

INVITED REVIEW

MEDICAL EDUCATION

Why is it necessary for every medical specialty to learn point-of-care ultrasound (POCUS)? A comprehensive review

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ABSTRACT

A crucial diagnostic tool that revolutionizes medical practice is point-of-care ultrasound (PoCUS), which offers real-time, non-invasive imaging at the patient's bedside. Anesthesia, emergency medicine, infectious diseases, nephrology, obstetrics, orthopedics, urology, and internal medicine are just a few of the medical professions that have employed it. PoCUS improves accuracy and safety in anesthesia by supporting regional anesthetic guiding, heart function monitoring, and preoperative evaluations. Through the Focused Assessment with Sonography for Trauma (FAST) test, PoCUS facilitates rapid diagnosis in trauma treatment, allowing for prompt decision-making for crucial interventions.

PoCUS aids in the detection of fluid collections and abscesses in infectious disorders, assisting in the formulation of treatment plans. It is crucial for kidney assessments and directing biopsies in nephrology, which enhances patient care. PoCUS has helped obstetrics with labor management, fetal monitoring, and early pregnancy evaluation. It transforms the diagnosis of tendon rupture and joint effusion in orthopedics. It is employed in urology to guide treatments such as biopsies and catheter implantation, as well as to evaluate the kidney and bladder.

By enhancing patient care, the cutting-edge imaging technology PoCUS has the potential to completely transform healthcare. However, issues including resource availability, specific training, and operator experience prevent it from being widely used. Integrating organized training programs across medical disciplines is necessary to reach its full potential, improving accuracy, cost, and accessibility.

Abbreviations: AI: artificial intelligence, AKI: acute kidney injury, FAST: Focused Assessment with Sonography for Trauma; PEA: pulseless electrical activity, PoCUS: point-of-care ultrasound, RUSH: Rapid Ultrasound in Shock

Key Words: Abdominal Point-Of-Care Ultrasound; Cardiopulmonary Point of Care Ultrasound; Point of Care Ultrasound (Pocus); Emergency Medicine; Obstetrics and Gynecology; Anesthesiology; Patient Safety; POCUS Training; Training

Citation: Zahid MA, Nasir H, Abid S, Shuja Ul Islam MHS, Sawwa A, Jamil S. Why is it necessary for every medical specialty to learn point-of-care ultrasound (POCUS)? A comprehensive review. *Anaesth. pain intensive care* 2025;29(4):392-399. DOI: [10.35975/apic.v29i4.2827](https://doi.org/10.35975/apic.v29i4.2827)

Received: May 09, 2024; **Revised:** October 26, 2024; **Accepted:** January 01, 2025

1. INTRODUCTION

Modern healthcare would not be complete without point-of-care ultrasound (PoCUS), a noninvasive, real time imaging tool that can dramatically aid clinical decision making. Advances in technology once kept diagnostic imaging confined to the radiology department but now that technology is being brought directly to the patient's bedside, giving clinicians the ability to make timely, critical decisions in order to improve outcomes.

PoCUS is being used more and more across specialties. In Anesthesia it helps to monitor cardiac and respiratory status and to guide nerve blocks. In a trauma setting, it can be required for trauma care, for recognizing internal bleeding, cardiac tamponade or cardiac arrest. Infectious disease, nephrology and internal medicine use PoCUS to ascertain the position of abscesses and track infections, follow the progress of cardiomyopathy and help guide renal biopsies. PoCUS facilitates early pregnancy assessments and fetal monitoring in obstetrics and diagnosis of musculoskeletal injuries and guidance of injections in orthopedics. PoCUS helps bladder and renal assessments and also procedures such as catheter placement in urology.

Although promising, widespread adoption of PoCUS is hampered by such obstacles as variability in operator expertise and specialized training needed. This essay reviews PoCUS's many applications, its benefits to patient care and the obstacles to wider uptake. To exploit the potential for this technology to impact medical practice efficiently across departments, it is important to understand its role.

2. Pocus in Anesthesia

PoCUS has revolutionized perioperative care by providing real-time, bedside imaging that enhances clinical decision-making. Its applications span preoperative assessments, cardiac function monitoring and guiding regional anesthesia.

2.1. Preoperative Assessment

PoCUS with dynamic imaging has increased accuracy in preoperative evaluation, compared with the traditional methods such as chest X-ray or ECG. It can detect valvular abnormalities, ischemia, pericardial effusions and fluid status of undiagnosed cardiac conditions and nonspecific symptoms.¹

2.2. Cardiac Function Monitoring

Real time assessment of the heart function in the perioperative setting is indispensable of cardiac PoCUS. It instantaneously provides information on biventricular dysfunction, valvular defects, ischemia, pericardial

effusions and helps to guide surgical decisions. For this, in addition to measuring the collapsibility of the inferior vena cava helps us to evaluate volume status and fluid management.²

2.3. Guiding Regional Anesthesia

Regional anesthesia has been transformed by PoCUS, allowing it the precise, real-time visualization of nerves, blood vessels and tissues. Unlike the traditional landmark-based techniques), ultrasound guidance improves accurate needle placement, decreases risks such as vascular punctures or nerve injury and increases the effect of anesthesia.³ In addition to improving procedural safety and enhanced successful rates, ultrasound guidance leads to a reduction of procedure time, making the latter an indispensable tool in modern anesthesia practice.⁴

The ability of PoCUS to enhance safety, accuracy and efficiency, has made it an essential adjunct to perioperative care and thereby has an enormous impact on patient outcomes

3. Emergency Medicine (ER)

PoCUS guided Focused Assessment with Sonography for Trauma (FAST) exam has become the cornerstone of trauma evaluation, because it allows for quick identification of life-threatening conditions like hemoperitoneum, cardiac tamponade or significant pleural effusions.⁵ The FAST exam is critical in cases of blunt abdominal trauma, especially for unstable patients, for quick surgical decision making by ruling out the possibility of internal bleeding.

To spot free fluid in the abdomen, pelvis or around the heart, that helps us identify internal bleeding. FAST is popped widely in trauma center due to its speed, noninvasive, high sensitivity as well as specificity in detecting of significant hemoperitoneum.⁶

4. Cardiac Arrest & Shock

4.1. Assessing Cardiac Function and Guiding Resuscitation

PoCUS provides real time assessment of cardiac function in cardiopulmonary resuscitation (CPR), fluid status and resuscitation efforts in cases of cardiac arrest and shock, determining whether there is any reversible cause and enabling specific therapy and leading to improved outcomes.⁵

4.1.1. Cardiac Arrest: PoCUS diagnoses cause of arrest and specifically in non-shockable rhythm, such as asystole or pulseless electrical activity (PEA). It (thoracoabdominal examination)

identifies reversible conditions including hypovolemia, tension pneumothorax, pericardial tamponade and pulmonary embolism. Cardiac motion during pulse checks is a key prognostic marker, where presence of motion correlates with greater likelihoods of successful resuscitation.

4.1.2. Shock Assessment: RUSH (Rapid Ultrasound in Shock) protocol classifies shock as hypovolemic, cardiogenic or obstructive by means of evaluation of the heart pump (pump), fluid status (tank) and vasculature (pipes). It identifies pathologies like pericardial effusions, left or right ventricular dysfunction, improving diagnostic accuracy in emergencies and directing the proper interventions.

4.1.3. Fluid Status Monitoring: In septic or hypovolemic shock, real time monitoring of inferior vena cava (IVC) for collapsibility or distension is allowed by PoCUS. It also can detect signs of fluid overload through lung ultrasound in order to optimize fluid management in case of cardiac shock.⁶

Rapid, precise diagnostics by PoCUS are indispensable in trauma, cardiac arrest, shock and are indispensable for rapid interventions and improved patient outcomes.

5. PoCUS in Infectious Diseases

5.1. Abscess and Fluid Collection Detection

The usefulness of Point of Care ultrasound in infectious disease management is in detecting abscesses and fluid collections, even from challenging locations. With real time imaging, abscesses, phlegmons and infected cysts are differentiated from other masses (tumors or hematomas), readily allowing precise and timely clinical decisions. Treatment strategies are guided with PoCUS including surgical drainage of abscesses or antibiotic therapy for diffuse infections.⁷

This tool is helpful for detecting abscesses in areas (neck, abdomen and pelvis) where physical examination or other imaging can be poor. Some examples are parapharyngeal, liver or renal abscesses and PoCUS also helps with guiding interventions such as drainage or biopsy.

5.2. Monitoring Organ Function in Systemic Infections

PoCUS also plays a crucial role in monitoring for organ function and the progression of disease in systemic infections such as sepsis. Diagnosis as early as possible and within an adequate time frame, following this PoCUS enable clinicians to monitor and examine multiple organ systems in real time, assessing early signs of dysfunctions.⁸

5.2.1. Heart and Circulatory Function: It evaluates biventricular function, valvular integrity and global cardiac performance. Rapid Ultrasound in Shock (RUSH) protocol allows for a comprehensive heart (“pump”), vasculature (“pipes”) and fluid status (“tank”) assessment of the hemodynamic status in a rapid fashion to guide fluid resuscitation and vasopressor therapy in a precise fashion to identify the cause of shock and direct targeted treatment.

5.2.2. Lung and Abdominal Organ Function: PoCUS detects the fluid accumulated in the lungs in conditions such as pneumonia and pleural effusion. In addition, abdominal abscesses and fluid collections are detected, providing essential information related to spread of conditions such as peritonitis or cholecystitis and also guiding the surgical intervention.⁹

5.2.3. Renal Function: In conditions such as pyelonephritis or urosepsis PoCUS can evaluate renal vasculature, cortex and medulla. The study of urinary tract dilation, bladder function and obstructive nephropathy allows for catheterization activities to occur.¹⁰

PoCUS provides accurate, real-time insights into the management of infectious disease and systemic infection by allowing timely and targeted interventions and better patient outcomes.

6. POCUS in Internal Medicine

Point of care ultrasonography (PoCUS) is increasingly critical for chronic disease management and rapid diagnosis in internal medicine. Because it is a real time, noninvasive technology it improves decision making and patient outcome in conditions such as congestive heart failure (CHF), liver disease and kidney dysfunction. In CHF, PoCUS can assist with cardiac function, fluid status and complication such as pericardial effusion and pulmonary edema to guide diuretic use and to detect decompensation early.¹¹ It helps with liver disease by providing detailed imaging of liver texture, size and possible masses in providing a detailed scan of liver disease for detection of complications such as ascites, cirrhosis and hepatocellular carcinoma. PoCUS is invaluable in kidney dysfunction to diagnose and monitor for chronic kidney disease or acute kidney injury

(AKI) and differentiate pre and post renal causes in guiding timely management.¹²

PoCUS is also beyond chronic conditions, with quick diagnosis of pneumonia and discerning between bacterial and viral types, jump starting treatment. It will recognize even tiny volumes of pleural effusions and direct thoracentesis. At the bedside, PoCUS has become the gold standard for diagnosis of deep venous thrombosis (DVT) and avoids the need for invasive testing.¹³ Though PoCUS has a lot going for it, the limitations of PoCUS rightfully warrant appropriate training and supervision to minimize diagnostic error in diagnosing pneumothorax, cardiac effusions and DVT. The increasing availability and improving accessibility of hand-held devices, together with its evolution as a tool for clinical practice, is revolutionizing patient care in internal medicine, where new PoCUS capabilities are set to become a cost effective and transformative technology for clinicians.¹⁴

7. POCUS in Nephrology

7.1. Kidney Evaluation

PoCUS is now a key adjunct to nephrology and is used to assess the size of the kidney and to detect cysts and in assessing fluid status in patients on dialysis. Traditionally, fluid balance is difficult to manage in kidney disease but with PoCUS it has already proven a dramatic improvement over physical exam techniques, providing real time, real bedside insights. For nephrologists, it means it can detect any cysts, stones, hydronephrosis that couldn't be found during a physical exam. For instance, PoCUS has been demonstrated to detect subclinical lung congestion in hemodialysis patients about 50% more frequently than chest X-ray, in a population that is deemed at increased risk for cardiac events and mortality. By reducing reliance on follow up imaging, this tool addresses care fragmentation and improves patient satisfaction by providing rapid, actionable answers to such critical questions as the presence of hydronephrosis, obstructive uropathy or fluid overload.¹⁵

7.2. Guidance for Biopsy

PoCUS performs a key role in guiding renal biopsies providing real time imaging to confirm accurate needle placement. This makes the biopsy safer by eliminating procedural risks and increasing success rates as it allows nephrologists to check out biopsy sites, avoid highly vascularized areas and find potential peri-nephric complications. Nephrologists can rely on PoCUS in emergencies to help them quickly make important decisions, such as detecting pericardial effusion or to

evaluate fluid status. With the growth of nephrologists' proficiency with PoCUS, it is now slowly becoming a bedrock of routine clinical practice offering significant diagnostic and procedural benefits.¹⁶

8. Obstetrics and Gynecology

8.1. Pregnancy and Liver Protection

Pregnancy offers a protective effect against liver injury and dysfunction, similar to the benefits seen in early pregnancy fetal monitoring.

8.2. Early Pregnancy Fetal Monitoring

In obstetrics, PoCUS is becoming more frequently used in early pregnancy, to identify ectopic pregnancy, evaluate fetal viability and estimate gestational age. It is important to identify early ectopic pregnancies, because not doing so can lead to severe and life-threatening maternal complications. When used in suspected ectopic pregnancy PoCUS permits early diagnosis of intrauterine pregnancy, allows identification of a non-visualized gestational sac and will recognize free intraperitoneal fluid indicative of rupture. In addition, measuring fetal viability and crown rump length confirms early fetal development.¹⁷

8.3. Labor and Delivery

In labor and delivery, PoCUS provides guidance on decision making. It is used to see the levels or amount of amniotic fluid; e.g., check for conditions such as oligohydramnios or polyhydramnios and also to evaluate fetal position to help decide the mode of delivery. It observes fetal wellness throughout childbirth and shows the detection patterns of the heart cells and problems like umbilical cord prolapse along with fetal stress.¹⁸

8.4. Limitations of PoCUS in ObsGyn

The main PoCUS limitation in obstetrics and gynecology is the lack of access to high frequency transvaginal probes, which provide superior imaging for early pregnancy evaluations. Diagnostic accuracy is similarly highly operator dependent and training plays a crucial role. PoCUS application among ObsGyn practitioners can only be enhanced by adequate and structured training programs.¹⁹

8.5. The Need for PoCUS Programs in OBGYN

In obstetrics and gynecology, structured PoCUS training programmes are increasingly essential. ObsGyn clinicians and residents need competency in focused ultrasound exams because the ability to do so is extremely important in emergency scenarios such as ruptured ectopic pregnancy or acute pelvic pain. This

PoCUS can channel into the healthcare disparities; particularly in resource limited settings as it provides crucial diagnostic imaging at the point of care.¹⁷

9. POCUS in Orthopedics

9.1. Joint Effusion Diagnostics: A Game-Changer in Emergency Care

Orthopedic diagnoses in the emergency department (ED) can be challenging as these are often joint effusions and PoCUS is an invaluable tool for evaluating an effusion. Clinical history and physical examination alone are often inadequate for differentiating conditions such as septic arthritis, bursitis, crystal arthropathies or traumatic effusions. PoCUS is a rapid and noninvasive tool used to differentiate among these conditions and therefore, improves diagnostic accuracy and patient outcome.²⁰

9.2. PoCUS in Hip Joint Effusions

Effusion of the hip joint is an urgent diagnosis and treatment in the pediatric patient as well as in the patient who presents with acute hip pain. Hip effusion can be rapidly detected with PoCUS, which is a vital step in the diagnosis of life-threatening septic arthritis, which if untreated can lead to destruction of the joint and systemic infection. PoCUS studies were shown to significantly reduce the time from presentation to diagnosis compared to radiology ultrasounds. Treatment initiation is expedited with PoCUS compared to traditional imaging with a median time of 68 minutes being obtained from PoCUS vs 208.5 minutes from traditional imaging.²¹

Hip effusions are effectively identified in all pediatric populations using PoCUS with a sensitivity of 85% and specificity of 100%. Effusion is defined as greater than 5 mm or 2 mm difference compared to the contralateral hip and a high frequency linear probe is used.

9.3. PoCUS in Detecting Tendon Ruptures

Tendon injuries, such as ruptures of the Achilles tendon, commonly caused by sports or trauma, are most effectively diagnosed by PoCUS. Tendon discontinuity, hematoma and tissue damage are readily identified in real-time imaging as are sensitivity (79.6%–100%) and specificity (100%) in all cases. Timely treatment is important because it helps to avoid unnecessary immobilization, reduce the need for VTE prophylaxis and fast track physiotherapy or surgical referrals.²²

9.4. Occult Fractures: PoCUS as a Diagnostic Adjunct

Occult fractures are especially well detected by PoCUS in the absence of plain radiograph findings.

Subperiosteal fluid, cortical disruptions and periosteal hematomas can be visualized, with a specificity of 94% and a negative predictive value of 97%. PoCUS is a useful rapid screening tool in pediatric trauma that may decrease time to diagnosis, decrease radiation exposure and act as a bridge to an advanced imaging such as CT or MRI.²¹

10. Impact of PoCUS Training

PoCUS is now central to modern surgical practice, most notably in trauma care and resource limited settings. In addition to raising confidence among surgical residents, training in PoCUS changes their practice of clinical medicine as it brings real time diagnostic and procedural capabilities into both the emergency and elective care.

10.1. PoCUS Training: Enhancing Resident Confidence and Skills

Surgical residents' confidence in applying ultrasound in complex clinical scenarios is significantly improved with structured PoCUS training. Curricula are hands on, concentrating on key applications like the FAST exam, soft tissue, vascular and obstetric ultrasound, to teach residents to proficiently identify pericardial and peritoneal fluid, perform ultrasound guided procedures and assess cardiac function. These practical sessions give immediate feedback which increases skills development in addition to making the training highly effective.²³

PoCUS training engages residents in real world scenarios in order to develop procedural proficiency, diagnostic accuracy and autonomy in clinical decision making. This robust and interactive way of promoting the implementation of PoCUS ensures the transfer of learning theory from theory to confident PoCUS use in daily surgical practice.

10.2. Addressing Global Healthcare Challenges through PoCUS

Training in PoCUS has huge implications for improved healthcare in resource limited and global settings. PoCUS can fill many medical needs because it is a cost-effective diagnostic tool that can be utilized for a range of purposes, such as fracture detection or cardiologic diagnosis, when more expensive imaging is not needed (e.g. CT or MRI). What makes it so important in locations with no access to advanced diagnostics is its portability and versatility.

When PoCUS is integrated with surgical residency programs, residents become empowered to provide timely and effective care in environments which may be under served or no longer available during a disaster scenario. PoCUS trained residents reduce diagnostic

time and avoid unnecessary advanced imaging, aiding in patient outcomes and adapting to the relative constraints in resource poor environment.²⁴

11. PoCUS in Urology

In urology, point-of-care ultrasound (PoCUS) is an important tool for real time, noninvasive imaging of diagnostics and management of a wide variety of conditions. Applications in the treatment of urinary tract and kidney evaluation and guiding urological procedures have been explored.

11.1. Bladder and Kidney Evaluation

PoCUS in bladder assessment is invaluable to diagnose urinary retention and obstruction and therefore allow timely intervention. The measurement of the post void residual volume can assist in the decision as to whether a catheterization or operation is necessary. PoCUS can quickly screen for conditions that need kidney evaluation, like kidney stones, cysts, tumors or hydronephrosis. Early renal masses or obstructions are ascertained early enough to guarantee speedy diagnosis and management.²⁵

11.2. Guided Procedures

Urological procedures including catheter placement, kidney biopsy, prostate evaluation can be safely and precisely improved with the aid of PoCUS. It would contribute to accurate urethral and suprapubic catheter placement in anatomic cases, decreases the incidence of complication during kidney biopsies by avoiding vascular structure and improves the safety and accuracy of transrectal prostate biopsies. It also helps to determine the size of the prostate and to detect problems like benign prostatic hyperplasia or tumors.²⁶

11.3. Benefits of PoCUS in Urology

PoCUS has major advantages in urology, including speed, portability and the ability to quickly obtain clinically important information. It helps to make timely decision, especially in emergencies or surgery, without requiring the invasive procedures and costly imaging such as CT scans or MRIs. Being a cost-effective alternative, in resource limited environments PoCUS expedites diagnoses and reduces hospital stays.

POCUS is of great utility in pregnant patients, in whom traditional imaging is contraindicated for certain procedures like DJ stenting or fluoroscopy guided interventions. Ultrasound guided procedures provide safer, noninvasive solutions with targeted tracking and no risk of harm to patient.^{25, 26}

12. CONCLUSION

Point of care ultrasound (PoCUS) has transformed medical practice through increased diagnostic acuity, patient safety and treatment efficiency across a variety of specialties. PoCUS provides real time, portable imaging and allows clinicians to make real time decisions at the bedside more rapidly, which increases healthcare quality and decreases delays in treatment due to timely relevant information. In general, it is versatile enough to be used in emergency medicine, obstetrics orthopedics, urology and the surgery, for making a diagnosis of trauma, heart failure, infectious diseases, fractures or organ obstructions. PoCUS goes beyond quickening diagnosis; it reduces the amount of discomfort to the patient as well as unnecessary hospital stays and healthcare costs.

With the ever-changing technology, device miniaturization will allow for PoCUS to be more portable, unaffordable and available in both high and low resources. By coupling PoCUS with artificial intelligence (AI), image interpretation will accelerate and become more accurate, which will allow for extending its utility into underserved or remote regions. The potential of this integration is to help close the global healthcare gap by providing indispensable diagnostic information and directing interventions to enhance outcomes worldwide.

In order for PoCUS to truly achieve its potential, it needs widespread training across every specialty. Ultrasound competence can be introduced into the medical curricula at undergraduate, residency and postgraduate levels to train clinicians to make informed decisions and also to improve patient care. The introduction of PoCUS serves as a monumental step towards strengthening the healthcare system and enhancing patient's outcomes worldwide for its ability to improve efficiency, accessibility and safety.

13. Conflict of interests

Authors acknowledge their earnest desire to propagate practical PoCUS training in every medical teaching institution for its extreme benefits in the patientcare.

14. Authors contribution

All authors took part in the literature search and manuscript drafting and editing.

All authors have read this manuscript and approved for publishing.

15. REFERENCES

1. Kalagara H, Coker B, Gerstein NS, Kukreja P, Deriy L, Pierce A, et al. Point-of-care ultrasound (POCUS) for the

- cardiothoracic anesthesiologist. *J Cardiothorac Vasc Anesth.* 2022;36(4):1132-47. [PubMed] DOI: [10.1053/j.jvca.2021.01.018](https://doi.org/10.1053/j.jvca.2021.01.018)
2. Haskins SC, Bronshteyn Y, Perlas A, El-Boghdadly K, Zimmerman J, Silva M, et al. American Society of Regional Anesthesia and Pain Medicine expert panel recommendations on point-of-care ultrasound education and training for regional anesthesiologists and pain physicians—Part I: Clinical indications. *Reg Anesth Pain Med.* 2021;46(12):1031-47. [PubMed] DOI: [10.1136/rapm-2021-102560](https://doi.org/10.1136/rapm-2021-102560)
 3. Naji A, Chappidi M, Ahmed A, Monga A, Sanders J. Perioperative point-of-care ultrasound use by anesthesiologists. *Cureus.* 2021;13(5):e15217. [PubMed] DOI: [10.7759/cureus.15217](https://doi.org/10.7759/cureus.15217)
 4. Zieleskiewicz L, Lopez A, Hraiech S, Baumstarck K, Pastene B, Di Bisceglie M, et al. Bedside POCUS during ward emergencies is associated with improved diagnosis and outcome: an observational, prospective, controlled study. *Crit Care.* 2021;25:34. [PubMed] DOI: [10.1186/s13054-021-03466-z](https://doi.org/10.1186/s13054-021-03466-z)
 5. Martin Lewis D, Rang L, Kim D, Robichaud L, Kwan C, Pham C, et al. Recommendations for the use of point-of-care ultrasound (POCUS) by emergency physicians in Canada. *Can J Emerg Med.* 2019;21(6):721-6. [PubMed] DOI: [10.1017/cem.2019.392](https://doi.org/10.1017/cem.2019.392)
 6. Zanza C, Longhitano Y, Artico M, Cammarota G, Barbanera A, Racca F, et al. Bedside cardiac POCUS in emergency setting: a practice review. *Rev Recent Clin Trials.* 2020;15(4):269-77. [PubMed] DOI: [10.2174/1574887115666200802023306](https://doi.org/10.2174/1574887115666200802023306)
 7. Declerck C, Mahieu R, Sanderink D, de la Chapelle M, Abgueguen P, Vandamme YM, et al. Implementation of point-of-care ultrasonography in an infectious disease ward. *Infect Dis Now.* 2022;52(2):87-92. [PubMed] DOI: [10.1016/j.idnow.2021.11.008](https://doi.org/10.1016/j.idnow.2021.11.008)
 8. Cibinel GA. POCUS infectious disease management: Point-of-care ultrasound in the integrated management of infectious diseases. *Ital J Emerg Med.* 2023;12(2):67-80. DOI: [10.23736/S2532-1285.23.00190-8](https://doi.org/10.23736/S2532-1285.23.00190-8)
 9. López Palmero S, López Zúñiga MA, Rodríguez Martínez V, Reyes Parrilla R, Alguacil Muñoz AM, Sánchez-Yebra Romera W, et al. Point-of-care ultrasound (POCUS) as an extension of the physical examination in patients with bacteremia or candidemia. *J Clin Med.* 2022;11(13):3636. [PubMed] DOI: [10.3390/jcm11133636](https://doi.org/10.3390/jcm11133636)
 10. B elard S, Tamarozzi F, Bustinduy AL, Wallrauch C, Grobusch MP, Kuhn W, et al. Point-of-care ultrasound assessment of tropical infectious diseases—a review of applications and perspectives. *Am J Trop Med Hyg.* 2016;94(1):8-21. [PubMed] DOI: [10.4269/ajtmh.15-0421](https://doi.org/10.4269/ajtmh.15-0421)
 11. Elhassan MG, Grewal S, Nezarat N. Point-of-care ultrasonography in internal medicine: Limitations and pitfalls for novice users. *Cureus.* 2023;15(8):e43655. [PubMed] DOI: [10.7759/cureus.43655](https://doi.org/10.7759/cureus.43655)
 12. Ma IW, Arishenkoff S, Wiseman J, Desy J, Ailon J, Martin L, et al. Internal medicine point-of-care ultrasound curriculum: Consensus recommendations from the Canadian Internal Medicine Ultrasound (CIMUS) Group. *J Gen Intern Med.* 2017;32:1052-7. [PubMed] DOI: [10.1007/s11606-017-4071-5](https://doi.org/10.1007/s11606-017-4071-5)
 13. Mellor TE, Junga Z, Ordway S, Hunter T, Shimeall WT, Krajnik S, et al. Not just hocus POCUS: Implementation of a point of care ultrasound curriculum for internal medicine trainees at a large residency program. *Mil Med.* 2019;184(11-12):901-6. [PubMed] DOI: [10.1093/milmed/usz124](https://doi.org/10.1093/milmed/usz124)
 14. Cid-Serra X, Hoang W, El-Ansary D, Cauty D, Royse A, Royse C. Clinical impact of point-of-care ultrasound in internal medicine inpatients: A systematic review. *Ultrasound Med Biol.* 2022;48(2):170-9. [PubMed] DOI: [10.1016/j.ultrasmedbio.2021.09.013](https://doi.org/10.1016/j.ultrasmedbio.2021.09.013)
 15. Koratala A, Reisinger N. POCUS for nephrologists: Basic principles and a general approach. *Kidney360.* 2021;2(10):1660-8. [PubMed] DOI: [10.34067/KID.0002482021](https://doi.org/10.34067/KID.0002482021)
 16. Romero-Gonz alez G, Manrique J, Slon-Roblero MF, Husain-Syed F, De la Espriella R, Ferrari F, et al. Point-of-care ultrasound (POCUS) in sepsis management: Evidence and practice. *Crit Care.* 2021;25:1-13.
 17. Recker F, Weber E, Strizek B, Gembruch U, Westerway SC, Dietrich CF. Point-of-care ultrasound in obstetrics and gynecology. *Arch Gynecol Obstet.* 2021;303(3):871-6. [PubMed] DOI: [10.1007/s00404-021-05972-5](https://doi.org/10.1007/s00404-021-05972-5)
 18. Easter SR, Hameed AB, Shamshirsaz A, Fox K, Zelop CM. Point of care maternal ultrasound in obstetrics. *Am J Obstet Gynecol.* 2023;228(5):509-e1. [PubMed] DOI: [10.1016/j.ajog.2022.09.036](https://doi.org/10.1016/j.ajog.2022.09.036)
 19. Nyamankolly E, Leitao J, Lescure M, Shipley E, Maz e J, Desclaux A, et al. Ultrasonography performed by an infectiologist in hip and knee prosthetic joint and native joint infections. *Infect Dis Now.* 2023;53(5):104689. [PubMed] DOI: [10.1016/j.idnow.2023.104689](https://doi.org/10.1016/j.idnow.2023.104689)
 20. Oluku J, Stagl A, Cheema KS, El-Raheb K, Beese R. The role of point of care ultrasound (PoCUS) in orthopaedic emergency diagnostics. *Cureus.* 2021;13(1):e13046. [PubMed] DOI: [10.7759/cureus.13046](https://doi.org/10.7759/cureus.13046)
 21. Katz-Dana H, Stankevich R, Dana E, Friedman N, Lackner G, Rosenbloom E, et al. Diagnostic accuracy of point-of-care ultrasound (PoCUS) for the diagnosis of hip effusion in the pediatric emergency department. *Can J Emerg Med.* 2024;26(12):875-882. [PubMed] DOI: [10.1007/s43678-024-00788-z](https://doi.org/10.1007/s43678-024-00788-z)
 22. Bengtzen RR, Lee J. Point-of-care ultrasound and the septic prosthetic hip joint. *J Emerg Med.* 2019;57(5):701-4. [PubMed] DOI: [10.1016/j.jemermed.2019.08.004](https://doi.org/10.1016/j.jemermed.2019.08.004)
 23. Kotagal M, Quiroga E, Ruffatto BJ, Adedipe AA, Backlund BH, Nathan R, et al. Impact of point-of-care ultrasound training on surgical residents' confidence. *J Surg Educ.* 2015;72(4):e82-7. [PubMed] DOI: [10.1016/j.jsurg.2015.01.021](https://doi.org/10.1016/j.jsurg.2015.01.021)

24. Rajamani A, Miu M, Huang S, Elbourne-Binns H, Pracher F, Gunawan S, et al. Impact of critical care point-of-care ultrasound short-courses on trainee competence. *Crit Care Med.* 2019;47(9):e782-4. [\[PubMed\]](#) DOI: [10.1097/CCM.0000000000003867](https://doi.org/10.1097/CCM.0000000000003867)
25. Uy M, Lovatt CA, Hoogenes J, Bernacci C, Matsumoto ED. Point-of-care ultrasound in urology: Design and evaluation of a feasible introductory training program for Canadian residents. *Can Urol Assoc J.* 2021;15(4):e210-4. [\[PubMed\]](#) DOI: [10.5489/cuaj.6637](https://doi.org/10.5489/cuaj.6637)
26. Point-of-care ultrasound in urology. In *Practical Urological Ultrasound: Third Edition.* Springer International Publishing. 2020. p. 315-331. DOI: [10.1007/978-3-030-52309-1_17](https://doi.org/10.1007/978-3-030-52309-1_17)
27. Kim DJ, Bell CR, Jelic T, Thavanathan R, Heslop CL, Myslik F, et al. Point-of-care ultrasound (POCUS) literature primer: key papers on renal and biliary POCUS. *Cureus.* 2023;15(4):e37294. [\[PubMed\]](#) DOI: [10.7759/cureus.37294](https://doi.org/10.7759/cureus.37294)