Soni NJ, Schnobrich D, Mathews B, et al. Point-of-care Ultrasound for Hospitalists: a Position Statement of the Society of Hospital Medicine.

**Selected evidence for clinical applications**

Appendix 1: Cardiac Ultrasound

Appendix 2: Lung & Pleural Ultrasound

Appendix 3: Abdominal Ultrasound

Appendix 4: Vascular Ultrasound

Appendix 5: Musculoskeletal Ultrasound

Appendix 6: Hypotension, Pulseless Electric Activity, and Resuscitation

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**Appendix 9: Billing**

Table 1. Frequently used CPT codes for point-of-care ultrasound billing

**Appendix 10: References for Appendices**

**Appendix 1: Cardiac Ultrasound**

Point-of-care ultrasound can improve the hospitalists’ ability to diagnose many important cardiac abnormalities. These abnormalities include the qualitative assessment of [left ventricular systolic function](https://drive.google.com/drive/folders/1uYnZtp01G9c1rHjJ1ZxsUohG4KiGDJ2S?usp=sharing) (LVSF); the estimation of right atrial pressure (RAP); and the detection of pericardial effusions, right ventricular dysfunction, chamber hypertrophy, chamber enlargement, and some gross valvular abnormalities. The use of cardiac POCUS has repeatedly been shown to influence management decisions,1–3 including a hospital medicine study in which it changed management in 37% of patients.4

* **Qualitative assessment of LVSF:** Hospitalists can qualitatively assess LVSF accurately. In one randomized study of hospitalists, POCUS had an LR+ of 5.7, a LR- of 0.2.4 In two studies by Martin, POCUS improved hospitalists’ detection of left ventricular dysfunction compared to traditional physical examination, and approached but did not match the acquisition and interpretation scores of formal echocardiography.5,6 Numerous studies of other acute care physicians corroborate the ability of physicians with focused training to assess LVSF.7–12
* **Pericardial effusion:** Hospitalists accurately detected moderate or larger pericardial effusions with a LR+ of 7.7, LR- of 0 in one study,4 detected effusions at rates similar to a cardiology fellow in another,5 and vastly exceeded their detection compared to physical examination in a third.6 Numerous other studies of acute care physicians have shown similar results.7,9,10,13
* **Chamber hypertrophy and enlargement:** POCUS allows detection of chamber hypertrophy and enlargement. Left ventricular hypertrophy (LVH) and left atrial enlargement (LAE) are two such examples which are useful to detect in hospitalized patients and which may be detected with POCUS.14–16 In one study of hospitalists, LVH was detected with LR+ of 1.6 and LR- of 0.7, while LAE had LR+ of 2.4, LR- of 0.4.4
* **Right ventricular function**: POCUS may be useful in the detection of right ventricular dysfunction in severe cases of acute pulmonary embolism, particularly in combination with lower extremity venous ultrasound.17,18
* **Right atrial pressure (RAP) estimation**: Ultrasound measurements of the inferior vena cava (IVC) may be useful in the assessment of right atrial pressure,19,20 may be used in combination with other findings to diagnose heart failure exacerbations,21,22 and may distinguish etiologies of shock.23,24,25 Internal jugular veins may also be used.26,27
* **Severe valvular disease:** POCUS may help hospitalists and similarly trained physicians detect some types of valvular disease, such as severe mitral regurgitation4 and severe aortic stenosis28. However, for many valvular abnormalities formal echocardiography will be necessary.5
* **Limitations:** More sophisticated and quantitative assessments, such as evaluation of pericardial constriction, pulmonary hypertension, and quantified severity of valvular stenotic or regurgitation are beyond the scope of most hospitalists, but may be performed when a hospitalist has had sufficient training.

**Appendix 2: Lung and Pleural Ultrasound**

Pulmonary ultrasound is highly useful in detecting lung pathology. The most common uses include the detection and characterization of pleural effusions; interstitial syndromes, most commonly pulmonary edema; alveolar syndromes, such as pneumonias; and pneumothoraces. Ultrasound is also an important tool in improving the safety of thoracentesis.

* **Pleural effusion:** POCUS detects pleural effusions with high accuracy. A 2010 meta-analysis of four primary studies showed that ultrasound detected effusions with a 93% sensitivity and 96% specificity.29 POCUS outperformed anterior-posterior chest radiography in two studies.30,31 Ultrasound may also be used to estimate pleural effusion volume.32 Ultrasound can detect complex features that may suggest exudative effusion,33 or malignancy.34
* **Interstitial syndromes**: Pulmonary ultrasound is superior to chest radiography in both ruling in and ruling out interstitial syndromes, such as cardiogenic and non-cardiogenic pulmonary edema, and pulmonary fibrosis.35,36 In a 2014 systematic review of seven studies, B-lines were found to have a sensitivity of 94% and specificity of 92% for acute cardiogenic pulmonary edema.37 Other studies have demonstrated that increasing numbers of B-lines correlate with several different measures of increasing extravascular lung water,38–40 that B-lines decrease in number as volume is removed,41–43 and that they may be useful in predicting mortality,44 readmission,43 and other important metrics.45
* **Alveolar syndromes:** Lung ultrasound is highly useful in the detection of ultrasonic alveolar syndromes, such as bacteria pneumonia. In a 2017 meta-analysis of 20 primary studies, pooled sensitivity was found to be 0.85 and specificity 0.93.46
* **Pneumothorax**: In a 2013 meta-analysis of 13 studies, ultrasound had a higher sensitivity than chest radiography (78.6% vs 39.8%) with similar specificity (98.4% vs 99.3%).47
* **Thoracentesis:** Ultrasound can be used to identify pleural effusions amenable to bedside thoracentesis, guide site selection, and evaluate for post-procedure complications.33,48–51 Importantly, use of ultrasound has been shown to decrease the odds of pneumothorax, the most common complication of thoracentesis.52–55 The success rate of this procedure also increases with ultrasound guidance.48,49,56,57 A large retrospective cohort study suggested that ultrasound guidance may decrease the risk of hemorrhage, although this finding failed to reach statistical significance.54 Finally, ultrasound can be used immediately after thoracentesis to evaluate for pneumothorax with better sensitivity than supine or upright chest radiography.47,50,58,59

**Appendix 3: Abdominal Ultrasound**

Numerous abdominal POCUS applications may be of high utility to the hospitalist, including detection of intraperitoneal free fluid, hydronephrosis, splenomegaly, hepatomegaly, acute cholecystitis, and abdominal aortic aneurysms, as well as estimation of kidney size and bladder volume. Use of ultrasound guidance for paracentesis improves selection of optimal needle insertion site.

* **Intraperitoneal free fluid:** POCUS outperforms traditional physical exam maneuvers and has evolved to become the standard test for detection of intraperitoneal fluid with the ability to detect as little as 100-300ml of fluid.60–62
* **Hydronephrosis:** POCUS allows the clinician to detect or exclude hydronephrosis.63 The overall reported sensitivity of ultrasound for detection of moderate or greater hydronephrosis ranges from 72%-87% when compared to CT. Sensitivity increases with increased ultrasound experience of the provider, as well as increased size of an underlying nephrolith.64–66
* **Renal size:** Ultrasound may detect reduced renal size, reduced cortical thickness, and increased cortical echogenicity; suggesting chronic rather than acute renal disease.67,68 Evaluation of complex renal cysts and masses for malignant potential is outside the scope of POCUS.
* **Bladder volume**: Bladder volume may be reliably estimated with POCUS to determine if there is urinary retention or obstruction.69,70 POCUS can confirm correct placement of a Foley catheter by visualizing the balloon within the bladder.
* **Hepatobiliary:** Several studies have shown that non-radiologists can be trained to assess the gallbladder for signs of cholelithiasis (sensitivity 96%, specificity 88%)71 and acute cholecystitis (sensitivity 87%, specificity 82%)72 and may be similar to results performed by radiology.72 While visualization and evaluation of the gallbladder can be performed by novice ultrasound users after a short training period, identification and accurate measurement of the common bile duct may be a more advanced application requiring longer training.73,74
* **Hepatomegaly and splenomegaly**: Ultrasound may be used reliably to detect hepatomegaly and splenomegaly.75–78
* **Abdominal aortic aneurysm (AAA)**: A 2014 meta-analysis of 11 studies of non-radiologists’ ability to use ultrasound for the detection of AAA demonstrated a pooled sensitivity of 97.5% and pooled specificity of 98.9% when compared to gold standard testing.79
* **Paracentesis:** Use of ultrasound guidance for paracentesis has become the standard of care.80 Ultrasound outperforms physical examination in selecting an optimal needle insertion site. It allows detection of small amounts of ascites as low as 100 ml,81 identification of underlying abdominal organs and loops of bowel,82,83 visualization of loculations and superficial abdominal wall vessels,84–86 and measurement of abdominal wall thickness.87 Use of ultrasound guidance for paracentesis has been shown to increase success rates of fluid aspiration,88 reduce post-procedural bleeding regardless of INR or platelet count,53,89 and has been associated with reduced hospitalization costs and mortality.53,54 To maximize benefits of using ultrasound, experts recommend a “2-probe technique” with a low-frequency probe for fluid localization and a high-frequency probe for vessel identification along the anticipated needle path.85,86,90 Post-procedurally, re-evaluation of the abdomen and needle insertion site permits assessment for residual fluid and screening for abdominal hematoma and hemoperitoneum in a timely manner at the bedside.91

**Appendix 4: Vascular Ultrasound**

POCUS can accurately detect lower extremity deep venous thrombosis by compression ultrasonography. Use of ultrasound guidance is critical for safe insertion of central venous catheters, and is useful for performance of other vascular access procedures, including peripheral intravenous (IV) and arterial line placement.

* **Deep venous thrombosis (DVT):** POCUS can detect lower extremity DVTs. Two-dimensional compression ultrasound is used to evaluate the femoral and popliteal regions for proximal lower extremity DVTs. A 2012 meta-analysis of 16 studies that compared emergency physician-performed compression ultrasonography to color flow Duplex ultrasound or angiography by radiology demonstrated a weighted mean sensitivity of 96.1% and specificity of 96.8%.92 A 2100 patient randomized, multi-center trial comparing emergency physician-performed POCUS exams and D-dimer to radiology-performed exams found the two diagnostic strategies to be equivalent.93 High sensitivity has also been demonstrated in critically ill patients. In one critical care study, 14 hours passed between ordering and reporting of the radiology-performed lower extremity DVT examinations.94
* **Central venous line insertion:** The advantages of using real-time ultrasound guidance for insertion of central venous catheters have been well demonstrated in the medical literature. The use of ultrasound increases overall procedure success rate and the number of successful first-pass attempts, while reducing the mechanical and infectious complications, number of needle passes, and time to cannulation.95,96 Ultrasound is used to survey the target vessel(s) and surrounding structures, and several studies have elucidated the anatomic variations between the internal jugular vein (IJV) and common carotid artery (CCA).97 Moreover, in one study 75% of hemodialysis patients had sonographic venous abnormalities (such as thrombosis) that required a change in venous access approach, especially in patients with previous catheters.98 Ultrasound can also be used to visualize the guidewire in the lumen of the target vein with high sensitivity prior to dilation.99,100 Post-procedure pneumothorax can be ruled out with high sensitivity using a high-frequency linear-array transducer to detect bilateral lung sliding following a neck or chest cannulation.47,58,59,101
* **Peripheral venous line insertion:** Ultrasound-guided peripheral IV cannulation is most useful for patients with difficult venous access (patients that have had 2 unsuccessful landmark-based attempts at PIV access or a history of difficult access due to edema, obesity, intravenous drug use, chemotherapy, vasculopathy, or multiple prior hospitalizations). Use of ultrasound guidance reduces procedure time, needle insertion attempts, and needle redirections compared to traditional approaches among patients with difficult venous access. In a study of the placement of PIV catheters in difficult-access patients by emergency physicians, the use of ultrasound guidance for peripheral venous access had higher success rate than traditional “blind” techniques (97% vs. 33%), required less time (13 vs. 30 min), decreased the number of percutaneous punctures (1.7 vs. 3.7), and improved patient satisfaction.102 In a study with pediatric patients with difficult venous access, use of ultrasound increased overall success rate (80% vs 64%), reduced total procedure time (6.3 vs 14.4 minutes), required fewer attempts (1 vs 3), and had fewer needle redirections (2 vs 10).103
* **Arterial Line Insertion:** Several randomized controlled trials have assessed the value of ultrasound guidance for arterial catheter insertion. Shiver et alrandomized 60 patients admitted to a tertiary center emergency department to either palpation or ultrasound-guided arterial cannulation. They demonstrated a first-pass success rate of 87% in the ultrasound group compared with 50% in the landmark technique group. In the same study, the use of ultrasound was also associated with reduced time to establish arterial access and a 43% reduction in development of hematoma at the insertion site.104 Levin et aldemonstrated a first-pass success rate of 62% using ultrasound versus 34% by palpation alone in 69 patients requiring intra-operative invasive hemodynamic monitoring.105 A meta-analysis, including 4 trials and 311 patients showed that ultrasound guidance for arterial catheterization was associated with a 71% improvement in the likelihood of first pass successful attempt (relative risk: 1.71, 95% CI 1.25-2.32).106 Another meta-analysis that analyzed seven RCT’s with 482 patients showed that ultrasound guidance significantly increased first-attempt success rates of radial artery catheterization (RR 1.51; 95%CI 1.07-2.14, P=0.02). Ultrasound guidance significantly reduced mean attempts to success, mean time to successful cannulation, and risk of hematoma (RR 0.17, 95%CI 0.07-0.41; P=0.0001).107

**Appendix 5: Musculoskeletal Ultrasound**

POCUS is a useful tool in the evaluation of soft tissues and the musculoskeletal system. Applications of interest to the hospitalist include the detection of cellulitis and abscess, joint effusions, fractures, tendon injuries, and bursitis, as well as use of ultrasound guidance for arthrocentesis and lumbar puncture.

* **Cellulitis and abscess:** Ultrasound has been shown to improve the clinical assessment of patients with cellulitis and possible abscess in several studies and has further been shown to improve decision-making and choice of treatment.108,109
* **Joint effusions and arthrocentesis:** POCUS allows clinicians to detect joint effusions and differentiate them from other soft tissue abnormalities.110 Ultrasound-guided arthrocentesis and knee injection are superior to traditional landmark-based arthrocentesis using palpation alone. Studies have demonstrated significantly less procedural pain, improved procedural success rates, greater synovial fluid yield, and improved clinical outcomes.111–116
* **Fractures and tendon injuries:** Ultrasound detection of bone fractures has been studied in the emergency medicine setting showing reasonable diagnostic accuracy.117 Ultrasound may also be useful in detection of tendon and ligament injury.118,119
* **Bursitis:** Ultrasound allows the rapid, bedside differentiation between arthritis and bursitis with early goal directed treatment.120
* **Lumbar puncture:** Use of ultrasound to mark a needle insertion site prior to performance of lumbar puncture improves procedural success rates and may reduce complication rates.121,122 Ultrasound can be used for lumbar spine mapping to select the widest interspinous space for needle insertion and to estimate the needle insertion depth required to access the subarachnoid space.123–127 Compared to a traditional landmark-based lumbar puncture technique, use of ultrasound to identify the optimal needle insertion site can result in improved procedure success rates and a decrease in the number of attempts and needle redirections.122,128–130 A limited number of studies have reported higher success rates and reduced number of attempts using real-time ultrasound guided lumbar punctures, although direct comparison with ultrasound-guided site marking has not been performed.131–134 Use of ultrasound for lumbar puncture site selection decreases the risk of a traumatic tap as well as post-procedure back pain.121,122,130,135 Though a reduction in post-procedure headache was reported in a study where spinal anesthesia was administered under ultrasound guidance, similar results have not yet been reported for ultrasound-guided lumbar punctures.136 Use of a low frequency probe with color flow Doppler allows for imaging of interspinous blood vessels as small as 0.5mm. However, studies have not yet demonstrated a reduction in epidural bleeding when lumbar puncture is performed using ultrasound guidance.137

**Appendix 6: Hypotension, Pulseless Electric Activity, and Resuscitation**

A multi-system approach with POCUS may be used in the systematic evaluation of shock, hypotension, and pulseless electrical activity (PEA) arrest, and may be used to guide resuscitation.

* **Shock and hypotension**: Shock and hypotension may be evaluated using a systematic ultrasound examination of the heart, lungs, abdomen, and lower extremities. These examinations can differentiate shock types and detect potentially reversible life-threatening etiologies, such as cardiac tamponade, acute core pulmonale, and tension pneumothorax. Studies have suggested that POCUS may improve diagnostic accuracy in shock evaluation and shorten the diagnostic process.138–140 Numerous protocols have been described for hypotension.23,24,138,141
* **PEA arrest:** Several common etiologies of PEA arrest may be detected rapidly with ultrasound. This task that has been demonstrated to be feasible without interfering with the resuscitation, and several protocols have been described.142–146
* **Resuscitation:** Ultrasound may influence fluid and vasopressor management in 14-50% of critically ill patients.2,147,148 Respiratory variation of the IVC diameter has been shown to be of utility in predicting fluid responsiveness in mechanically ventilated patients that are completely passive on the ventilator.25,149 In general, in spontaneously breathing patients, when the IVC is small and collapsed it may be safe to give fluids.150 Serial evaluations for interstitial syndromes during resuscitation allows early detection of pulmonary edema and may be useful in determining an endpoint for fluid resuscitation.151

**Appendix 7: Acute Respiratory Failure and Dyspnea**

Point-of-care ultrasound is used in the evaluation of acute respiratory failure and dyspnea through evaluation of the lungs, heart, and lower extremity veins.

* **Pulmonary ultrasound:** Lichtenstein demonstrated that with pleural, pulmonary, and deep vein ultrasound analysis alone a trained provider could determine the etiology of acute respiratory failure in 90% of critically ill patients without any additional clinical information.152 In one study, internal medicine residents improved their diagnostic accuracy in hospitalized patients with dyspnea.153 Numerous authors have demonstrated the ability to differentiate COPD and CHF using lung ultrasound.154,155
* **Cardiac**: The use of cardiac POCUS to assess chamber size, ventricular function, pericardial effusion, and inferior vena cava size can be combined with pulmonary ultrasound in the assessment of dyspnea.14,156 In emergency medicine patients, a combination of cardiac and pulmonary ultrasound findings may effectively exclude acute heart failure.157 Additional benefits may be found when combined with other findings, such as BNP.158
* **Ascites:** Ascites as a cause of dyspnea can be confidently ruled out with abdominal POCUS (sensitivity of 95.8%).62

**Appendix 8: Acute Kidney Injury**

POCUS is used to assess the kidneys and bladder in patients with acute kidney injury, usually combined with an evaluation of volume status. See Appendix 3 for additional details about the kidneys and bladder.

* **Intravascular volume**: Volume depletion is a common cause of acute kidney injury. Evaluation of the heart, IVC, and other areas can guide estimation of volume status.150,159–161 Findings consistent with cardiorenal injury may be detected by evaluation of the heart and IVC.
* **Urinary system:** Imaging of the kidneys and bladder may detect moderate or greater hydronephrosis. A focused ultrasound examination of the bladder can reveal urinary retention or lack of urine suggestive of oliguria or anuria. **Appendix 9: Billing**

Note for all procedures listed in **Table**, the use of ultrasound guidance is included in the CPT code; however, only ultrasound guidance for vascular access is billed separately.

If more than one area was scanned as part of the study, more than one bill can be submitted. For example, if POCUS examination of the lungs, heart, and LE veins is performed as part of PE protocol scan, then the provider can bill for CPT codes 76604, 93308, and 93971.

A peculiar caveat regarding CPT code-based billing is worth mentioning. Each code consists of 2 components: technical fee (added modifier -TC), which is the charge for using the equipment, and professional fee (added modifier -26) which is the charge for image acquisition and interpretation. A code combining both technical and professional fees is called a global fee and has no added modifier. The technical component can only be billed if the physician or practice group owns the US machine. However, Medicare rules specifically prohibit use of global billing codes in hospital setting regardless of equipment ownership. This does not mean that physician groups cannot get reimbursed for their expenses related to purchase/rental and maintenance of the US equipment. However, in order to accomplish that physician groups will have to either bill their respective hospitals or negotiate a contract regarding reimbursement.

Medicare Outpatient Prospective Payment System considers the technical fee for ultrasound-guided procedures to be a packaged service, which is paid for through reimbursement of the procedure being performed. Of note, Medicare reimbursement for technical charges is often more robust than the professional charges.

Only one bill for a particular CPT code can be submitted per day.

**Table 1: Frequently used CPT codes for point-of-care ultrasound billing**

|  |  |
| --- | --- |
| **Diagnostic Ultrasound** | |
| Abdominal Ultrasound, limited | 93308 |
| Retroperitoneal (e.g., renal, aorta, nodes), limited | 76775 |
| Pelvic (non-obstetrical) or bladder, limited | 76857 |
| Deep venous thrombosis, limited | 93971 |
| Chest (lungs) | 76604 |
| Musculoskeletal, extremity, non-vascular (all joints) | 76882 |
| Soft Tissue: Neck (thyroid) | 76536 |
| Ocular (B-scan) | 76512 |
| Ultrasound, other | 76999 |
| **Ultrasound-guided procedures** | |
| Thoracentesis | 32555 |
| Paracentesis | 49083 |
| Arthrocentesis | 20611 |
| Non-tunneled central venous catheter | 36556 |
| US guided venous access (midline or peripheral) or ABG | 36600 |
| Ultrasonic guidance for needle placement | 76942 |

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