Utilizing Point of Care Ultrasound to Evaluate for Small Bowel Obstruction in Emergency Department Patients

Danielle Biggs, Laura Kolster, Amy Patwa, Andrew Graziano, Devansh Pandey, Joe Heiney, and Brian Walsh

Abstract

Small bowel obstruction (SBO) is a common diagnosis made in the Emergency Department (ED) representing about 15% of hospital admissions for acute abdominal complaints. We sought to investigate if bedside ultrasound as performed by ED physicians is a reliable test to diagnose and rule out SBO. This was a prospective cohort study of nonconsecutive patients who presented to an academic, suburban ED with a census of approximately 100,000 patients per year between November 2018 and May 2019. Patients with a history of prior abdominal surgeries who presented to the ED with nausea and/or vomiting and had a CT Abdomen and Pelvis with PO contrast ordered by their provider were consented for a bedside ultrasound. Interpretation was performed by the physician performing the study at bedside. The physician performing the study identified the largest loops of bowel in each of the four quadrants and measured the identified loops from bowel wall to bowel wall. A diameter of greater than 2.5 cm was considered positive for dilated bowel and probable obstruction. At the completion of the study the physician entered their interpretation of the result which was later reviewed by an ultrasound fellowship-trained physician. There were 101 patients included in the study. Study personnel were accurate in 92% of cases. Overall the sensitivity of point of care ultrasound (POCUS) for SBO was 90% (72.7 to 97.8) and specificity was 92% (82.7 to 96.9). The positive and negative likelihood ratios were 10.76 (4.95 to 23.38) and 0.11 (0.04 to 0.33). Given that our study demonstrated a low negative likelihood ratio, those with low probability of an SBO on history could have an ultrasound examination performed at the bedside which could be sufficient to rule out this disease without requiring patients to undergo further imaging.

Keywords: POCUS, small bowel obstruction, ultrasound.

I. INTRODUCTION

Small bowel obstructions (SBO) comprise about 15% of hospital admission for acute abdominal complaints [1]. Adhesions from prior surgeries comprise approximately 70% of small bowel obstruction in developed countries, followed by malignancy, inflammatory bowel diseases, and hernias [2]. Ultrasound is becoming a more useful tool for diagnosis of abdominal pathology for various conditions in the emergency department, including the first line for imaging in intussusception, appendicitis, and pyloric stenosis in children [3]. This study was undertaken to demonstrate the utility of POCUS in SBO in adults prospectively to add to the existing literature, with a specific focus on the Emergency Department setting.

As [4] discussed, these patients often wait hours for evaluation, lab testing, and computed tomography (CT) scans to be completed and interpreted [4]. This leads to delays in care, problems with ED patient flow, and the potential for decreased patient satisfaction [4]. Furthermore, CT scans with IV and PO contrast expose patients to ionizing radiation and contrast media [4, 5]. Previous studies have demonstrated that ultrasound is a valuable tool in the diagnosis of SBO and has similar diagnostic accuracy to CT [4]. Previous retrospective studies have shown that ultrasound may be non-inferior to conventional imaging with CT [4]. We sought to investigate if bedside ultrasound performed in the ED is a reliable test to diagnose and rule out SBO.

The ultrasound diagnosis of small bowel obstruction is a diagnostic modality that has been studied somewhat from a radiology perspective but recently has been of interest to the point-of-care ultrasound community in the ED. Diagnostic work up for small bowel obstruction include plain radiograph, CT scan, and surgery. Abdominal radiograph has a diagnostic accuracy of 55-80%, and up to 20% of diagnosed obstructions have no radiographic evidence of obstruction [6]. Multiple studies have shown that ultrasound is superior to plain radiographs for the detection of SBO [6]-[8]. However,
abdominal radiographs remain the initial diagnostic evaluation due to the widespread availability, low cost, and ability to follow disease progression. CT scan has a 93% sensitivity for diagnosis of small bowel obstruction, and CT is also beneficial for diagnosis of the source of bowel obstruction [6].

As prior studies have shown, ultrasound can be used by emergency physicians for evaluation of small bowel obstruction. The linear or curvilinear probe could be used, and the scan should be performed in a continuous and steady fashion to obtain uniform texture and optimal resolution. Scanning through both flanks may be more accurate than scanning on the anterior surface of the abdomen as bowel air may rise to the anterior abdominal wall and obscure the images. Small bowel obstruction can be diagnosed on ultrasound when the lumen of fluid filled bowel loops are greater than 2.5 cm, the length of the dilated bowel segment is greater than 10cm, and/or peristalsis of the dilated segment is increased, and loops of distal bowel collapsed. If there is dilation present with no peristalsis that is diagnostic of paralytic ileus. The presence of dilated small bowel loops (>25mm in jejunum or >15mm in the ileum) was the most sensitive (95%) and specific (84%) sonographic finding for small bowel obstruction [1].

II. MATERIALS AND METHODS

A. Study Design

This was a prospective cohort study of a convenience sample of patients who presented to an academic, suburban ED with a census of approximately 100,000 patients per year between November 2018 and May 2019. Inclusion criteria included age greater than 18, ability to provide written informed consent, a history of prior abdominal surgery, presentation to the ED with nausea and/or vomiting and having a CT Abdomen and Pelvis with PO contrast ordered. The use of IV contrast for the CT abdomen/pelvis was at the discretion of the ED provider. Any ED provider could identify a potential patient for enrollment based on their clinical presentation and having an abdominal CT done in the ED, but enrollment was actually done by ultrasound fellowship-trained ED faculty, the ultrasound fellows, and/or emergency medicine residents who were educated on bowel ultrasound through hands-on training during their ultrasound rotation as well as a 10-minute training video made by two ED ultrasound faculty members. Once patients meeting criteria were identified, written informed consent was obtained from the patient. The patient’s name and medical record number were recorded with each study to ensure thorough chart review at the completion of the study. A point of care abdominal ultrasound study to identify loops of bowel was then performed with the Zonare ultrasound machine (ZONARE MEDICAL SYSTEMS, MOUNTAIN VIEW, CA.). The ultrasound was planned to take approximately 5 minutes to complete. A curvilinear, 3 MHz low frequency probe was utilized to image the four quadrants of the patients’ abdomen (right upper quadrant, left upper quadrant, right lower quadrant, and left lower quadrant). The physician(s) performing the study identified the largest loops of small bowel, identified by presence of plicae circulares, in each of the four quadrants and measured the identified loops from bowel wall to bowel wall. For some patients, two physicians present in the ED contemporaneously interpreted the ultrasound study. Radiologists have used measures of a diameter of greater than 2.5 cm was considered positive for dilated bowel and probable obstruction [9]. Five second clips of bowel loops were obtained in each of the four quadrants to identify peristalsis and confirm the presence of bowel. Bowel loops were then measured with still images in all four quadrants. At the completion of the study the physician entered their interpretation of the result. The results were either interpreted as positive or negative based on the bowel measuring less than or greater than 2.5 cm [9]. Indeterminate results were not allowed. All ultrasounds were completed and interpreted prior to the CT scan being performed and the radiologists interpreting the CT scans did not have access to the ultrasound results. Patients initially enrolled but for whom a CT was not performed were excluded from the analysis since they lacked the criterion standard.

C. Data Analysis

All studies were interpreted at the time of the ultrasound by the person performing the study and these are the results that are reported below. All studies were reviewed during weekly ultrasound quality assurance sessions by one senior ultrasound faculty and two ultrasound fellows to monitor for deviations from the study protocol, of which there were none. Following the enrollment of participants, a chart review was performed by an ultrasound fellow that included reviewing the results of the point of care ultrasound and the patient’s final CT results. In cases of ultrasound false positives, the final CT diagnosis was reviewed and recorded to determine if there was a common pattern amongst the false positive results. Data was imported to MICROSOFT Excel (MICROSOFT CORPORATION, REDMOND, WA), and analysis performed to determine the sensitivity, specificity and likelihood ratios of identifying a small bowel obstruction utilizing point of care ultrasound compared to a CT scan with PO contrast.

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III. RESULTS
From November 2018 to May 2019, we enrolled 106 patients. Five patients who never received a CT were excluded from the data analysis. Of the 101 patients with completed CT scans, 65% were female with an average age of 65 years, and an average BMI of 28.7. All patients in the study received oral contrast and administration of IV contrast was at the discretion of the treating physician. Studies were performed and interpreted by residents, ultrasound fellows, or ultrasound faculty in 39, 47 and 24 subjects, respectively. The total numbers of patients with and without small bowel obstructions confirmed by CT scan were 29 and 72, respectively (Table I). Amongst the POCUS performed there were 26 true-positives, 6 false-positives, 66 true-negatives and 3 false negatives. In the case of the 6 false positives, the final CT diagnosis was determined to be: prominent loops of bowel without obstruction, acute cholecystitis, hydronephrosis, constipation, colitis, and a gastric outlet obstruction. Overall accuracy was 92%. All false positives and false negatives were amongst the studies performed and interpreted by US faculty or fellows. Overall, the sensitivity of POCUS for SBO was 90% (95% CI: 73 to 98) and specificity was 92% (95% CI: 83 to 97). The positive and negative likelihood ratios were 11 (95% CI: 5 to 23) and 0.11 (95% CI: 0.04 to 0.33), respectively (Table II).

IV. DISCUSSION
Our study demonstrated that ultrasound had a 92% specificity and a 90% sensitivity for diagnosis of small bowel obstruction. The diagnosis of small bowel obstruction was made based on dilated loops of bowel greater \( \geq 2.5 \) cm in any quadrant. Since the negative likelihood ratio of 0.11 is low, for patients with a low pretest probability of SBO, a negative bedside ultrasound examination may be sufficient to allow discharge without requiring CT scanning. This could decrease the number of CT scans performed, shorten length of stay, or help exclude SBO from the differential and improve appropriate work-up and management. For example, if we had 100 patients with a pretest probability of 10% and applied the results of our study to them then we would eliminate performing 100 CT scans but would miss one SBO. It is likely if discharged, that one patient with SBO would return with continued symptoms, unless the SBO resolved spontaneously. Of the patients with a false positive diagnosis, the diagnosis found on CT were prominent loops of bowel without obstruction, acute cholecystitis, hydronephrosis, constipation, colitis, and gastric outlet obstruction. Of these, cholecystitis and hydronephrosis could be identified by extending the ultrasound exam and the others could be diagnosed with further work-up and/or other radiologic tests. In our study we relied on the CT scan as the criterion standard of diagnosis given only a portion of patient’s ultimately have surgery to confirm the diagnosis.

In a case report by [1], POCUS identified dilated loops of bowel which was confirmed by CT; this early diagnosis of dilated loops on POCUS allowed for earlier surgical intervention [1]. In a study by [10] it was found that POCUS performed by ED residents had a sensitivity of 97% and a specificity of 92.7% for SBO, which is similar to our findings even though their diagnostic criteria differed somewhat from ours. Their diagnostic criteria for SBO included dilated small bowel loops in three segments, increased peristalsis, and collapsed colonic lumen, with dilated loops of small bowel having the most diagnostic accuracy [1].

Our study further contributed to the existing literature that ultrasound is a valuable tool in the diagnosis of SBO with a sensitivity and specificity comparable to that of CT [4]. Ultrasound would reduce radiation exposure and since it can be done quickly and without delay, could save time as well. It may also be particularly valuable in settings with limited or no access to CT as [4] stated.

Reference [4] stated in their study that further studies from an emergency department perspective would need to be performed to further evaluate the diagnosis of SBO on ultrasound, and our study helps to fill that gap. Our study is applicable to the general emergency department patient. In those with prior abdominal surgeries, POCUS should be used as a diagnostic modality for emergency department providers. In future studies, one could continue to research those with nausea/vomiting and/or abdominal pain without prior abdominal surgeries, the pediatric population, as well as the ease of teaching those with limited ultrasound knowledge.

POCUS has many advantages in the diagnosis of SBO, including fast time to diagnosis, no associated radiation, and a high specificity and sensitivity as shown by our study. The results of our study are further contributing to the literature supporting the use of the utility of point of care ultrasound for small bowel obstruction.

V. LIMITATIONS
Our study was limited in several regards. Firstly, a general limitation of ultrasound in this modality is that the presence of air-filled loops of small and/or large bowel without fluid may decrease sensitivity or lead Similarly, fluid filled loops of bowel decreases the sensitivity of plain radiographs. These two bedside tests used in conjunction may increase each other’s sensitivities and specificities if CT is or will be unavailable for a significant amount of time. A CT scan was used as the gold standard as prior literature states computed tomography (CT) has become the test of choice due to its superior resolution and increased ability to identify both obstruction and its etiology [1], [11]. However, CT is only 93% sensitive for the detection of small bowel obstruction. Although the finding at surgery is the best criterion standard for SBO, this is not available for the many patients whose SBO resolves after conservative treatment and do not need surgical intervention.
Also, this was a convenience sample, therefore people enrolling the patient could have included patients with higher pretest probability or excluded people from enrollment with lower likelihood of having a small bowel obstruction. We excluded patients that did not have prior abdominal surgery. However, including them would likely not have changed our results much since they represent a very small portion of patients with SBO. Reference [12] found that of 689 patients with SBO over a 5-year period only 9% had virgin abdomens.

Additionally, we used a convenience sample of patients in one single center. Though physicians were initially blinded to CT results, and this was a prospective study, limiting selection and confirmation biases, there remains doubt in terms of the generalizability of these results. For example, this study was primarily performed by or under supervision of ultrasound-trained attending staff. Some resident physicians performed these studies, but this is within the context of a residency program that regularly emphasizes the learning and applying of ultrasound techniques. Emergency physicians at community centers without formal ultrasound training (especially those who trained before the use of bedside ultrasound became widespread) may not be able to readily replicate these results.

We additionally found in our review of literature that scanning the patient’s flanks in addition to anterior abdomen, and number of plicae (ileum with central and right abdomen), and number of plicae (ileum with central and right abdomen) may be more accurate given that air rises to the anterior abdominal surface and thus may obscure images. We did not include scanning the flanks as a mandatory component of our exams. This may have led to more inconclusive exams than we would have had if all patients had their flank areas imaged. We additionally may have been able to increase our sensitivity by applying previously referenced upper limits of normal of ileal diameter of >15 mm. Distinguishing ileum from jejunum relies on location (ileum is found more in the jejunum relies on location (ileum is found more in the central and right abdomen), and number of plicae (ileum with <3 folds/2.5 cm of bowel). Our goal was to use a protocol that could be replicable by as many physicians as possible while still striving for the highest sensitivity and specificity possible, and so we used the single value of 2.5 cm bowel diameter as our cutoff, as has been used in previous research [9].

Sensitivity may have been improved by utilizing other criteria for SBO beyond small bowel dilatation e.g. peristaltic activity (especially “back and forth” activity), swirling movement of bowel contents proximally and collapse of bowel distally. The use of peristaltic activity in combination with dilatation of bowel may help distinguish dynamic ileus vs obstruction. We did not use these as criteria initially to preserve the simplicity and binary nature of each study’s interpretation. However, the most accurate way to diagnose obstruction is finding diluted bowel loops with or without peristaltic activity and a zone of transition beyond which dilation is not appreciated. Other techniques, such as scanning to locate a transition point or closed loop, may improve specificity and provide valuable information to surgeons regarding the type and grade of bowel obstruction.

VI. Conclusion

Ultrasound can be used as an effective tool for diagnosis of small bowel obstruction for those with prior abdominal surgeries and nausea and/or vomiting. Initial bedside evaluation of these patients should include ultrasound to guide management.

REFERENCES