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Development and Implementation of a Point-of-Care Ultrasound Curriculum at the Undergraduate Medical Education Level

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Research Article

Keywords: POCUS, Medical Education, Hands-on, Standardized Patient

Posted Date: August 27th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10593471/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Point-of-care ultrasound (POCUS) is increasingly used by clinicians to enhance diagnostic accuracy, yet it remains underrepresented in undergraduate medical education (UME), particularly during clinical rotations. The purpose of this study was to design, implement, and evaluate using simulated patient (SP) encounters as a key element in a POCUS curriculum for fourth-year medical students during their internal medicine acting internship.

Methods

A four-week recurring course was developed and implemented at the University of Alabama at Birmingham Heersink School of Medicine (UAB-HSOM) from May 2022 to April 2023. The curriculum included didactic lectures, hands-on scanning sessions, and a standardized patient encounter. Students completed pre- and post-course surveys assessing knowledge and confidence. Statistical analysis compared knowledge scores and self-rated confidence levels before and after the intervention.

Results

Thirty-six students participated in the curriculum. Average knowledge scores improved from 45% to 76% ($P < .001$). Students reported significant improvements in confidence with cardiac, lung, and IVC ultrasound techniques. Faculty and SP evaluations of an observed clinical patient encounter using POCUS indicated competency in image acquisition and integration into clinical reasoning.

Conclusion

A focused, simulation-based POCUS curriculum can significantly enhance fourth-year medical students' confidence and competency in basic ultrasound techniques. Incorporating SP encounters offers a valuable opportunity to assess application and communication skills. The model is scalable and suitable for broader UME integration.

Background

Point-of-care ultrasound (POCUS) has become an increasingly important skill for clinicians to enhance their diagnostic ability in certain clinical scenarios.[1] Technological advances and increased access to innovations such as portable ultrasound systems have led providers and researchers alike to study the use of these modalities in trainees at the undergraduate medical education (UME) level. Case reports dating back three decades demonstrate improved student motivation toward anatomy learning with

ultrasound in German classrooms.[2] More recently, research has demonstrated that ultrasonography in undergraduate medical education “helps medical students learn basic subjects, improve physical examination skills, and acquire diagnostic and procedural skills”.[3] However, despite this evidence, POCUS education has not been widely implemented at the clinical level in UME. A recent review of accredited U.S. medical schools noted that only 35.4% had a POCUS curriculum during clinical rotations.[4]

While POCUS can be utilized at any time, it is particularly valuable during off-hours (nights and weekends) when the full array of diagnostic resources may not be available. Patients require 24/7 inpatient care, yet certain imaging, consulting, and laboratory services are not always accessible in real-time. Delays for transthoracic echocardiograms, often essential for patients with cardiac complaints, have been reported to be as long as 22 hours at one institution.[5] A principal benefit of POCUS is its immediacy, low cost, and ability to inform care on the spot. In many clinical scenarios, POCUS has also been shown to improve transparency, patient understanding, and satisfaction with care.[5]

We developed curriculum to train fourth-year medical students at the University of Alabama at Birmingham Heersink School of Medicine (UAB-HSOM) in basic POCUS skills, equipping them with diagnostic tools that extend and complement their physical exam. As a secondary goal we examined the role of simulated patients (SPs) in POCUS education. Our intervention targets clinical scenarios that are common during after-hours care or among patients with limited access to traditional diagnostic resources.

Our goal is to prepare future physicians to use bedside ultrasound with greater confidence and competence, to improve diagnostic accuracy, and to reduce medical errors.

Methods

Learning objectives

We designed the curriculum to teach a defined set of foundational ultrasound skills rather than mastery of any one organ system. First, we introduced the students to basic ultrasound machine operations and then to fundamentals of cardiac and pulmonary ultrasound. For each organ system, we taught how to select the appropriate probe, identify key anatomical landmarks, and apply correct probe positioning.

Target learners

We voluntarily recruited fourth-year medical students (MS4s), rotating on their internal medicine acting internship, during orientation. Prior to this course, students had limited exposure to formal ultrasound education, with most reporting only informal or sporadic teaching from residents on prior clinical rotations.

Course and survey instrument design

We delivered the curriculum in 4-week blocks between May 2022 and April 2023. Each session included didactic and hands-on phases. Prior to the sessions, we administered a pre-course survey to assess students' baseline POCUS knowledge, confidence, and perceptions of ultrasound education (see Additional File 1 for the complete pre-course survey). We assessed knowledge using multiple-choice questions; perceptions and confidence were evaluated using 5-point Likert-type items.

Each educational block included in-person didactic lectures introducing ultrasound principles and clinical applications and hands-on sessions with faculty POCUS instructors focusing on image acquisition and interpretation. The educational blocks began with a 33-minute introductory lecture on POCUS, including machine basics: "knobology," transducer types, and modes. We then led a 45-minute lecture and a 45-minute hands-on cardiac session, focusing on assessment of ejection fraction, pericardial effusion, and inferior vena cava/fluid status. This was followed by a 45-minute lecture and 45-minute hands-on pulmonary session, focusing on pneumothorax, A- vs B-lines, and pleural effusion. In week four of each block, students participated in a summative clinical encounter with SPs, simulating real-world scenarios. During the SP encounter, faculty observers used a checklist to evaluate technical skill, clinical integration, and professionalism. SPs also completed a checklist assessing communication and patient-centered behaviors. Students received formative feedback from both faculty and SPs. To reassess knowledge and confidence, we administered a post-course survey (see Additional File 2 for the complete post-course survey).

Case design and standardized patient methodology

We employed best practices in simulation methodology to develop a clinical case scenario.[6] We recruited seven adult male SPs to portray the patient, a 65-year-old man with COPD and heart failure presenting with shortness of breath, for the entirety of the curriculum. We trained the SPs in role portrayal, checklist completion, and delivery of feedback. Students received a "door note" outlining the patient's chief complaint, relevant past medical history, and tasks to complete during the encounter. We allotted 20 minutes for the students to complete the encounter and provided all necessary ultrasound equipment in each exam room.

Data collection and analysis

We collected and stored all survey, checklist, and video data using the Elevate LearningSpace online data management system. We performed all statistical analyses using IBM SPSS v29. To evaluate differences between the students' pre- and post-course responses to knowledge-based questions, we conducted paired samples t-tests comparing the percentage of students who selected the correct answer for each question in the pre- versus the post-survey. Additionally, we calculated the pre- and post-course mean scores for the knowledge-based questions and conducted a paired samples t-test to compare the overall

mean scores. To assess student pre- and post-course confidence levels, we used the Wilcoxon signed-rank test. We set the level of significance at an alpha value of .05 for all statistical tests. The University of Alabama at Birmingham Institutional Review Board reviewed this study and deemed it exempt, as it involved educational research without identifiable data.

Results

Between May 2022 and June 2023, we implemented the POCUS curriculum with 36 fourth-year medical students. Each student completed both pre- and post-course surveys assessing knowledge, confidence, and perceptions of POCUS. Prior to the course, 100% (n = 36) of students rated POCUS skills as “Quite” or “Extremely” beneficial for patient care. However, 69.4% (n = 25) reported their existing ultrasound curriculum to be either “Not Effective/Not Present” or “Minimally Effective” (Fig. 1A). Students expressed a strong desire to learn more about POCUS, with 72% (n = 26) wanting a higher level of exposure during medical school (Fig. 1B).

We evaluated responses to the knowledge-based questions (Questions 1–4; see Additional File 1 and Additional File 2) on the pre- and post-course surveys and found statistically significant improvements on three out of four questions (Fig. 2A). When analyzing overall performance, students scored an average of 45% (SD 33%) prior to participation in the curriculum. After course completion, the mean knowledge-based score increased significantly to 76% (SD 25%) ($P < .001$) (Fig. 2B). Students also reported increased confidence in all POCUS domains taught (Fig. 2C). Wilcoxon signed-rank tests showed significant improvement across all areas after participation in the course (Cardiac: $Z = -5.018$, $P < .001$; IVC: $Z = -4.972$, $P < .001$; Lung: $Z = -5.159$, $P < .001$). Overall, students shifted from reporting low baseline confidence to “Moderately” or “Quite” confident by course end.

Faculty observers evaluated student performance during the SP clinical encounter. Most students (n = 33, 92%) achieved competency in “Most” or “All” criteria in preparation, image acquisition, image optimization, and clinical integration. All students (n = 36, 100%) demonstrated competency in at least some elements of each category, with many meeting all criteria (Fig. 3A). SPs also rated student performance using a structured checklist. SP evaluations were consistent with faculty scores and reflected high rates of task completion, communication, and appropriate use of POCUS in the patient encounter (Fig. 3B).

Discussion

Our curriculum builds on the existing literature supporting the feasibility and efficacy of ultrasound education at the undergraduate medical education (UME) level. Our intervention demonstrates that fourth-year medical students can meaningfully improve their POCUS knowledge and confidence within a four-week period when supported by a structured and simulation-based curriculum.

Our findings align with previous studies showing that hands-on learning and focused ultrasound education improve both skill acquisition and learner confidence.[7] We also echo the concern raised by other authors that POCUS is inconsistently taught at the UME level, often leaving students without the tools or training to use it during residency.[4]

A unique strength of our curriculum is its use of SP encounters as both an educational and evaluative tool. Few published curricula incorporate SP-based summative assessments in POCUS training. These encounters provided a controlled environment in which faculty could evaluate student performance, and patients could give structured feedback on communication, professionalism, and bedside manner.

Importantly, students demonstrated a marked improvement in confidence across all domains. While confidence does not necessarily reflect technical proficiency, the combination of SP feedback and faculty observation suggests students developed meaningful skills in probe handling, image optimization, and clinical reasoning. These encounters also allowed students to integrate communication and shared decision-making into their POCUS approach, a valuable aspect not always emphasized in technical skills training.

From an implementation standpoint, the curriculum was both low-cost and high yield. Most of the equipment we used was already available through the SP center. Instructor time was the primary resource required, with didactics, scanning sessions, and SP encounters designed for small groups of 2–4 learners.

The principal challenge in this initiative was scheduling: balancing the availability of students, faculty instructors, SPs, and ultrasound machines across multiple blocks. However, once implemented, the modular structure of the curriculum allowed for scalability and repeatability across academic years.

Limitations

Our study has several limitations. It was conducted at a single institution with a relatively small sample size. While we observed statistically significant improvements in knowledge and self-reported confidence, we cannot definitively claim that the curriculum improved diagnostic accuracy or long-term retention. Additionally, we relied on self-reported confidence scores, which may not correlate perfectly with real-world clinical performance. There is also a risk of selection bias, as the students who opted into this POCUS elective may have had greater preexisting interest or aptitude for ultrasound. Another limitation is the lack of longitudinal evaluation to show continued retention of POCUS knowledge, skills, and application in the clinical setting. Finally, although the SP encounter offers a valuable simulation of real-world conditions, it may not fully reflect the challenges of ultrasound use in high-acuity or resource-limited clinical environments.

Conclusion

Point-of-care ultrasound is a valuable tool that enhances bedside diagnostic accuracy and decision-making, particularly in situations with limited access to advanced imaging. Our curriculum demonstrates that fourth-year medical students can significantly improve their ultrasound knowledge and confidence through a structured, simulation-based course.

Incorporating SP encounters as both a teaching and evaluative strategy may further enhance learner engagement and realism while providing valuable feedback on communication and clinical reasoning. Our model is reproducible, cost-effective, and can be adapted by other institutions seeking to integrate POCUS into undergraduate medical education.

Future directions include assessing long-term knowledge retention, expanding to other specialties (e.g., emergency medicine, pediatrics), and integrating POCUS earlier in the medical school curriculum.

Abbreviations

POCUS
point-of-care ultrasound
UME
undergraduate medical education
SP
standardized patient
UAB-HSOM
University of Alabama at Birmingham Heersink School of Medicine
MS4
fourth-year medical student

Declarations

Human ethics approval and consent to participate

This project was reviewed by the University of Alabama at Birmingham Institutional Review Board (IRB) and was determined to be exempt as an educational initiative and not to constitute human subjects research (IRB Record Number 300008821). The review was conducted in accordance with the ethical principles of the Belmont Report and the requirements of the U.S. Common Rule (45 CFR 46), as implemented through the University of Alabama at Birmingham Human Research Protection Program.

Consent for publication:

All data included in this manuscript are fully de-identified. As no identifiable individual information is included, consent for publication was not required.

Competing interests:

The authors declare no conflicts of interest relevant to this work.

Clinical Trial Number

not applicable

Funding:

This work was supported by the Society of Bedside Medicine through the Bedside Scholars Program, funded by the Gordon and Betty Moore Foundation (grant #10542) via a subaward from Johns Hopkins University to the University of Alabama at Birmingham.

Author Contribution

Timothy Kennell Jr., MD, PhD facilitated hands-on POCUS teaching sessions, drafted the manuscript, and edited it for publication. Tara G. Edmonds, PhD provided design expertise for the educational survey, performed the statistical analysis, and assisted with manuscript editing. Benjamin Melancon, MD facilitated hands-on POCUS teaching sessions and designed the educational survey. Robert Smola, MD facilitated hands-on POCUS teaching sessions and contributed design expertise to the study. F. Shawn Galin, PhD provided design expertise for the educational survey, performed the statistical analysis, and assisted with manuscript editing. Winter Williams, MD provided assistance in editing the manuscript. Rebekah Weil provided assistance in editing the manuscript. Anderson Marshall designed the study, facilitated hands-on POCUS teaching sessions, and provided oversight for the study contributors.

Acknowledgement

Emily Knowling provided some initial wording for parts of the manuscript drafting.

Data Availability

Deidentified data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Figures

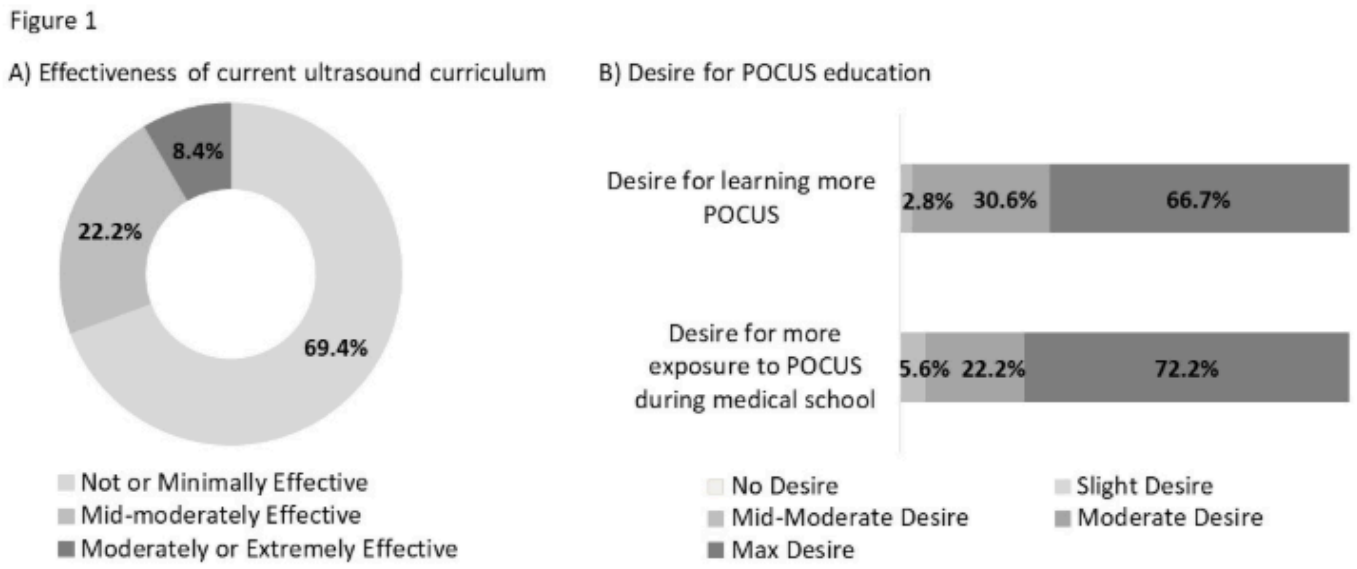


Figure 1

Pre-course student perceptions of POCUS. Students rated their perceptions regarding POCUS on 5-point Likert-type items.

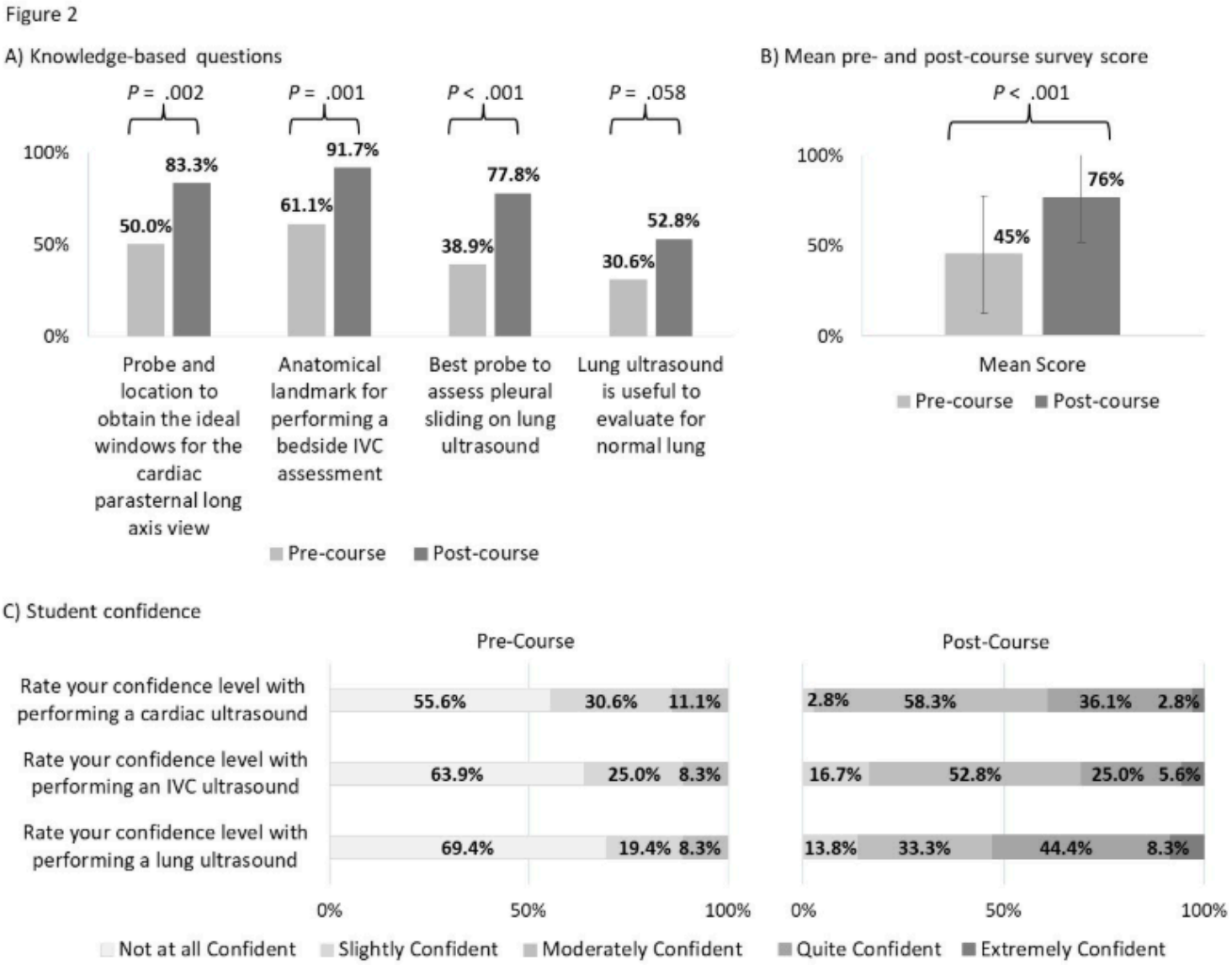


Figure 2

Comparison of pre- and post-course survey knowledge-based questions and students' POCUS skill confidence before and after hands-on exposure during the course. Studentknowledge of basic POCUS principles was assessed using four questions designed to have one correct evidence-based response. (A) The percentage of students selecting the correct answer prior to and after course completion was calculated and compared for each question. (B) Each student received a score based on their performance across the four knowledge questions. The mean score for the entire student group was then calculated to compare the mean pre-course score to the mean post-course score. Student confidence in performing each type of ultrasound exam taught in the course was assessed. (C)

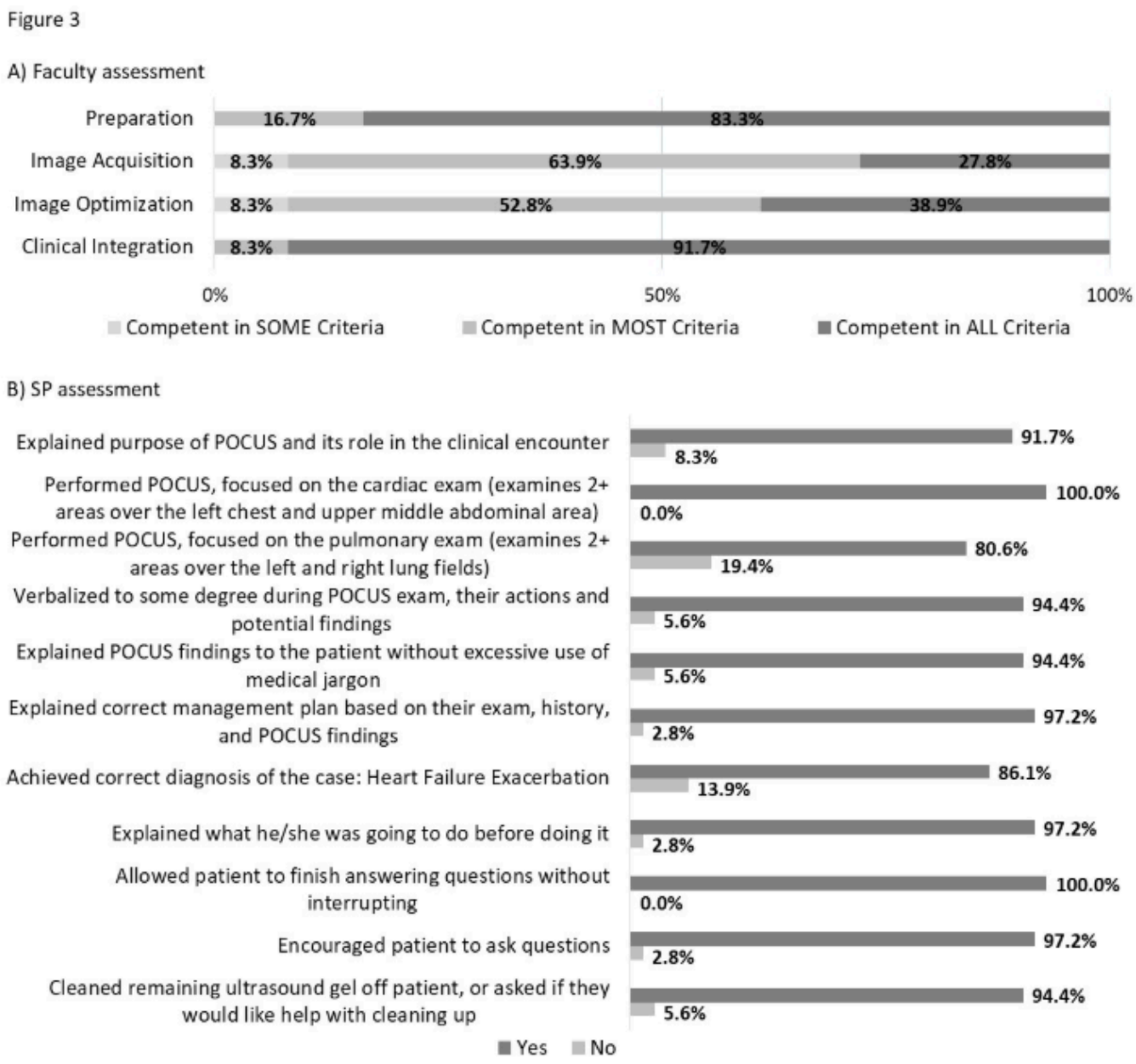


Figure 3

Evaluation of students' performance during the clinical scenario. (A) Faculty observers evaluated student competency in "Some", "Most", or "All" facets of each category. (B) Standardized patients assessed whether or not a student performed each task during the clinical encounter.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AdditionalFile2.pdf
- AdditionalFile1.pdf