Implementation of a Longitudinal POCUS Curriculum in the Core Internal Medicine Residency Program at Dalhousie University

Whitney Faiella, Allen Tran, Simon Houston, Ashley Miller, Chris Gray, Alex Nelson, Brent Culligan, Ciorsti MacIntyre, Kim Styles, Sarah Ramer, Babar Haroon, Nabha Shetty, Ian Epstein, Christine Short, Sharon Mulvagh

Department of Medicine, Dalhousie University, Halifax, Canada

Author for correspondence: Whitney Faiella: Wh818396@dal.ca

Received: 12 August 2020; Accepted: 24 November 2020; Published: 2 September 2021.

DOI: https://doi.org/10.22374/cjgim.v16i3.482

Abstract

Background
Point-of-care ultrasound (POCUS) has become a useful diagnostic tool across multiple specialties. However, no standardized curriculum is currently in place for Canadian Internal Medicine (IM) residency programs. This report aims to describe the development of a longitudinal POCUS curriculum at Dalhousie University and reports on resident knowledge, confidence, and perceived clinical utility of POCUS also.

Methods
Residents in the core IM program were invited to complete a POCUS survey and knowledge test in December 2019. The survey evaluated self-reported confidence in acquired POCUS skills and clinical use in practice, whereas the knowledge test evaluated image interpretation skills.

Results
A total of 34/45 (75.6%) residents participated, who agreed that POCUS training should be a formal component of residency (4.56 ± 0.56). Scores on the knowledge test improved based on time spent in the curriculum, with postgraduate year (PGY) 1s scoring an average of 70.0% (21/30) and PGY3s 82.8% (24.9/30; P = 0.02). Residents reported the strongest confidence in lung imaging for detecting A and B lines (4.10 ± 0.79), pleural effusions (3.92 ± 0.90), and lung sliding (3.89 ± 0.92).

Conclusion
Dalhousie University is among the first IM programs in Canada to implement a formal longitudinal POCUS curriculum, which has enabled the incremental acquisition of POCUS knowledge, confidence, and clinical utility amongst residents.
Résumé

Contexte
L'échographie au point d'intervention (POCUS) est devenue un outil de diagnostic utile dans de multiples spécialités. Toutefois, aucun programme normalisé n’est en place actuellement dans les programmes de résidence en médecine interne au Canada. Ce rapport vise à décrire l’élaboration d’un programme longitudinal sur la POCUS à l’Université Dalhousie et rend compte des connaissances et de l’assurance des résidents relatives à la POCUS et de leur perception quant à son utilité clinique.

Méthodologie
Des résidents du programme de médecine interne tronc commun ont été invités à répondre à un sondage sur la POCUS et à effectuer un test de connaissances en décembre 2019. Le sondage a évalué le degré d’assurance quant aux compétences acquises sur la POCUS et à son utilisation clinique dans la pratique, tandis que le test de connaissances a évalué les compétences en matière d’interprétation des images.

Résultats
Au total, 34 des 45 résidents ayant participé au sondage (75,6 %) sont d’avis que la formation sur la POCUS devrait être une composante officielle de la résidence (4,56 ± 0,56). Les scores du test de connaissances s’améliorent en fonction du temps passé dans le programme, le score des résidents de première année d’études postdoctorales (PGY-1) étant de 70,0 % (21/30) en moyenne et celui des résidents de troisième année (PGY-3) de 82,8 % (24,9/30; P = 0,02). Les résidents mentionnent faire preuve de la meilleure assurance en matière d'imagerie pulmonaire dans la détection des lignes A et B (4,10 ± 0,79), des épanchements pleuraux (3,92 ± 0,90) et des glissements pulmonaires (3,89 ± 0,92).

Conclusion
L’Université Dalhousie figure parmi les premiers programmes de médecine interne au Canada à mettre en œuvre un programme longitudinal officiel sur la POCUS, ce qui a permis l’acquisition progressive parmi les résidents des connaissances et de l’assurance relatives à la POCUS et de l’utilité clinique de cet outil de diagnostic.

Introduction
Bedside point-of-care ultrasound (POCUS) has been increasingly recognized as a useful diagnostic tool across multiple medical subspecialties over the last decade.1–4 Integrating POCUS into the traditional history and physical examination enhances patient assessment and can reduce time to diagnosis. POCUS is portable, accessible, and uses no ionizing radiation.5,6 Additionally, studies have demonstrated reduced procedure-related complications with the use of ultrasound guidance.7–10

With its increasing use, POCUS has successfully been incorporated into multiple subspecialty training programs. Emergency and Critical Care Medicine programs have been early adopters of this technology, while uptake by Internal Medicine (IM) programs has been more gradual. The American College of Physicians published a statement in 2018 formally acknowledging the importance of POCUS in IM.3 Despite this, no formal curriculum currently exists for core IM residency programs across Canada.11–13 Cited challenges to implementing such a curriculum include lack of experienced faculty, cost of and access to equipment, and lack of educational time.14–17

In 2017, the Canadian Internal Medicine Ultrasound (CIMUS) Group published a series of consensus recommendations for incorporating POCUS into core IM training programs including applications and ultrasound-guided procedures.17 This was followed by 22 education indicators in 2018 to guide curriculum development.18 These indicators include recommendations about teaching time, equipment access, faculty-to-learner ratio, and mechanisms for appropriate quality assurance.

At Dalhousie University, a longitudinal POCUS curriculum was launched in July 2017 for all core IM residents, with the first cohort recently completing the program in June 2020. This report aims to describe the development of a POCUS curriculum at our center and share our assessment of knowledge, confidence, and perceived clinical utility of POCUS amongst residents at different stages in the curriculum.
POCUS Curriculum Overview

Session structure

The curriculum begins with an introductory session during the postgraduate year (PGY) 1 Bootcamp week in July. This session combines a didactic component focusing on the fundamentals of POCUS with a hands-on session where residents practice scanning under direct supervision. This model accounts for an expected range of prior POCUS exposure among learners.

Following the PGY1 Bootcamp, residents begin a rotating schedule comprising weekly respiratory, cardiovascular, and integration POCUS sessions from September through May. Each week, there are separate junior (PGY1) and senior (PGY2/3) sessions. Stratification of groups allows residents to demonstrate an increasing level of competence as they progress through the curriculum. In a year, a resident will attend at least 5–6 unique sessions. Each session is 90 minutes in length and includes a 15-minute didactic component focusing on the topic to be covered, followed by supervised, hands-on scanning of inpatients. Residents attend sessions in groups of 3–4 learners supervised by an attending physician (general internist, respirologist, or cardiologist). Senior residents have the option to revisit the didactic component as a review before hands-on scanning or can proceed directly to hands-on scanning. A schedule assigning residents and staff to their respective sessions is created at the beginning of the year. Faculty training sessions are held separately through dedicated elective course offerings and guided access to recommended online resources.

Curriculum content

Curriculum content focuses primarily on the respiratory and cardiovascular exams, as these were felt to be most relevant for IM residents (Figure 1). The junior (PGY1) curriculum is divided into 10 respiratory, 10 cardiovascular, and 10 integration sessions, each with its specific learning objectives (Table 1). The sessions are administered in a linear incremental program, incorporating both acquisition and interpretation skills simultaneously. The integration sessions are incorporated into the latter third of the year for junior (PGY1) learners and year-round for senior (PGY2/3) learners. Residents are also provided with specific online resources to be accessed before each session.

Complementary to the sessions described above, ultrasound-guided procedures including central venous catheter insertion, thoracentesis, chest drain insertion, paracentesis, and peripherally inserted central catheter (PICC) line use were taught biannually in the simulation lab during full-day sessions.

Curriculum Evaluation

Formal POCUS teaching sessions are regularly assessed using electronic evaluations on the One45 medical education management platform. Evaluations are completed by residents after each session, allowing them to provide feedback on both the session and their instructor. Evaluations are compiled and reviewed by the POCUS Committee at quarterly meetings to ensure the changes that can be made to the session structure or content based on the received feedback. Session instructors also receive a copy of evaluations from residents who attended their session.

A POCUS survey and knowledge test were administered to all residents in the program in December 2019 during an academic half-day, as described in Appendices 1 and 2. The survey evaluated self-reported confidence in acquired POCUS skills and clinical use in practice, whereas the knowledge test evaluated image interpretation skills. The survey also provided residents with the opportunity to give feedback on the formal teaching sessions. The test knowledge was particularly useful as it provided an assessment of our curriculum and identified the learning gaps, which was helpful to guide future changes.

Methods

Residents in the core IM program were invited to complete an anonymous survey and knowledge test in December 2019. All participants had been taught POCUS since PGY1 using the curriculum described in Figure 1.

The anonymized survey and knowledge test (Appendices 1 and 2) were administered during an academic half-day session in paper format. The nonvalidated survey contained nine questions that evaluated the clinical use of POCUS outside of formal teaching sessions concerning the frequency and specific application and self-reported confidence in acquired POCUS skills. Residents were also surveyed on their perception of the relevance of POCUS in IM and future subspecialty training, as well as their comfort in teaching POCUS to junior learners. All questions were administered using a five-point Likert scale.

The 30-item knowledge test included a series of short answer questions that evaluated the resident’s understanding of technical POCUS skills and ability to interpret images of the respiratory and cardiovascular exams. More specifically, residents were assessed on their ability to identify an A versus B line pattern, presence of a pleural effusion, and utility of lung sliding in the respiratory POCUS exam. Questions also addressed the ability to identify a parasternal long axis, parasternal short axis apical 4-chamber, and subcostal view in the cardiovascular POCUS exam.

Data from the survey and knowledge test were analyzed in Microsoft Excel. Knowledge test scores were compared between PGY1 and PGY3 residents using an unpaired t-test. A P value of 0.05 was considered the threshold for statistical
Table 1. Objectives for respiratory, cardiovascular, and integration POCUS learning sessions.

<table>
<thead>
<tr>
<th>POCUS session</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory</strong></td>
<td>Acquire standard views for a respiratory POCUS exam including at least four zones in each hemithorax, with the diaphragm in one of those views. Demonstrate optimization of POCUS images and recognize when an image is not satisfactory for interpretation. Demonstrate a systematic approach to interpreting images of the respiratory POCUS exam. Interpret POCUS images, commenting on lung sliding, presence of A-lines versus B lines, signs of consolidation, and presence/absence of pleural effusions.</td>
</tr>
<tr>
<td><strong>Cardiovascular</strong></td>
<td>Acquire standard views for a cardiovascular POCUS exam including PLAX, PSAX, apical 4/5 chambers to primarily assess LV and RV size and function, and to appreciate normal valvular, aortic, and left atrial appearance also. Limited color flow doppler may be used for the assessment of massive regurgitant valvulopathy. Acquire subcostal views to assess for pericardial effusions and visualize the IVC with dynamic respiratory assessment for volume status. Demonstrate optimization of POCUS images and recognize when an image is not satisfactory for interpretation. Interprets POCUS images, commenting on gross LV size and function, presence/absence of a pericardial effusion, and features of the IVC.</td>
</tr>
<tr>
<td><strong>Integration</strong></td>
<td>Acquire and interpret images from both the respiratory and cardiovascular POCUS exams within the context of a patient’s presentation to formulate a diagnosis and management plan. Understand the limitations of POCUS.</td>
</tr>
</tbody>
</table>

PLAX, parasternal long axis; PSAX, parasternal short axis; LV, left ventricular; RV, right ventricular; IVC, inferior vena cava.

**Figure 1.** Longitudinal POCUS curriculum overview for core internal medicine residents at Dalhousie University. LV, left ventricular; RV, right ventricular; IVC, inferior vena cava.
Implementation of a Longitudinal POCUS Curriculum

Figure 2. Resident reported use and application of POCUS outside of formal teaching sessions.

A total of 33/34 (97.1%) residents reported practicing POCUS exams outside of formal learning sessions, with an average use of 3.78 ± 2.39 times per month (Figure 2). The applications used most often include respiratory POCUS exams for lung sliding, A/B lines, pleural effusions, and visualization of the inferior vena cava to aid in volume assessments.

The survey assessed residents reported confidence (Figure 3) in obtaining and interpreting standard POCUS views of the respiratory and cardiovascular exams, which was strongest in lung imaging for A/B lines (4.10 ± 0.79), pleural effusions (3.92 ± 0.90), and lung sliding (3.89 ± 0.92). The lowest reported confidence was reported in obtaining apical 4/5 chamber views (3.32 ± 0.77), subcostal view (3.13 ± 0.72), and assessing gross left ventricular systolic function (2.79 ± 0.96).

A separate 30-item knowledge test was administered to evaluate the resident understanding of technical POCUS skills and ability to interpret images of the respiratory and cardiovascular exams. Scores on the knowledge test improved based on time spent in the curriculum, with PGY1s scoring an average of 70.0% (21/30) and PGY3s 82.8% (24.9/30; P = 0.02).

Discussion

Dalhousie University is one of the select IM programs in Canada to implement a formal longitudinal POCUS curriculum into its training program.20 Overall, the survey and knowledge test demonstrated that the curriculum has contributed to graded improvements in POCUS knowledge, confidence, and clinical utility amongst residents.

The survey revealed that residents agree that POCUS training should be a formal component of core IM residency training. Surveyed residents were at different levels in training and pursuing diverse subspecialties. Despite this, residents felt acquired skills would be useful in future practice. These results support the need for broad implementation of a formalized POCUS curriculum in core IM training programs.

Results also indicated a high uptake of residents practicing POCUS skills independently outside of formal teaching sessions. POCUS is highly user-dependent, which emphasizes the need for deliberate hands-on practice to refine skills.21 Residents reported practicing their skills most often on respiratory and vascular exams, consistent with the higher self-reported confidence in these same applications. Residents are less comfortable with the cardiac POCUS exam, explained by the increased complexity of views involved. This helps identify areas for future improvement, which includes adding more cardiac focused sessions with trained faculty.
Average scores on the 30-item knowledge test increased between PGY1 versus PGY3 residents. Several studies have examined the efficacy of longitudinal curriculums versus isolated POCUS workshops and have shown benefits to both approaches.22–25 Two recent studies in favor of longitudinal curriculums suggest that ongoing repetition and practice are required to maintain competency.22,23 The increase in scores amongst IM residents beginning versus completing the program supports the success of a longitudinal curriculum at our center.

There are many reported challenges in implementing a formal POCUS curriculum, some of which were encountered during this experience. A commonly cited barrier is the lack of equipment.14,26 At our center, there are two cart-based portable ultrasound machines (Sparq, Philips.com) and four hand-held ultrasound devices (three Vscan's, GE Healthcare.com; one Lumify, Philips.com) dedicated to the Department of Medicine (DOM) and available for use by residents, fellows, and staff. These machines are kept on our Medical Teaching Unit (MTU) and Intermediate Medical Care Unit (IMCU) and are used for the weekly formal POCUS sessions. In addition, some individual faculty and divisions possess hand-held devices, which were shared during teaching sessions. There is also a portable Sparq ultrasound machine in the emergency department; however, it is not dedicated to IM, meaning that it may be in use by either the emergency department staff or another consulting service at any given time.

Another cited barrier is the lack of trained faculty to teach hands-on sessions. At our center, we are fortunate to have a mix of five general internists, two respirologists, and nine cardiologists who volunteer to teach sessions. We focused our initial POCUS curriculum on cardiopulmonary system assessment. However, in future iterations, we intend to expand to other system assessments of importance to the internist including genitourinary and musculoskeletal applications. Collaboration with and guidance from radiologists at our center would enable optimal teaching and learning opportunities.

Outside of these formal sessions, exposure to POCUS teaching can be variable depending on the rotation. There are not always faculty trained in POCUS present in day-to-day work (i.e., MTU bedside rounding). This lack of consistency in encouraging and supervising POCUS by faculty members hampers the reinforcement of the formal curriculum and is an area for improvement in our program. Training sessions for faculty are available through dedicated intensive learning opportunities within DOM, in collaboration with the Department of Anesthesia and Critical Care. The ultimate goal is to eventually develop POCUS champions for each division and/or service. As residents’ cycle through the curriculum, there are more senior residents becoming comfortable with POCUS, which allows for mentoring and informal teaching onwards and overnight call shifts. Lastly, time can be a significant barrier as it can be difficult for residents to fit POCUS into already busy days or evening call shifts. Targeted teaching and role modeling of efficiency skills could improve this.

Patient identification for formal teaching sessions was also an early challenge for our curriculum, resulting in time spent during each session searching for suitable inpatient volunteers. As a solution, a system was developed to ensure patient identification before each session. Each week, a designated resident would identify and obtain consent from 2 patients + 1 “back-up” patient per group from the MTU, IMCU, or cardiology ward. These residents were also responsible for bringing the ultrasound machines to the sessions.

In 2019, the CIMUS group published several educational indicators as a framework to encourage the implementation of POCUS curriculums.18 Many factors would be useful to incorporate into our curriculum in the future. For example, efforts are currently being directed towards developing a user-friendly archiving system for learners to save scans for later review by staff. The current system in place is cumbersome. A more convenient system would encourage archiving and provide learners with feedback on their ability to acquire and interpret images. Given that learners independently practice their skills outside of formal POCUS sessions, this is a needed component to an effective POCUS curriculum from a patient safety perspective. It would also contribute to the development of a culture of quality assurance and affect the hidden curriculum.

The indicators also suggest a target number of scans for acceptable proficiency in a given application which will be gradually incorporated into our curriculum in the form of an entrusted professional activity (EPA) given the recent development of Competency by Design in core IM.27 We are currently drafting separate EPAs for the respiratory and cardiovascular POCUS exams, with a target number that should be met during each level of training based on published accepted thresholds and criteria.28,29

The POCUS curriculum evaluation component of our report has limitations. The resident response rate for both the Likert scale survey and knowledge test was 75.56% (34/45 residents), with the lowest response rate amongst PGY3s. Additionally, this was a cross-sectional study, which is associated with its limitations. A longitudinal intraparticipant comparison
would have allowed us to compare the learners’ scores as they progress through the curriculum.

Conclusion
The longitudinal POCUS curriculum at Dalhousie University, taught by both general internists and subspecialists, was launched in July 2017 for all core IM residents with the first cohort completing their program in June 2020. We have presented a description of our curriculum along with an assessment of its impact. Results revealed that the curriculum has enhanced POCUS knowledge, confidence, and clinical utility amongst residents. EPAs, thresholds, and criteria for competency are under development. Our center is actively pursuing the adoption of a cost-efficient archiving system, which is a needed component for both patient safety and resident education. Overall, the POCUS curriculum implementation into Dalhousie’s core IM residency program, along with challenges encountered along the way, can hopefully serve as a model for other IM programs across the country.

Disclosure
This study was reviewed by the Nova Scotia Health Authority Research Ethics Board. The Board agreed that this project was a Quality Improvement initiative and according to Article 2.5 of the TCPS does not require ethics approval.

References
POCUS Knowledge Test

1. 
   a. What is the name of this view?
   b. Identify the structures:
      i.  A)_________________
      ii.  B)_________________
      iii. C)_________________
      iv.  D)_________________

2. Please name each probe and give an example of what you would use each for:
   a.
   b.
   c.
3. What is the name of this view?
   a. Please identify the structures in this view:
      A) 
      B) 

4. 
   a. Describe what is seen?
   b. Give two differential diagnosis for this finding:
      i.
      ii.

5. 
   a. What is the name of this view?
   b. Please identify 3 different structures you see in this view:
      i.
      ii.
      iii.
6.   
   a. Where do you look for lung sliding?
   b. List 2 causes of absent lung sliding?

7.   
   a. What is the name of each view?
      i)___________________ ii)____________________ iii)_________________________

   b. Identify the landmarking to obtain the view above, including direction of the probe:

8.   
   a. Where do you measure the IVC in a volume assessment?
   b. What are 2 criteria that suggest a patient has an elevated central venous pressure?
9. Interpret the image.

10. 
   a. What is the structure?
   b. Normal or abnormal?
POCUS Survey

1. What year are you in?
   PGY1   PGY2   PGY3

2. Approximately how many POCUS sessions have you attended throughout your IM residency?
   a. Lung ________
   b. Cardiac________

3. POCUS training should be a formal component of IM residency:
   Strongly Disagree    Disagree     Neutral     Agree     Strongly Agree

4. I use POCUS on my own (outside of formal teaching sessions)?
   Yes               No
   a. If yes, how often do you use POCUS outside of formal teaching sessions? (approximate #/month)?
   b. What do you use it for?

   Interpreting Ejection Fraction
   Assessing for pericardial effusion
   Measuring IVC size and variability to assess volume status
   Imaging the pleura for lung sliding and obtain A vs B lines
   Assessing for pleural effusion

5. POCUS has changed my management of patients?
   Strongly Disagree    Disagree     Neutral     Agree     Strongly Agree

6. I anticipate using POCUS in my future subspecialty training and/or career.
   Strongly Disagree    Disagree     Neutral     Agree     Strongly Agree

7. I teach POCUS to junior learners (informally or formally).
   Strongly Disagree    Disagree     Neutral     Agree     Strongly Agree

8. Do you have any feedback on the formal POCUS teaching sessions?
9. I am confident in using POCUS to obtain the following cardiac/lung images (a-d) and determine the following via image interpretation (e-k):

1 - Strongly Disagree
2 – Disagree
3 – Neutral
4 – Agree
5 - Strongly Agree

<table>
<thead>
<tr>
<th>Prior to starting residency?</th>
<th>Now?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>a) Parasternal long and short axis views</strong></td>
<td></td>
</tr>
<tr>
<td><strong>b) Subxiphoid 4 chamber view</strong></td>
<td></td>
</tr>
<tr>
<td><strong>c) Apical 4/5 chamber view</strong></td>
<td></td>
</tr>
<tr>
<td><strong>d) Image the IVC</strong></td>
<td></td>
</tr>
<tr>
<td><strong>e) Interpreting Ejection Fraction</strong></td>
<td></td>
</tr>
<tr>
<td><strong>f) Assessing for pericardial effusion</strong></td>
<td></td>
</tr>
<tr>
<td><strong>g) Measuring IVC size and variability to assess volume status</strong></td>
<td></td>
</tr>
<tr>
<td><strong>h) Imaging the pleura and obtain A vs B lines</strong></td>
<td></td>
</tr>
<tr>
<td><strong>i) Assess for pleural effusion</strong></td>
<td></td>
</tr>
<tr>
<td><strong>j) Assess lung Sliding</strong></td>
<td></td>
</tr>
<tr>
<td><strong>k) Integrating heart, lung and IVC findings to determine the etiology of dyspnea</strong></td>
<td></td>
</tr>
</tbody>
</table>