SECTION 1

Selected Diagnosic and Therapeutic Techniques of Emergency Medicine

Chapter 1

Emergency Ultrasound

KEY CONCEPTS

EUS is the simultaneous performance and interpretation of a focused sonographic examination at the bedside of the patient for the diagnosis, resuscitation, monitoring, guidance, and treatment of emergency medical conditions.

The most common uses of EUS in decreasing order are trauma, cardiac (cardiac arrest and pericardial effusion), abdominal aortic aneurysm, pelvic, biliary, procedural, renal, and DVT.

FAST examination, originally focused on the detection of dependent peritoneal fluid and pleural effusion.

EUS guidance can assist many percutaneous procedures, such as vascular access, torso cavities evacuation,arthrocentesis, LP, abscess drainage, nerve blocks, and others.

PERSPECTIVE

Emergency ultrasound(EUS) is the simultaneous performance and interpretation of a focused sonographic examination at the bedside of the patient for the diagnosis, resuscitation, monitoring, guidance, and treatment of emergency medical conditions.

Not all pathologic processes will be detected by such examinations.

APPLIED ULTRASOUND PHYSICS AND INSTRUMENTATION

By definition,US is sound with frequencies higher than 20,000 Hz. US is kinetic energy, a longitudinal, mechanical, and directional wave.

US waves are characterized by their amplitude, wavelength, and frequency. Lower frequencies penetrate deeper tissue at the expense of resolution, whereas higher frequencies improve resolution but cannot penetrate deeper structures.

M-mode or motion mode displays received waves over both time and distance and is used to calculate rates, speeds, and distances by sending a steered one-dimensional line across tissue. The most familiar display is B-mode or brightness mode, which graphs the amplitude of reflected US waves as shades of gray from black to white on a monitor screen.

US resolution can be described as axial, in the long axis of the transducer, or lateral, perpendicular to the long axis of the transducer.The area from the probe to the focus is called the near field, and that from the focus to the end of the image is called the far field. The best imaging with maximum reduction in artifacts occurs at the focus.

Focal zones can be increased for more resolution, but frame rate will decrease, causing a slow-motion image that is poor for imaging of moving tissues.

Harmonics listens for multiples of the frequency sent out and often cleans up images near the screen, such as in the gallbladder, apex of the heart, or soft tissue of skin.

Doppler US shows the velocity of moving structures, typically red blood cells, thus representing flow. Color flow Doppler shows direction (by red or blue colors representing flow in opposite directions) and velocity of flow (by degrees of brightness of the color, where lighter is higher velocity). Power Doppler or power angiography describes only the presence of flow and not direction.

Other US terms and artifacts commonly used are listed in Box 1-1.

Box 1-1 Common Definitions

Window: soft tissue where transducer is placed to interrogate tissue in the body
Anechoic: without sounds (black)
Echogenic: with sounds (white)
Hyperechoic: with more reflected sounds than adjacent tissue(more echogenic)
Hypoechoic: with less sound than adjacent tissue (less echogenic)
Shadowing: sound blocked by a reflective barrier
Enhancement: more echogenicity due to increased velocity of sound, typically behind a fluid-filled structure, such as the bladder or gallbladder
Reverberation: an artifact that results from multiple reflections at a given interface, often in parallel
Mirror image: a propagation speed artifact that repeats images that are beyond a strong reflector (e.g., diaphragm), creating a mirror image
Lateral cystic shadowing: a refraction artifact seen on the edge of cystic structures, causing an artificial shadow
Beam width artifact: a volume-averaging artifact causing artifactual echoes in the inferior aspect of anechoic structures or spaces

EQUIPMENT AND SAFETY

A variety of US machines are available, including palm size, laptop, cart based, and combination devices.

Probe design and footprints can be divided into three categories: flat linear array probes, curved linear array probes, and phased array probes.Transesophageal echocardiographic, three-dimensional, and biplanar probes are recently being used in emergency US, creating new imaging venues.

The ALARA (as low as reasonably achievable) principle suggests that the least amount of energy be used to produce satisfactory imaging. Doppler modes should be minimized over sensitive tissue, including early gestation, germinal tissue, and mucosal or neural tissue. The thermal index should be kept below 2.0, and the mechanical index should be kept below 1.9.

APPLICATIONS AND CATEGORIZATION

Grouping of these US applications into categories of resuscitative, diagnostic, symptom or sign based, procedural guidance, and monitoring and therapeutic helps describe the relationship between the uses of US in emergency medicine (Table 1-1).

The most common uses of emergency US in decreasing order are trauma, cardiac (cardiac arrest and pericardial effusion), AAA, pelvic, biliary, procedural, renal, and DVT.

Table 1-1 Classification of Emergency Ultrasound Applications

RESUSCITATIVE	DIAGNOSTIC	SYMPTOM OR SIGN BASED	PROCEDURAL GUIDANCE	MONITORING AND THERAPEUTIC
Cardiac	Cardiac	Hypotension	Any emergency medicine procedure	Central vein size
Trauma	FAST	Dyspnea		Fluid collections
Abdominal aorta	Pregnancy	Chest pain		Cardiac contractility
Pregnancy	AAA	Abdominal pain		Fetal heart rate
Thoracic	Biliary	Extremity pain		Low-frequency clot dissolution
Procedural	Urinary tract			
	DVT			
	Soft tissue and musculoskeletal			
	Thoracic			
	Ocular			
	Advanced uses			
	New uses			

Trauma Ultrasound

The trauma US examination , also called the FAST examination, originally focused on the detection of dependent peritoneal fluid and pleural effusion. Newer versions include the EFAST (extended FAST) for the evaluation of potential pneumothorax and FAST for evaluation of the extremities.

The volume of fluid required for a positive US study depends on the site of injury and site of sonographic detection, but 250 mL or more is generally visible, and nearly 600 mL of fluid is necessary to cause a positive flank stripe when fluid is infused from the pelvis.

In general, 50 mL of pericardial fluid is required to cause hemodynamic compromise in a patient without prior pericardial inflammation. However, tears in the pericardium that communicate with the pleural space or even the peritoneum can cause false-negative examination findings.

Pleural fluid can be detected by US, but this depends on the position of the body. Pneumothorax detection is based on the absence of the normal sonographic sliding of the visceral and parietal pleurae.

Typically, fluid in the peritoneum, pericardium, and pleural cavity is anechoic, but it can have echogenicity with clotting, depending on the age of the clot or bowel contents.

The FAST technique uses a low- to middle-frequency probe (2-5 MHz). Within the peritoneum, dependent spaces include the following, grouped by tissue window: the right flank, which evaluates the hepatorenal space (also called Morison's pouch; Fig. 1-1), the right subphrenic space, and the right costophrenic angle; the left flank, which evaluates the perisplenic space between the diaphragm and spleen, the splenorenal space, the perirenal space, and the left subphrenic space; and the suprapubic view, which is performed by placement of the transducer superior to the pubic bone with a full bladder to visualize the pouch of Douglas in women and the retrovesical space in men. Extra views include the paracolic gutters inferior from the flank views and medial from the iliac spine to visualize free fluid surrounding the bowel.

The typical cardiac views include the transverse subcostal images, which visualize the four cardiac chambers and pericardial space, and the sagittal subcostal view to assess the pericardial space and the collapsibility and diameter of the IVC, indicating right-sided heart pressures.

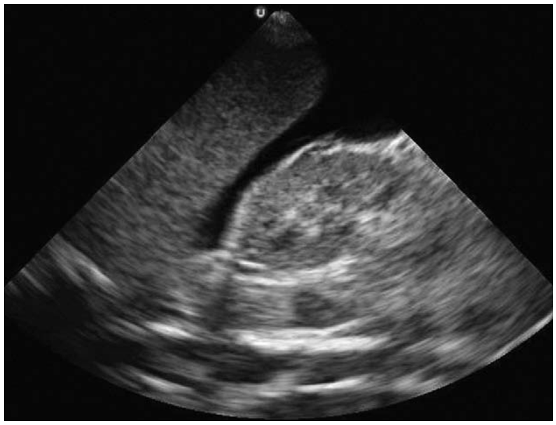

Fig. 1-1 Free fluid in the peritoneum in Morison's pouch seen from right flank.

For pleural fluid, the superiorly angled flank views allow visualization of the costophrenic angles. The evaluation for pneumothorax uses either a low-frequency probe at a shallow depth or, more typically, a high-frequency probe for better resolution, placed at the anterior chest in the second intercostal space for anterior pneumothorax and at the axilla for large pneumothoraces and pleural effusion. Diaphragm injuries have been described with dislocation of typical organ patterns.

The sensitivity of the FAST examination ranges from 60% to 99%, and its specificity ranges from 80% to 99%.

US can diagnose pneumothorax with excellent sensitivity and specificity compared with plain chest radiography and variable accuracy compared with CT scanning.

There are certain populations of patients in whom FAST evaluation has limited benefit.In patients with purely anterior penetrating trauma to the abdomen, the sensitivity of trauma US is poor because bowel injuries can occur without significant hemoperitoneum.

With pelvic fractures, the sensitivity ranges from 20% to 80%. More important, the detection of free fluid in an unstable patient with a pelvic fracture may be due to uroperitoneum from bladder injury rather than hemoperitoneum from vascular injury.In addition, retroperitoneal injuries to the genitourinary tract are not assessed with four-quadrant FAST examination.

Pelvic Ultrasound

Typically, pelvic US is used to confirm intrauterine pregnancy, which indirectly excludes ectopic pregnancy in most patients. Another use during pregnancy is the detection of fetal viability, incomplete abortion, ectopic pregnancy, and molar pregnancy. Pelvic US is used in nonpregnancy states to detect tubo-ovarian abscesses, masses, and hemoperitoneum in the hemodynamically unstable patient.

Indications for sonographic evaluation of the first-trimester pregnant patient include symptoms or signs that suggest an ectopic pregnancy, molar pregnancy, or fetal demise and dating of the pregnancy. Intrauterine pregnancy is confirmed with a gestational sac with a yolk sac or fetal pole within the fundus of the uterus (Fig. 1-2). An embryonic or fetal demise has US findings of a fetal pole measuring more than 5 mm without fetal heart rate or a gestational sac of more than 20 mm in diameter without a fetal pole. A molar pregnancy appears as an echogenic, cystic uterus with disorganized echoes and is associated with high β-human chorionic gonadotropin concentrations without the sonographic finding of intrauterine pregnancy. Findings of an ectopic pregnancy include a chorionic ring or gestational sac with evidence of a yolk sac or fetal pole outside the uterus or in an abnormal location in the uterus, such as the cornu or cervix.In addition, there is a class called indeterminate, which may account for 20% of pregnant patients presenting to the ED in the first and early second trimesters. Heterotopic pregnancies can occur at a rate of 1/5000 and be detected by the same techniques and definitions.

Pelvic US is performed by transabdominal or endovaginal techniques. The transabdominal technique uses a low-frequency transabdominal transducer placed over the lower abdomen suprapubically. Ideally, the patient has a full bladder, which provides a sonographic window, but this may not be necessary if the uterus is large or the patient is thin. In the endovaginal technique, the transducer is placed in the vagina, optimally with an empty bladder to visualize the same structures. Endovaginal transducers are high frequency, providing excellent axial resolution but poor penetration of distant structures with more accuracy. Endovaginal US can detect small (7 mL) amounts of peritoneal fluid. Endovaginal US in the hemodynamically compromised patient has replaced culdocentesis for detection of ruptured ectopic pregnancy.

Fig. 1-2 Intrauterine pregnancy with fetus on endovaginal scanning.

The gynecologic differential diagnosis of significant free fluid in a pregnant woman, in addition to ectopic pregnancy, should include uterine rupture and ruptured corpus luteum pregnancy. Pelvic US in nonpregnancy states has shown good accuracy for tuboovarian abscess and improved decision-making for female patients with right lower abdominal pain.

Cardiac Ultrasound

The use of cardiac US by emergency physicians is presentation and symptom specific and focused in nature. Indications include cardiac arrest, possible pericardial effusion, trauma, chest pain, hypotension, and procedural guidance. Cardiac US is often included in algorithms and protocols for certain symptoms or signs, such as dyspnea or hypotension.

Cardiac US is performed through the transthoracic and transabdominal windows with use of small curvilinear or phased array transducers. Typical views include the subcostal four-chamber and long-axis views, parasternal long-axis view, parasternal short-axis view, and apical four-chamber view. In addition, the apical four-chamber view provides excellent comparison of the right and left ventricles in terms of size and function. The long-axis subcostal view shows some of the right side of the heart but highlights the IVC, including size and respiratory variation.

Cardiac US shows good accuracy in detection of pericardial effusion (Fig. 1-3), assessment of left ventricular function, and evaluation of patients with undifferentiated shock. In addition, aspects of cardiac US are being used for the assessment of intravascular volume status and cardiac output and in the

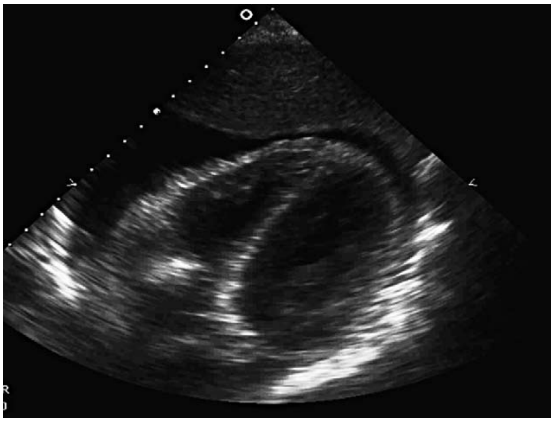

Fig. 1-3 Pericardial effusion in subcostal view.

evaluation of dyspnea.

In cardiac arrest, US can detect ventricular motion in both asystole and PEA.In asystole, the prognosis is poor in the absence of sonographic ventricular activity. Cardiac US can detect pseudoasystole by revealing Vf or coordinated cardiac contractions without a palpable pulse. Use of cardiac US in PEA and near-PEA states can be diagnostic for pericardial effusion. Cardiac US can detect ventricular capture when the patient is paced, transcutaneously or by a transvenous pacer. US can also identify pneumothorax, another treatable cause of cardiac arrest. Cardiac US is feasible during pulse checks and prehospital life support, as advanced cardiac life support guidelines suggest minimizing non–cardiopulmonary resuscitation intervals.

Emergency cardiac US is diagnostic for both medical and traumatic pericardial effusions with excellent accuracy.

Cardiac US is used for detection of pericardial effusions, chamber enlargement, and global activity in chest pain syndromes for the evaluation of pericardial tamponade, pulmonary embolus, cardiogenic shock, aortic dissection, pneumothorax, and bony chest wall fracture.

US protocols have been developed to evaluate undifferentiated hypotension. Cardiac US windows with the addition of abdominal views can assess for effusion, global ventricular activity, ventricular chamber size, IVC size and respiratory change, peritoneal fluid, and AAA to narrow the differential diagnosis. Sepsis is the most common diagnosis for patients with hyperdynamic ventricular activity.

Central pressures can be estimated by examination of the IVC size and collapsibility. This technique has good accuracy in assessment of blood loss, hypovolemia, and CHF.

Cardiac US is also a procedural guide for placement of transvenous pacer wires and for pericardiocentesis.

Abdominal Vascular Ultrasound

Emergency physicians use abdominal US to detect AAA, another silent disease in patients with flank, abdominal, or back pain, and to evaluate unexplained hypotension in the older patient. The use of US to detect aortic dissection and occlusion is described as well.

The technique involves imaging of the aorta from the subxiphoid space to the umbilicus to evaluate for dilation above a diameter of 3 cm (Fig. 1-4). For the detection of infrarenal aneurysms, the technique should visualize the aorta from the diaphragm to the aortic bifurcation. Fusiform aneurysms are more common, but detection of saccular aneurysms requires both the transverse and longitudinal planes. If an aneurysm is found, a peritoneal view of Morison's pouch is performed to detect intraperitoneal fluid. Proximal iliac arteries may be followed if it is technically feasible or time allows.

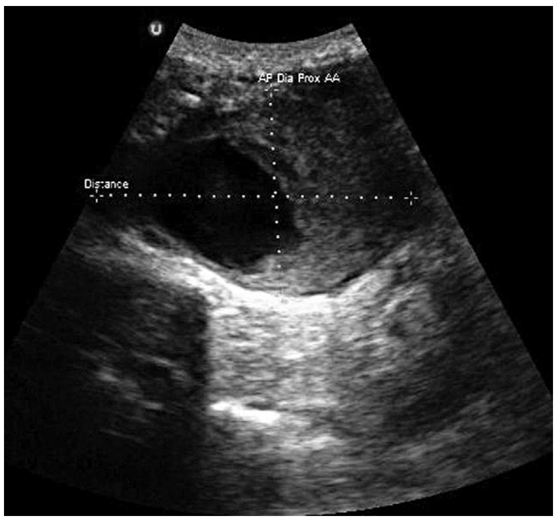

Fig. 1-4 Large AAA with echogenic intraluminal clot.

Emergency physician use of US for AAA detection has shown good accuracy compared with other imaging modalities and laparotomy.

Aortic dissection may be detected by a combination of abdominal and cardiac scanning. A linear echogenic flap, anywhere across the lumen of the aorta, is suggestive of dissection, sometimes with the detection of different flows on either side of the flap by color Doppler scanning. The cardiac US examination can show unexplained pericardial effusion; a dilated aortic root; aortic insufficiency; and a linear echogenic flap seen in the ascending aorta, aortic arch , or descending aorta.

Aortic occlusion is another condition that may be detected by US. Echogenic thrombus may fill the aorta and disrupt perfusion below the diaphragm. Clear identification of the borders and lack of Doppler flow in the abdominal aorta are characteristic of the syndrome.

Biliary Ultrasound

Biliary US to detect gallstones and associated cholecystitis was one of the early applications of US in emergency medicine. The sonographic technique involves a modified biplanar approach to the right upper quadrant. A complete evaluation includes visualization of the common bile duct. The diagnosis of cholelithiasis is made after identification of echogenic foci within the gallbladder lumen with shadowing (Fig. 1-5). Other image patterns include stones that will not shadow, sludge, and the wall echo sign of a gallbladder full of gallstones. Signs of cholecystitis include a dilated gallbladder, increased gallbladder wall thickness, sonographic Murphy's sign, and pericholecystic fluid. A nonmobile stone in the gallbladder neck is highly suggestive of eventual cholecystitis. Biliary US is fast and accurate, with a sensitivity of 87% to 94% and a specificity of 82% to 96% in detection of gallstones, comparable to radiology ultrasonography. Biliary US has replaced nuclear medicine testing.

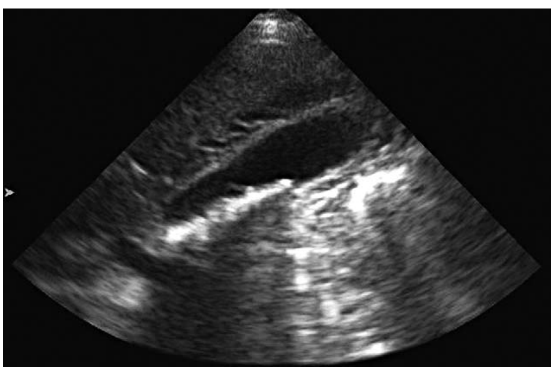

Fig. 1-5 Echogenic layering gallstones seen in gallbladder with posterior shadowing.

Urinary Tract Ultrasound

Renal or urinary tract US can detect hydronephrosis or urinary retention.

Renal US includes biplanar views of the kidneys with emphasis on dilation of the calyceal system and pelvis of the respective kidney (Fig. 1-6). In addition, visualization of the bladder can diagnose secondary hydronephrosis from an obstructed bladder stone and may demonstrate nonobstructive bladder jets through the use of Doppler US. The windows for the two kidneys are similar to those of the trauma flank series, with the exception that the patient may be rolled on the opposite side so that the transducer may be placed more posteriorly on the back if necessary. The bladder view is performed suprapubically, and calculations of volume may be made with on-machine calculators or by formula.

Renal US has a sensitivity of 83% and a specificity of 92% in detection of hydronephrosis (Fig. 1-6). Bladder US is useful for detection of a full bladder and the presence of a Foley catheter and for guidance during suprapubic aspiration or Foley placement.

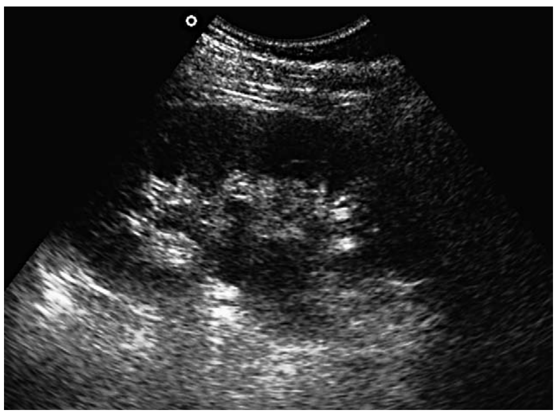

Fig. 1-6 Hydronephrosis in renal pelvis and calyces.

Deep Venous Thrombosis Ultrasound

The swollen extremity often requires sonographic imaging to assess for DVT. Emergency physicians commonly use compression US to rule out DVT. The two-level compression technique involves visualization of the compressibility of the common femoral and popliteal veins. The three-level technique adds the junction of the superficial femoral and deep femoral veins (Fig. 1-7). Use of upper extremity veins is less common because Doppler US is needed for the subclavian vein, which is not compressible under the clavicle.The accuracy of this technique ranges from 70% to 99%, depending on operator experience.

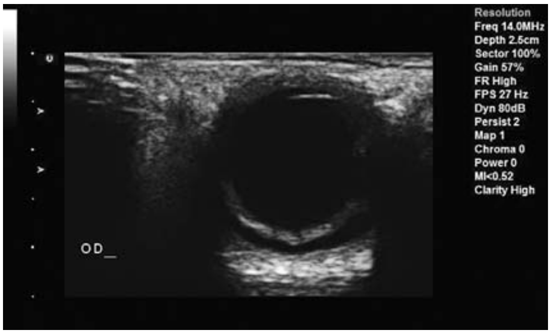

Fig. 1-7 DVT with layering clot in popliteal vein seen on compression US examination.

Thoracic and Tracheal Ultrasound

Thoracic applications include the detection of pleural effusion, pneumothorax, pneumonia, and interstitial edema. The technique of thoracic US uses a low-frequency probe to survey for pleural effusions and a high-frequency probe to detect pleurallines and related artifacts. Pleural fluid appears as an anechoic collection above the diaphragm (Fig. 1-8). In addition, a collapsed lung may be visualized as an echogenic floating structure. Normally, the parietal and visceral pleural lines slide against each other, and lack of sliding is the finding most consistent with pneumothorax (on M-mode, called the seashore sign). Additional findings of pneumothorax include the presence of horizontal artifacts called A-lines (on M-mode, called the stratosphere sign) and the absence of B-lines (vertical white lines from reverberation of air with fluid) at the parietal-visceral pleural line (Fig. 1-9). Confounding factors include adhesions of the pleura, COPD, prior pneumothorax, and mainstem bronchus intubation. A lung point sign is the edge of the pneumothorax where the lung is still adherent to the parietal pleura, and part of the image shows no sliding until the lung moves into the interspace with respirations. The accuracy of US for detection of pneumothorax (sensitivity 100%, specificity 98%) is better than that of plain chest radiography in the acute setting, but there may be reduced accuracy after 24 hr.

Severe pneumonia is visualized as echogenic “liver-like” echogenicity as the lung accumulates fluid with consolidation. Peripneumonic collections are common and may indicate inflammation. The

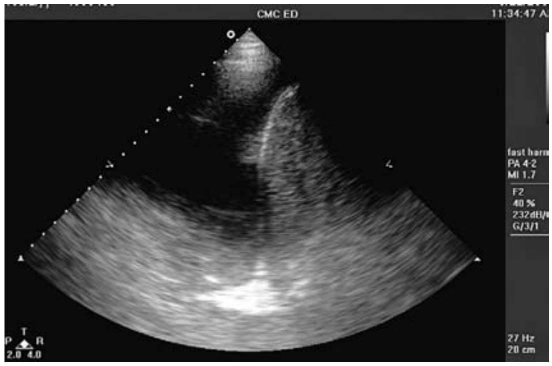

Fig. 1-8 Large pleural effusin.

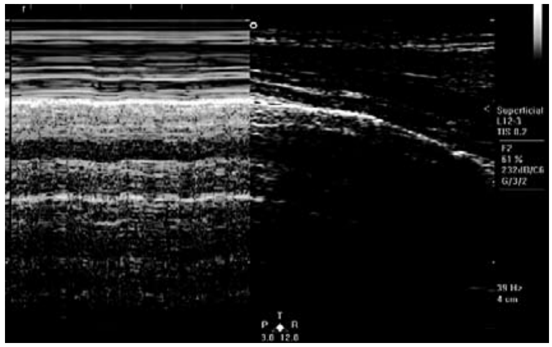

Fig. 1-9 M-mode image of normal lung sliding.

dynamic air bronchogram, hyperechoic areas within bronchi that move with respiration, usually within “heparinized” lung, has been described as another sign of alveolar consolidation. Pulmonary edema is indicated by the presence of comet tails (B-lines), which are reverberation artifacts that reflect from the parietal pleural interface into the lung. Normally found in dependent areas of the lung, the widespread distribution of these artifacts in an apical lung may indicate increased lung congestion. Dynamic tracheal US for the confirmation of endotracheal intubation has relatively good sensitivity and specificity, but static US seems to lack accuracy. This technique may have a role in patients in cardiac arrest or with equivocal $ETco_2$ levels.

Ocular Ultrasound

The eye is an excellent acoustic window, and short-duration gray scale US over a closed eyelid can visualize both the anterior and the posterior chamber well. Ocular US has been described for intraocular disease, such as retinal detachment, retinal hemorrhage,vitreal hemorrhage, intraocular foreign body, dislocated lens, and retro-orbital hemorrhage. The sensitivity of ocular US for retinal detachment by emergency physicians is 100%, and the specificity is 83% to 92%. In addition, the optic nerve sheath diameter can be measured behind the eye, reflecting intracranial pressure. The sensitivity of such measurements ranges from 83% in children to 100% in adults.

Soft Tissue Ultrasound

Soft tissue US is used to differentiate cellulitis from abscess,to detect foreign bodies and hernias,and to evaluate other soft tissue pathologic processes, including masses, pseudoaneurysms, and glands. A high-frequency linear transducer moves from normal skin to the abnormal area. Cellulitis or edema will cause an echogenic pattern with cobblestoning between fat lobules (Fig. 1-10). Abscesses are irregular hypoechoic to anechoic collections within the subcutaneous layer but may connect with the surface (Fig. 1-11). US is diagnostic in soft tissue disease for cellulitis, abscess, and necrotizing fasciitis.

US can differentiate peritonsillar abscess from cellulitis and can be used for guidance of peritonsillar aspiration. It can also detect early Ludwig's angina

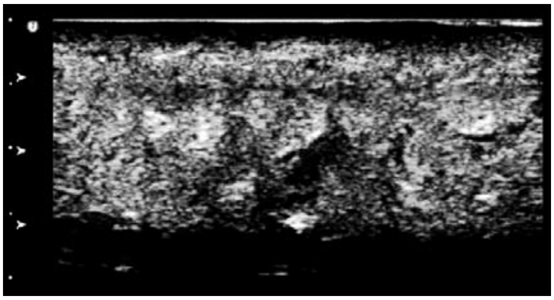

Fig. 1-10 Sonographic cellulitis with echogenic subcutaneous tisse.

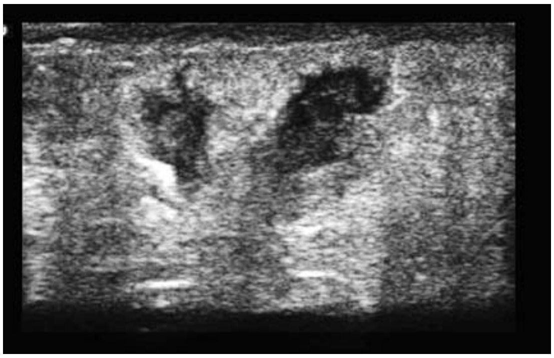

Fig. 1-11 Sonographic subcutaneous abscess.

with abscess, dental abscess, epiglottitis, glandular abnormalities, and pseudoaneurysm in soft tissues and fascia of the face. US has also been used in various body areas, including the penis and scrotum, for signs of disruption or infection.

Detection of foreign bodies is characterized by variable echogenicity in the tissue with shadowing beneath the foreign body. Metal foreign bodies, such as bullets and intrauterine devices, have characteristically high-reflective echogenicity and ring-down artifacts.

Musculoskeletal Ultrasound

US has been particularly useful for joint effusion and muscle, tendon, and bone injury. US is excellent for detection of fluid in joints, confirmation of effusions, and guidance of drainage procedures. Joint effusions typically are anechoic or echogenic, depending on type and age.

Diagnosis of ligamentous injuries and muscle avulsion and hemorrhage has also been reported. Muscle and tendon abnormalities are detected by anechoic and heterogeneous abnormalities.

Fractures are seen as a defect in the bony cortex.

US is accurate in the detection of fractures, joint effusions, bursitis, cysts, and hematomas.

Transcranial Doppler Ultrasound

Transcranial Doppler US has been used for detection of abnormal flow patterns in the brain and for detection and treatment of middle cerebral artery strokes.

Testicular Ultrasound

Testicular scanning is an advanced US application that requires visualization of the normal and symptomatic testicle with a high-frequency probe. Absent or decreased flow on the affected side indicates possible torsion, whereas increased flow indicates epididymitis.

Abdominal Bowel Ultrasound

The use of bedside US for evaluation of appendicitis, diverticulitis, and other bowel disease is an area of increasing interest. There has been variable experience with the use of graded compression US to detect appendicitis (>6 mm), with reported sensitivity of 67% and specificity of 92% (Fig. 1-12).In women, endovaginal US can be used to rule out adnexal

Fig. 1-12 Image of noncompressible appendix compatible with appendicitis.

disease.

The use of US for diverticulitis, intussusception, volvulus, and SBO has been reported. Thickening of the bowel, dilated bowel with fluid-filled loops, and changes invascularity suggest disease.

Hernias, described in the soft tissue section, may also be detected as masses in the ventral, inguinal, paramedian, femoral, and scrotal areas.

Ultrasound for Procedural Guidance

The use of US for procedural guidance has expanded for many emergency procedures, especially vascular access, and is advocated for error reduction.

Procedural guidance can be static or dynamic. Static guidance suggests that US has been placed over the anatomic area, and the area is marked while angle and distance information is noted. Dynamic guidance describes procedures performed with real-time US visualization of the needle entering the anatomic area on the monitor as well as on the patient.

There are two common axis approaches to vein cannulation: transverse, in which the vein appears as a circular structure on the screen; and longitudinal, in which the vein appears as a tubular structure along the width of the screen. In the transverse approach, the probe's long axis is centered transverse to the long axis of the anatomic area, guiding the needle to bisect the probe at its center, which gives centering and depth information (Fig. 1-13). In the longitudinal axis , the probe is placed along the long axis of the anatomic area, and the needle is introduced in the long axis of the probe, giving depth and trajectory information (Fig. 1-14). Finally, an oblique axis has been described, essentially approaching the vessels at 45 degrees but visualizing the target vessels and

Fig. 1-13 Transverse image of internal jugular vein for procedural guidance.

Fig. 1-14 Longitudinal image of the needle in an internal jugular vein for procedural guidance.

surrounding structures.

The most studied and most advocated use of US procedural guidance is for central line insertion. US guidance for internal jugular central line insertion can be recommended as a safe and best practice.

US permits the physician to assess the internal jugular for overlap with the carotid artery, vessel diameter, and presence of luminal clot or vessel obliteration.

US does not prevent posterior vein wall penetration as reported in case reports and simulated models. Adverse events (hematoma, arterial cannulation, pneumothorax, and unsuccessful placement) can occur in up to 20% of patients having US-guided internal jugular catheterization.

Femoral vein insertion has been studied in cardiac arrest patients, and improved cannulation rate and reduced complications have been reported.

US does not contribute to procedural success in subclavian vein cannulation because of the lack of a convenient window for the subclavian vein under the clavicle.The supraclavicular fossa is a window for central line insertion.

Emergency physicians are able to use US to insert peripheral intravenous catheters in patients with difficult access with high success rates. Veins that are large in width (0.4 cm) or at moderate depth (0.3-1.5 cm) have a higher success rate.

Sonographic confirmation of intraosseous placement has also been described with detection of Doppler flow outside the bone and inside the marrow. Numerous other procedures using US guidance have been described in emergency practice (Table 1-2).

Table 1-2 Ultrasound-Guided Emergency Procedures

ULTRASOUND	PROCEDURE
Vascular access	Central venous access Internal jugular vein Subclavian near axillary vein Subclavian with supraclavicular approach Femoral vein Peripheral vein Basilic Brachial Cephalic Forearm veins Intraosseous needle Arterial cannulation Radial artery Arterial sampling
Torso fluid collections	Paracentesis Thoracentesis Pericardiocentesis
Cardiac	Pacer placement
Musculoskeletal	Arthrocentesis Hip Knee Other joints Fracture reduction Foreign body removal Tendon sheath injection
Soft tissue	Abscess drainage Hernia reduction
Anesthesia	Interscalene Peripheral nerves Axillary Femoral nerve Hematoma block
Airway	Endotracheal tube placement
Urinary bladder	Suprapubic aspiration and cystostomy Foley guidance
Neurologic	LP

Out-of-Hospital Ultrasound: Disasters and Remote Settings

US has been used in the out-of-hospital, military battlefield, disaster, and international medicine settings. The use of US has been described in European and other settings by physicians in the out-of-hospital arena, including ground, helicopter, air, and space, and by paramedics for FAST and abdominal aorta examinations.

INTEGRATION INTO EMERGENCY MEDICINE PRACTICE

US has been integrated into emergency medicine practice because of the need for effective, noninvasive, nonpainful, portable imaging techniques. US is a skill that requires constant attention with hands-on practice and interpretation. Emergency US, the performance and interpretation of ultrasonographic examination at the bedside in the emergency setting, has enhanced many aspects of emergency care, making diagnosis and treatment more rapid, efficient, safe, and accurate.

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