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Point-of-care ultrasound should end the outdated practice of “marking for a tap”

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A 55 year old man with a history of alcoholic cirrhosis decompensated by esophageal varices status post banding presented to the emergency room with abdominal pain. He also noted increased abdominal girth with associated poor oral intake and early satiety as well as a 10 lb. weight gain over 2 weeks. On examination, the patient was afebrile with stable vital signs and no respiratory distress. His abdominal examination revealed tense ascites with mild tenderness to palpation of the left upper quadrant. There was no jaundice or asterixis. Laboratory testing was significant for mild thrombocytopenia but no leukocytosis or abnormal liver tests. Liver synthetic function was preserved.

Abdominal computed tomography (CT) scan revealed a cirrhotic liver with evidence of portal hypertension including splenomegaly, large ascites and peri-esophageal and peri-splenic varices. The overnight admitting medical team planned to perform a diagnostic and therapeutic paracentesis and referred the patient to radiology to be “marked for a tap.” The next morning, the patient was transported by stretcher to a radiology suite where an ultrasound technologist acquired multiple ultrasound images of the ascites and marked the skin on the patient’s right lower quadrant. The radiologist formally interpreting the images commented on ascites but declined to confirm a “pocket to tap” as he was not provided images of fluid in two orthogonal planes. The day team used point-of-care ultrasound and readily identified a large volume of simple intra-peritoneal fluid (Figure 1). They selected a new site for paracentesis, mindfully avoiding the inferior epigastric arteries and underlying small bowel. The skin entry region marked by the technologist was no longer ideal given repositioning after the patient’s return to the hospital floor. At the bedside, 4.2L of ascites was safely removed by paracentesis [1]. The patient experienced immediate relief of abdominal discomfort and was discharged that same day on diuretics after the ascites cell count result was not concerning for spontaneous bacterial peritonitis.

Paracentesis is a frequently performed inpatient and outpatient procedure. It is recommended for patients with new-onset or tense ascites and patients with ascites and any infectious signs or symptoms [2]. Furthermore, paracentesis is recommended for any patient with ascites admitted to the hospital because it is associated with increased short-term survival [2,3]. Overall complication rates are as low as 1% with more severe complications such as bowel entry by the needle and hemoperitoneum occurring in less than 0.1% of patients [2].

Point-of-care ultrasonography (POCUS) has emerged as a useful adjunct to the physical examination to diagnose ascites [2]. Ultrasound guidance is also recommended for paracentesis to select the ideal site to avoid bowel, solid organs, and blood vessels [1,2,4]. The practice of transporting inpatients off the hospital floor for a formal ultrasound solely for skin marking is therefore unwarranted in routine cases, given the growing availability of training

![Figure 1. Representative examples of ascites prior to paracentesis as seen on point-of-care abdominal ultrasound.](image-url)
and access to POCUS in emergency medicine, internal medicine, and critical care.

For the patient, this “mark for tap” practice adds unnecessary cost, inconvenience, and delay. In cases of spontaneous bacterial peritonitis (SBP), delayed diagnosis could postpone appropriate treatment, which can lead to severe sepsis and death [2]. For the institution, utilizing limited resources such as patient transportation, sonography, and radiology for unnecessary studies creates delays for other patients. For the clinician performing the paracentesis, a radiology-marked site could provide false confidence, because the operator should instead be aware of all anatomic structures at the time of the procedure. As in the above case, “blindly” using a previously marked site would not have been ideal; loops of bowel and soft tissue anatomy change with patient positioning and should not be assumed to be constant in relation to the fluid target for aspiration. Although rare, hemorrhagic complications to paracentesis might be avoided by identification of abdominal wall vasculature using POCUS [4].

Bedside paracentesis is a safe, routine, and potentially life saving procedure. While formal imaging studies are necessary to evaluate for liver morphology, tumor, and splanchnic thrombosis, transporting inpatients solely to be “marked for a tap” is an outdated practice and could lead to unnecessary cost or delays in care [2].

References

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Case Presentation

A healthy, four month-old female infant presented to a local emergency department with a 12-hour history of decreased activity, non-bilious vomiting and one episode of dark red blood in the stools. There was no history of fever. Telephone consultation was completed and the patient was transferred to a tertiary, pediatric centre for further evaluation. On arrival, the infant appeared pale and was lethargic during the exam. Heart rate was 137 bpm, respiratory rate was 50/min, blood pressure was 118/61, oxygen saturation was 99%, and rectal temperature was 37.0 degrees Celsius. Bedside glucose was 4.6 mmol/L. The mucous membranes were moist and the posterior fontanelle was flush. Pupils were equal and reactive to light and the throat was clear. The chest was clear and heart sounds were normal. The patient’s abdomen was slightly distended with a palpable mass in the mid-abdomen just below the umbilicus. Rectal examination was positive for fecal occult blood.

The patient was resuscitated with a 20 mL/kg normal saline bolus. Bloodwork obtained revealed a hemoglobin of 122 g/L, platelets of 418 x10^9/L and a white blood cell count of 21.6 x10^9/L with a neutrophil count of 17.9 x10^9/L. Electrolytes showed a sodium of 135 mmol/L and potassium of 3.8 mmol/L and a chloride of 102 mmol/L and a bicarbonate of 19 mmol/L.

A Point of care ultrasound (POCUS) performed by the staff pediatric emergency medicine physician revealed the following image: (Figure 1)

Discussion

Upon obtaining the above image, the diagnosis of intussusception was suspected and consultations to radiology and pediatric surgery were requested simultaneously. The patient was assessed by the general surgical team within 30 minutes of consultation, however the radiology team felt that a formal ultrasound was necessary prior to the completion of an air enema reduction. Approximately two hours post-presentation, a formal ultrasound was completed by the on-call ultrasound technician who was called in from home, which revealed an ileocolic intussusception in the pararembilical region. Doppler interrogation confirmed flow to the periphery with minimal central flow. Free fluid was noted in the abdomen. No lead point was identified.

Approximately three hours later, two intussusception reduction attempts were made, with the administration of an air enema, however reduction to the level of the sigmoid colon was not evident. An exploratory laparotomy six hours post-presentation was performed and although the colon was able to be reduced manually from the sigmoid all the way to the cecum, the cecum appeared ischemic. A segmental resection of the cecum was subsequently performed. The patient remained in hospital for three additional days and there was no recurrence of the intussusception.

Intussusception is the most common cause of bowel obstruction apart from pyloric stenosis. Given that the telescoping bowel can cause and may result in obstruction, necrosis and possible perforation, a timely diagnosis and treatment is of paramount importance since any delay in either the diagnosis or treatment of intussusception may compromise the bowel’s blood supply. Studies have shown that the sensitivity of ultrasound for intussusception ranges from 96.6% to 100% while the specificity ranges from 88% to 100%. The use of Point of care ultrasound for intussusception has been previously described.

Many Canadian pediatric emergency medicine physicians have training in bedside ultrasound consistent with the Canadian Emergency Ultrasound Society’s core certification. Some pediatric emergency medicine physicians may have additional training to identify pathology such as intussusception. [1] The technique we used in our patient involved a 5-2-MHz curvilinear probe was placed transversely in the Right lower quadrant following the path of the large intestine. (A linear probe would also be appropriate). The depth was set to 6cm, and the identification of the psoas muscle was used as a landmark. Graded compression was utilized until a mass was identified. In the transverse view, a target sign was identified shown in Figure 1, and in the longitudinal plane, the pseudokidney sign was identified.

The early model of emergency bedside ultrasound equipped the emergency physician with ultrasound findings (ie.) enlarged abdominal aortic aneurysm that would trigger a surgical response before a formal ultrasound was completed by diagnostic imaging in patients with a time-sensitive diagnosis.

Intussusception is a time-sensitive diagnosis with a surgical intervention rate of approximately 15-20 %. Ideally a positive POCUS for intussusception would trigger a dual response from surgery and diagnostic imaging with the latter being asked to complete an air enema reduction. In the majority of patients with intussusception, the response from diagnostic imaging is the rate-limiting step.

This is very important especially in the context of a patient who is at risk for possible failed air enema and operative intervention. Potential risk factors for failed enema reduction and operative intervention have
been identified in the literature in several different studies [2]. Patients younger than six months of age have been shown to have higher enema failure rates, as well as patients who have had symptoms for over 24 hours, bloody diarrhea, and with documented lethargy.

We would advocate for operators trained in Intussusception POCUS detection, for use in their respective emergency departments. Patients that are at increased risk of surgical intervention may benefit even more than a patient deemed to be at lower risk from POCUS provided an operator trained in this skill is readily available. At a local level, it would make sense for a POCUS champion to educate the diagnostic imaging department that all positive reads should trigger a rapid response for an air enema especially for patients at increased risk for operative intervention.

Clinical Pearls
1. Intussusception is an important and common cause of bowel obstruction in children that may not have the classic triad of colicky abdominal pain, bilious vomiting and “currant jelly” stool.
2. High risk patients at risk of failed air enema reductions should have a greater awareness to decrease delays in time to treatment.
3. POCUS is an evolving technology with numerous applications that can aid in rapid detection and subsequent shortening of treatment times in high risk patients.

References
Pilot Project: Does formal bedside training of medical students with a FAST exam increase their knowledge and comfort level with ultrason use in a community family medicine practice setting?

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Abstract
As point of care ultrasound (PoCUS) becomes increasingly popular and a standard of care in many clinical settings, the interest for integration in medical undergraduate curriculum is also growing [1]. This project aims to assess whether formal bedside Focused Abdominal Scan for Trauma (FAST) exam training of medical students increases their knowledge and comfort with the use of bedside ultrasound in a family medicine setting at Queen’s University. Third year medical students (n=18) were recruited to participate in a training session involving a 1-hour online video and 2-hour hands-on session. Knowledge based surveys were completed before and after the training. A survey was completed 4 months after the teaching session evaluating knowledge retention, comfort, and application of skills. Student knowledge of PoCUS and FAST increased and was maintained (pre-training 56%±20%, post-training 82%±10%, p<0.001). Self-evaluation of comfort performing a FAST examination (5-point Likert scale) similarly increased post-training session (pre-training 1.4±0.8, post-training 3.8±0.9, p<0.005), but decreased 4 months later (3±1.2, p=0.005). Students in this study were unanimously interested in ultrasound training and the methods used effectively increased theoretical knowledge and comfort with use. Students did not retain their comfort levels with FAST exam 4 months after the training session, nor did they have the opportunity to utilize the skills learned. Further evidence is required to identify the applicability of these results to undergraduate curriculum development.

Introduction
Point of care ultrasound (PoCUS) has become a new standard of care and clinical tool used commonly by physicians in many clinical settings including the Emergency Department, hospital wards, and outpatient clinics. Preliminary pilot projects from the USA, UK, and Canada demonstrate feasibility and benefit to integrating teaching into undergraduate medical education (UGME) curriculum and surveys of Canadian medical school vice-deans and medical students show strong support and interest in formalized teaching of bedside ultrasound [1,2,3,4,5,6,7]. Comprehensive studies demonstrate bedside ultrasound is a skill that medical students are able to learn and enhances their anatomy knowledge, clinical accuracy, and physical exam skills. Formalized bedside ultrasound training in Canada is a developing field and there is opportunity to create a program at Queen’s University.

We elected to provide ultrasound teaching focused on medical students beginning community family medicine rotations as they will be exposed to elements of acute care in these practice settings. Family physicians work in a wide variety of settings where PoCUS is applied and a critical skill, especially if there is decreased access to formalized ultrasound in the acute care setting.

Given the applicability of the FAST examination in a variety of clinical settings, we chose it to act as a model module for teaching bedside ultrasound. This project aims to assess whether the introduction of structured FAST training improves medical students’ knowledge and comfort level with ultrasound use.

Methods
Our study population consisted of (n=18) third-year medical students who were entering the clerkship phase of their curriculum in fall 2016 and were participating in their family medicine core rotations at a variety of community sites associated with Queen’s University. Due to recruitment challenges, recruitment was opened to all third-year medical students to increase sample size. Following recruitment, the students signed letters of consent in compliance with Queen’s University Health Sciences and Affiliated Hospitals Research Ethics Board.

Students completed an electronic survey at three points throughout the study – before any training, immediately after hands-on training session, and 4 months into clerkship. Each survey similarly assessed knowledge of the FAST exam, self-rated comfort level with use of the ultrasound machine, and number of PoCUS exams performed and/or observed. The surveys were designed with standardized 5-point Likert evaluation scales to gather information on opinions and comfort levels. The second and third surveys had additional components evaluating the teaching session and barriers to using bedside ultrasound.

Students watched a 45 min video on the FAST exam at home prior to the 2-hour hands on training session. This session had a ratio of 1:3 instructor to learner ratio with six scanning stations with standardized patients and certified instructors. The FAST exam to act as a model module for teaching bedside ultrasound due to its applicability in a variety of clinical settings. The FAST exam is defined as an assessment of the hepatorenal recess, the splenorenal recess, 4-chamber view of the heart and pericardium, and the retrovesicular space.

An objective structured clinical examination (OSCE) was held the day after the training session to assess technical skills and students’ comfort with the use of the
ultrasound machine to perform a FAST exam. Certified ultrasound providers evaluated this using a standardized evaluation tool that rated students on a 5-point scale (1=inferior, 2= Novice, 3=Competent, 4=Advanced, 5=Superior) across multiple aspects of ultrasound performance (preparation, image acquisition, image optimization, clinical integration, entrustment decision).

Data were recorded in Excel and statistical analysis was performed using Excel's data analysis tool. Descriptive data, where applicable, was expressed as mean±SD. Significant differences were determined by repeated measures ANOVA for comparison of knowledge acquisition and self-reported scores of comfort. A subgroup analysis was performed to see if there were any differences between students at community sites versus urban sites.

Results
The majority (61%) of students had no prior formal ultrasound training. Those that had done prior training had performed 5 or fewer FAST examinations prior to the training session. Of the 18 study participants, 8 were beginning clerkship in community sites and comprised our subgroup population.

Students initially scored a mean score of 56%±20% on the content-based knowledge survey. This significantly increased to a score of 82%±10% (p<0.001) after the teaching session. When this survey was repeated 4 months into clerkship there was no significant difference compared to the post-test results (71%±28%, p=0.17).

Student self-evaluation of their comfort performing a FAST examination increased from an average rating of 1.4±0.8 on a 5-point Likert scale to 3.8±0.9 after the training session. This was statistically significant (p<0.001). Four months after the training session the students’ self-evaluation had decreased from 3.8±0.5 to 3±1.2, which was also statistically significant (p=0.005). Results were similar in the sub group analysis.

According to instructor evaluations of student OSCE performances to superior, the median overall rating was a score of 2, or “novice performance”. Students scored similarly across the various components of the OSCE assessment.

Discussion
These results demonstrate that the online and hands-on training were effective in increasing student knowledge about bedside ultrasound and the FAST examination. Similarly, students felt significantly more comfortable performing a bedside examination after a single training session. However there is a discrepancy between the students' comfort levels and instructor evaluation of performance of the FAST examination. This illustrates that a single training session was insufficient to make students competent in the FAST exam, as well as the importance of objectively measuring skill acquisition. While increased student comfort performing the examination is beneficial, it is important to be wary of false confidence. This was similarly demonstrated in a paper from McGill, where the students self-rated scores on bedside ultrasound performance grossly overestimated the scores assigned by instructors [7].

There was a significant decrease in students’ comfort with ultrasound use 4 months after the training session. This is unsurprising as none of the students performed a bedside ultrasound during the study period after the training session. While there was no decrease in students’ knowledge over the study period, there was a decrease in comfort which suggests that knowledge is likely only a single factor that determines student comfort level. The study by Steinmetz et al from McGill University suggests that multiple sessions throughout the year help students maintain their comfort level with ultrasound use, along with the theoretical knowledge for ultrasound use [7].

Barriers to ultrasound use during the study period, as cited by the students, included preceptor discomfort with its use, lack of opportunity due to patient presentation or machine availability, student personal comfort level, and expectation that it is a skill restricted to residents and staff physicians. Although the students did not perform bedside ultrasound, those that witnessed it in clinical use unanimously reported a better understanding of what they were seeing.

This pilot project highlights some of the barriers to use specific to the medical student perspective, which include availability of machines and preceptor familiarity. Previous studies looking at ultrasound training
in family medicine residency programs cited lack of trained faculty and limited access to ultrasound equipment as common barriers [8].

According to a working group termed ‘Ultrasound in Medical Education, California’ (UMECal), successful integration of ultrasound education in undergraduate medical training requires consideration of several key themes for success [10]. A bottom-up approach with medical student involvement and integration of ultrasound in the preclinical years are key items for program success. This pilot project encompassed some of these key themes that could be built upon moving forwards. Similarly, the concept of longitudinal training is critical and can be achieved in several ways. An online curriculum, such as the video distributed prior to the teaching session, can help to maximize the time spent with hands on learning. Continuing these types of components across time could be another strategy to help retain knowledge when access to ultrasound machines is limited.

Some of the limitations to this study relate to the scale and timeframe of the project. Due to resource limitations we were only able to accommodate 18 students which resulted in a small overall sample size. We were also unable to administer another OSCE to evaluate skill retention due to time and logistical constraints. As evidenced by the study from McGill, student self-rated assessment varied from instructor evaluations and cannot be used as a surrogate marker for skill retention [7]. While knowledge retention is beneficial, we are unable to comment on skill retention, which is an important aspect of bedside ultrasound training. As well, since all of our participants were volunteers, there is volunteer bias, which limits the external validity of this study.

Conclusion

This pilot project demonstrates that students are very interested in ultrasound training and the methods used to teach were effective in increasing knowledge and comfort with ultrasound use. While no students in the group performed the skill in the 4-month period after the teaching session, students reported a better understanding when they witnessed bedside ultrasound performed.

Some of the barriers identified through this project such as preceptor knowledge regarding the use of PoCUS, and attitudes towards medical students performing this skill may change with training of clinicians across all levels and a bottom-up approach with education at the undergraduate medical education level.

Future studies would benefit from larger sample size, repeated teaching sessions and online curriculum to maintain exposure to PoCUS. A longer duration of follow up and re-testing skill acquisition would be an important component of curriculum assessment. Further evidence is required to identify the optimal way to integrate ultrasound into undergraduate curriculum development.

References:

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Announcements

5th World Congress, Ultrasound in Medical Education
wcume2017.org
October 12-15, 2017 – Montreal, QC, Canada

Canadian Cardiovascular Congress (CCC) 2017
www.cardiocongress.org
Oct 21-24, 2017 – Vancouver, BC, Canada

Scientific Sessions of the American Heart Association
aha2017.com
Nove 11-15 2017 – Anaheim, CA, USA

The Canadian Society of Echocardiography has formed a new POCUS subcommittee.
More information coming soon
cseecho.ca

The American Society of Echocardiography is in the process of creating a POCUS taskforce.
More information coming soon.
asescientificsessions.org

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