Innovating Point-of-Care Ultrasound (POCUS) Education:

A New Era of Undergraduate Medical Education at the University of Ottawa

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ABSTRACT

The University of Ottawa's Point-of-Care Ultrasound (POCUS) curriculum in Undergraduate Medical Education (UGME) serves as a strong foundation for the increasing expectations of POCUS proficiency in Postgraduate Medical Education and clinical practice. Our program has seen notable successes, particularly in the realms of medical student engagement, educational innovation, and interdisciplinary support. These successes are evidenced through robust student participation in curriculum development and implementation, research with national and international presentations, and interest groups. The success of this curriculum continues to have the support from UGME and many departments within the institution. This support is illustrated by the active involvement of faculty members in POCUS teaching, POCUS research initiatives and financial investments into POCUS equipment.

As we transition to Competency-Based Medical Education and incorporate Entrustable Professional Activities, our curriculum requires ongoing refinement. Key areas for development include formalizing clerkship objectives, diversifying assessment methods, and leveraging technology for future clinical practice. To evaluate the effectiveness of this curriculum, a plan for program evaluation will be implemented. This will include regular feedback from students and faculty to assess POCUS objective relevance, and formative/summative assessments to monitor learner competence and skill acquisition.

While the POCUS curriculum at the University of Ottawa marks significant strides in medical education, a focused approach toward addressing these evolving demands will further solidify its role as a cornerstone in preparing future clinicians.

RÉSUMÉ

Le curriculum sur l'échographie au point d'intervention (POCUS) de l'Université d'Ottawa dans le cadre des études médicales de premier cycle (EMPC) sert de base solide pour répondre aux attentes croissantes en matière de maîtrise de POCUS dans la formation médicale postdoctorale et la pratique clinique. Notre programme a connu des succès notables, en particulier dans les domaines de l'engagement des étudiants en médecine, de l'innovation pédagogique et du soutien interdisciplinaire. Ces succès se traduisent par une forte participation des étudiants à l'élaboration et à la mise en œuvre du programme, par des recherches présentées à l'échelle nationale et internationale, et par la création de groupes d'intérêt. Le succès de ce programme continue de bénéficier du soutien de l'EMPC et de nombreux départements au sein de l'établissement. Ce soutien est illustré par la participation active des membres du corps professoral à l'enseignement, aux initiatives de recherche et aux investissements financiers dans l'équipement, le tout dans le cadre de POCUS.

Alors que nous passons à une formation médicale basée sur les compétences et intégrons des activités professionnelles confiables, notre curriculum nécessite des améliorations continues. Les domaines clés à développer comprennent la formalisation des objectifs du stage, la diversification des méthodes d'évaluation et l'exploitation de la technologie pour la pratique clinique future. Afin d'évaluer l'efficacité de ce programme, un plan d'évaluation sera mis en œuvre. Il comprendra des commentaires réguliers des étudiants et du corps enseignant afin d'évaluer la pertinence des objectifs du POCUS, ainsi que des évaluations formatives/sommatives pour contrôler les compétences et l'acquisition des aptitudes des apprenants.

Si le programme POCUS de l'Université d'Ottawa marque une avancée significative dans l'enseignement médical, une approche ciblée visant à répondre à ces exigences en constante évolution renforcera encore son rôle de pierre angulaire dans la formation des futurs cliniciens.

INTRODUCTION

In the last decade, point-of-care ultrasonography (POCUS) has emerged as a core competency in many different medical specialties[1]. Clinicians use POCUS as a non-invasive diagnostic tool to complement clinical assessments. In contrast to other imaging modalities, POCUS has several distinct advantages. In addition to being non-ionizing, it can be implemented at the bedside to provide rapid diagnosis and treatment as well as optimize safety of invasive procedures[2]. Since the New England Journal of Medicine published a review article on POCUS, there has been widespread adoption of POCUS across clinical specialities[21]. This includes but is not limited to disciplines such as Family Medicine, Emergency Medicine, Intensive Care and Anesthesiology[22-24]. Bedside ultrasound has helped clinicians narrow down differential diagnoses in settings of acute dyspnea, shock, and abdominal pain[22]. Additionally, its utility extends to the outpatient settings, where POCUS has been utilized to aid the diagnosis of medical conditions such as cholelithiasis, achilles tendon rupture, ascites, and fetal breech presentation[25,26].

Moreover, the versatility and portability of POCUS has revolutionized healthcare delivery, particularly in underserved and marginalized communities[3,4]. In these settings, where access to healthcare services and resources may be limited, POCUS has the potential to significantly improve patient care and health outcomes. Its cost-effectiveness and immediate diagnostic ability makes it an invaluable tool in resource-limited environments, enabling treatment initiation that could otherwise be delayed due to lack of access to certain diagnostic modalities.

POCUS has become a core competency for Emergency medicine, General Internal Medicine, Anesthesia, and Critical care, with potential to integrate into numerous other specialties[27-30]. As POCUS takes a more prominent role in various medical fields, graduating medical students should have a basic understanding and competency in bedside imaging. As a result, POCUS education has been gradually integrated into curricula across Canadian medical schools[5,6]. In addition to being an important clinical skill, POCUS has several benefits to medical education and has been shown to improve students' physical exam proficiency and increase their knowledge of anatomy and physiology[7–9]. This article provides an overview of the current integration of POCUS in Undergraduate Medical Education (UGME) at the University of Ottawa.

OVERVIEW OF THE POCUS CURRICULUM

The current UGME POCUS curriculum at the University of Ottawa is divided into two main stages of learning: clerkship and pre-clerkship.

Pre-clerkship

In pre-clerkship, the primary goal is for students to understand the basics of POCUS image generation and interpretation. At this stage, the learning objectives are linked to learning the basic principles of ultrasound, including knobology, artifacts, selection of transducer, and ultrasound imaging limitations. For instance, knobology refers to basic operation of an ultrasound machine such as adjusting gain, depth and focus to create optimal images. Conversely, artifacts are features in ultrasound images generated from interaction of ultrasound waves with tissue, machine settings or probe positioning. Artifacts can be useful diagnostic aids that enable clinicians to identify pathology on ultrasound images. These fundamental concepts are important to understand in order to effectively generate and interpret ultrasound in a clinical setting.

Students have also been taught how to scan standardized patients and interpret normal ultrasound findings, focusing on the following systems: cardiac, respiratory, thyroid/neck, musculoskeletal, gastrointestinal/abdominal, and vascular. Through learning objectives and virtual modules, students are also able to appreciate basic science concepts within the study of POCUS such as anatomy, physiology, and pathology

Clerkship

In the clerkship stage, the goal is for students to learn how to use POCUS in real clinical settings and utilize this tool to complement patient assessments. There is currently a lack of specific POCUS learning objectives in the clerkship curriculum. While POCUS exposure is present in clerkship, it is not delivered in a standardized manner as teaching varies depending on the clinical rotation. During clerkship rotations, students have the opportunity to spend time with clinicians who have incorporated POCUS into their practice, enabling clerks to receive real-time training in identifying scenarios where such imaging techniques are applicable. Furthermore, students can finetune their judgement regarding which diagnostic imaging technique is most appropriate for a given clinical scenario while also appreciating a tool's limitations.

Teaching Modalities

The UGME POCUS curriculum is delivered through a variety of teaching modalities. These include didactic lectures, physician skill development (PSD) sessions, self-directed learning, peer teaching through the POCUS interest groups (IG), and bedside teaching on clerkship rotations. The primary POCUS teaching method at the University of Ottawa has been PSD sessions[10]. PSD sessions are small-group scanning sessions composed of six to eight students led by a POCUS expert. These sessions allow for hands-on training where students can practice scanning standardized patients with direct guidance and feedback from a trained clinician. PSD sessions have been shown to increase students' confidence with their clinical skills and POCUS knowledge[11]. Self-directed learning encompasses a broad variety of resources students can access. This includes the University of Ottawa Brightspace POCUS modules that cover the ultrasound basics, instructional videos and cases that can be seen in the **Appendix**. An example of an emergency medicine POCUS case can be seen in **Figure 1**. Additionally, there are also instructional eBooks, notably Dr. Zacchary Fredette (uOttawa Faculty of Medicine) introductory POCUS manual[12]. Furthermore, the POCUS IG, composed of a small group of medical students provide optional scanning workshops and small teaching sessions. Lastly, in clerkship, students spend time with providers trained in POCUS and practice various scans in clinical settings such as the emergency medicine, anesthesiology, and internal medicine. Student's gain exposure to how POCUS is used to narrow down a differential diagnosis, observe ultrasound-guided procedures, and learn to differentiate normal scans from pathological ones.

Overall, the UGME POCUS curriculum at the University of Ottawa's effectively blends foundational knowledge and hands-on practice, employing a variety of teaching modalities to prepare medical students for real-world clinical applications. However, as POCUS continues to evolve, so too must the educational approaches that support it.

FUTURE DIRECTIONS AND CHALLENGES

The POCUS curriculum at the University of Ottawa has seen considerable integration and advancement. Despite these strides, there remain challenges and opportunities for further refinement.

Learning Objectives

One of the most pressing concerns is the absence of formalized learning objectives in the clerkship stage. While the pre-clerkship stage is well-structured, the clerkship stage is less defined, making it difficult for students to develop POCUS competency in clinical settings. This is particularly evident beyond Emergency Medicine rotations, where stu-

Case 3: Emergency Medicine

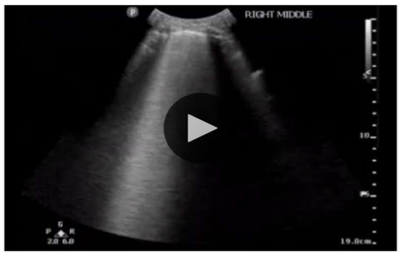
A 38-year-old male presents to the emergency department with a 3-day onset of fever, productive cough and shortness of breath. He has a past medical history of hypertension. His vital signs are: temperature 38.3°C, RR 25/min, HR 110/min, BP 120/80 mmHg and O_2 saturation is 92%.

On physical exam, there are crackles on the right lung on auscultation.

What is your most important differential diagnosis?

Which POCUS exams do you conduct?

Lung ultrasound (right side only)



Source: The POCUS Atlas

R4 lung zone

Source: Tambelli, R. The POCUS Atlas

L4 lung zone

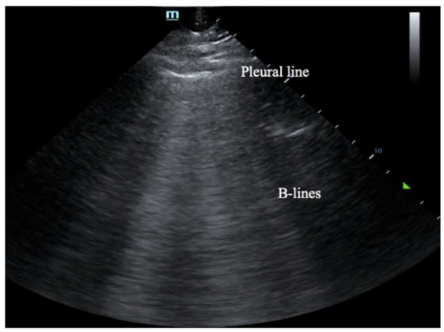
Source: CDEL4 - Dr. Pageau

POCUS Interpretation?

Ultrasound findings indicate right-sided multifocal pneumonia.

Lung Ultrasound

- L4 lung zone ultrasound is normal.
- R4 lung zone ultrasound shows parenchymal consolidation with air bronchograms (b).
- Lung ultrasound demonstrates an absence of A-lines and greater than 3 B-lines in an intercostal space on the right side. This is indicative of a localized lung abnormality (a).



(a)
Source: The POCUS Atlas

(b)
Source: Tambelli, R. PLAPS consolidation. The POCUS Atlas.

Figure 1: The University of Ottawa Brightspace Module Example

dents have little POCUS exposure and fewer opportunities to develop their POCUS competency. To address this gap, the University is moving towards a spiral curriculum where core topics are revisited more than once at different stages of medical education. This is advantageous compared to the current curriculum where core topics are just visited once. This model is complemented by online modules accessible to students before, during, and after lectures or clerkship rotations, reinforcing learning through repetition[13].

Moreover, there is an ongoing shift towards competency-based UGME. POCUS is well-positioned to align with this model, particularly incorporating Entrustable Professional Activities (EPAs) like EPA1 ("Perform a patient history and physical examination") and EPA11 ("Perform general procedures"). These EPAs provide a structured framework for evaluating student competence in key tasks and would further encourage students to seek POCUS opportunities in order to fulfill formal objectives[14]. Such an approach would ensure that students demonstrate required competencies in POCUS under supervision before transitioning to unsupervised practice.

Hands on procedures

Another area for improvement is the curriculum's limited focus on hands-on teaching of ultrasound-guided procedures. This deficiency is likely due to the general scarcity of such procedures within the existing curriculum. Incorporating more hands-on procedures and offering ample opportunities for practice under expert supervision could bridge this gap. Simulation technology offers a promising avenue for achieving this in a low-risk environment[15,16].

Student Assessment

Assessment of students also warrants attention. The current methods primarily consist of multiple-choice exams and self-assessments on Brightspace modules. While these methods are valid, they may not fully capture the practical skills required to perform POCUS. Including a POCUS logbook, Objective Structured Clinical Examinations and frequent feedback sessions could provide a more comprehensive evaluation of students' abilities and areas requiring improvement[17].

Resource Constraints

Technological and resource constraints pose another challenge. The current teaching model predominantly uses expensive cart-based ultrasound systems. These are not only costly but also limited in number, restricting opportunities for in-person teaching. An emerging solution is remote learning through web-based modules and virtual training platforms. These have proven effective, particularly during the COVID-19 pandemic, in delivering comparable educational outcomes to in-person training[18]. The transition from cart-based systems to more affordable handheld ultrasound (HHU) devices can significantly augment POCUS education. These devices, which can be connected to smartphones or tablets, offer an affordable alternative and have been endorsed for producing "comparable" images to traditional machines[19]. The goal is for every medical student to have a HHU for their duration of the training including Postgraduate Medical Education (PGME) and eventual clinical practice.

Demand for POCUS tutors

Lastly, there is an increasing demand for qualified POCUS tutors, currently exceeding the supply. Tutors are mostly from the Departments of Emergency Medicine, Anesthesia, Radiology, and Internal Medicine. It is important to note that POCUS supports an inter-professional educational model that includes many Sonographers as tutors, which also helps with this demand. Here is an initiative to further diversify the pool of educators by including faculty from other specialties especially the Department of Family Medicine and implementing a train-the-trainer model. Such an approach would create a sustainable educational environment better equipped to meet growing needs[20].

While the UGME POCUS curriculum at the University of Ottawa has made significant advances, further improvements are needed. Addressing these challenges involves formalizing clerkship objectives, enriching hands-on training, enhancing assessment methods, leveraging technology, and expanding the educator pool. The shift towards competency-based UGME and the inclusion of EPAs offer promising frameworks for the curriculum's future evolution.

CONCLUSION

The University of Ottawa's UGME POCUS curriculum serves as a pivotal foundation for PGME, aligning with rising POCUS demands for clinical training. This is substantiated by strong student engagement in research, publications, and IGs, coupled with robust backing from UGME and various departments within the Faculty of Medicine. As we transition to CBME and incorporate EPAs, the curriculum is well-positioned but necessitates ongoing fine-tuning. Areas for focus include formalizing clerkship objectives, di-

versifying assessment methods, and leveraging technology advancements for broader educational impact. In summary, while making significant strides, targeted improvements will further solidify the curriculum's role in preparing future clinicians.

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Conflicts of Interest Disclosure
There are no conflicts of interest to declare.

APPENDIX

The University of Ottawa Brightspace POCUS Modules (accessible to uOttawa students only due to Brightspace uOttawa restrictions):

POCUS Module Topic	Brightspace Link
Cardiac	https://uottawa.brightspace.com/d2l/le/content/252787/viewContent/4061480/View
Respiratory	https://uottawa.brightspace.com/d2l/le/content/252787/viewContent/5136943/View
Abdomen	https://uottawa.brightspace.com/d2l/le/content/252787/viewContent/4553252/View
Musculoskeletal	https://uottawa.brightspace.com/d2l/le/content/252787/viewContent/4866972/View
Vascular	https://uottawa.brightspace.com/d2l/le/content/252787/viewContent/4280027/View
Neck	https://uottawa.brightspace.com/d2l/le/content/252787/viewContent/4470354/View
Central Venous Catheterization	https://uottawa.brightspace.com/d2l/le/content/252787/viewContent/4053200/View
POCUS cases	https://uottawa.brightspace.com/d2l/le/content/252787/viewContent/4840341/View