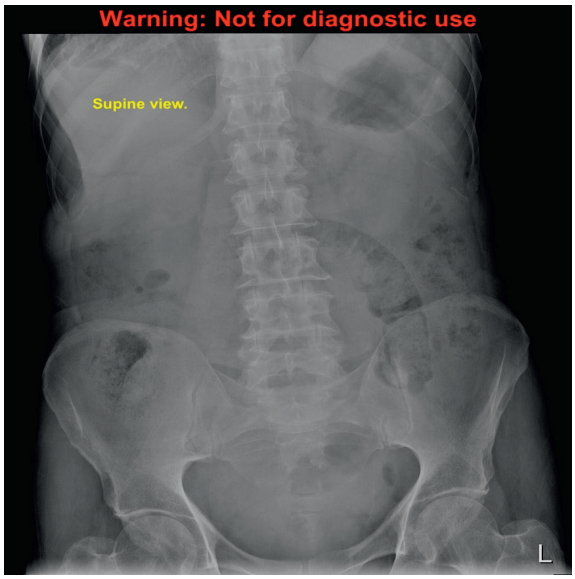

Figure 2. *Abdominal X-ray with supine and lateral decubitus views.*

48.9%-80.9%) for AXR. Boniface et al. [13] conducted a prospective, observational ED-based study to evaluate the diagnostic accuracy of POCUS compared with CT scan. In their 125 patients, sensitivity was 87.5% and specificity was 75.3% [13]. Another study, by Becker et al. [16], showed similar results with a total of 217 patients. POCUS was 88% sensitive, but less specific. The authors did not find the limited specificity to be a major limitation for using US to evaluate SBO, as the goal in ED practice is to rule out life-threatening diseases. In addition, the specificity was higher in the expert group (82% *vs*. 54%), emphasizing the importance of training and quality assurance process.

In the present study, the training of the operators was a short 10-min lecture, followed by a 10-min hands-on training. This limited period of training, combined with high diagnostic performance, suggests that POCUS is an easy-to-use modality across many levels of operators. Similar results were shown by Jang et al. [11] and Becker et al. [16], who limited their training for the study operators to be 10 and 30 minutes, respectively.

The present study has some limitations. First, although the training session was standardized, the sonographic skills of the emergency medicine (EM) residents varied. There is a chance that more experienced residents would have higher diagnostic accuracy. This was shown by Becker et al.'s [16] study, which found that accuracy was higher for POCUS performed by physicians with more experience and training of the sonographic appearance of SBO than junior residents. This observation reflects daily practice, and this study aimed to look for overall diagnostic accuracy across all operators rather than at individual levels. Second, the respective time was not recorded that was taken to perform POCUS and AXR. From the authors' experience, POCUS was performed more quickly than AXR view, since POCUS was performed by the treating physicians and at the bedside. This was supported by Boniface et al. [13] who showed the time to obtain AXR was longer than for POCUS (98 minutes *vs.* 11 minutes, respectively). Third, POCUS should be blind to the AXR results, but full control of this blinding procedure could not be observed in this study. Fourth, due to the risk of radiation and contrast-induced nephropathy, not all patients underwent CT scan. However, all the patients were followed up through phone calls and chart reviews to evaluate the final diagnosis. Due to the limited number of cases in the present study, it could not be shown that using POCUS would have any positive impact on the patients' clinical-oriented outcome. Finally, although the protocol for AXR was to perform erect and supine X-rays, not all the patients could get the two views. Around 18% did not have erect or lateral decubitus view, the reason was that patients were either too unstable to go to the radiology suite or there was difficulty positioning patients such as those who were morbidly obese or bedridden. In such situations, the treating physician made a decision based on the single supine portable view. This was found to be an advantage of POCUS, which can be done at the bedside while monitoring and resuscitation measures can continue.

Conclusion

POCUS performed by EM residents for the diagnosis of SBO has a high diagnostic accuracy as compared to that of AXR. The accuracy is higher if all the sonographic signs are present or absent. US is a reasonable, accurate diagnostic tool for emergency physicians to rule out SBO.

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List of abbreviations

AXR	Abdominal X-ray
CI	Confidence interval
CT	Computerized tomography
ED	Emergency department
EM	Emergency medicine
LR	Likelihood ratio
POCUS	Point-of-care ultrasound
PGY	Postgraduate year
PSMMC	Prince Sultan Military Medical City
SBO	Small bowel obstruction
US	Ultrasound

Conflict of interest
The authors declare that there is no conflict of interest regarding the publication of this article.

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Consent to participate
Informed consent was obtained from all the participants.

Ethical approval
The study was approved by the PSMMC Institutional Research Board (No. 1057, approved on March 14, 2018).

Author details
Dina Saad Alsufyani[1], Sawan Bagabas[2], Areej Alhamdi[3], Nawaf Basulaib[1], Maha Aleid[4], Ali Hasan Alkhulaif[5]

1. Consultant of Emergency Medicine, Prince Sultan Military Medical City, Riyadh, Saudi Arabia
2. Consultant of Emergency Medicine, Al Iman General Hospital, Riyadh, Saudi Arabia
3. Emergency Medicine Resident, King Saud University Medical City, Riyadh, Saudi Arabia
4. Researcher, King Faisal Specialist Hospital & Research Center, Riyadh, Saudi Arabia
5. Consultant of Emergency Medicine, King Abdullah bin Abdulaziz University Hospital, Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia

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