CLINICAL RESEARCH STUDY

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Internal Medicine Residency Point-of-Care Ultrasound (POCUS) Consensus Recommendations for Core Indications and Applications

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ABSTRACT

BACKGROUND: Bedside point-of-care ultrasound (POCUS) is quickly becoming a routine part of internal medicine practice and training. The optimal POCUS training venue for internists is at the graduate medical education or residency stage of their career. Despite increased training, clinical use, and broad internal medicine society endorsement in the United States, no internal medicine POCUS consensus curricula exist. The goal of this consensus process was to guide the core elements for inclusion within internal medicine residency POCUS curricula in the United States.

METHODS: A 4-step modified Delphi methodology was used to establish consensus (75% agreement) recommendations for core indications and applications among a panel of 14 inpatient- and outpatient-based, residency-affiliated, internal medicine POCUS experts in the United States.

RESULTS: The consensus process identified 12 core diagnostic and 6 procedural POCUS *indications* (eg, dyspnea, shock, chest pain, thoracentesis, etc.), with an associated 15 diagnostic POCUS *applications* (eg, focused cardiac, gallbladder, urinary bladder, etc.) and 52 specific *skill components* (eg, identification of pericardial effusion, cholelithiasis, bladder volume, etc.) that reached consensus for inclusion in core curricula.

CONCLUSIONS: This consensus process represents the first expert and evidence-based recommendation for what POCUS elements should fall into a core internal medicine residency-based curriculum in the United States. Many areas not meeting consensus for inclusion still fall within the broader internal medicine POCUS scope and can be clinically impactful for specific subgroups of internists, such as advanced internal medicine POCUS users, and specific inpatient and outpatient clinical environments.
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INTRODUCTION

Point-of-care ultrasound (POCUS) has become an essential provider skillset across a wide array of medical specialties. As an adjunct to the traditional physical exam, POCUS improves diagnostic efficiency, safety, patient understanding and satisfaction, and important system outcomes. It additionally adds value to medical education through improved understanding of anatomy and physiology.

The overt clinical use of POCUS within Internal Medicine came in the wake of Emergency Medicine,[1-5] with scattered residency adoption beginning in the mid-2000s followed by the rapid growth of continuing medical education courses for internists.[6-10] POCUS has since received formal endorsement from multiple specialty societies, including the American College of Chest Physicians in 2009, and the American College of Physicians, the Society of Hospital Medicine, and the Alliance for Academic Internal Medicine.[11-14] Despite its growth, endorsement by internal medicine specialty societies, and recent internal medicine curricula published from Canada and the Netherlands,[15,16] no internal medicine POCUS consensus curricula have been published in the United States.

The optimal educational pathway for POCUS exists as a longitudinal curriculum over the 3 years of internal medicine residency training, where hands-on technical and clinical mentorship align well with clinical medicine and space for consolidated clinical learning. The establishment of core curricular elements and clinical POCUS applications expected among future United States graduating internal medicine residents is the next step towards full realization of the benefits of widespread POCUS use. To address this need, we developed a consensus-based set of core indications and applications that provides a clinically-centered and differential-driven approach to the foundational elements of internal medicine POCUS for inclusion in residency-based POCUS curriculum.

CLINICAL SIGNIFICANCE

- This study provides the first United States consensus recommendations for core Internal Medicine residency POCUS indications (18), applications (15), and specific skill components (52).
- The consensus elements apply to inpatient and outpatient Internal Medicine clinical environments and training.
- The scope of Internal Medicine POCUS and training is not limited to these core elements, but they provide a common starting point for programs from which individualized residency-based curricula can be built.

MATERIALS AND METHODS

Study Design

This study utilized a 4-step modified Delphi methodology.[17] To minimize bias in voting throughout the study, votes and discussion comments were kept anonymous, with only a designated nonvoting member of the panel—the facilitator—knowing individual voting results.

Participants

The expert voting panel of 14 inpatient and outpatient internal medicine POCUS experts was invited to participate based on 1) national recognition of POCUS teaching and expertise, and 2) involvement with designing and teaching POCUS in residency programs. Individual expert characteristics can be found in Supplementary Table 1.

Data Acquisition

Data were collected by alternating rounds of anonymous voting and discussion. Each topic received at least 2 rounds of voting unless unanimous consensus existed after round one. After each vote, experts reviewed results, and a follow-up discussion determined whether an additional round of voting was appropriate. Voting was performed using an online survey program (Survey Monkey, San Mateo, Calif). Virtual, anonymous discussions (2-3 week duration) were held using online document sharing software (Google, Mountain View, Calif) where experts engaged in back-and-forth discussion by leaving de-identified comments. After each discussion period, subsequent voting occurred.

Round 1 of voting determined which clinical and procedural *indications* commonly encountered by internists (eg, acute kidney injury, chest pain, thoracentesis, etc.) could be assessed with POCUS and should be included in a core internal medicine residency POCUS curriculum. When voting, experts considered the likelihood of encountering an indication clinically, test characteristics of POCUS for the indication, and technical and cognitive difficulty of the associated POCUS tasks for a basic user. Round 2 of voting identified specific POCUS diagnostic and procedural *applications* (eg, bladder and kidney ultrasound, pleural ultrasound, etc.) required to evaluate the consensus *indications*. Finally, round 3 identified specific *skill components,* including structure identification, acquisition technique, and image interpretation (eg, kidney for hydronephrosis, bladder volume estimation, lung sliding to rule out pneumothorax, etc.) required to perform each consensus POCUS *application*. After completion of all voting rounds summary data was distributed to the panel for review and comment.

Analysis

Survey software analyzed voting results by simple count. Consensus for inclusion or exclusion was defined *a priori* as >75% agreement in a dichotomous fashion. Items that did not meet >75% agreement for inclusion or exclusion were categorized as “did not meet consensus.”

RESULTS

A total of 12 diagnostic and 6 procedural *indications* associated with 15 diagnostic POCUS *applications* and 52 specific POCUS *skill components* met criteria for inclusion (Figure 1). Full voting results are in Supplementary Table 2. Note that, unless otherwise specified, the use of "met consensus" in this manuscript refers to meeting the threshold for *inclusion* (not *exclusion*) consensus.

Consensus Indications: Diagnostic POCUS

A brief discussion of considerations within each of the 12 diagnostic *indications* follows.

Dyspnea and Hypoxemia. Diagnostic and therapeutic approaches to dyspnea/hypoxemia can be improved with multi-system POCUS.[18] Test characteristics of lung and pleural ultrasound often exceed chest radiography and are similar to those of chest computed tomography.[19-21] Navigating the dyspnea/hypoxemia differential (eg, cardiogenic pulmonary edema, pneumonia, pulmonary embolism) can be expedited with combined pulmonary and focused cardiac POCUS.[22-30] Basic POCUS users should be able to identify the following pleural structures: ribs and intercostal space, intercostal vasculature (primarily for procedural guidance), visceral and parietal pleura, and the diaphragm. Using these structures, users should be able to evaluate the pleura for lung sliding, lung pulse, and for the presence of pleural fluid using the "spine sign" and "curtain sign." Users should be able to characterize pleural fluid as simple or complex and differentiate it from ascites. Lung parenchyma should be identified with recognition of normal A-line and/or pathologic B-line artifacts. Users should also be able to identify parenchymal consolidation, but experts agreed that using static vs. dynamic air bronchograms to further inform between pneumonia and atelectasis was beyond core content.

Incorporation of POCUS findings from other systems is crucial in evaluating the dyspneic/hypoxic patient, specifically the focused cardiac ultrasound, inferior vena cava (IVC), and deep vein thrombosis exams. Key cardiac structures that basic users should be able to identify are outlined in Supplementary Table 2. Using 4 common cardiac views—parasternal long axis, parasternal short axis, apical 4 chamber, and subcostal 4 chamber—users should be able to evaluate for qualitative left ventricular systolic function, right ventricular enlargement, left atrial enlargement, and left ventricular wall thickening. Basic users should be able to assess categories of normal, hyperdynamic, and severely reduced left ventricular systolic function. Further refinement, such as mildly reduced and moderately reduced, did not meet consensus. To aid in semi-quantitative systolic assessment, users should be able to evaluate semi-quantitatively for endocardial excursion, myocardial thickening, and E-point septal separation using B-mode. Experts agreed that additional quantitative measurements of these evaluations using M-mode introduced a potential for error among basic users, and therefore, caliper-based measurement of E-point septal separation and fractional shortening were excluded as were Doppler-based calculations for cardiac output. Basic users should be able to identify the presence of a pericardial effusion; however determination of cardiac tamponade with ultrasound did not meet consensus. Evaluation for cardiac valvular abnormalities was felt to be outside the scope of a basic user and met the exclusion.

Assessing for lower extremity deep vein thrombosis is included (see "*Unilateral lower limb pain/swelling*" below) when considering pulmonary embolism, while the more technically difficult assessment for upper extremity thrombosis was excluded.

Determination of Volume Status. Accurate estimation of "volume status"—more accurately stated as a combined assessment of cardiac filling pressures, intravascular vs. extravascular volume, and fluid responsiveness/tolerance—is difficult with traditional physical exam and laboratory values alone.[31] POCUS assessment of IVC size and collapsibility can be used to estimate right atrial pressure and met the inclusion for this indication.[32-34] Key structures that basic users should be able to identify include the IVC in both short and long axis, the liver, the right atrium, the hepatic vein, and the aorta. Experts agreed that qualitative assessment ("eyeballing") of the IVC was more appropriate for core content than either B- or M-mode quantitative measurements, which introduce potential for error and met consensus for exclusion. The clinical integration of an elevated right atrial pressure noted by a dilated IVC with minimal collapsibility requires careful integration with other POCUS applications such as cardiac (chamber size and function) and pulmonary ultrasound (A-lines, B-lines, pleural effusion). The clinical pitfall of assuming IVC characteristics directly inform overall volume status or fluid responsiveness should be emphasized in teaching. Other advanced POCUS applications that may assist in this evaluation met exclusion criteria, specifically assessment for tricuspid valve regurgitation, assessment of diastolic dysfunction, and the venous excess ultrasound score (VExUS).

Chest Pain. Evaluation of chest pain has traditionally involved careful history, laboratory, electrocardiogram, and physical exam integration to efficiently triage patients in the hospital and clinic. While these non-POCUS elements are central to the evaluation, several core POCUS elements aid in expedited management. The likelihood of myocardial ischemia is increased in the setting of newly reduced systolic function, which met the inclusion for the core content. While identification of new wall motion abnormalities is also useful and is often used by advanced POCUS users, this did not meet inclusion due to the relatively poor test characteristics of this exam by nonexperts.[35,36] Additional POCUS elements meeting consensus included those that support nonischemic etiologies of chest pain, such as pneumothorax, pericardial effusion, alveolar consolidation/pneumonia, or RV dilation with concomitant pulmonary parenchymal abnormalities or deep vein thrombosis suggestive of acute pulmonary embolism.[37]

Shock. Undifferentiated shock evaluation requires rapid assessment of multiple organ systems and clinical integration of multiple data points.[38] The addition of POCUS to the evaluation increases diagnostic accuracy and reduces time to diagnosis and treatment.[39-41] Core applications meeting inclusion include assessment with pleural ultrasound for pneumothorax; lung ultrasound for consolidation and pulmonary edema; focused cardiac ultrasound for pericardial effusion, decreased, normal or hyperdynamic systolic function, right ventricular dilation, IVC diameter and collapsibility; abdominal ultrasound for intraperitoneal free fluid which may signify acute intraabdominal hemorrhage or ruptured abdominal aortic aneurysm; and lower extremity venous ultrasound related to likelihood of pulmonary embolism.

Cardiac Arrest. POCUS use in cardiac arrest and resuscitation efforts expedites diagnosis and treatment by identifying potential reversible causes with high sensitivity and specificity (cardiac tamponade, tension pneumothorax, pulmonary embolism, massive myocardial infarction, hypovolemia) and informs outcome prognostication.[40,42-45] Thus, POCUS to assess for systolic function, pericardial effusion, lung sliding, right ventricular dilation, deep vein thrombosis, and IVC characteristics falls within the core *applications* meeting consensus for this *indication* like they did for

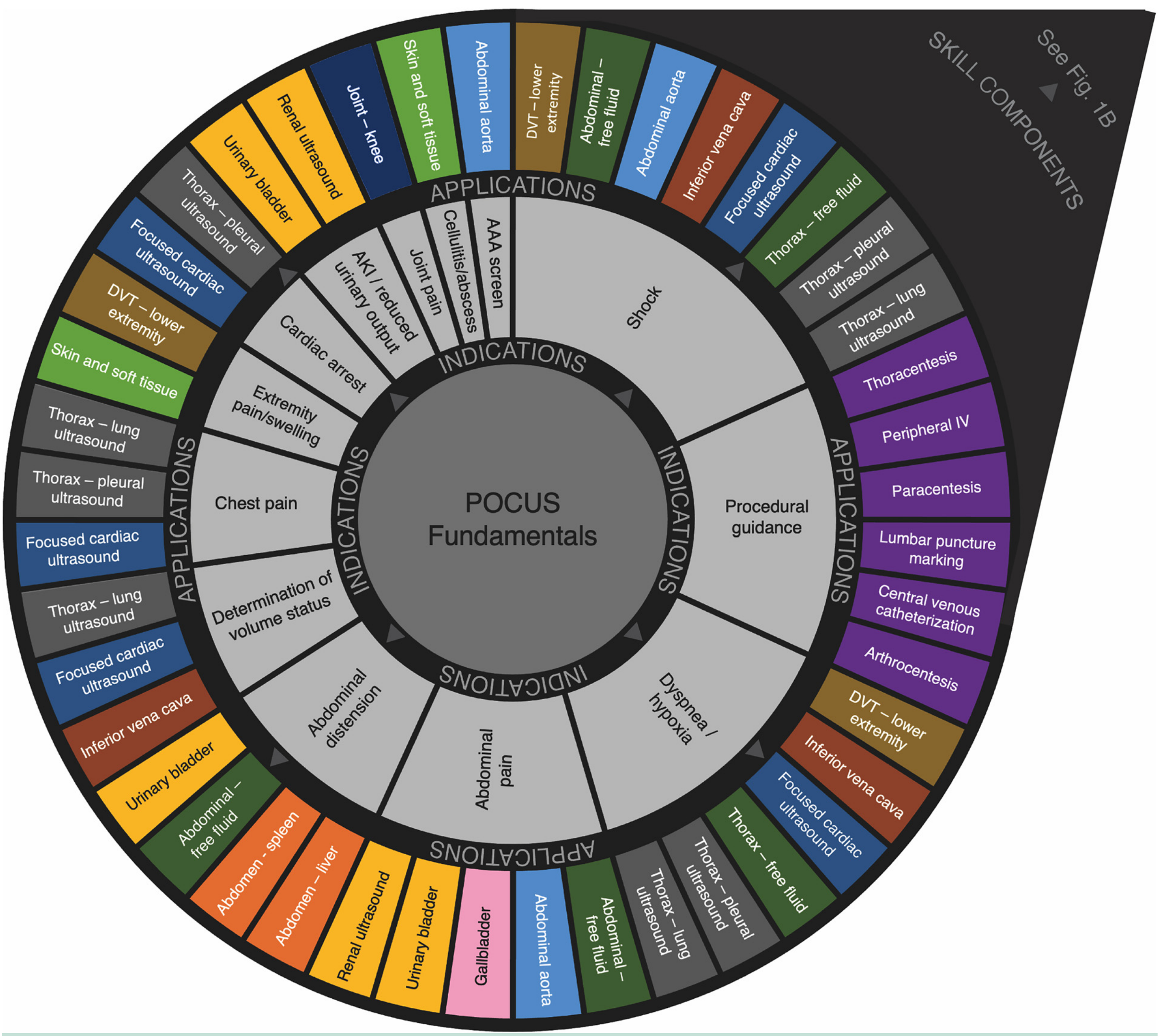

Figure 1 (**A**) Consensus POCUS core indications, applications. (**B**) Consensus POCUS core skill components by application. 2D = 2-dimensional; 4AC = apical 4 chamber; A5C = apical 5 chamber; AAA = abdominal aortic aneurysm; AKI = acute kidney injury; AV = aortic valve; B-mode = brightness mode; DVT = deep vein thrombosis; IVC = inferior vena cava; L/R = left/right; LA = left atrium; LV = left ventricle; LVOT = left ventricular outflow tract; LVSF = left ventricular systolic function; MV = mitral valve; PLAX = parasternal long axis; PSAX = parasternal short axis; PV = pulmonic valve; RAP = right atrial pressure; RVOT = right ventricular outflow tract; SC4 = subcostal 4 chamber; TV = tricuspid valve; UPJ = ureteropelvic junction.

SPECIFIC POCUS SKILL COMPONENTS BY APPLICATION

Abdominal aorta

Structure identification	Evaluation for
Proximal, mid and distal aorta	Aortic diameter (cross section)
Bifurcation of the aorta	Aortic diameter (longitudinal)
Vertebral body	Aneurysm diameter (cross section)
Inferior vena cava	
Celiac trunk	
Superior mesenteric artery	
Proximal iliac arteries	

Skin and soft tissue

Structure identification	Evaluation for
Muscle	Abscess
Bone	Subcutaneous edema/ "cobblestoning"
Skin	Cyst
Subcutaneous fat	Subcutaneous air
Tendon (+Anisotropy)	
Nerve	
Fascial plane	
Lymph Node	

Joint - knee

Structure identification	Evaluation for
Patella and patellar tendon	Joint effusion
Quadriceps muscle and tendon	Baker's cyst
Femur	
Tibia	
Suprapatellar recess (Supine)	

Renal

Structure identification	Evaluation for
Parenchyma and pyramids	Hydronephrosis
Cortex	Renal cyst
Collecting system components	Kidney size
Ureter and UPJ	

Urinary bladder

Structure identification	Evaluation for
Bladder	Bladder volume
Prostate	Foley balloon
Uterus/vagina	

Lower extremity DVT

Structure identification	Evaluation for
Common femoral vein and artery	2D compression for rule out thrombus
Deep femoral vein and artery	
(Superficial) femoral vein and artery	
Popliteal vein and artery	
Saphenous vein	
Lateral perforator vein	
Popliteal vein branching	
Lymph node	

Focused Cardiac Ultrasound

Structure identification	Evaluation for
Parasternal long axis (PLAX)	
LA, LV, LVOT, RVOT	Qualitative LVSF (hyperdynamic/normal/mildly to moderately reduced/severely reduced)
MV – anterior and posterior mitral valve leaflets	Endocardial excursion
Pericardium	Myocardial thickening
Descending thoracic aorta	E-point septal separation (B-mode)
AV – right coronary cusp and non-coronary cusp	LA enlargement ("eyeballing" compared to proximal aorta size)
Epicardial fatpad	Evaluation for aortic stenosis with aortic valve gross calcification and gross impaired opening
Pericardial effusion	Evaluation for wall motion abnormalities: mid-and-basal anteroseptal and mid-and-basal inferolateral
Left pleural effusion	
Parasternal short axis (PSAX)	
Aortic valve level: LA, RVOT, RA, TV, PV	Qualitative LVSF (hyperdynamic/normal/mildly to moderately reduced/severely reduced)
Mitral valve level: Interventricular septum, LV, LV wall segments, RV, mitral valve	RV pressure/volume overload
Mid-papillary level: Interventricular septum, LV, LV wall segments, RV, papillary muscles, pericardium	RV enlargement
Apical level: LV, LV wall segments	
Apical four chamber (4AC)	
LV, RV, LA, RA	Qualitative LVSF (hyperdynamic/normal/mildly to moderately reduced/severely reduced)
Pericardial space	Pericardial effusion
AV – (A5C)	RV enlargement
Descending thoracic aorta	
L/R pleural space	
Subcostal four chamber (SC4)	
LV, RV, LA, RA	Qualitative LVSF (hyperdynamic/normal/mildly to moderately reduced/severely reduced)
Aortic valve	RV enlargement
Pericardial space	L/R pleural effusion
Liver	Pericardial effusion
Diaphragm	
L/R pleural space	
Peritoneal (ascitic space)	

Abdominal – Free fluid

Structure identification	Evaluation for
Liver	Anechoic signal
Right and left kidney	Bowel loops
Hepatorenal recess	Loculations/septations
Spleen	
Splenorenal recess	
Diaphragm	
Bladder	
Subdiaphragmatic space/recess	
Inferior liver tip (R paracolic gutter)	
Inferior spleen tip (L paracolic gutter)	
Rectovesical pouch (male patients)	
Rectouterine pouch of Douglas (female patients)	
Uterovesical pouch (some female patients)	
Bowel	

Thorax – Free fluid

Structure identification	Evaluation for
Lung	Presence of pleural fluid
Visceral/parietal pleura	Complexity of pleural fluid
Diaphragm	Ascites vs. pleural fluid
Ribs	

Thorax - Pleural

Structure identification	Evaluation for
Ribs and intercostal space	Lung sliding
Visceral and parietal pleura	Pleural fluid
Diaphragm	Lung pulse
Intercostal vasculature	

Thorax - Lung

Structure identification	Evaluation for
Lung	Normal lung sliding
Diaphragm	Interstitial processes
Visceral pleura	Spine sign
Ribs	Curtain sign
	Consolidation (in general)
	Air bronchograms

Gallbladder/biliary

Structure identification	Evaluation for
Gallbladder (short axis)	Cholelithiasis
Gallbladder (long axis)	Sonographic Murphy sign
Portal vein	Cholecystitis – anterior wall thickness

Liver

Structure identification	Evaluation for
Liver	Liver size
Portal vein	
Hepatic vein	

Spleen

Structure identification	Evaluation for
Spleen	Spleen size

Procedural guidance

Procedure	Technique	Procedure	Technique
Arthrocentesis	Static needle guidance (marking site)	Paracentesis	Static needle guidance (marking site)
Central venous catheterization	Dynamic needle guidance (out of plane)	Peripheral IV	Dynamic needle guidance (out of plane)
	Dynamic needle guidance (in plane)		Dynamic needle guidance (in plane)
Lumbar puncture marking	Static needle guidance (marking site)	Thoracentesis	Static needle guidance (marking site)

**"Anatomic study for critical structure identification" met consensus for all listed procedures

Inferior vena cava

Structure identification	Evaluation for
IVC (long axis)	RAP – B-mode – "Eyeballing"
IVC (short axis)	
RA	
Liver	
Hepatic vein	
Aorta	

Figure 1 Continued.

shock as the pulseless electrical activity (PEA) arrest (especially, with sinus tachycardia) is part of the shock/hypotension spectrum.

Acute Kidney Injury and Reduced Urinary Output. Acute kidney injury and reduced urine output are common among patients and generate a differential diagnosis of prerenal, intrinsic, and postrenal etiologies.[46] POCUS is sensitive and specific, and can reduce the time to diagnosis for identification of a postrenal etiology with evaluation for hydronephrosis and bladder volume, both of which met consensus.[47,48] Foley catheter identification also met consensus and can be useful in treating kidney injury and troubleshooting reduced urinary output.

Diagnosis of prerenal etiologies, including shock, hypovolemia, and heart failure, involves the integration of cardiac, IVC, and urinary POCUS applications, all meeting consensus. Newer methods for assessment of venous congestion (VExUS) may help diagnose kidney injury secondary to venous congestion, but were felt to be advanced skills and met consensus for exclusion.[49]

Intrinsic renal pathologies are generally beyond the ability of ultrasound and the scope of core internal medicine POCUS. However, consensus was met for evaluation of kidney size and echotexture, which can provide clues to the chronicity of kidney disease and intrinsic renal pathology. Experts agreed that the identification of simple renal cysts should be included, given the high rate of this incidental finding. Identification of renal masses and nephrolithiasis did not meet consensus.

Abdominal Aortic Aneurysm (AAA) Screening. The U. S. Preventive Services Task Force recommends screening for abdominal aortic aneurysm with ultrasonography in men aged 65 to 75 years who have ever smoked, and POCUS allows for cost-effective and efficient screening in an outpatient setting.[50-52] Experts agreed that users should be able to identify, in long and short axis, a normal and aneurysmal aorta at its proximal, mid, and distal portion, including its bifurcation into the proximal iliac arteries as well as important landmarks including the vertebral bodies, celiac trunk, and superior mesenteric artery. While not necessary to visualize, experts felt that identifying the IVC should be included in this topic, as mistakenly identifying the IVC as the aorta is an important pitfall of screening.

Abdominal Distention. Abdominal distention is common among patients,[53] and POCUS can rapidly narrow its broad differential. POCUS applications meeting inclusion for abdominal distention were evaluation for ascites, hepatomegaly, splenomegaly, and urinary bladder distension. Important anatomical structures to identify included the liver, spleen, bilateral kidneys, diaphragm, urinary bladder, and bowel, as well as the potential spaces of the hepatorenal recess, splenorenal recess, subdiaphragmatic recess, right and left paracolic gutters, rectovesicular pouch (male patients), rectouterine pouch of Douglas and vesicouterine pouch (female patients). Basic users should be able to identify free abdominal fluid and evaluate for loculations/septations.

Abdominal Pain. Like distention, abdominal pain has a broad differential. Several potentially life-threatening etiologies can be rapidly excluded with POCUS applications meeting inclusion including assessment for peritoneal free fluid, abdominal aortic aneurysm, cholelithiasis/cholecystitis, hydronephrosis, and urinary retention.[54−56] The identification or exclusion of these etiologies using POCUS not only expedites diagnosis but may also limit unnecessary emergency department visits, specialty consultation, or additional laboratory and radiologic workup in the in- and outpatient environments. Small bowel and appendix ultrasound did not meet the inclusion but offer additional tools for specific users and patient populations.

Unilateral Lower Extremity Pain or Swelling. In patients with unilateral leg pain or swelling, compression ultrasound to rule out deep vein thrombosis has utility across inpatient and outpatient settings, especially when combined with establishment of pretest probability and adjunct testing, such as D-dimer and comprehensive venous ultrasound, in an algorithmic approach.[57-60] Basic users should be able to identify the vascular tree of the lower extremity from the common femoral vein to the popliteal vein, paying specific attention to the major confluence points (greater saphenous vein, lateral perforator vein, deep femoral vein from the femoral vein, popliteal vein trifurcation). Various compression protocols have been described, including 2-point compression, 2-zone compression, and extended-compression. Experts agreed that the 2-point exam is insufficient. Neither of the remaining 2 protocols (2-zone and extended-compression) met consensus for inclusion or exclusion and are both reasonable protocols for inclusion in a core curriculum. The identification of lymph nodes should be included, as they may be mistaken for a thrombosed vein. Additionally, the characteristic ultrasound visualization of a Baker's cyst is helpful, especially in the outpatient setting, to differentiate between a cyst and popliteal vein pathology. Unilateral extremity pain or swelling due to infectious etiologies is also aided with core POCUS applications (see *below*).

Cellulitis and Abscess. POCUS can rapidly and accurately distinguish uncomplicated cellulitis from diagnoses requiring additional imaging or intervention, such as abscess and necrotizing fasciitis.[61,62] POCUS can help guide incision and drainage of abscesses and the choice of antibiotics.[63] Evaluation for subcutaneous edema ("cobblestoning"), abscess, and subcutaneous air all met consensus.

Joint Pain or Swelling. Knee pain accounts for nearly 4 million primary care visits annually.[64] POCUS met inclusion for the assessment of common knee issues such as effusion and Baker's cyst, and can help guide arthrocentesis and injection (see procedural section).[65] Although frequently evaluated by internists, use of POCUS for evaluation of the hip, shoulder, elbow, wrist, ankle, and smaller joints did not meet consensus, as some experts felt these joints required more frequent repetition to maintain skill than is typically present in a basic user.

Consensus Indications: Procedural Pocus

A total of 6 procedural *indications* met the inclusion criteria. Each is accompanied by its necessary critical structure evaluations and technical *skill components* (Figure 1). A brief discussion of each procedural indication for POCUS follows. For in-depth discussion and the evidence base for each, refer to the series of position statements from the Society of Hospital Medicine's POCUS Task Force.[66-69]

Central Venous Catheterization. Dynamic ultrasound guidance is the standard of care when performing central venous catheterization, increasing success rates and reducing mechanical and infectious complications.[70] Both real-time in-plane and out-of-plane techniques for internal jugular and common femoral vein cannulation met consensus. Importantly, no expert endorsed static (ultrasound-marked) guidance, as only real-time ultrasound guidance significantly reduces mechanical complications compared to landmark-based cannulation.[71] Critical structures to identify are the target vein and accompanying artery, and for the internal jugular cannulation, the thyroid gland. Before cannulation, patency is assessed by fully compressing the vein. Confirmation that the correct vessel has been cannulated is done by identifying the guidewire within the compressible vessel, and can be assisted by identifying the presence of venous valves. Applications not meeting consensus for basic POCUS-guided central venous catheterization, but commonly used in clinical practice, included identification of the subclavian vessels and assessment of the pleural line before and after the procedure for the presence of pneumothorax.

Peripheral Venous Catheterization. As with central catheterization, experts agreed that real-time in-plane or out-of-plane ultrasound guidance with the high-frequency linear array transducer can be used to increase the success of peripheral venous catheterization.[72] Critical anatomy to identify includes the target vein and surrounding arteries, tendons, and nerves. As peripheral arteries can often be compressed, identification of venous valves gives additional assurance that the target is a vein.

Paracentesis. Paracentesis is a common bedside procedure performed by internists for which POCUS increases the success rate and decreases complications.[73,74] Experts agreed that for a sufficiently large collection of ascites, a static, "2-probe technique" is appropriate. This technique uses a low-frequency transducer to 1) identify deep structures (ascites, bowel, liver, and spleen); 2) locate the largest ascites collection; and 3) measure depth from the peritoneum to deep structures. The second transducer, a high-frequency transducer, is used to identify skin, soft tissue, and superficial vasculature, and to measure skin-to-peritoneum distance. Experts agreed that identification of the rectus sheath and inferior epigastric vessels with Doppler is important to decrease bleeding risk. The benefits of a "2-probe technique" may also be accomplished with a single transducer with a wide frequency range. It is important to note that *dynamic* guidance for paracentesis did not meet inclusion as the need often implies accessing a small fluid collection—frequently beyond a basic procedural POCUS user's skillset.

Thoracentesis. Static ultrasound guidance for thoracentesis met the inclusion for a core POCUS procedural skillset as it decreases the risk of pneumothorax and dry tap compared to landmark-guided.[75] As with paracentesis, a similar "2-probe technique" is recommended. Critical structures to identify with a low-frequency transducer are the boundaries of the pleural effusion, including the diaphragm, ribs, visceral pleura lining the collapsed lung, and parietal pleura lining the chest wall.[76] A high-frequency transducer measures distance from the skin to the parietal pleura. Experts also agreed on Doppler to identify intercostal vessels. Finally, evaluation for postprocedure pneumothorax met consensus.[77] As with paracentesis, *dynamic* guidance for thoracentesis did not meet inclusion for a similar reason.

Lumbar Puncture. Static POCUS guidance for lumbar puncture increases the success rate and decreases needle passes and redirections.[78-79] Experts agreed on the use of a high-frequency transducer to identify the sacrum, lumbar spinal levels, and spinous processes in both transverse and longitudinal planes to identify the widest appropriate interspinous space. While the use of the curvilinear transducer did not quite reach consensus, POCUS is often considered most helpful in obese patients whose body habitus may necessitate a lower-frequency transducer.[80] The curvilinear transducer is also helpful in the longitudinal paramedian view to identify the lamina and measure depth to the ligamentum flavum.[81] Therefore, the use of a curvilinear transducer, if available, may still be an important adjunct in these situations that often require more advanced procedural POCUS skills.

Arthrocentesis. Experts reached consensus that POCUS is particularly useful for static guidance of knee arthrocentesis, increasing the success rate and volume of aspiration while decreasing pain.[82] A high-frequency transducer can be used to identify the distal femur, patella, and quadriceps tendon, and assess for knee effusion in the suprapatellar recess. The patellar ligament can also be identified and avoided. As with lumbar puncture, the use of a lower-frequency curvilinear transducer did not meet consensus but may be needed in patients with larger body habitus.

Outpatient Subgroup Analysis

Acknowledging the number of outpatient experts on the panel (n = 4, 29%) was disproportionate to inpatient providers (n = 10), we examined voting within the outpatient subgroup to determine if an *indication* or *application* would have reached consensus for inclusion or exclusion within the outpatient expert subgroup alone (3 out of 4 outpatient experts). We found no difference in any voting outcome between the outpatient-only and combined expert groups. In other words, all *indications* and *applications* that reached the 75% inclusion threshold in the outpatient subgroup also met consensus for inclusion in the primary analysis that included all experts. There were, however, some clinical *indications* that would have been excluded by the outpatient expert subgroup (≤25% of votes) that ultimately fell into the "did not meet consensus" category in the primary analysis including: anasarca, hepatomegaly, splenomegaly, flank pain, injury—foreign body, lymphadenopathy, sepsis, and syncope.

CONCLUSIONS

The Alliance for Academic Internal Medicine has previously endorsed POCUS integration into internal medicine residency, as the optimum opportunity for longitudinal and clinically integrated training is within this phase of an internist's career.[12] However, several barriers during residency including limited curricular space and time exist.[83] Establishment of these consensus applications allows residency programs to focus limited resources on rigorous training within a subset of POCUS tied intimately to, and built directly from, common clinical indications encountered by internists. It also helps build a foundation for multi-institutional outcome research within internal medicine.

The results of this consensus panel represent the first expert and evidence-based recommendation for which POCUS elements should fall into a United States core internal medicine residency-based curriculum. These recommendations share similarities to, but also important differences from, those published for the core Canadian curriculum.[15] Canadian recommendations outline 11 diagnostic and 7 procedural applications. Of those, only one diagnostic (internal jugular vein for volume status) and 2 procedural (arterial line insertion, arterial blood gas) applications were not included by this panel. Furthermore, our recommendations outline additional *applications* and very specific *skill components* needed to properly perform each POCUS application. The reason for this difference may lie in the fact that the authors of the Canadian study aimed to define the "minimum" number of applications given resource limitations. Our panel set out to envision the optimum core *indications* and *applications*, not restrained by resource limitations. Defining this "ideal" model puts these recommendations in line with those of the American College of Emergency Physicians circa 2001, when Emergency Medicine began defining POCUS training pathways.[1] Another potential reason for differences between these 2 curricula is that our process uniquely started by defining the core clinical *indications* (eg, shortness of breath, acute kidney injury, etc.) for internal medicine and then worked backwards to define the necessary POCUS *applications* and *skill components* needed for each *indication*.

LIMITATIONS

It is important to emphasize that the aim of this consensus panel was to define the common *core* POCUS content for internal medicine residency training programs developing curricula, but it was not meant to limit or define the scope of POCUS practice among internists. POCUS applications that did not meet consensus in this study should not be seen as less valuable to the internist, as individual practice environments and internists with advanced skill in POCUS may find applications outside of this core content valuable. Though the majority of initial internal medicine POCUS use has occurred in the inpatient environment, the tool has the potential to be even more impactful in the outpatient environment, especially when diagnostic resources are limited.[84-85] This panel included a mix of in- and outpatient internists in an effort to find common core overlap between these environments to include in a single group of recommendations, but the panel recognizes that several applications such as musculoskeletal ultrasound, sinus ultrasound, valvular screening, athlete preparticipation exam elements such as hypertrophic cardiomyopathy, etc., may be considered key curricular elements for programs with residents focused on primary care despite not meeting consensus among this panel. The number of outpatient internists included on this panel allowed any consensus recommendation to be stopped by a unanimous outpatient opinion; however, a unanimous agreement by the outpatient subgroup alone would not have reached the consensus threshold. Thus, the subgroup analysis evaluated items meeting 75% consensus among the outpatient subgroup not included in the overall consensus items. The lack of any elements in this category supports a common overlap of at least the core inpatient and outpatient POCUS elements, but also leaves open future outpatient-specific work to establish refined core and advanced curricula for the outpatient-focused resident and practitioner.

FUTURE DIRECTIONS

Despite some recent emergence of internal medicine-specific POCUS outcome data,[86] there is a significant need for future outcome studies to help inform POCUS use among internists across inpatient and outpatient environments. As POCUS training becomes standard in internal medicine training, recommendations such as these will move away from the granular elements of what to teach, and instead towards other elements of running an effective POCUS program such as educational methods, competency assessment, documentation, credentialing and privileging, quality assurance and ultrasound program management, and value and reimbursement.[87] Other newer technological innovations, such as artificial intelligence integration and automation of image acquisition, will also influence how POCUS is learned and used by the internist.

There are still barriers to internal medicine POCUS training and use, and establishing a comprehensive, robust curriculum within IM residencies will be an aspirational goal for many. Local needs and resources must establish the foundation for each residency program's model. However, we hope these consensus-based recommendations help programs facilitate and standardize the most important components of their POCUS program, and that they can serve as a goal for long-term programmatic development and a common base for outcome research.

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SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjmed.2025.05.033.

Supplementary Table 1 Expert Characteristics.

Column1	Residency Type	Residency Program Role	Percentage Outpatient	Years Since Completing Residency	Years Using POCUS
Expert 1	Community	PD	15%	15	15
Expert 2	Community	Core faculty	10%	9	13
Expert 3	Community	Faculty	70%	3	3
Expert 4	University	Faculty	0%	6	8
Expert 5	Community	Core faculty	90%	2	4
Expert 6	University	Faculty	0%	16	19
Expert 7	University	APD	100%	30	15
Expert 8	University	APD	0%	9	7
Expert 9	University	Faculty	20%	8	8
Expert 10	Community	APD	66%	6	8
Expert 11	Community	APD	0%	16	13
Expert 12	University	Core faculty	0%	5	7
Expert 13	University	Core faculty	0%	10	7
Expert 14	Community	Faculty	0%	7	8

APD = associate program director; PD = program director.

Supplemental Table 2 Voting Results by Indication, Application, Skill, and Round of Voting.

Diagnostic Indications	Voting Round #1 Results		Voting Round #2 Results		Voting Round #3 Results		Final Outcome
	Yes	No	Yes	No	Yes	No	
AAA screening	93%	7%	86%	14%			Met inclusion
Abdominal distension	93%	7%	86%	14%			Met inclusion
Abdominal pain	93%	7%	36%	64%	100%	0%	Met inclusion
Acute eye pain	21%	79%	0%	100%			Met exclusion
Acute vision loss	36%	64%	7%	93%			Met exclusion
AKI/Reduced urinary output	100%	0%					Met inclusion
Altered mental status	14%	86%	0%	100%			Met exclusion
Anasarca	79%	21%	29%	71%			Did not meet
Cardiac arrest	86%	14%	71%	29%	86%	14%	Met inclusion
Cardiac palpitations	43%	57%	7%	93%			Met exclusion
Cellulitis/Abscess evaluation	100%	0%					Met inclusion
Chest pain	93%	7%	71%	29%	86%	14%	Met inclusion
Concern for hernia	71%	29%	21%	79%			Met exclusion
Concern for temporal arteritis	29%	71%	14%	86%			Met exclusion
Cough	79%	21%	57%	43%			Did not meet
Determination of volume status	100%	0%					Met inclusion
Dyspnea/hypoxia	100%	0%					Met inclusion
Dysuria	29%	71%	14%	86%			Met exclusion
Elevated LFTs	50%	50%	21%	79%			Met exclusion
Evaluation for cardiac valvular abnormalities	57%	43%	21%	79%			Met exclusion
Evaluation for internal bleeding (FAST)	79%	21%	21%	79%	57%	43%	Did not meet
Evaluation of intracranial pressure	43%	57%	14%	86%			Met exclusion
Extremity pain/swelling	93%	7%	100%	0%			Met inclusion
First trimester pregnancy	7%	93%	0%	100%			Met exclusion
Flank pain	86%	14%	57%	43%			Did not meet
Foreign body	86%	14%	50%	50%			Did not meet
Generalized weakness	29%	71%	0%	100%			Met exclusion
Headache	29%	71%	0%	100%			Met exclusion
Injury–concern for boney fracture	57%	43%	21%	79%			Met exclusion
Intubation	36%	64%	14%	86%			Met exclusion
Joint pain/swelling	93%	7%	86%	14%			Met inclusion
Leukocytosis	7%	93%	0%	100%			Met exclusion
Lymphadenopathy	57%	43%	36%	64%			Did not meet
Metabolic acidosis	7%	93%	0%	100%			Met exclusion
Nausea/vomiting	29%	71%	7%	93%			Met exclusion
Neuropathic symptoms concerning for entrapment syndrome	29%	71%	14%	86%			Met exclusion
Perioperative evaluation	71%	29%	14%	86%			Met exclusion
Preathletic cardiac screening	29%	71%	7%	93%			Met exclusion

Supplemental Table 2 (*Continued*)

Diagnostic Indications	Voting Round #1 Results		Voting Round #2 Results		Voting Round #3 Results		Final Outcome
	Yes	No	Yes	No	Yes	No	
Sepsis	50%	50%	29%	71%			Did not meet
Shock	100%	0%					Met inclusion
Sinusitis	64%	36%	36%	64%			Did not meet
Soft tissue mass	79%	21%	50%	50%			Did not meet
Syncope	71%	29%	36%	64%			Did not meet
Tendinopathy	64%	36%	21%	79%			Met exclusion
Testicular pain/mass	29%	71%	7%	93%			Met exclusion
Thyroid pain/mass	43%	57%	21%	79%			Met exclusion
Undifferentiated fever	29%	71%	0%	100%			Met exclusion

Procedural indications	Voting round #1 results		Voting round #2 results		Voting round #3 results		Final outcome
	Yes	No	Yes	No	Yes	No	
Arthrocentesis	100%	0%					Met inclusion
Central venous catheterization	100%	0%					Met inclusion
Lumbar puncture marking	93%	7%	86%	14%			Met inclusion
Paracentesis	100%	0%					Met inclusion
Pericardiocentesis	14%	86%	0%	100%			Met exclusion
Peripheral IV	86%	14%	71%	29%	86%	14%	Met inclusion
Thoracentesis	100%	0%					Met inclusion

Diagnostic indications	Associated applications	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
AAA screening	Thorax–Lung ultrasound	0%	100%			Met exclusion
	Thorax–Pleural ultrasound	0%	100%			Met exclusion
	Thorax–Free fluid	0%	100%			Met exclusion
	Focused cardiac ultrasound	0%	100%			Met exclusion
	Inferior vena cava	14%	86%	43%	57%	Did not meet
	Renal ultrasound	0%	100%			Met exclusion
	Urinary bladder	0%	100%			Met exclusion
	Gallbladder	0%	100%			Met exclusion
	Abdominal aorta	100%	0%	100%	0%	Met inclusion
	Abdominal–Free fluid	14%	86%	0%	100%	Met exclusion
	Abdomen–spleen	0%	100%			Met exclusion
	Abdomen–liver	0%	100%			Met exclusion
	Abdomen–small bowel	0%	100%			Met exclusion

Supplemental Table 2 (*Continued*)

Diagnostic indications	Associated applications	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	0%	100%			Met exclusion
	DVT–upper extremity	0%	100%			Met exclusion
	Skin and soft tissue	0%	100%			Met exclusion
	Joint–shoulder	0%	100%			Met exclusion
	Joint–hip	0%	100%			Met exclusion
	Joint–elbow	0%	100%			Met exclusion
	Joint–knee	0%	100%			Met exclusion
	Joint–wrist	0%	100%			Met exclusion
	Joint–ankle	0%	100%			Met exclusion
	Small joints	0%	100%			Met exclusion
	Other (please specify)	0%	100%			Met exclusion
Abdominal Distension	Thorax–Lung ultrasound	0%	100%			Met exclusion
	Thorax–Pleural ultrasound	0%	100%			Met exclusion
	Thorax–Free fluid	0%	100%			Met exclusion
	Focused cardiac ultrasound	7%	93%	0%	100%	Met exclusion
	Inferior vena cava	7%	93%	0%	100%	Met exclusion
	Renal ultrasound	29%	71%	21%	79%	Met exclusion
	Urinary bladder	21%	79%	86%	14%	Met inclusion
	Gallbladder	0%	100%			Met exclusion
	Abdominal aorta	7%	93%	7%	93%	Met exclusion
	Abdominal–Free fluid	100%	0%	93%	7%	Met inclusion
	Abdomen–spleen	64%	36%	86%	14%	Met inclusion
	Abdomen–liver	57%	43%	86%	14%	Met inclusion
	Abdomen–small bowel	36%	64%	43%	57%	Did not meet
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	0%	100%			Met exclusion
	DVT–upper extremity	0%	100%			Met exclusion
	Skin and soft tissue	0%	100%			Met exclusion
	Joint–shoulder	0%	100%			Met exclusion
	Joint–hip	0%	100%			Met exclusion
	Joint–elbow	0%	100%			Met exclusion
	Joint–knee	0%	100%			Met exclusion
	Joint–wrist	0%	100%			Met exclusion
	Joint–ankle	0%	100%			Met exclusion
	Small joints	0%	100%			Met exclusion

Supplemental Table 2 (*Continued*)

Diagnostic indications	Associated applications	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Other (Gastric bubble)	7%	93%	7%	93%	Met exclusion
Abdominal Pain	Thorax–Lung ultrasound	0%	100%			Met exclusion
	Thorax–Pleural ultrasound	0%	100%			Met exclusion
	Thorax–Free fluid	7%	93%	7%	93%	Met exclusion
	Focused cardiac ultrasound	0%	100%			Met exclusion
	Inferior vena cava	0%	100%			Met exclusion
	Renal ultrasound	71%	29%	79%	21%	Met inclusion
	Urinary bladder	79%	21%	93%	7%	Met inclusion
	Gallbladder	93%	7%	86%	14%	Met inclusion
	Abdominal aorta	79%	21%	86%	14%	Met inclusion
	Abdominal–Free fluid	86%	14%	100%	0%	Met inclusion
	Abdomen–spleen	64%	36%	71%	29%	Did not meet
	Abdomen–liver	64%	36%	64%	36%	Did not meet
	Abdomen–small bowel	64%	36%	43%	57%	Did not meet
	Abdomen–appendix	21%	79%	0%	100%	Met exclusion
	Abdomen–pancreas	21%	79%	7%	93%	Met exclusion
	DVT–lower extremity	0%	100%			Met exclusion
	DVT–upper extremity	0%	100%			Met exclusion
	Skin and soft tissue	0%	100%			Met exclusion
	Joint–shoulder	0%	100%			Met exclusion
	Joint–hip	0%	100%			Met exclusion
	Joint–elbow	0%	100%			Met exclusion
	Joint–knee	0%	100%			Met exclusion
	Joint–wrist	0%	100%			Met exclusion
	Joint–ankle	0%	100%			Met exclusion
	Small joints	0%	100%			Met exclusion
	Other (Gastric bubble)	7%	93%	0%	100%	Met exclusion
Acute Kidney Injury/Reduced urinary output	Thorax–Lung ultrasound	7%	93%	36%	64%	Did not meet
	Thorax–Pleural ultrasound	0%	100%			Met exclusion
	Thorax–Free fluid	7%	93%	14%	86%	Met exclusion
	Focused cardiac ultrasound	43%	57%	57%	43%	Did not meet
	Inferior vena cava	50%	50%	71%	29%	Did not meet
	Renal ultrasound	100%	0%	100%	0%	Met inclusion
	Urinary bladder	100%	0%	100%	0%	Met inclusion
	Gallbladder	0%	100%			Met exclusion
	Abdominal aorta	0%	100%			Met exclusion
	Abdominal–Free fluid	7%	93%	0%	100%	Met exclusion
	Abdomen–spleen	0%	100%			Met exclusion

Supplemental Table 2 (*Continued*)

Diagnostic indications	Associated applications	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Abdomen–liver	0%	100%			Met exclusion
	Abdomen–small bowel	0%	100%			Met exclusion
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	0%	100%			Met exclusion
	DVT–upper extremity	0%	100%			Met exclusion
	Skin and soft tissue	0%	100%			Met exclusion
	Joint–shoulder	0%	100%			Met exclusion
	Joint–hip	0%	100%			Met exclusion
	Joint–elbow	0%	100%			Met exclusion
	Joint–knee	0%	100%			Met exclusion
	Joint–wrist	0%	100%			Met exclusion
	Joint–ankle	0%	100%			Met exclusion
	Small joints	0%	100%			Met exclusion
	Other (please specify)	0%	100%			Met exclusion
Cardiac Arrest	Thorax–Lung ultrasound	29%	71%	21%	79%	Met exclusion
	Thorax–Pleural ultrasound	71%	29%	86%	14%	Met inclusion
	Thorax–Free fluid	43%	57%	21%	79%	Met exclusion
	Focused cardiac ultrasound	100%	0%	100%	0%	Met inclusion
	Inferior vena cava	50%	50%	43%	57%	Did not meet
	Renal ultrasound	0%	100%			Met exclusion
	Urinary bladder	0%	100%			Met exclusion
	Gallbladder	0%	100%			Met exclusion
	Abdominal aorta	29%	71%	14%	86%	Met exclusion
	Abdominal–Free fluid	29%	71%	14%	86%	Met exclusion
	Abdomen–spleen	0%	100%			Met exclusion
	Abdomen–liver	0%	100%			Met exclusion
	Abdomen–small bowel	0%	100%			Met exclusion
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	50%	50%	64%	36%	Did not meet
	DVT–upper extremity	0%	100%			Met exclusion
	Skin and soft tissue	0%	100%			Met exclusion
	Joint–shoulder	0%	100%			Met exclusion
	Joint–hip	0%	100%			Met exclusion
	Joint–elbow	0%	100%			Met exclusion
	Joint–knee	0%	100%			Met exclusion
	Joint–wrist	0%	100%			Met exclusion

Supplemental Table 2 (*Continued*)

Diagnostic indications	Associated applications	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Joint–ankle	0%	100%			Met exclusion
	Small joints	0%	100%			Met exclusion
	Other (please specify)	0%	100%			Met exclusion
Cellulitis/abscess evaluation	Thorax–Lung ultrasound	0%	100%			Met exclusion
	Thorax–Pleural ultrasound	0%	100%			Met exclusion
	Thorax–Free fluid	0%	100%			Met exclusion
	Focused cardiac ultrasound	0%	100%			Met exclusion
	Inferior vena cava	0%	100%			Met exclusion
	Renal ultrasound	0%	100%			Met exclusion
	Urinary bladder	0%	100%			Met exclusion
	Gallbladder	0%	100%			Met exclusion
	Abdominal aorta	0%	100%			Met exclusion
	Abdominal–Free fluid	0%	100%			Met exclusion
	Abdomen–spleen	0%	100%			Met exclusion
	Abdomen–liver	0%	100%			Met exclusion
	Abdomen–small bowel	0%	100%			Met exclusion
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	7%	93%	21%	79%	Met exclusion
	DVT–upper extremity	0%	100%			Met exclusion
	Skin and soft tissue	100%	0%	100%	0%	Met inclusion
	Joint–shoulder	0%	100%			Met exclusion
	Joint–hip	0%	100%			Met exclusion
	Joint–elbow	0%	100%			Met exclusion
	Joint–knee	0%	100%			Met exclusion
	Joint–wrist	0%	100%			Met exclusion
	Joint–ankle	0%	100%			Met exclusion
	Small joints	0%	100%			Met exclusion
	Other (please specify)	0%	100%			Met exclusion
Chest pain	Thorax–Lung ultrasound	100%	0%	93%	7%	Met inclusion
	Thorax–Pleural ultrasound	100%	0%	86%	14%	Met inclusion
	Thorax–Free fluid	86%	14%	71%	29%	Did not meet
	Focused cardiac ultrasound	100%	0%	100%	0%	Met inclusion
	Inferior vena cava	29%	71%	36%	64%	Did not meet
	Renal ultrasound	0%	100%			Met exclusion
	Urinary bladder	0%	100%			Met exclusion
	Gallbladder	0%	100%			Met exclusion
	Abdominal aorta	7%	93%	7%	93%	Met exclusion

Supplemental Table 2 (*Continued*)

Diagnostic indications	Associated applications	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Abdominal–Free fluid	0%	100%			Met exclusion
	Abdomen–spleen	0%	100%			Met exclusion
	Abdomen–liver	0%	100%			Met exclusion
	Abdomen–small bowel	0%	100%			Met exclusion
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	43%	57%	71%	29%	Did not meet
	DVT–upper extremity	0%	100%			Met exclusion
	Skin and soft tissue	0%	100%			Met exclusion
	Joint–shoulder	0%	100%			Met exclusion
	Joint–hip	0%	100%			Met exclusion
	Joint–elbow	0%	100%			Met exclusion
	Joint–knee	0%	100%			Met exclusion
	Joint–wrist	0%	100%			Met exclusion
	Joint–ankle	0%	100%			Met exclusion
	Small joints	0%	100%			Met exclusion
	Other (please specify)	0%	100%			Met exclusion
Determination of volume status	Thorax––Lung ultrasound	79%	21%	93%	7%	Met inclusion
	Thorax–Pleural ultrasound	29%	71%	14%	86%	Met exclusion
	Thorax–Free fluid	71%	29%	71%	29%	Did not meet
	Focused cardiac ultrasound	86%	14%	93%	7%	Met inclusion
	Inferior vena cava	100%	0%	100%	0%	Met inclusion
	Renal ultrasound	29%	71%	7%	93%	Met exclusion
	Urinary bladder	29%	71%	14%	86%	Met exclusion
	Gallbladder	0%	100%			Met exclusion
	Abdominal aorta	7%	93%	0%	100%	Met exclusion
	Abdominal–Free fluid	21%	79%	21%	79%	Met exclusion
	Abdomen–spleen	0%	100%			Met exclusion
	Abdomen–liver	7%	93%	0%	100%	Met exclusion
	Abdomen–small bowel	0%	100%			Met exclusion
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	0%	100%			Met exclusion
	DVT–upper extremity	0%	100%			Met exclusion
	Skin and soft tissue	0%	100%			Met exclusion
	Joint–shoulder	0%	100%			Met exclusion
	Joint–hip	0%	100%			Met exclusion
	Joint–elbow	0%	100%			Met exclusion

Supplemental Table 2 (*Continued*)

Diagnostic indications	Associated applications	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Joint–knee	0%	100%			Met exclusion
	Joint–wrist	0%	100%			Met exclusion
	Joint–ankle	0%	100%			Met exclusion
	Small joints	0%	100%			Met exclusion
	Other (please specify)	0%	100%			Met exclusion
Dyspnea/Hypoxia	Thorax–Lung ultrasound	100%	0%	100%	0%	Met inclusion
	Thorax–Pleural ultrasound	100%	0%	93%	7%	Met inclusion
	Thorax–Free fluid	100%	0%	100%	0%	Met inclusion
	Focused cardiac ultrasound	100%	0%	100%	0%	Met inclusion
	Inferior vena cava	93%	7%	79%	21%	Met inclusion
	Renal ultrasound	0%	100%			Met exclusion
	Urinary bladder	0%	100%			Met exclusion
	Gallbladder	0%	100%			Met exclusion
	Abdominal aorta	0%	100%			Met exclusion
	Abdominal–Free fluid	21%	79%	21%	79%	Met exclusion
	Abdomen–spleen	0%	100%			Met exclusion
	Abdomen–liver	0%	100%			Met exclusion
	Abdomen–small bowel	0%	100%			Met exclusion
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	64%	36%	100%	0%	Met inclusion
	DVT–upper extremity	7%	93%	0%	100%	Met exclusion
	Skin and soft tissue	0%	100%			Met exclusion
	Joint–shoulder	0%	100%			Met exclusion
	Joint–hip	0%	100%			Met exclusion
	Joint–elbow	0%	100%			Met exclusion
	Joint–knee	0%	100%			Met exclusion
	Joint–wrist	0%	100%			Met exclusion
	Joint–ankle	0%	100%			Met exclusion
	Small joints	0%	100%			Met exclusion
	Other (please specify)	0%	100%			Met exclusion
Extremity pain/swelling	Thorax–Lung ultrasound	7%	93%	0%	100%	Met exclusion
	Thorax–Pleural ultrasound	7%	93%	0%	100%	Met exclusion
	Thorax–Free fluid	7%	93%	0%	100%	Met exclusion
	Focused cardiac ultrasound	7%	93%	7%	93%	Met exclusion
	Inferior vena cava	7%	93%	0%	100%	Met exclusion
	Renal ultrasound	0%	100%			Met exclusion
	Urinary bladder	0%	100%			Met exclusion

Supplemental Table 2 (*Continued*)

Diagnostic indications	Associated applications	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Gallbladder	0%	100%			Met exclusion
	Abdominal aorta	0%	100%			Met exclusion
	Abdominal–Free fluid	7%	93%	0%	100%	Met exclusion
	Abdomen–spleen	0%	100%			Met exclusion
	Abdomen–liver	0%	100%			Met exclusion
	Abdomen–small bowel	0%	100%			Met exclusion
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	100%	0%	100%	0%	Met inclusion
	DVT–upper extremity	43%	57%	43%	57%	Did not meet
	Skin and soft tissue	93%	7%	86%	14%	Met inclusion
	Joint–shoulder	14%	86%			Met exclusion
	Joint–hip	14%	86%			Met exclusion
	Joint–elbow	14%	86%			Met exclusion
	Joint–knee	36%	64%			Did not meet
	Joint–wrist	14%	86%			Met exclusion
	Joint–ankle	14%	86%			Met exclusion
	Small joints	14%	86%			Met exclusion
	Other (please specify)	14%	86%			Met exclusion
Joint pain/swelling	Thorax–Lung ultrasound	0%	100%			Met exclusion
	Thorax–Pleural ultrasound	0%	100%			Met exclusion
	Thorax–Free fluid	0%	100%			Met exclusion
	Focused cardiac ultrasound	0%	100%			Met exclusion
	Inferior vena cava	0%	100%			Met exclusion
	Renal ultrasound	0%	100%			Met exclusion
	Urinary bladder	0%	100%			Met exclusion
	Gallbladder	0%	100%			Met exclusion
	Abdominal aorta	0%	100%			Met exclusion
	Abdominal–Free fluid	0%	100%			Met exclusion
	Abdomen–spleen	0%	100%			Met exclusion
	Abdomen–liver	0%	100%			Met exclusion
	Abdomen–small bowel	0%	100%			Met exclusion
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	29%	71%			Did not meet
	DVT–upper extremity	21%	79%			Met exclusion
	Skin and soft tissue	36%	64%			Did not meet
	Joint–shoulder	64%	36%	50%	50%	Did not meet
	Joint–hip	43%	57%	36%	64%	Did not meet

Supplemental Table 2 (*Continued*)

Diagnostic indications	Associated applications	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Joint–elbow	43%	57%	36%	64%	Did not meet
	Joint–knee	100%	0%	100%	0%	Met inclusion
	Joint–wrist	43%	57%	43%	57%	Did not meet
	Joint–ankle	43%	57%	36%	64%	Did not meet
	Small joints	36%	64%	14%	86%	Met exclusion
	Other (please specify)	0%	100%			Met exclusion
Shock	Thorax–Lung ultrasound	71%	29%	93%	7%	Met inclusion
	Thorax–Pleural ultrasound	93%	7%	93%	7%	Met inclusion
	Thorax–Free fluid	86%	14%	79%	21%	Met inclusion
	Focused cardiac ultrasound	100%	0%	100%	0%	Met inclusion
	Inferior vena cava	100%	0%	100%	0%	Met inclusion
	Renal ultrasound	0%	100%			Met exclusion
	Urinary bladder	7%	93%	7%	93%	Met exclusion
	Gallbladder	7%	93%	0%	100%	Met exclusion
	Abdominal aorta	71%	29%	79%	21%	Met inclusion
	Abdominal–Free fluid	86%	14%	79%	21%	Met inclusion
	Abdomen–spleen	0%	100%			Met exclusion
	Abdomen–liver	0%	100%			Met exclusion
	Abdomen–small bowel	0%	100%			Met exclusion
	Abdomen–appendix	0%	100%			Met exclusion
	Abdomen–pancreas	0%	100%			Met exclusion
	DVT–lower extremity	79%	21%	93%	7%	Met inclusion
	DVT–upper extremity	0%	100%			Met exclusion
	Skin and soft tissue	0%	100%			Met exclusion
	Joint–shoulder	0%	100%			Met exclusion
	Joint–hip	0%	100%			Met exclusion
	Joint–elbow	0%	100%			Met exclusion
	Joint–knee	0%	100%			Met exclusion
	Joint–wrist	0%	100%			Met exclusion
	Joint–ankle	0%	100%			Met exclusion
	Small joints	0%	100%			Met exclusion
	Other (please specify)	0%	100%			Met exclusion

Procedural indications	Associated applications	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
Arthrocentesis	Static needle guidance (marking site)	86%	14%	100%	0%	Met inclusion
	Dynamic needle guidance (in plane)	64%	36%	64%	36%	Did not meet
	Dynamic needle guidance (out of plane)	36%	64%	36%	64%	Did not meet
	Dynamic needle guidance (oblique plane)	0%	100%			Met exclusion
	Anatomic study for critical structure identification	64%	36%	86%	14%	Met inclusion
Central venous catheterization	Static needle guidance (marking site)	21%	79%	21%	79%	Met exclusion
	Dynamic needle guidance (in plane)	64%	36%	64%	36%	Did not meet
	Dynamic needle guidance (out of plane)	79%	21%	93%	7%	Met inclusion
	Dynamic needle guidance (oblique plane)	0%	100%			Met exclusion
	Anatomic study for critical structure identification	79%	21%	93%	7%	Met inclusion
Lumbar puncture marking	Static needle guidance (marking site)	93%	7%	100%	0%	Met inclusion
	Dynamic needle guidance (in plane)	0%	100%			Met exclusion
	Dynamic needle guidance (out of plane)	0%	100%			Met exclusion
	Dynamic needle guidance (oblique plane)	0%	100%			Met exclusion
	Anatomic study for critical structure identification	79%	21%	86%	14%	Met inclusion
Paracentesis	Static needle guidance (marking site)	100%	0%	100%	0%	Met inclusion
	Dynamic needle guidance (in plane)	36%	64%	36%	64%	Did not meet
	Dynamic needle guidance (out of plane)	29%	71%	29%	71%	Did not meet
	Dynamic needle guidance (oblique plane)	0%	100%			Met exclusion
	Anatomic study for critical structure identification	79%	21%	100%	0%	Met inclusion
Peripheral IV	Static needle guidance (marking site)	29%	71%	21%	79%	Met exclusion
	Dynamic needle guidance (in plane)	57%	43%	71%	29%	Did not meet
	Dynamic needle guidance (out of plane)	64%	36%	86%	14%	Met inclusion
	Dynamic needle guidance (oblique plane)	0%	100%			Met exclusion
	Anatomic study for critical structure identification	57%	43%	64%	36%	Did not meet
Thoracentesis	Static needle guidance (marking site)	100%	0%	100%	0%	Met inclusion
	Dynamic needle guidance (in plane)	29%	71%	29%	71%	Did not meet
	Dynamic needle guidance (out of plane)	29%	71%	29%	71%	Did not meet
	Dynamic needle guidance (oblique plane)	0%	100%			Met exclusion
	Anatomic study for critical structure identification	79%	21%	100%	0%	Met inclusion

Diagnostic applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
Fundamentals–Physics	Frequency	100%	0%			Met inclusion
	Penetration	93%	7%	100%	0%	Met inclusion
	Reflection/Refraction/Scatter/Absorption	100%	0%			Met inclusion
	Echogenicity and image formation	100%	0%			Met inclusion
	Doppler principles	93%	7%	93%	7%	Met inclusion
	Thermal/Mechanical Index (ALARA)	50%	50%	50%	50%	Did not meet
Fundamentals–Transducer selection	Linear Array	100%	0%			Met inclusion
	Curvilinear Array	100%	0%			Met inclusion
	Phased Array	100%	0%			Met inclusion
Fundamentals–Transducer movements	Sliding	100%	0%			Met inclusion
	Rocking	100%	0%			Met inclusion
	Tilting	93%	7%	93%	7%	Met inclusion
	Rotating	100%	0%			Met inclusion
	Compression	100%	0%			Met inclusion
Fundamentals–Modes	2D/B-mode	100%	0%			Met inclusion
	Color Flow Doppler	100%	0%			Met inclusion
	M-Mode	100%	0%			Met inclusion
	Power Doppler	64%	36%	86%	14%	Met inclusion
	Spectral Doppler	29%	71%	14%	86%	Met exclusion
Fundamentals–Image Optimization	Exam Type Presets	100%	0%			Met inclusion
	Depth	100%	0%			Met inclusion
	Gain	100%	0%			Met inclusion
	Focus	93%	7%	93%	7%	Met inclusion
	Time Gain Compensation	86%	14%	79%	21%	Met inclusion
Fundamentals–Color doppler optimization	Nyquist limit	57%	43%	36%	64%	Did not meet
	Color box size	93%	7%			Met inclusion
	Steering	50%	50%	14%	86%	Met exclusion
	Color gain	79%	21%	86%	14%	Met inclusion
	Pulse Repetition Frequency (PRF)	43%	57%	43%	57%	Did not meet
Fundamentals–Artifacts	Posterior Acoustic Shadow	100%	0%			Met inclusion
	Posterior Acoustic Enhancements	93%	7%	100%	0%	Met inclusion
	Reverberation	100%	0%			Met inclusion
	Edge Shadow	93%	7%	93%	7%	Met inclusion
	Side Lobe	79%	21%	93%	7%	Met inclusion
	Aliasing	71%	29%	86%	14%	Met inclusion
Fundamentals–Machine Maintenance	Transducer Care	100%	0%			Met inclusion
	Cleaning	100%	0%			Met inclusion
	Cord Management	86%	14%	93%	7%	Met inclusion
	Sterile Technique for Probe Use	100%	0%			Met inclusion

Supplemental Table 2 (*Continued*)

Diagnostic applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
Fundamentals–POCUS as a Diagnostic Test	Test characteristics–Sensitivity/Specificity/Likelihood ratios	100%	0%			Met inclusion
	Bias specific to POCUS	86%	14%	100%	0%	Met inclusion
Fundamentals–Physician/Patient Interaction–Appropriate Draping	Response	100%	0%			Met inclusion
Abdomen–Liver: Structure Identification	Liver	100%	0%			Met inclusion
	Portal Vein	79%	21%	86%	14%	Met inclusion
	Hepatic Vein	71%	29%	79%	21%	Met inclusion
	Hepatic Artery	21%	79%	14%	86%	Met exclusion
Abdomen–Liver: Evaluation of	Liver size	86%	14%	100%	0%	Met inclusion
	Liver echotexture	79%	21%	36%	64%	Did not meet
	Liver contour	57%	43%	14%	86%	Met exclusion
	Liver mass	57%	43%	21%	79%	Met exclusion
	Hepatic vein flow–spectral doppler (VEXUS)	0%	100%			Met exclusion
	Portal vein flow–spectral doppler (VEXUS)	7%	93%	0%	100%	Met exclusion
Abdomen–Spleen: Structure Identification–Spleen	Response	100%	0%			Met inclusion
Abdomen–Spleen: Evaluation of–Spleen size	Response	100%	0%			Met inclusion
Abdominal Aorta: Structure Identification	Proximal aorta	100%	0%			Met inclusion
	Mid aorta	100%	0%			Met inclusion
	Distal aorta	100%	0%			Met inclusion
	Celiac trunk	93%	7%	93%	7%	Met inclusion
	Superior mesenteric artery	86%	14%	93%	7%	Met inclusion
	Bifurcation of the aorta	100%	0%			Met inclusion
	Proximal iliac arteries	79%	21%	100%	0%	Met inclusion
	Vertebral body	100%	0%			Met inclusion
	Inferior vena cava	100%	0%			Met inclusion
Abdominal Aorta: Evaluation for	Aortic diameter (cross section)	100%	0%	93%	7%	Met inclusion
	Aortic diameter (longitudinal)	79%	21%			Met inclusion
	Aneurysm diameter (cross section)	93%	7%	100%	0%	Met inclusion
	Aneurysm diameter (longitudinal)	79%	21%	64%	36%	Did not meet
Abdominal Aorta: Pitfalls	Response	100%	0%			Met inclusion
Abdomen–Free Fluid: Structure Identification	Liver	100%	0%			Met inclusion
	Right kidney	100%	0%			Met inclusion
	Left kidney	100%	0%			Met inclusion
	Hepatorenal recess	100%	0%			Met inclusion

Supplemental Table 2 (*Continued*)

Diagnostic applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Spleen	100%	0%			Met inclusion
	Splenorenal recess	100%	0%			Met inclusion
	Diaphragm	100%	0%			Met inclusion
	Subdiaphragmatic space/recess	93%	7%	100%	0%	Met inclusion
	Inferior liver tip (right paracolic gutter)	93%	7%	100%	0%	Met inclusion
	Inferior spleen tip (left paracolic gutter)	93%	7%	100%	0%	Met inclusion
	Rectovesical pouch (male patients)	86%	14%	100%	0%	Met inclusion
	rectouterine / pouch of Douglas (female patients)	93%	7%	100%	0%	Met inclusion
	Uterovesical pouch (some female patients)	64%	36%	93%	7%	Met inclusion
	Bowel	93%	7%	100%	0%	Met inclusion
	Bladder	100%	0%			Met inclusion
Abdomen–Free Fluid: Evaluation for	Anechoic signal	100%	0%			Met inclusion
	Loculations/septations	93%	7%	100%	0%	Met inclusion
	"Plankton sign"	50%	50%	50%	50%	Did not meet
	Bowel loops	100%	0%			Met inclusion
Abdomen–Free Fluid: Pitfalls	Response	100%	0%			Met inclusion
LE DVT: Structure Identification	Common Femoral vein and artery	100%	0%			Met inclusion
	Saphenous vein	93%	7%	100%	0%	Met inclusion
	Lateral perforator veins	93%	7%	93%	7%	Met inclusion
	Deep Femoral vein and artery	100%	0%			Met inclusion
	(Superficial) Femoral vein and artery	100%	0%			Met inclusion
	Popliteal vein and artery	100%	0%			Met inclusion
	Popliteal vein branching	71%	29%	93%	7%	Met inclusion
	Lymph node	93%	7%	93%	7%	Met inclusion
LE DVT: Evaluation for DVT	2D compression for rule out thrombus	93%	7%	86%	14%	Met inclusion
	2-point compression ultrasound method	21%	79%	7%	93%	Met exclusion
	2-zone compression ultrasound method	71%	29%	57%	43%	Did not meet
	Extended compression ultrasound method	50%	50%	64%	36%	Did not meet
	Color flow doppler of veins	50%	50%	29%	71%	Did not meet
	Respiratory variation	21%	79%	7%	93%	Met exclusion
	Augmentation	14%	86%	7%	93%	Met exclusion
LE DVT: Pitfalls	Response	100%	0%			Met inclusion
FCU PLAX: Structure Identification	LA	100%	0%			Met inclusion
	LV	100%	0%			Met inclusion
	LVOT	100%	0%			Met inclusion
	RVOT	100%	0%			Met inclusion
	MV–anterior and posterior mitral valve leaflets	100%	0%			Met inclusion
	AV–right coronary cusp and noncoronary cusp	86%	14%	93%	7%	Met inclusion

Supplemental Table 2 (*Continued*)

Diagnostic applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Pericardium	100%	0%			Met inclusion
	Epicardial fat pad	93%	7%	100%	0%	Met inclusion
	Descending thoracic aorta	100%	0%			Met inclusion
	Pericardial effusion	93%	7%	100%	0%	Met inclusion
	Left pleural effusion	93%	7%	100%	0%	Met inclusion
FCU PLAX: Evaluation for LVSF (Qualitative)	Hyperdynamic	71%	29%	93%	7%	Met inclusion
	Normal	100%	0%			Met inclusion
	Reduced (regardless of degree as opposed to graded [mildly/moderately/severely])	50%	50%	71%	29%	Did not meet
	Mildly reduced	36%	64%	29%	71%	Did not meet
	Moderately reduced	64%	36%	50%	50%	Did not meet
	Severely reduced	86%	14%	86%	14%	Met inclusion
FCU PLAX: Evaluation for LVSF	Endocardial excursion	85%	15%	100%	0%	Met inclusion
	Myocardial thickening	92%	8%	100%	0%	Met inclusion
	E-point septal separation (B-mode)	77%	23%	100%	0%	Met inclusion
	E-point septal separation (B-mode with measurement)	23%	77%	0%	100%	Met exclusion
	E-point septal separation (M-mode with measurement)	23%	77%	7%	93%	Met exclusion
FCU PLAX: Evaluation for wall motion abnormalities	Mid and basal anteroseptal	100%	0%			Met inclusion
	Mid and basal inferolateral	100%	0%			Met inclusion
FCU PLAX: Evaluation for mitral regurgitation with color flow doppler	Response	57%	43%	21%	79%	Met exclusion
FCU PLAX: Evaluation for LV hypertrophy	Response	57%	43%	21%	79%	Met exclusion
FCU PLAX: Evaluation for left atrial enlargement	2D size measurements	36%	64%	14%	86%	Met exclusion
	LA area calculation	0%	100%			Met exclusion
	"Eyeballing" (compared to proximal aorta size)	93%	7%	86%	14%	Met inclusion
FCU PLAX: Evaluation for aortic regurgitation with color flow doppler	Response	57%	43%	21%	79%	Met exclusion
FCU PLAX: Evaluation for aortic stenosis with 2D/B-mode	Gross calcification	82%	18%	100%	0%	Met inclusion
	Gross impaired opening	100%	0%			Met inclusion
FCU PLAX: Evaluation for aortic stenosis with color flow doppler	Response	14%	86%	7%	93%	Met exclusion
FCU PLAX: Evaluation for valvular vegetations	Response	43%	57%	21%	79%	Met exclusion
FCU PSAX: Structure Identification–Mid-Papillary Level	Interventricular septum	100%	0%			Met inclusion
	LV	100%	0%			Met inclusion

Supplemental Table 2 (*Continued*)

Diagnostic applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	RV	100%	0%			Met inclusion
	Papillary muscles	100%	0%			Met inclusion
	Pericardium	100%	0%			Met inclusion
	LV wall segments	64%	36%	100%	0%	Met inclusion
FCU PSAX: Structure Identification–Mitral Valve Level	Interventricular septum	100%	0%			Met inclusion
	LV	100%	0%			Met inclusion
	RV	100%	0%			Met inclusion
	Mitral valve	100%	0%			Met inclusion
	Wall segments	43%	57%	100%	0%	Met inclusion
FCU PSAX: Structure Identification–Aortic Valve Level	AV	100%	0%			Met inclusion
	LA	92%	8%	100%	0%	Met inclusion
	RVOT	92%	8%	100%	0%	Met inclusion
	RA	92%	8%	100%	0%	Met inclusion
	TV	85%	15%	92%	8%	Met inclusion
	PV	85%	15%	83%	17%	Met inclusion
	Pulmonary trunk/pulmonary arteries	62%	38%	67%	33%	Did not meet
FCU PSAX: Structure Identification–Apical Level	LV	100%	0%			Met inclusion
	Wall segments	46%	54%	100%	0%	Met inclusion
FCU PSAX: Evaluation for	LVSF (qualitative)	93%	7%	100%	0%	Met inclusion
	LVSF (quantitative)	7%	93%	0%	100%	Met exclusion
	LV hypertrophy	57%	43%	21%	79%	Met exclusion
	RV pressure/volume overload	79%	21%	79%	21%	Met inclusion
	RV enlargement	71%	29%	79%	21%	Met inclusion
	Regional wall motion abnormalities	21%	79%	7%	93%	Met exclusion
FCU A4C: Structure identification	LV	100%	0%			Met inclusion
	RV	100%	0%			Met inclusion
	LA	100%	0%			Met inclusion
	RA	100%	0%			Met inclusion
	AV–(A5C)	79%	21%	92%	8%	Met inclusion
	Desc Thoracic Ao	79%	21%	100%	0%	Met inclusion
	L/R pleural space	79%	21%	92%	8%	Met inclusion
	Pericardial space	100%	0%			Met inclusion
FCU A4C: Evaluation for	LVSF	100%	0%			Met inclusion
	RV Longitudinal Systolic Function (TAPSE)–B-mode	46%	54%	17%	83%	Met exclusion
	RV Longitudinal Systolic Function (TAPSE)–M-mode	15%	85%	17%	83%	Met exclusion
	LA enlargement	77%	23%	58%	42%	Did not meet
	CFD for gross MR	69%	31%	42%	58%	Did not meet
	RA enlargement	69%	31%	42%	58%	Did not meet

Supplemental Table 2 (*Continued*)

Diagnostic applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	CFD for gross TR	62%	38%	42%	58%	Did not meet
	RV enlargement	85%	15%	83%	17%	Met inclusion
	L/R pleural effusion	62%	38%	58%	42%	Did not meet
	Pericardial effusion	100%	0%			Met inclusion
	Cardiac output (A5c)	0%	100%			Met exclusion
FCU SC4: Structure identification	LV	100%	0%			Met inclusion
	RV	100%	0%			Met inclusion
	LA	100%	0%			Met inclusion
	RA	100%	0%			Met inclusion
	AV	86%	14%			Met inclusion
	Descending Thoracic Aorta	57%	43%	62%	38%	Did not meet
	L/R pleural space	79%	21%	100%	0%	Met inclusion
	Pericardial space	100%	0%			Met inclusion
	Peritoneal (ascitic) space	79%	21%	100%	0%	Met inclusion
	Liver	100%	0%			Met inclusion
	Diaphragm	100%	0%			Met inclusion
FCU SC4: Evaluation for	LVSF	79%	21%	100%	0%	Met inclusion
	RV enlargement	86%	14%	92%	8%	Met inclusion
	L/R Pleural effusion	79%	21%	92%	8%	Met inclusion
	Pericardial effusion	100%	0%			Met inclusion
	Cardiac Tamponade	57%	43%	46%	54%	Did not meet
Focused cardiac ultrasound – Pitfalls	Response	100%	0%			Met inclusion
Gallbladder US: Structure identification	Gallbladder in short axis	93%	7%			Met inclusion
	Gallbladder in long axis	93%	7%			Met inclusion
	Portal vein	57%	43%	86%	14%	Met inclusion
	Hepatic artery	50%	50%	14%	86%	Met exclusion
	CBD	43%	57%	29%	71%	Did not meet
	2nd portion duodenum	64%	36%	57%	43%	Did not meet
Gallbladder US: Evaluation of	Cholelithiasis	93%	7%			Met inclusion
	Polyp	64%	36%	71%	29%	Did not meet
	cholecystitis–anterior wall thickness	79%	21%	79%	21%	Met inclusion
	cholecystitis–pericholecystic fluid	64%	36%	71%	29%	Did not meet
	sonographic Murphy's sign	79%	21%	100%	0%	Met inclusion
	Dilated CBD	29%	71%	29%	71%	Did not meet
Gallbladder – pitfalls	Response	100%	0%			Met inclusion
IVC US: Structure identification	IVC in short axis	79%	21%	86%	14%	Met inclusion
	IVC in long axis	100%	0%			Met inclusion
	RA	100%	0%			Met inclusion

Supplemental Table 2 (*Continued*)

Diagnostic applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Liver	100%	0%			Met inclusion
	Hepatic vein	100%	0%			Met inclusion
	Aorta	100%	0%			Met inclusion
IVC US: Evaluation for	RAP–B mode–"Eyeballing"	93%	7%	100%	0%	Met inclusion
	RAP–B mode with measurements	50%	50%	14%	86%	Met exclusion
	RAP M mode with measurements	21%	79%	0%	100%	Met exclusion
IVC pitfalls	Response	100%	0%			Met inclusion
Joint knee: Structure identification	Patella and patellar tendon	100%	0%			Met inclusion
	Quadriceps muscle and tendon	100%	0%			Met inclusion
	Femur	100%	0%			Met inclusion
	Tibia	100%	0%			Met inclusion
	Suprapatellar recess (Supine)	93%	7%	93%	7%	Met inclusion
	Medial approach for smaller effusions	57%	43%	36%	64%	Did not meet
Joint knee: Evaluation for	Joint effusion. Milking technique (Urysev)	100%	0%			Met inclusion
	Bakers cyst	86%	14%	86%	14%	Met inclusion
Joint knee: Pitfalls	Response	100%	0%			Met inclusion
Renal US: Structure identification	Parenchyma and pyramids	100%	0%			Met inclusion
	Cortex	100%	0%			Met inclusion
	Collecting system components	93%	7%	93%	7%	Met inclusion
	Renal artery	36%	64%	21%	79%	Met exclusion
	Renal vein	36%	64%	21%	79%	Met exclusion
	Ureter and UPJ	86%	14%	71%	29%	Did not meet
Renal US: Evaluation for	Hydronephrosis	100%	0%			Met inclusion
	Renal cyst	86%	14%	86%	14%	Met inclusion
	Kidney size	79%	21%	71%	29%	Did not meet
	Renal mass	57%	43%	36%	64%	Did not meet
	Cortical thinning (CKD)	57%	43%	43%	57%	Did not meet
	Echogenicity compared to liver and spleen (CKD)	57%	43%	36%	64%	Did not meet
	Stones	57%	43%	29%	71%	Did not meet
	VEXUS–renal artery–spectral doppler	0%	100%			Met exclusion
	VEXUS–intrarenal venous flow–spectral doppler	0%	100%			Met exclusion
Renal ultrasound – Pitfalls	Response	100%	0%			Met inclusion
Skin and soft tissues: Structure identification	Muscle	100%	0%			Met inclusion
	Bone	100%	0%			Met inclusion
	Ligament	86%	14%	71%	29%	Did not meet
	Tendon (+ anisotropy)	93%	7%	93%	7%	Met inclusion
	Nerve	93%	7%	100%	0%	Met inclusion
	Skin	100%	0%			Met inclusion

Supplemental Table 2 (*Continued*)

Diagnostic applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
	Subcutaneous fat	100%	0%			Met inclusion
	Fascial plane	79%	21%	93%	7%	Met inclusion
	Lymph node	86%	14%	100%	0%	Met inclusion
Skin and soft tissues: Evaluation for	Abscess	100%	0%			Met inclusion
	Cyst	93%	7%	100%	0%	Met inclusion
	Subcutaneous edema/"cobblestoning"	100%	0%			Met inclusion
	Subcutaneous air	86%	14%	86%	14%	Met inclusion
Skin and soft tissues – Pitfalls	Response	100%	0%			Met inclusion
Thorax–free fluid: Structure identification	Lung	100%	0%			Met inclusion
	Visceral/Parietal pleura	100%	0%			Met inclusion
	Diaphragm	100%	0%			Met inclusion
	Ribs	100%	0%			Met inclusion
Thorax–free fluid: Evaluation for	Presence of pleural fluid	100%	0%			Met inclusion
	Complexity of pleural fluid	93%	7%	93%	7%	Met inclusion
	Ascites vs. pleural fluid	93%	7%	100%	0%	Met inclusion
Thorax–free fluid – Pitfalls	Response	100%	0%			Met inclusion
Thorax–lung: Structure identification	Lung	100%	0%			Met inclusion
	Diaphragm	100%	0%			Met inclusion
	Visceral pleura	100%	0%			Met inclusion
	Ribs	93%	7%	100%	0%	Met inclusion
Thorax–lung: Evaluation for	Normal lung	100%	0%			Met inclusion
	Spine sign	93%	7%	100%	0%	Met inclusion
	Curtain sign	93%	7%	100%	0%	Met inclusion
	Consolidation (in general)	93%	7%	100%	0%	Met inclusion
	Consolidation lobar vs. subpleural	57%	43%	50%	50%	Did not meet
	Partial alveolar processes	50%	50%	14%	86%	Met exclusion
	Interstitial processes	100%	0%			Met inclusion
	Atelectasis	57%	43%	43%	57%	Did not meet
	Air bronchograms	86%	14%	86%	14%	Met inclusion
Thorax–lung–Pitfalls	Response	100%	0%			Met inclusion
Thorax–pleural: Structure identification	Ribs and intercostal space	100%	0%			Met inclusion
	Intercostal vasculature	93%	7%	86%	14%	Met inclusion
	Visceral and parietal pleura	100%	0%			Met inclusion
	Diaphragm	100%	0%			Met inclusion
Thorax–pleural: Evaluation for	Lung sliding	100%	0%			Met inclusion
	Lung pulse	86%	14%	93%	7%	Met inclusion
	Pleural fluid	100%	0%			Met inclusion
Thorax–pleural–Pitfalls	Response	100%	0%			Met inclusion

Supplemental Table 2 (*Continued*)

Diagnostic applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
Urinary bladder: Structure identification	Bladder	100%	0%			Met inclusion
	Ureteral entry location / jets	57%	43%	43%	57%	Did not meet
	Urethral exit location	50%	50%	21%	79%	Met exclusion
	Prostate	93%	7%	93%	7%	Met inclusion
	Uterus/vagina	93%	7%	93%	7%	Met inclusion
Urinary bladder: Evaluation for	Bladder volume	100%	0%			Met inclusion
	Gross prostate enlargement	71%	29%	71%	29%	Did not meet
	Bladder mass	57%	43%	36%	64%	Did not meet
	Foley balloon	86%	14%	100%	0%	Met inclusion
	UVJ stone	21%	79%	21%	79%	Met exclusion
Urinary bladder–Pitfalls	Response	100%	0%			Met inclusion

Procedural applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
Procedures–Arthrocentesis: Static guidance	Linear probe	100%	0%			Met inclusion
	Curvilinear probe	21%	79%	7%	93%	Met exclusion
	Phased array probe	0%	100%			Met exclusion
Procedures–Arthrocentesis: Anatomic study for critical structure identification	Femur	100%	0%			Met inclusion
	Patella	100%	0%			Met inclusion
	Patellar tendon	100%	0%			Met inclusion
	Effusion	100%	0%			Met inclusion
	Suprapatellar recess	100%	0%			Met inclusion
Procedures–CVC: Dynamic guidance	Linear probe	100%	0%			Met inclusion
	Ability to follow needle tip (out-of-plane)	100%	0%			Met inclusion
	Ability to follow needle tip (in-plane)	100%	0%			Met inclusion
Procedures–CVC: Anatomic study for critical structure identification	Internal jugular vein	100%	0%			Met inclusion
	Carotid artery	100%	0%			Met inclusion
	Subclavian vein	50%	50%	29%	71%	Did not meet
	Subclavian artery	50%	50%	29%	71%	Did not meet
	Femoral vein	86%	14%	93%	7%	Met inclusion
	Femoral artery	86%	14%	93%	7%	Met inclusion
	Target vein compression	100%	0%			Met inclusion
	Venous valves	79%	21%	79%	21%	Met inclusion
	Target vein (CFD)	57%	43%	36%	64%	Did not meet
	Thyroid	93%	7%	86%	14%	Met inclusion
	Pleura	71%	29%	43%	57%	Did not meet
	Wire identification in compressible vessel	100%	0%			Met inclusion

Supplemental Table 2 (*Continued*)

Procedural applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
Procedures–LP: Static guidance	Linear probe	93%	7%	93%	7%	Met inclusion
	Curvilinear probe	79%	21%	64%	36%	Did not meet
Procedures–LP: Anatomic study for critical structure identification	Spinous processes–cross section	100%	0%			Met inclusion
	Spinous processes–longitudinal	100%	0%			Met inclusion
	Interspinous space	100%	0%			Met inclusion
	Paramedian view–Lamina and depth to ligamentum flavum	64%	36%	43%	57%	Did not meet
	Sacrum and L5/L4/L3 vertebral bodies	79%	21%	79%	21%	Met inclusion
Procedures–paracentesis: Static guidance	Curvilinear/phased-array probe only	29%	71%	7%	93%	Met exclusion
	Linear probe only	7%	93%	7%	93%	Met exclusion
	2-probe technique	86%	14%	93%	7%	Met inclusion
Procedures–paracentesis: Anatomic study for critical structure identification	Skin	100%	0%			Met inclusion
	Vasculature (2D/B-mode) under needle insertion site	86%	14%	100%	0%	Met inclusion
	Vasculature (CFD) under needle insertion site	79%	21%	79%	21%	Met inclusion
	Abdominal free fluid	100%	0%			Met inclusion
	Bowel (fluid and air filled)	100%	0%			Met inclusion
	Liver	100%	0%			Met inclusion
	Spleen	100%	0%			Met inclusion
	Rectus muscles	93%	7%	86%	14%	Met inclusion
	Inferior epigastric vessels in rectus sheath	93%	7%	93%	7%	Met inclusion
	Oblique muscles	57%	43%	29%	71%	Did not meet
	Depth to peritoneum	100%	0%			Met inclusion
	Depth to bowel	100%	0%			Met inclusion
Procedures–PIV: Dynamic guidance	Linear probe: Ability to follow needle tip (out-of-plane)	100%	0%			Met inclusion
	Linear probe: Ability to follow needle tip (in-plane)	100%	0%			Met inclusion
Identification of valves	Response	100%	0%			Met inclusion
Identification of nerves	Response	100%	0%			Met inclusion
Identification of arteries	Response	100%	0%			Met inclusion
Flush testing for confirmation	Response	100%	0%			Met inclusion
Procedures–thoracentesis: Static guidance	Phased-array/curvilinear probe only	29%	71%	7%	93%	Met exclusion
	Linear probe only	0%	100%			Met exclusion
	2-probe technique	79%	21%	86%	14%	Met inclusion

Supplemental Table 2 (*Continued*)

Procedural applications	Associated skill components	Voting round #1 results		Voting round #2 results		Final outcome
		Yes	No	Yes	No	
Procedures–thoracentesis: Anatomic study for critical structure identification	Diaphragm	100%	0%			Met inclusion
	Ribs and intercostal space	100%	0%			Met inclusion
	Visceral and Parietal pleura	100%	0%			Met inclusion
	Intercostal vessels (CFD)	79%	21%	93%	7%	Met inclusion
	Intercostal vessels (Power Doppler)	50%	50%	50%	50%	Did not meet
	Pleural fluid	100%	0%			Met inclusion
	Pericardial fluid/space	71%	29%	64%	36%	Did not meet
	Depth to pleura	93%	7%	93%	7%	Met inclusion
	Depth to lung	93%	7%	79%	21%	Met inclusion
Evaluation for lung sliding pre and post procedure	Response	100%	0%			Met inclusion
Procedural vessel identification–Include BOTH color flow and power doppler	Response	100%	0%			Met inclusion

2D = 2-dimensional; A4C = apical 4 chamber; A5C = apical 5 chamber view; AAA = abdominal aortic aneurysm ; AKI = acute kidney injury; ALARA = as low as reasonably achievable ; AV = aortic valve; B-mode = brightness mode; CBD = common bile duct; CFD = color flow doppler; CKD = chronic kidney disease; Desc = descending ; DVT = deep venous thrombosis; FAST = focused assessment with sonography in trauma; FCU = focused cardiac ultrasound; L/R = left/right; LA = left atrium; LFTs = liver function tests; LP = lumbar puncture ; LV = left ventricle; LVOT = left ventricular outflow tract; LVSF = left ventricular systolic function; M-mode = motion mode; MV = mitral valve; PIV = peripheral intravenous ; PLAX = parasternal long axis view; POCUS = point of care ultrasound; PRF = pulse repetition frequency ; PSAX = parasternal short axis view; RA = right atrium; RAP = right atrial pressure; RV = right ventricle; RVOT = right ventricular outflow tract; SC4 = subcostal 4 chamber view; TAPSE = tricuspid annular plane systolic excursion ; UPJ = ureteropelvic junction; US = ultrasound; UVJ = ureterovesicular junction.