Medical Education Original Article

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The assessment of point-of-care-ultrasound (POCUS) in acute care settings is benefitted by early medical school integration and fellowship training

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Abstract

Context: Point-of-care ultrasound (POCUS) has widespread utilization in multiple clinical settings. It has been shown to positively influence clinician confidence in diagnosis and can help appropriately manage patients in acute care settings. There has been a growing trend of increased emphasis on incorporating POCUS training in the first 2 years of the medical school curriculum.

Objectives: This article aims to analyze the clinical use of POCUS in acute settings and how training early in medical school may strengthen clinician confidence and utilization.

Methods: An anonymous 10-question survey on POCUS use was conducted via a secure online platform and distributed to board-certified practicing physicians (MDs and DOs) with educational agreements with Midwestern University (MWU) across acute care specialties. This included preceptors within the MWU graduate medical education clinical consortium. Survey questions were aimed at assessing frequency of use, machine type, reasons for utilizing POCUS, initial ultrasound training, confidence in performing/interpreting POCUS, and perceived impact on patient outcomes. Surveys less than 50% complete were excluded. All surveys returned were more than 50% complete and thus included in the study. Statistical analyses were conducted utilizing the statistical software R version 4.0.

Results: Surveys were sent out to 187 participants with 68 responses (36.4% response rate). The survey results demonstrated a relationship between learning POCUS earlier in one's medical career (medical school, residency, or fellowship) to increased use in acute settings when compared to learning POCUS during clinical practice. Of the 68 respondents, 65 (95.6%) indicated that they agree or strongly agree that POCUS use improves patient care, and 64 (94.1%) indicated that they agree or strongly agree that the use of POCUS can improve patient outcomes.

Conclusions: Our survey of acute care physicians indicated that most respondents utilize POCUS daily or weekly (90.8%), and this was related to fewer years of practice (under 10 years from medical school graduation, 94.6%). Moreover, POCUS was utilized primarily in acute care settings for procedures (25%, n=17/68 respondents). These survey results indicate that early integration of POCUS education in osteopathic medical school curricula and throughout fellowship training could likely enhance POCUS utilization in acute care settings.

Keywords: acute care; continuing medical education; medical school curriculum; point-of-care ultrasound; ultrasonography.

Point-of-care ultrasound (POCUS) continues to gain traction as a reliable tool in the evaluation and management of patients in various clinical settings. POCUS can provide a noninvasive evaluation of organ function (e.g., cardiac and pulmonary assessments) that is rapidly attainable in most emergency departments (EDs), intensive care units (ICUs) [1], and other acute care settings. The use of POCUS has been shown to enhance diagnostic performance and positively influence clinician confidence in the management of patients in acute distress [2]. Early exposure to this imaging modality has also been demonstrated to improve medical students' diagnostic accuracy [3].

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Although the current study did not specifically evaluate medical student use of POCUS, there has been documented increased emphasis on incorporating POCUS training in the first 2 years of medical school curricula [4]. A study by Nydam et al. [5] surveyed student perceptions of ultrasound workshops held in a first-year medical anatomy course; the majority of students felt that ultrasound training should begin early and was an integral part of their curriculum, serving to improve their understanding of both the anatomy and clinical correlations of the area scanned. A comparable study of first-year medical students investigated whether ultrasound-aided practice would improve students' ability to correctly locate and identify soft tissue structures via unaided palpation. Indeed, practice with ultrasound-assisted guidance increased proficiency in tissue palpatory skills after two instructional ultrasound sessions [6]. An additional study showed increased comprehension of basic anatomy and retention of practical POCUS skills based on instructor evaluations and self-assessments after clinical teaching sessions [7]. Similarly, Nausheen et al. [8] demonstrated a significant correlation between student confidence and the ability to identify specific anatomic structures with bedside ultrasound after receiving hands-on training; most students agreed that this training improved their physical examination skills, and most students found ultrasound integration in the basic science curriculum to be an excellent resource. The current literature supports that having ultrasound incorporated into the didactic curriculum provides a valuable clinical tool and educational adjunct, to be reinforced throughout all four years [9–11]. A study assessing the influence of student-performed POCUS (SP-POCUS) on patient diagnosis and management in the ED showed that physicians agreed with the SP-POCUS diagnosis 95% of the time and in 50% of cases did not require further imaging, altogether reducing the time to disposition [12]. Overall, these published findings suggest that the integration of ultrasound training beginning in the first year of medical education not only could improve patient care in an acute setting such as the ED, but also could also be instrumental to medical students in enhancing, refining, and solidifying their overall knowledge base and basic science education.

Compared to experienced physicians who rely solely on the physical exam, POCUS training has been shown to provide enhanced accuracy in the clinical setting, such as in the diagnosis of heart disease, estimation of liver size, blunt abdominal trauma, and ectopic pregnancy [13, 14]. Similar to the standard use of a stethoscope, incorporating bedside ultrasound in the physical exam can also aid in clinical decisions and influence treatment plans [15].

It has also been demonstrated that clinician ultrasound experience can affect interpretability of POCUS echocardiography [16], and some residents believe that more ultrasound examinations should be required in their emergency ultrasound education [17]. A cross-sectional study showed that a greater number of ultrasound scans performed by emergency medicine residents were associated with improved performance on their observed structural clinical examinations (OSCE) [18]. Additionally, early POCUS training was shown to significantly improve ultrasound performance in a group of junior surgical residents [19].

Moreover, overtesting is prevalent in acute settings to avoid a missed diagnosis; however, out-of-pocket fees for more expensive scans can deter patients from agreeing to have the suggested imaging [20]. Utilizing bedside ultrasound has been shown to improve the use of hospital resources and decrease medical expenses for patients. A previous study showed that early employment of a focused assessment with sonography for trauma (FAST) examination can reduce the time to definitive care, reduce hospital admission lengths, and decrease treatment costs as patients underwent less computed tomography (CT) scans [21].

Interestingly, studies aimed at identifying the use of POCUS and its perceived importance on patient care in acute settings are limited. There is also scarce information regarding whether receiving hands-on training in the use and interpretation of ultrasound prior to entering clinical practice impacts the frequency of use and confidence in the ability to utilize POCUS as a diagnostic tool. Current studies that survey the use of POCUS have a focused, narrower scope, e.g., limiting their data to internists at a few facilities [22] or assessing specific pathologies in a single specialty [23]. Moreover, many of these studies were not conducted in the United States and do not investigate whether there are relationships between medical training and the continued use of POCUS later in clinical practice.

This study aimed to analyze the clinical usefulness of POCUS in the evaluation of patients in acute care settings. We surveyed clinicians in the ED, ICU/critical care units (CCUs), general/trauma surgery, and anesthesia. The results of this study may help to reinforce the clinical relevance of what is being taught in the first- and second-year medical curricula and to determine how we can enhance and further develop POCUS training in the preclinical years.

Methods

Survey development

A novel 10-question survey/questionnaire on POCUS use was developed (Appendix) and approved by the Midwestern University (MWU)

Institutional Review Board (IRB; protocol #1463). The questionnaire was based on a needs analysis survey, and the questions that were utilized in the survey were reviewed by experts in the use of POCUS. The survey was implemented via REDCap, a secure online platform for the creation and management of surveys and databases; the answer responses were taken from this survey response tool. Questions in the survey were aimed at assessing POCUS use in the following regard: frequency of POCUS use, type of machine, barriers/enablers to utilize, commonly utilized ultrasound procedures, initial ultrasound training (medical school – didactics/rotations, residency, fellowship, clinical practice, or never), confidence in performing POCUS/interpreting images, and the perceived impact of the use of POCUS on patient care/outcomes.

Participants were asked multiple choice–style questions relating to their clinical department of employment, frequency of use, ultrasound machine type utilized, when they were first introduced to ultrasound, and their reasons for ultrasound use in clinical practice. Participants were invited to provide additional comments regarding their POCUS use. A 9-point ranking question was utilized to determine the frequency of imaging modalities commonly utilized from a list of nine modalities; a rank of 1 indicates the most frequent imaging modality utilized, and a rank of 9 indicates the least frequent imaging modality utilized. A 5-point Likert scale was utilized for questions regarding the participants' assessment of confidence in performing POCUS examinations and their confidence in evaluating POCUS imaging, along with their perceptions of POCUS to improve patient care and outcomes. For the Likert scale: Strongly Disagree =1, Disagree =2, Neutral =3, Agree =4, and Strongly Agree =5. Surveys were emailed to practicing physicians between May 2021 and June 2021. The initial survey was sent out on May 28, 2021, with reminders sent to those who were unresponsive 7, 11, and 17 days later.

Participants

This voluntary, anonymous survey was distributed via email to board-certified practicing physicians (MDs and DOs) with educational agreements with MWU across acute care specialties including emergency medicine, ICU/CCU, surgical ICU, and general/trauma surgery and anesthesia, at various MWU preceptor sites across Arizona, California, Illinois, Utah, and Pennsylvania. This included preceptors within the MWU graduate medical education clinical consortium. Per the MWU IRB guidelines, informed consent was expressed by those who chose to fill out the survey. A convenience sample was utilized for this study given that the purpose was to assess the needs and confidence levels of practicing clinicians. The survey was sent to 187 participants, and 68 responses were obtained (36.4% response rate). Survey responses were all at least 50% complete. Therefore, no participant responses were removed from the analysis, and all 68 survey responses were included in the study analysis.

Statistical analysis

Quantitative responses from the survey were analyzed for each question, and qualitative responses such as comments from participants were reviewed and provided in a table. Quantitative descriptive statistics in terms of counts and percentages were utilized to summarize categorical question responses. Summary statistics including mean, standard deviation, and the minimum and maximum values were calculated for continuous question responses (Table 1). Graphs were also created to look at categorical responses to two questions to see the distribution of responses. Fisher's exact test was utilized to investigate whether there was an association between the two question responses. The significance level was $\alpha<0.05$. All statistical analyses were conducted utilizing the statistical software R version 4.0 [24]. The data were assessed by the members of the study group and a biostatistician from the Office of Research and Sponsored Programs at MWU.

Table 1: Summary statistics of survey.

Summary statistics	n, %
Total participants invited to complete survey	187
Total responses	68
Response rate	36.4%
Department type[a]	
Emergency department	57 (85.1)
Critical care	6 (9.0)
Intensive care unit	3 (4.5)
Trauma surgery	1 (1.5)
Number of years in clinical practice	
Mean	11.65 years (SD, 9.4)
Range	1 year (min) to 45 years (max)
1–9 years	37 (54.4)
10–19 years	17 (25.0)
20+ years	14 (20.6)
Initial introduction to POCUS	
Medical school (years 1 and 2)	3 (4.4)
Medical school (years 3 and 4)	16 (24.0)
Residency	30 (44.1)
Fellowship	4 (6.7)
Clinical practice	14 (20.6)
Never	1 (1.5)
POCUS use[b]	
Daily	34 (52.3)
Weekly	25 (38.5)
Monthly	4 (6.2)
Yearly	1 (1.5)
Never	1 (1.5)
Ultrasound machine most utilized[a]	
Portable machine (e.g., Sonosite, Mindray, GE, other)	57 (85.1)
Handheld device (e.g., Butterfly iQ)	10 (14.9)

Percentages are based on total number of responses for survey. GE, General Electric; POCUS, point-of-care ultrasound. [a]Calculations utilizing n=67. [b]Calculations utilizing n=65.

Results

Clinical Use Survey participants that responded to the question about POCUS use (n=65) indicated that they utilize POCUS daily (n=34, 52.3%) or weekly (n=25, 38.5%). Less

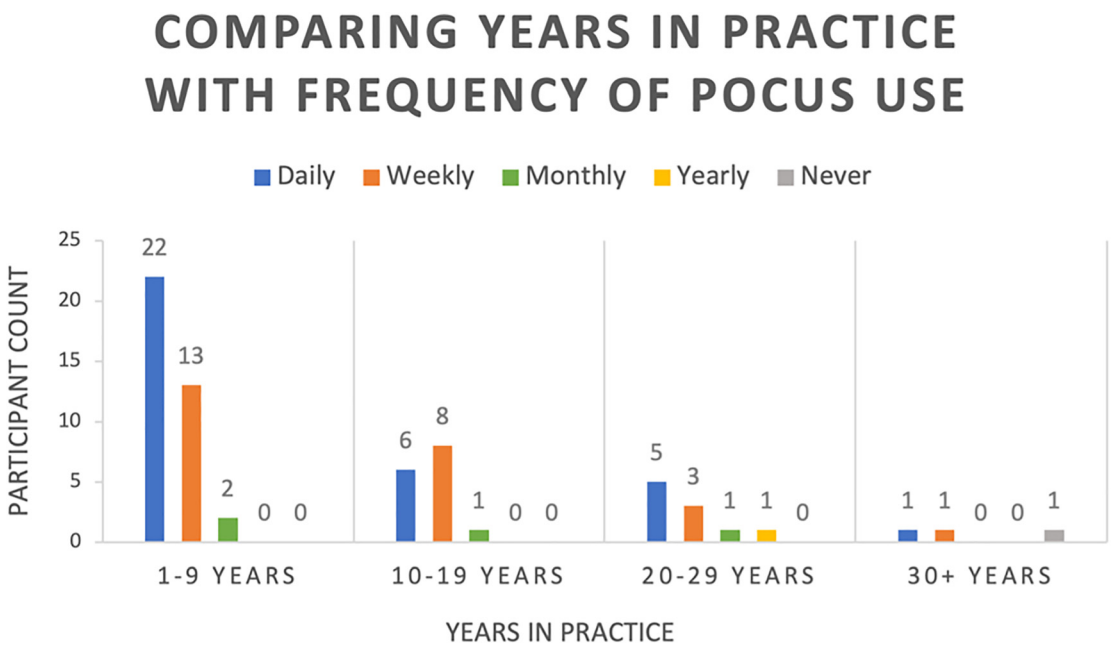

Figure 1: Comparing years in practice with the frequency of POCUS use. POCUS, point-of-care ultrasound. The data include only those participants who answered both survey questions.

than 10% (n=6, 9.2%) of the respondents utilized POCUS monthly, annually, or not at all. We compared the years in practice, indicated by each respondent, with their frequency of POCUS use (Figure 1). Among the clinicians who have been practicing for under 10 years, most utilize POCUS either daily (n=22, 59.5%) or weekly (n=13, 35.1%). There was not a statistically significant association between the years in practice and the frequency of POCUS use (p=0.1804 from Fisher's exact test).

A ranking question in the survey aimed to assess the frequency of the imaging modalities most commonly utilized from a list of nine modalities in the acute care setting (pulmonary, cardiac, abdominal FAST, musculoskeletal, procedures, ocular, thyroid, OB/GYN, and vascular). Results indicated that POCUS was ranked as most frequently utilized for procedures (n=17, 25.0%) followed by thyroid imaging (n=15, 22.1%) across all specialties.

Additionally, we calculated the top imaging modalities for each department. For respondents who practice in the ED (n=57), procedures were ranked as the most common imaging modality (number 1) for 13 physicians (n=13, 22.8%), and thyroid was ranked as the most common for 14 ED physicians (n=14, 24.6%). For the nine respondents who practice in the CCU and ICU, procedures were ranked as most common for 4 respondents (n=4, 44.4%) and thyroid was not ranked as most common for any respondents in the CCU or ICU.

Our survey also sought to assess the perceived importance of POCUS on patient care and patient outcomes. Of the 68 total respondents, 65 (95.6%) indicated that they agree or strongly agree that POCUS use improves patient care, and 64 (94.1%) indicated that they agree or strongly agree that the use of POCUS can improve patient outcomes (Table 2).

Medical education and POCUS training

A Likert scale (ranging from strongly agree to strongly disagree) was utilized for the participants' assessment of confidence in both performing POCUS examinations and in evaluating POCUS imaging. We evaluated the number of participants that rated their confidence in performing POCUS examinations and evaluating/interpreting POCUS imaging based on their initial introduction of POCUS (medical school, residency, fellowship, clinical practice, or never).

For residency-trained respondents, 83.9% (n=26) agreed or strongly agreed that they were confident in performing POCUS, and 80.6% (n=25) agreed or strongly agreed they were confident in interpreting POCUS images. For the respondents who were first introduced to ultrasound in the didactic years of medical school (years 1–2), 100.0% (n=3) agreed or strongly agreed that they were confident in both performing and interpreting POCUS examinations, and for those trained during medical school rotations (years 3–4), 93.8% (n=15) indicated confidence in both performing POCUS and interpreting POCUS images. Among the fellowship-

Table 2: Summary table of the Likert scale responses.

Likert scale	n, %
POCUS improves patient care	
Strongly agree	41 (60.3)
Agree	24 (35.3)
Neutral	1 (1.5)
Disagree	0
Strongly disagree	2 (2.9)
POCUS improves patient outcomes	
Strongly agree	35 (51.5)
Agree	29 (42.7)
Neutral	2 (2.9)
Disagree	0
Strongly disagree	2 (2.9)
I am confident in performing POCUS[a]	
Strongly agree	30 (45.5)
Agree	27 (40.9)
Neutral	3 (4.5)
Disagree	4 (6.0)
Strongly disagree	2 (3.0)
I am confident in evaluating POCUS imaging	
Strongly agree	33 (48.5)
Agree	25 (36.8)
Neutral	7 (10.3)
Disagree	2 (2.9)
Strongly disagree	1 (1.5)

Percentages are based on the total number of responses for the survey. POCUS, point-of-care ultrasound. [a]Calculations utilizing n=66.

Table 3: Additional comments from survey participants.

Comments
"The ability to learn and understand POCUS imaging should begin in medical school because it does require continued use and reinforcement to become comfortable and proficient."
"… A learning curve is evident and not enough teaching in the department is available for it."
"I was never trained in ultrasound until I took some courses. I Still don't feel qualified to perform some examinations. I utilize it primarily in codes and in OB and vascular procedures. I think it is a good idea to introduce it early into training. The second year of med school seems good."
"It was embedded in our curriculum. However, hospitals are requiring a training course or fellowship for credentials, which is unrealistic. If this is embedded in the curriculum from medical school, then it should not require special credentialling. It is like utilizing a stethoscope."
"Because I trained many years ago in internal medicine, I did not have supervised training in POCUS. I Learned on-the-job (and I would not recommend it!), and I took a course and engage in occasional online education in the subject. I've been utilizing it more and more and find it very valuable."
"I also instruct in basic ultrasound courses."
"Will become integral to patient care, equivalent to the stethoscope, by providing all clinicians real-time diagnostic data. This is a skill that should be learned, not relied on technicians to perform and radiologist to read."
"Excellent tool for central line insertion, cardiac evaluation, and FAST exams in the ED."
"POCUS helps me figure out what is going on with a patient."
"I would like continuing education."
"Should be part of training (it was not mandatory in my pulmonary critical care fellowship although it was available)."
"Not utilized when I trained. However, I am planning on learning it before I retire."
"Should be part of the physical examination in all patients with shock or hypotension."

ED, emergency department; FAST, focused assessment with sonography for trauma; OB, obstetrics; POCUS, point-of-care ultrasound.

trained respondents, 33.3% (n=1) were not confident (strongly disagree) in both performing and interpreting. Likert scale responses for questions regarding the perceived importance of POCUS and confidence of use/evaluation are indicated in Table 2.

Our survey included an optional section for additional comments (Table 3). Among the 68 respondents, 13 (19.1%) included comments, some of which touched on barriers to utilizing POCUS. Among those respondents who commented, the majority (n=9, 69.2%) were in emergency medicine, 1 (7.7%) was in trauma surgery, and 3 (23.1%) were in critical care. Two respondents stated that POCUS should be introduced in medical school as it "require(s) continued use and reinforcement to be proficient," and one respondent "would like to have continued medical education" in POCUS. Four respondents indicated that they did not receive formal training, two of which took a course on their own, because there was no department training available. One respondent said that POCUS was embedded in their medical school curriculum but stated that some hospitals are requiring a fellowship or specific training course for credentialing.

There was an overall positive attitude toward POCUS and the effect it has on patient care and patient outcomes. In the optional free response section, there were no negative remarks regarding the cost or integration of this curricula into medical programs. In fact, the free responses held a lot of positive comments regarding the benefits of having POCUS integrated earlier in medical education. Additionally, several participants who commented believe that POCUS is an integral tool in diagnostics and equate it to the stethoscope. Respondents were invited to indicate which, if any, type of ultrasound machine was utilized. Among the 68 respondents, 85.1% (n=57) indicated that they utilize regular ultrasound devices, and 14.9% (n=10) utilize a handheld portable ultrasound device.

Discussion

Our results demonstrate an overall positive response to the importance of POCUS in both patient care and patient outcomes. However, the lack of formalized training encourages those who wish to utilize this tool to enroll in additional courses or utilize formalized peer-to-peer training. Limited training can thus affect confidence, as one respondent stated: "I was never trained in ultrasound until I took some courses. I still don't feel qualified to perform some exams. I utilize it primarily in codes, OB and vascular procedures. I think it is a good idea to introduce it early into training. The second year of med school seems good." POCUS use has become increasingly utilized in critical care settings and has been shown to be effective in real-time, minimally invasive diagnostics [25]. However, it has not been utilized at the same capacity across the medical field due to various economical, availability, and training barriers [22]. Given the participants' responses, limited formal training and competence appear to be two of the most common barriers to POCUS use.

To prove beneficial, students who receive training in their first two years of medical school should continue to utilize their ultrasound training in their third or fourth year or they risk losing that knowledge prior to entering residency and clinical practice [26]. This requires ultrasound-competent clerkship advisors throughout the entire medical education, leading to additional costs of training faculty members. Although this is often one of the most expensive tasks, ultrasound is operator-dependent, and properly trained faculty are vital to increase the exposure of ultrasound to medical students early on. While in-person workshops might be ideal, utilizing virtual technology to train at multiple sites concurrently could potentially decrease costs and reduce time constraints. Additionally, this could ensure that all faculty members would receive the same type of training, ensuring uniformity in delivery and expectations.

There may be some concern that with an already overwhelming schedule, there will be little time to incorporate additional curricula for both students and instructors. In order to include ultrasound into the curricula, it may be necessary to restructure how courses are taught in order to accommodate ultrasound. In addition, to successfully incorporate bedside ultrasound, both academic faculty and hospital administrators must first approve the budget. However, it is important to acknowledge the benefits. Incorporating ultrasound training in preclinical courses [5, 6] reinforces didactic material while bringing in hands-on experience with clinical tools early in the curriculum. Also, as some respondents mentioned in the comment section of our survey, the continued use and reinforcement of POCUS is necessary to be competent. This early introduction of POCUS during didactics and continued exposure throughout rotations would allow students to begin residency already trained and knowledgeable on the use of ultrasound.

Furthermore, utilizing POCUS can be of great benefit if physicians are trained in both how to perform examinations and how to correctly interpret the images. In our study, 95.6% (n=65) either agree or strongly agree that the use of ultrasound improves patient care, and 94.1% (n=64) agree or strongly agree that ultrasound improves patient outcomes, despite only 4.4% (n=3) of physicians being trained on how to utilize ultrasound during their first and second years of medical education. These improved outcomes may include decreased mortality, decreased length of stay, or any additional improved outcome perceived by the physician. These findings are consistent with the favorable attitudes regarding POCUS use [22, 27]. Given our smaller sample size in the acute care setting, it is hypothesized that with an increased number of survey respondents, our initial survey would be indicative of a larger population and various areas of medicine in acute care settings. Our study indicates the importance of POCUS training and, therefore, its use as a complementary tool in the diagnosis and treatment of patients.

Limitations

A limitation to our study is the relatively small sample size (68 respondents). Further, our survey involved physicians from several specialties including emergency medicine, critical care (medical and surgical), trauma surgery, and anesthesia; however, 83.8% of respondents were from emergency medicine (n=57). Therefore, our survey could be subject to bias from an emergency medicine perspective due to the high response rate of that specialty. Qualitative data collection on enablers and barriers for the use of POCUS were not incorporated into this study. However, the addition of qualitative data collection should be utilized in future studies to gather specific data on what the participants feel the barriers and enablers of POCUS are. Among our survey participants, only 4.4% received POCUS education within the first and second years of medical education. Therefore, in a future study, we aim to address this limitation by increasing the population of physicians who have received POCUS training in their first and second years of medical education.

The survey, although novel, was not a validated questionnaire, which can contribute to potential measurement error of the results/conclusions. However, the focus of the survey questionnaire was a needs-analysis survey to assess

participants' confidence in performing POCUS and evaluating POCUS images considering that limited survey questionnaires are available to address this topic. Additionally, clarifying questions to include in a future survey could assess specific barriers, enabling factors encountered in the respondents' respective fields of medicine, and clarification in the definition of the first use of POCUS. The survey results showed a relationship between the use of ultrasound and the physician's perception of improvement of patient outcomes; however, the survey did not specify what defined a good outcome (e.g., duration of emergency room visit, total duration of hospital stay, mortality rate). Specific outcome measures should be addressed in future studies.

Conclusions

We believe that early clinical integration and continued reinforcement of POCUS imaging and education in osteopathic medical school curricula may enhance ultrasound utilization in acute care settings, as indicated by the physician survey respondents in acute care settings. Implementing POCUS into the curriculum throughout all four years of medical school should increase hands-on clinical skills, improve confidence in performing and interpreting ultrasound imaging, and reinforce the integration of curricular content presented during the first two years of medical school. Future directions could include assessments of POCUS use in other primary care settings such as family medicine, internal medicine, obstetrics and gynecology, and pediatrics. The results from the current survey could be utilized to compare data obtained from other clinical disciplines, which could help identify ways to improve patient care in clinical practice. Another future avenue of interest could be to evaluate POCUS use by graduates of the Arizona College of Osteopathic Medicine (AZCOM) when they are in residency after four years of a POCUS-integrated medical school curriculum.

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References

1. Cid X, Canty D, Royse A, Maier A, Johnson D, El-Ansary D, et al. Impact of point-of-care ultrasound on the hospital length of stay for internal medicine in patients with cardiopulmonary diagnosis at admission: study protocol of a randomized controlled trial-the IMFCU-1 (Internal Medicine Focused Clinical Ultrasound) study. Trials 2020;21:53.
2. Parks AR, Verheul G, LeBlanc-Duchin D, Atkinson P. Effect of a point-of-care ultrasound protocol on the diagnostic performance of medical learners during simulated cardiorespiratory scenarios. CJEM 2015;17:263–9.
3. Coiffier B, Shen PCH, Lee EYP, Kwong TSP, Lai AYT, Wong EMF, et al. Introducing point-of-care ultrasound through structured multifaceted ultrasound module in the undergraduate medical curriculum at the University of Hong Kong. Ultrasound 2020;28: 38–46.
4. Whitson MR, Mayo PH. Ultrasonography in the emergency department. Crit Care 2016;20:227.
5. Nydam R, Patel A, Finch C. Incorporation of clinically-based ultrasound workshops in a 1st year medical anatomy course. Faseb J 2018;32:636.5.
6. Walrod BJ, Boucher LC, Conroy MJ, McCamey KL, Hartz CA, Way DP, et al. Beyond bones: assessing whether ultrasound-aided instruction and practice improve unassisted soft tissue palpation skills of first-year medical students. J Ultrasound Med 2019;38:2047–55.
7. Steinmetz P, Oleskevich S, Lewis J. Acquisition and long-term retention of bedside ultrasound skills in first-year medical students. J Ultrasound Med 2016;35:1967–75.
8. Nausheen F, Young C, Brazil J, Dunagan T, Bhupathy R, Elango S, et al. Confidence level and ability of medical students to identify abdominal structures after integrated ultrasound sessions. Ultrasound Int Open 2020;6:E7-13.
9. Hoppmann RA, Rao VV, Poston MB, Howe DB, Hunt PS, Fowler SD, et al. An integrated ultrasound curriculum (iUSC) for medical students: 4-year experience. Crit Ultrasound J 2011; 3:1–12.
10. Bahner DP, Adkins EJ, Hughes D, Barrie M, Boulger CT, Royall NA. Integrated medical school ultrasound: development of an ultrasound vertical curriculum. Crit Ultrasound J 2013;5:6.
11. Decara JM, Kirkpatrick JN, Spencer KT, Ward RP, Kasza K, Furlong K, et al. Use of hand-carried ultrasound devices to augment the accuracy of medical student bedside cardiac diagnoses. J Am Soc Echocardiogr 2005;18:257–63.
12. Udrea DS, Sumnicht A, Lo D, Villarreal L, Gondra S, Chyan R, et al. Effects of student-performed point-of-care ultrasound on physician diagnosis and management of patients in the emergency department. J Emerg Med 2017;53:102–9.

13. Kobal SL, Trento L, Baharami S, Tolstrup K, Naqvi TZ, Cercek B, et al. Comparison of effectiveness of hand-carried ultrasound to bedside cardiovascular physical examination. Am J Cardiol 2005; 96:1002–6.
14. Mouratev G, Howe D, Hoppmann R, Poston MB, Reid R, Varnadoe J, et al. Teaching medical students ultrasound to measure liver size: comparison with experienced clinicians using physical examination alone. Teach Learn Med 2013;25:84–8.
15. Sekiguchi H, Harada Y, Villarraga HR, Mankad SV, Gajic O. Focused cardiac ultrasound in the early resuscitation of severe sepsis and septic shock: a prospective pilot study. J Anesth 2017; 31:487–93.
16. Bobbia X, Pradeilles C, Claret PG, Soullier C, Wagner P, Bodin Y, et al. Does physician experience influence the interpretability of focused echocardiography images performed by a pocket device? Scand J Trauma Resuscitation Emerg Med 2015;23:52.
17. Stolz LA, Stolz U, Fields JM, Saul T, Secko M, Flannigan MJ, et al. Emergency medicine resident assessment of the emergency ultrasound milestones and current training recommendations. Acad Emerg Med 2017;24:353–61.
18. Duanmu Y, Henwood PC, Takhar SS, Chan W, Rempell JS, Liteplo AS, et al. Correlation of OSCE performance and point-of-care ultrasound scan numbers among a cohort of emergency medicine residents. Ultrasound J 2019;11:3.
19. Hosseini M, Bhatt A, Kowdley GC. Effectiveness of an early ultrasound training curriculum for general surgery residents. Am Surg 2018;84:543–6.
20. Meka AP, Porath JD, Iyengar R, Morrow C, Fagerlin A, Meurer WJ, et al. Risk, benefit, and cost thresholds for emergency department testing: a cross-sectional, scenario-based study. Acad Emerg Med 2017;24:686–90.
21. Melniker LA, Leibner E, McKenney MG, Lopez P, Briggs WM, Mancuso CA. Randomized controlled clinical trial of point-of-care, limited ultrasonography for trauma in the emergency department: the first sonography outcomes assessment program trial. Ann Emerg Med 2006;48:227–35.
22. Wong J, Montague S, Wallace P, Negishi K, Liteplo A, Ringrose J, et al. Barriers to learning and using point-of-care ultrasound: a survey of practicing internists in six North American institutions. Ultrasound J 2020;12:19.
23. Wang WL, Kruse K, Fowler JR. A survey of the use of ultrasound by upper extremity surgeons. Hand 2017;12:31–8.
24. R Core Team. R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2020. Available from: https://www.R-project.org/ [Accessed 13 Jul 2021].
25. Guevarra K, Greenstein Y. Ultrasonography in the critical care unit. Curr Cardiol Rep 2020;22:145.
26. Lane N, Lahham S, Joseph L, Bahner DP, Fox JC. Ultrasound in medical education: listening to the echoes of the past to shape a vision for the future. Eur J Trauma Emerg Surg 2015;41:461–7.
27. Schnobrich DJ, Gladding S, Olson APJ, Duran-Nelson A. Point-of-care ultrasound in internal medicine: a national survey of educational leadership. J Grad Med Educ 2013;5:498–502.

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