Bedside ultrasonography for the detection of small bowel obstruction in the emergency department

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ABSTRACT

Background Plain film radiography (x-ray) is often the initial study in patients with suspected small bowel obstruction (SBO) to expedite patient care.

Objective To compare bedside ultrasonography (US) and x-ray for the detection of SBO.

Methods This was a prospective study using a convenience sample of patients presenting to the emergency department (ED) with abdominal pain, vomiting, or other symptoms suggestive of a SBO. Patients were evaluated with US prior to x-ray and CT. US was performed by emergency physicians (EPs) who completed a 10 min training module and five prior US exams for SBO. The criterion standard for the diagnosis of SBO was the results of CT read by board-certified radiologists.

Results In all, 76 patients were enrolled and evaluated with US for SBO. A total of 33 (43%) were diagnosed as having SBO. Dilated bowel on US had a sensitivity of 91% (95% CI 75 to 98%) and specificity of 84% (95% CI 69 to 93%) for SBO, compared to 27% (95% CI 14 to 46%) and 98% (95% CI 86 to 100%) for decreased bowel peristalsis on US. x-Ray had a sensitivity of 46.2% (95% CI 20.4 to 73.9%) and specificity of 66.7% (95% CI 48.9 to 80.9%) for SBO when diagnostic, but was non-diagnostic 36% of the time.

Conclusion EP-performed US compares favourably to x-ray in the diagnosis of SBO.

INTRODUCTION

Small bowel obstructions (SBOs) represent 20% of surgical admissions for acute abdominal pain,[1] but are difficult to diagnose since they can mimic other causes of abdominal pain.[2] Classically, diagnosis was made by history and physical exam with confirmation by plain film radiography (x-ray).[3] The Eastern Association of the Surgery of Trauma (EAST) recommends x-ray for all patients being evaluated for SBO,[4] but x-ray is frequently non-diagnostic[1 2] and may have a sensitivity less than 70%,[2] thus necessitating further imaging with CT.[4–6] Unfortunately, CT requires technician time, incurs increased expense and exposes patients to greater radiation. Therefore, it has been suggested that using x-ray to triage patients for further imaging would optimise efficiency and cost.[5 6]

Ultrasonography (US) may be a possible alternative to x-ray in patients with suspected SBO[3 4 7–10] with the potential to decrease cost.[3] The purpose of this study was to compare emergency physician (EP)-performed US and x-ray in patients in the emergency department (ED) for the detection of SBO.

METHODS

Study design

This was an institutional research board (IRB)-approved prospective study of patients conveniently sampled between June 1, 2006 and December 31, 2007, when a participating EP was available to perform US prior to x-ray and CT for the diagnosis of SBO. The study EPs were not the treating doctors and were blinded to all patient data until after the US was performed and results were recorded.

Study setting

This study was conducted at an urban, academic ED with 49 000 annual adult visits. The ED serves as an equal partner in a two-institution emergency medicine training programme where resident doctors spend 50% of their clinical time.

Selection of participants

All patients presenting to the ED with abdominal pain, nausea, or vomiting were eligible for participation if their treating doctors were ordering a CT to evaluate for an SBO and one of the participating EPs was available to perform US for the diagnosis of SBO.

All of the participating EPs were resident doctors who completed an introductory course on emergency US, performed at least 10 prior US exams before enrolling patients and volunteered for participation in the study. Each EP completed a 10 min hands-on lecture/demonstration of US for the diagnosis of SBO and performed five prior US exams for SBO before initiation of the study.

Protocol

Consenting patients underwent US for the diagnosis of SBO before x-ray or CT. The US results were recorded and compared to the results of subsequent x-ray and CT assessing specifically for SBO. There were separate radiologists reading the x-ray and CT, each blinded to the results of the other studies. At our institution, abdominal/pelvis CTs performed for the evaluation of SBO involve oral and intravenous contrast, unless the patient has specific contraindications. The criterion standard for the diagnosis of SBO was the board-certified radiologist's final CT interpretation, based on proximal small bowel distension ≥25 mm associated with collapsed, distal bowel loops.[1 2 5 6]

Study measurements

US exams were performed using an Ultrasonix CEP (Ultrasonix, Richmond, British Columbia, Canada) with a phased array probe in the bilateral colic gutters, epigastric and suprapubic regions to assess for (1) the presence of fluid-filled, dilated bowel (defined as ≥25 mm) proximal to normal or

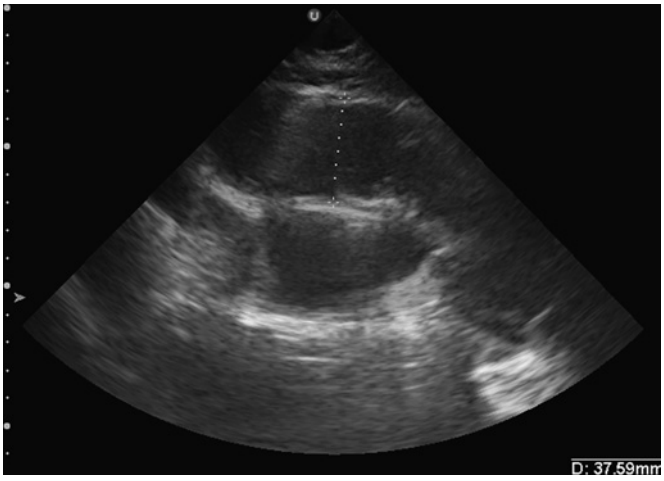

Figure 1 Example of dilated small bowel seen in epigastrium measuring 3.8 cm.

collapsed bowel (figures 1 and 2), and (2) decreased or absent bowel peristalsis (defined as back and forth movements of spot echoes inside the fluid-filled bowel). Either finding was considered 'positive' for an SBO.

Three view abdominal series x-rays (AXR) were considered positive for an SBO if (1) there was an abnormal gas distribution, consisting of multiple gas-filled or fluid-filled loops of dilated bowel with a small or moderate amount of colonic gas or (2) dilated gas-filled or fluid-filled loops of bowel with a gasless colon consistent with prior descriptions in the literature.[2] A 'non-specific bowel gas pattern' was considered 'non-diagnostic' or 'equivocal' for an SBO.

Data analysis

Data were collected in an Excel database (Microsoft Excel, Microsoft, Redmond, Washington, USA) and translated into a native SAS format using DBMS/Copy (Dataflux Corporation, Cary, North Carolina, USA). Analyses were conducted using SAS V.9.1 (SAS Institute, Cary, North Carolina, USA). Descriptive statistics were calculated for all variables. The sensitivity, specificity and likelihood ratios of US and AXR were compared using 95% CIs.

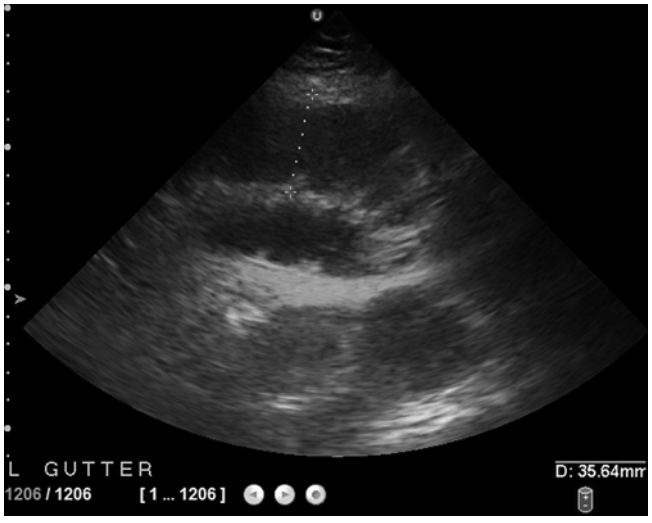

Figure 2 Example of dilated small bowel seen in left colic gutter measuring 3.6 cm.

Table 1 Clinical characteristics of patients

Characteristics	No. of patients	Percentage of total
Prior SBO	9	12
Prior abdominal surgery	74	97
Constipation	16	21
Diffuse abdominal pain	67	88
Nausea	65	86
Vomiting	53	70
Absent bowel sounds on exam	0	0
Decreased bowel sounds on exam	35	46
Diffuse tenderness on exam	56	74
Distended abdomen on exam	53	70
Focal point of maximal tenderness on exam	17	22
Guarding on exam	28	37
Rebound tenderness on exam	0	0

SBO, small bowel obstruction.

RESULTS

A total of 133 patients presented to the ED and were evaluated for an SBO when a study doctor was available, 76 (58%) of whom were enrolled and evaluated with US (table 1). In all, 15 (11%) refused participation due to concern for pain during the exam, 20 (15%) had x-rays obtained from the waiting room before US could be performed, and 20 (15%) were otherwise missed. There were no indeterminate US studies, while 27 patients (36%) had non-diagnostic AXR. No CTs were read as 'equivocal' or 'indeterminate'.

In all, 33 (43%) patients were diagnosed as having SBO by CT. The test characteristics of US and AXR for SBO are shown in table 2. The diagnoses of patients without SBO are shown in table 3.

DISCUSSION

SBO can be difficult to diagnose. Unfortunately, AXR is often non-diagnostic and transport out of the clinical area for a CT may not always be feasible. EP-performed US compares favourably to AXR and appears to be a reasonable alternative to AXR as the initial imaging modality in suspected SBO. It is non-invasive, does not require technician time, contrast administration, or radiation exposure, and may be performed quickly without removing patients from the clinical area. Furthermore, US may offer better prognostic information than AXR.[3 10] Although many clinicians may prefer to pursue further imaging with CT, it may not always be feasible and, at the very least, it seems reasonable to consider replacing x-ray with US in current algorithms.[2 4 6]

Our data regarding the sensitivity of AXR for SBO is consistent with prior reports,[2 3] where 61% of studies were non-diagnostic. In contrast, US was diagnostic in every case, likely due to the ease of differentiating the characteristic, normal appearance of aerated bowel from dilated, fluid-filled bowel. Since dilated, fluid-filled loops of bowel are easily distinguished from normal, aerated bowel, the distinction is not subtle and, in our experience, most operators can learn to accurately make this distinction after 10–20 exams.

Limitations

This study had several limitations. First, 20 patients (15%) were missed due to convenience factors, which may represent a selection bias where 'difficult' patients were not enrolled. Likewise, the prevalence of SBO in our sample was high (43%), which could have biased the data towards better sensitivity.

Table 2 Performance characteristics of ultrasound (US) and x-ray for small bowel obstruction (SBO)

	Sensitivity	Specificity	LR+	LR−
US: decreased peristalsis TP 9, TN 32, FP 1, FN 24	27.3% (95% CI 13.9 to 45.8)	97.7% (95% CI 86.2 to 99.9)	11.7 (95% CI 1.6 to 88.0)	0.7 (95% CI 0.6 to 0.9)
US: dilated bowel TP 30, TN 36, FP 7, FN 3	90.9% (95% CI 74.5 to 97.6)	83.7% (95% CI 68.7 to 92.7)	5.6 (95% CI 2.8 to 11.1)	0.1 (95% CI 0.04 to 0.3)
US: decreased peristalsis or dilated bowel TP 31, TN 35, FP 8, FN 2	93.9% (95% CI 78.4 to 98.9)	81.4% (95% CI 66.1 to 91.1)	5.0 (95% CI 2.7 to 9.5)	0.07 (95% CI 0.02 to 0.29)
Abdominal series x-ray: TP 6, TN 24, FP 12, FN 7	46.2% (95% CI 20.4 to 73.9)	66.7% (95% CI 48.9 to 80.9)	1.38 (95% CI 0.7 to 2.9)	0.8 (95% CI 0.5 to 1.4)

FN, false negative; FP, false positive; LR, likelihood ratio; TN, true negative; TP, true positive.

Second, the study EPs could not be blinded to all clinical parameters since they could observe pain or nausea, abdominal distension, or localisation of pain while performing the exam. These factors may have biased their findings, but is normative for clinicians performing bedside US in the ED. This could have been mitigated by having post hoc review of US images by another clinician blinded to all clinical information. Likewise, there was no assessment of inter-rater reliability. Future work should involve an assessment of inter-rater reliability since US is known to be operator dependent.

Table 3 Diagnoses of patients without small bowel obstruction (SBO)

Diagnosis	N
Abdominal aortic aneurysm	1
Abdominal abscess	3
Appendicitis	5
Ascites	2
Cyclic vomiting	1
Diverticulitis	2
Fat herniation	4
Gastritis	1
Hernias	5
Ileitis/inflammatory bowel disease	1
Ileus	1
Incarcerated mesentery	1
Mesenteric adenitis	1
Metastatic cancer	1
Pancreatitis	7
Pelvic inflammatory disease	1
Pulmonary embolism	1
Pyelonephritis	2
Renal stone	2
Splenic infarct	1

Finally, only seven doctors agreed to participate, representing a 'US interest' bias. These doctors were motivated and knew their results were going to be compared to a criterion standard, raising the potential for a Hawthorne effect. Our findings may not apply to less interested doctors.

Conclusion

EP-performed US compares favourably to x-ray in the diagnosis of SBO.

Competing interests None.

Ethics approval This study was conducted with the approval of the Olive View-UCLA Medical Center.

Provenance and peer review Not commissioned; externally peer reviewed.

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