Point-of-Care Ultrasound Curricula in Physician Assistant Programs: Recommendations From a Panel of Experts

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Introduction Point-of-care ultrasound (POCUS) integration into physician assistant (PA) program curricula continues to increase; however, guidance on specific curricular components is lacking. This study aims to establish expert consensus on essential POCUS curriculum components for PA programs.

Methods A validated survey was administered to an expert panel of 100 PAs. Respondents rated the appropriateness of various curriculum components on a 9-point Likert scale. Data analysis included descriptive statistics and measures of consensus. Recommendations were categorized as *strongly recommended*, *recommended*, *conditional recommended*, and *not recommended* based on appropriateness and consensus levels.

Results The survey had a 63% response rate (n = 63). *Strongly recommended* and *recommended* determinations were made for PA curricula to include foundational POCUS concepts, obtaining specific views for most body system areas, identification of specific anatomical structures and findings, and procedural guidance.

Discussion Integrating POCUS into PA education is essential for enhancing diagnostic and clinical skills. Foundational concepts received strong support, while advanced applications had varied consensus, suggesting tailored curricula based on program-specific goals. These recommendations provide a structured framework for comprehensive POCUS training, aligning with broader trends in medical education and equipping PAs with essential ultrasound skills for diverse clinical settings.

INTRODUCTION

Point-of-care ultrasound (POCUS) is a goal-directed ultrasound examination performed by a clinician to answer a specific diagnostic or therapeutic question.[1,2] Point-of-care ultrasound is widely applicable to many medical specialties and has been shown to improve diagnostic accuracy and efficiency of patient care.[3,4] Inclusion of this tool in educational training programs is increasing. While a 2019 survey of new-graduate physician assistants (PAs) indicated that only 14.9% of practicing PAs in the Emergency Department received exposure to POCUS while in PA school, the most recent PA Education Association (PAEA) Curriculum Report suggests that approximately two-thirds of PA programs have implemented POCUS into their curriculum.[5,6] In addition, a recent survey of prospective PA students showed that inclusion of POCUS influences where students would prefer to attend PA school.[7]

Not only has incorporation of POCUS into PA program curricula been shown to be feasible, but engagement in extracurricular student-interest groups and national competitions has also been described.[8-10] Various approaches to formal curriculum incorporation have been reported, including single workshop, self-directed learning, peer-learning groups, and fully integrated curriculum.[9,11,12] Furthermore, PA students have demonstrated the ability to obtain high-quality POCUS images with learning curves similar to other medical learners.[13-15]

Notably, while PAEA survey data show increased incorporation of POCUS into curricula, instruction varies substantially between PA programs.[5] The mean time for lecture is 7.1 hours (range, 1.0–100), and the mean time for laboratory instruction is 10.4 hours (range, 1.0–176). Moreover, neither formal consensus by experts and educators nor recommendations from PA professional organizations on what aspects of POCUS to include in PA programs exist. International consensus statements have been published for the incorporation of ultrasound into medical school curriculum.[16] While those authors correctly argue that their results could be a valuable resource for nonphysician health care providers, they also state "other healthcare providers will need to determine the specifics of their ultrasound curricula based on their accreditation and clinical practice standards."[16] Recently, Parker et al[17] surveyed PA Program Directors (PDs) on the state of POCUS in PA education. The survey items identified level of agreement on the identification of anatomical structures but did not outline which specific applications and pathology should be included. Importantly, they did find that PDs felt strongly that the current state of POCUS in PA education required further guidance and modification.

With POCUS becoming an increasingly necessary skillset for practicing PAs, and with its inclusion in PA programs becoming more common, clear recommendations are

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needed to prioritize appropriate POCUS applications for inclusion in PA program curricula. This research project aims to identify expert opinions to establish a scope of POCUS curriculum for PA programs. We hope our consensus recommendations will form the basis of future POCUS curriculum, assisting programs to meet the needs of their students and better prepare their graduates for the workplace.

METHODS

This study was approved by the Institutional Review Board (IRB Protocol Number 24-001884). Quantitative survey research was conducted to address the research aims. Validity of survey instrument development is demonstrated through a stepwise process, including literature review, PA expert review, and piloting of the instrument to optimize construct, content, and criterion validity. Literature review identified a previously validated survey used by the International Consensus Conference recommendations on ultrasound education for undergraduate medical students.[13] The 300-item survey was reviewed by PAs with expertise in POCUS education. Expertise for practicing clinicians was defined as PAs with greater than or equal to 2 years of clinical practice, prior experience educating PA students, regular use of POCUS in clinical practice, and previous experience teaching POCUS at a regional or national medical conference. Expertise for PA educators was defined as PAs who teach POCUS at an accredited PA program, and/or have published on inclusion of POCUS in PA programs within the last 5 years. Additionally, to provide the perspective of a new PA joining the workforce, 3 new graduates from different PA programs where POCUS was incorporated in the curriculum were included in the 100 survey invitations. The survey was developed using the RAND Health Care and University of California at Los Angeles Appropriateness Method (RAM). Per RAM standards, a 9-point Likert scale was used to rate the level of appropriateness for inclusion with one meaning extremely inappropriate, nine meaning extremely appropriate. After construction, the survey was piloted to ensure appropriate function.

The survey was administered to a panel of 100 experts. The experts were identified through their involvement in teaching POCUS at national conferences—such as American Academy of Physician Associates, iScan, or PAEA conferences—membership in the Society of Point of Care Ultrasound or by publishing on use of POCUS by PAs or in PA education. This panel of experts was convened to provide a diverse view of POCUS across a wide variety of clinical practice specialties and settings to best represent PA clinical practice patterns. PAs using ultrasound in clinical practice or in PA education were included. The survey was administered electronically through Qualtrics (Qualtrics, Provo, UT), with a reminder sent to nonresponders every 2 weeks for 2 reminders. Survey results were exported from Qualtrics to Microsoft Excel. Response rates and descriptive statistics for each item were calculated and analyzed, specifically the mean response was calculated to determine the average degree of appropriateness from the expert panel. Items were categorized as appropriate (average ratings 7–9), uncertain (average ratings 4–6), and inappropriate (average ratings 1–3). A degree of consensus was determined by assessing the dispersion of results. Interquartile ranges (IQRs) and median scores were calculated to quantify the degree of consensus. High consensus was defined as an IQR less than or equal to 1, moderate consensus was defined as an IQR of 1 to 2, and no consensus was defined as an IQR of greater than 2.

After determining the appropriateness and the degree of consensus, statements were categorized to guide recommendations (Table 1). *Strongly recommended* was defined as an appropriate POCUS application with high consensus. *Recommended* was defined as appropriate procedures with moderate consensus. A *conditional recommendation* was defined as an appropriate POCUS application with low consensus or uncertain POCUS applications with high consensus. Conditional recommendations are meant to support incorporation of the topic if it aligns with a specific program's goals. *Not recommended* was defined as an inappropriate POCUS application regardless of consensus or uncertain POCUS applications with low consensus.

RESULTS

The survey yielded a response rate of 63% (n = 63); 60 responses from expert PAs with greater than 2 years of clinical practice and 3 responses from new graduates with one year of clinical practice. Respondents' average number of years of PA experience was 13.9 (range, 1–27), and median years of experience was 12. The majority, 92.7%, used POCUS in their clinical practice, and 93.0% have taught POCUS at a regional or national medical conference. Twenty-nine respondents work in Academia, 9 in Critical Care, 5 in Emergency Medicine, 3 in Hospital Medicine, 3 in Orthopedics, 2 in Urgent Care, and one each in Austere Medicine, Dermatology, Family Medicine, outpatient Internal Medicine, Interventional Pain Management, Interventional Radiology, and Trauma Surgery.

All statements regarding the rationale for the curriculum were *strongly recommended* or *recommended* (Table 2). Most statements regarding the basic foundations of POCUS were either *strongly recommended* or *recommended* (Table 3). Notably, a *conditional recommendation* is made for the identification of refraction as an imaging artifact and identifying the endocavitary transducer. For spectral doppler, a *conditional recommendation* is provided for understanding the fundamental principles, explaining indications, and

Table 1. Categorization of Recommendations Based on Appropriateness and Consensus

Recommendation	Basis of Recommendation
Strongly recommended	Appropriate application with high consensus
Recommend	Appropriate application with moderate consensus
Conditional recommendation	Appropriate application with low consensus or uncertain application
Not recommended	Inappropriate application regardless of consensus

Table 2. Recommendations for the Rationale for the Curriculum

Strongly Recommended
PA students can learn POCUS
Inclusion of POCUS in the PA program curriculum enhances physical examination skills
Inclusion of POCUS in the PA program curriculum enhances clinical problem solving
Inclusion of POCUS in the PA program curriculum enhances the overall educational experience
Inclusion of POCUS in the PA program curriculum prepares learners for additional clinical training and/or practice opportunities
Inclusion of POCUS in the PA program curriculum aligns with competency-based education
Recommended
PA students can learn ultrasound guided procedures
Inclusion of POCUS in the PA program curriculum facilitates teaching of fundamental sciences
Inclusion of POCUS in the PA program curriculum encourages lifelong learning
Inclusion of POCUS in the PA program curriculum encourages self-directed learning
Inclusion of POCUS in the PA program curriculum aligns with accepted standards in PA education
Inclusion of POCUS in the PA program curriculum aligns with national POCUS guidelines

obtaining images with this imaging modality. For power doppler, a *conditional recommendation* is made for explaining indications and obtaining images with this imaging modality, while students understanding the fundamental principles of power doppler was *not recommended.*

Recommendations varied from our panel regarding inclusion of POCUS for specific organ systems, procedural guidance, as well as specific POCUS applications and protocols into PA program curricula (see Table, Supplemental Digital Content 1, http://links.lww.com/PAEA/A106). Findings are summarized below. All applications that are *strongly recommended* and *recommended* are also presented in tabular format (Table 4).

1. Abdomen—Image acquisition and identification of major intra-abdominal anatomy (liver, spleen, kidney, gallbladder, splenorenal, and hepatorenal spaces) was generally *strongly recommended* or *recommended.* Identification of abdominal free fluid and hydronephrosis were *strongly recommended.* Identification of renal cysts, renal masses, cholelithiasis, and cholecystitis received a *conditional recommendation.*
2. Cardiac—Image acquisition and identification of cardiac structures were broadly *recommended* or *strongly recommended.* Recommendations for identification of pathology varied. Identification of a pericardial effusion was *strongly recommended.* Identification of left atrial enlargement, right atrial enlargement, right ventricular enlargement, and determination of left ventricular systolic function received *conditional recommendations.*
3. Head and neck—Curricular inclusion of POCUS to assess the head and neck generally received a *conditional recommendation* or was *not recommended.* No applications were *recommended.*
4. Lungs—Lung POCUS was largely *strongly recommended* or *recommended.* Image acquisition, identification of anatomical structures, and identification of pathology such as absent lung sliding, B-lines, consolidations, and pleural effusions were either *recommended* or *strongly recommended.*
5. Musculoskeletal—Musculoskeletal POCUS components were mostly either *conditionally recommended* or not *recommended.* The only *recommended* application was identification of joint effusions.
6. Ocular—Ocular components generally received conditional recommendations. Image acquisition, identification of anatomical structures (such as the globe of the eye and the optic nerve), and diagnosis of retinal detachments and foreign bodies were *conditionally recommended.* Determination of optic nerve sheath diameter was *not recommended.*
7. Pelvis—Image acquisition and identification of the structures of the bladder, uterus, and a fetus were *recommended.* Identification of fetal heartbeat, distended bladder, and indwelling urinary catheter were *recommended.* POCUS of the testicles, ovaries, and additional obstetric applications were *not recommended.*
8. Soft tissue—Experts generally *recommended* soft tissue POCUS. Image acquisition, identification of structures (such as muscle, fascia, and vascular structures), and identification of pathology, including subcutaneous edema, subcutaneous air, abscess, and masses were either *strongly recommended* or *recommended.*
9. Vascular—Generally, image acquisition of most major arteries and veins of the lower extremities and abdomen were *recommended.* Diagnosis of abdominal aortic aneurysm, aortic dissections, and lower extremity deep vein thrombosis were *recommended.* Diagnosis of upper extremity deep vein thrombosis and superficial thrombophlebitis received a *conditional recommendation*.
10. Procedural guidance—Recommendations for use of POCUS for procedural guidance by experts varied. Specifically, peripheral vein cannulation, arthrocentesis, and intra-articular joint injections were *recommended.* Central vein cannulation, lumbar puncture, paracentesis, and thoracentesis received a *conditional recommendation.*

Table 3. Recommendations for Point-of-Care Ultrasound Fundamentals

Strongly Recommended
Students should be able to
Understand presets as they pertain to obtaining ultrasound images
Understand gain as it pertains to obtaining ultrasound images
Understand depth as it pertains to obtaining ultrasound images
Understand the screen indicator marker as it pertains to obtaining ultrasound images
Understand the transducer indicator marker as it pertains to obtaining ultrasound images
Describe the term anechoic as it pertains to ultrasound
Describe the term hyperechoic as it pertains to ultrasound
Describe the term hypoechoic as it pertains to ultrasound
Describe the term isoechoic as it pertains to ultrasound
Describe the term mixed echogenicity as it pertains to ultrasound
Describe the term homogenous as it pertains to ultrasound
Describe the term heterogenous as it pertains to ultrasound
Describe the term solid as it pertains to ultrasound
Describe the term cystic as it pertains to ultrasound
Identify acoustic shadowing ultrasound artifact
Distinguish the linear ultrasound transducer
Distinguish the curvilinear ultrasound transducer
Distinguish the phased array ultrasound transducer
Demonstrate the ultrasound transducer movement of sliding
Demonstrate the ultrasound transducer movement of rocking
Demonstrate the ultrasound transducer movement of fanning
Explain the fundamental principles of B mode
Obtain images using B mode
Recommended
Students should be able to
Be familiar with wavelength as it is related to the basics of ultrasound physics
Be familiar with amplitude as it is related to the basics of ultrasound physics
Be familiar with frequency as it is related to the basics of ultrasound physics
Be familiar with attenuation as it is related to the basics of ultrasound physics
Be familiar with absorption as it is related to the basics of ultrasound physics
Be familiar with resolution as it is related to the basics of ultrasound physics
Be familiar with reflection as it is related to the basics of ultrasound physics
Understand time gain compensation as it pertains to obtaining ultrasound images
Understand frequency as it pertains to obtaining ultrasound images
Understand focal zone as it pertains to obtaining ultrasound images
Identify reverberation ultrasound artifact
Identify mirroring ultrasound artifact
Identify acoustic enhancement ultrasound artifact
Explain the fundamental principles of M mode
Explain the fundamental principles of color flow mode
Explain the indications of B mode
Explain the indications of M mode
Explain the indications of color flow mode
Obtain images using M mode
Obtain images using color flow mode
Conditional Recommendation
Students should be able to
Identify refraction ultrasound artifact
Distinguish the endocavitary ultrasound transducer
Explain the fundamental principles of spectral Doppler mode
Explain the indications of power Doppler mode
Explain the indications of spectral Doppler mode
Obtain images using power Doppler mode
Obtain images using spectral Doppler mode
Not Recommended
Students should be able to
Explain the fundamental principles of power Doppler mode

11. POCUS applications and protocols—The extended Focused Assessment with onography in Trauma was *strongly recommended.* Both the Rapid Ultrasound in Shock and Hypotension (RUSH) and Bedside Lung Ultrasound in Emergency protocols were *recommended.* The 13-point shoulder examination received a *conditional recommendation.*

On subgroup analysis for the three new graduate respondents, less priority was placed on understanding POCUS basics. Understanding the concepts of wavelength,

Table 4. Strongly Recommended and Recommended Applications of Point-of-Care Ultrasound

Obtain Views	Identify Structures	Recognize Findings
Abdomen		
Right upper quadrant*	Liver*	Intra-abdominal free fluid*
Left upper quadrant*	Spleen*	Hydronephrosis*
Lower abdominal transverse*	Hepatorenal space*	
Kidney transverse bilateral	Splenorenal space*	
Kidney longitudinal bilateral	Kidneys bilateral*	
Gallbladder longitudinal	Gallbladder	
Lower abdomen transverse	Renal cortex	
	Renal pelvis	
	Renal calyces	
	Subdiaphragmatic space	
Cardiac		
Parasternal long axis*	Left atrium*	Pericardial effusion*
Parasternal short axis*	Right atrium*	IVC size
Apical 4 chamber*	Left ventricle*	IVC collapsibility
Subcostal 4 chamber*	Right ventricle*	Signs of cardiac tamponade
Inferior vena cava (IVC)	Mitral valve*	Distinguish pleural effusion from pericardial effusion
	Aortic valve*	
	Myocardium*	
	Pericardium	
	Descending thoracic aorta	
	Aortic arch	
Lungs and chest		
Anterior chest bilateral	Ribs*	Lung sliding*
Posterior chest bilateral	Rib shadows*	Absent lung sliding*
Lateral chest bilateral	Pleural line	B lines*
Costophrenic angles bilateral	Diaphragm	A lines
	Intra-abdominal organs	Lung point
		Simple pleural effusion
		Complex pleural effusion
		Consolidation
Musculoskeletal		
None recommended	None recommended	Joint effusions
		Carpal tunnel
Neck		
None recommended	None recommended	None recommended
Ocular		
None recommended	None recommended	None recommended
Pelvis		
Bladder transverse	Bladder	Distended bladder
Bladder longitudinal	Uterus	Foley catheter placement
Uterus transverse transabdominal	Fetus	
Uterus longitudinal transabdominal	Fetal heartbeat	

(*Continued*)

Table 4. Strongly Recommended and Recommended Applications of Point-of-Care Ultrasound (continued)

Obtain Views	Identify Structures	Recognize Findings
Soft tissue		
Soft tissue transverse	Muscle	Abscess or cyst*
Soft tissue longitudinal	Fascia	Cobblestoning
	Superficial vascular structures	Solid mass
		Foreign body
		Subcutaneous air
Vascular		
Longitudinal carotid artery	Abdominal aorta*	Abdominal aortic aneurysm
Transverse internal jugular (IJ) vein	Aortic bifurcation	Aortic dissection
Longitudinal IJ vein	Common femoral vein	Lower extremity deep vein thrombosis (DVT)
Transverse abdominal aorta	Deep femoral vein	Upper extremity DVT
Longitudinal abdominal aorta	Popliteal vein	
Lower extremity veins		

Procedures and Protocols

Procedures	Protocols
Peripheral vein cannulation	eFAST*
Arthrocentesis	RUSH
Intra-articular joint injection	BLUE

Strongly recommended components are denoted with an asterisk (*); all others are *recommended*.

amplitude, attenuation, absorption, and reflections received a *conditional recommendation* (instead of being *recommended* or *strongly recommended*). No other meaningful differences were noted.

DISCUSSION

The experts surveyed strongly believe that PA students can learn POCUS, and its inclusion in the PA curriculum enhances physical exam skills and clinical problem-solving. This sentiment aligns with previously published PA student perceptions that ultrasound as an educational technology is helpful, and objective data in medical students support improved anatomical knowledge.[18,19] Perhaps most importantly, they also believe ultrasound training better prepares learners for additional clinical training and practice opportunities. The consensus believes that teaching POCUS in PA programs aligns with accepted standards in PA education and encourages lifelong learning as well as self-directed learning. In addition, they strongly believe that including POCUS in PA program curriculums aligns with competency-based education. This is encouraging when considering the growing literature suggesting that PA students not only can accurately perform and interpret scans but also do so within academic time constraints.[13,15,20,21] Several themes emerged in the analysis of specific recommendations on POCUS curricular components. First, the expert panel agreed that most foundational concepts for ultrasound should be taught within PA program curriculum. This includes components colloquially referred to as "knobology," such as ultrasound physics, modes, artifacts, transducers, and transducer movements; most of these received *strongly recommended* or *recommended* designations. One notable exception was that inclusion of power doppler and spectral doppler received a conditional recommendation. Second, the panel more strongly believes in teaching basic views and structure identification, with less vigorous recommendations for identifying specific pathology. For example, identification of the gallbladder was *recommended*, while diagnosis of cholelithiasis and cholecystitis received a *conditional recommendation*. The third theme was that the expert panel clearly and with relative consistency prioritized specific POCUS applications over others. For example, image acquisition of cardiac views was *strongly recommended*, while other organ systems such as musculoskeletal were more likely to be *not recommended*. In addition, within a specific POCUS application, the expert panel was also able to prioritize specific POCUS findings and pathologies over others. Given curricular time constraints for PA programs, this guidance provides valuable insights into what programs should prioritize for inclusion. While this prioritization is important, the framework provided in this article allows programs the freedom to provide advanced knowledge in areas of emphasis that align with a given program's mission.

Based on the strength of recommendation and the level of consensus, in general, the expert panel recommends inclusion of the image acquisition, structure identification, and pathology identification for the following topics: abdominal aorta, bladder, heart, kidneys, lower extremity deep venous system, lungs, soft tissue, and the uterus. Use of POCUS for the extended Focused Assessment with Sonography in Trauma examination, Bedside Lung Ultrasound in Emergency protocol, and RUSH examination were also *recommended*. Procedural guidance for peripheral vein cannulation, arthrocentesis, and joint injections was also *recommended*.

When comparing with the international consensus recommendations on ultrasound education for undergraduate medical students, there is overall significant alignment, with several important differences.[16] The recommendations for the rationale for the curriculum and foundational concepts of ultrasound align very well without any notable differences. In general, the recommended ultrasound curriculum for medical students is broader than that for PA programs. For example, significant more musculoskeletal ultrasound was recommended for medical students, compared with PA programs. In addition, stronger recommendations for other applications, such as ocular ultrasound and neck ultrasound were noted for medical schools, compared with PA programs. It is hypothesized that these differences are due to different curricular time constraints in PA education compared with medical school. In addition, the consensus recommendation for medical schools was for medical ultrasonography (not specific to POCUS), while our article was specific to POCUS. This is likely consistent with the needs of the different training programs, as some students in medical school will go on to formal radiology training.

Overall, the recommendations from the expert panel align well with a prioritized list of the most widely applicable and commonly taught POCUS applications. Of the POCUS applications recommended by the expert panel, the specific pathologies to be included in the curriculum align well with guidelines established by the American College of Emergency Physicians, Society of Hospital Medicine, and American Academy of Family Physicians.[22-24] Notably, however, there were several unanticipated findings, such as a *conditional recommendation* for assessment of left ventricular systolic function, which run contrary to other published resources that should be taken into context when developing a POCUS curriculum for PA programs.

The breadth of experts included in the expert panel is a strength of the study design. Because of the versatility of the PA profession, seeking perspectives from various specialties was prioritized in the study design. The varied backgrounds and experiences of the expert panel participants ensure that the recommendations balance the opinions of those in PA education and those using POCUS clinically. In addition, this study provides specific and actionable recommendations for PA educators working toward incorporating POCUS into curriculum. Understanding which specific organ systems and pathologies should be prioritized provides vital guidance to PA programs nationally.[17]

This study has several limitations. While we acknowledge that our consensus could be more representative of the varieties of specialties in which PAs practice, the number of PAs in subspecialties with significant POCUS experience are limited. Inadvertent omission of individuals with expertise in POCUS is another potential limitation; however, the authors feel this is unlikely to significantly affect the results. Finally, response bias is possible. It is possible that PAs from various specialties, such as Emergency Medicine, Critical Care, and Hospital Medicine, were more likely to respond to the survey given their specialty-based affinity for POCUS when compared with PAs from other specialties. While this potentially could skew the results, it likely aligns with the areas where POCUS use is most ubiquitous and supported.

Over the last few decades, it has become clear that point-of-care ultrasound has improved patient care and safety while increasing efficiency and throughput.[3,4] While others have established global expert opinions for medical students, these publications did not take into consideration the time constraints of PA education.[16] Here, we present the most comprehensive consensus opinion to date of experienced PA clinician-educators to help elucidate minimum standards for PA student POCUS education.

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