Point-of-Care Ultrasonography: Tips and Tricks

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This lecture will focus on point-of-care ultrasonography for the small animal emergency practitioner and general practitioner. Ultrasound is becoming increasingly popular and affordable in small animal clinics, and is standard-of-care for making many diagnoses. With a small amount of knowledge and training, even a novice ultrasonographer can quickly gain imperative information about their patient.

Terminology:
FAST: Focused assessment with sonography for trauma
AFAST: Abdominal focused assessment with sonography for trauma
TFAST: Thoracic focused assessment with sonography for trauma
VetBLUE: Veterinary Bedside Lung Ultrasound Examination

Key Points:
Although initially used in human trauma patients, point-of-care ultrasound (POCUS) does not require trauma to be present. It does not replace a specialist's (ie. radiologist's) expertise. POCUS is often used in the unstable patient especially at the time of triage. The patient may be in cardiovascular shock or respiratory distress, and movement to the radiology suite may be contraindicated. Overall, POCUS is safe, inexpensive, rapid, reliable, non-painful, portable, and radiation-sparing.

Novice POC ultrasonographers often clip fur or use ultrasound gel, but this is often not required, is time consuming, and can upset some owners. Even in the furriest animal, fur can often be parted down to the skin and a small amount of alcohol applied to where the probe will be placed. Use a small amount of alcohol in pediatric patients (can cause hypothermia) and when animals will then be placed into an oxygen cage, as the fumes can be noxious. Large amounts of alcohol should also be avoided should electric defibrillation be potentially required. Curvilinear probes are recommended. Phased array probes are best for exclusively cardiology.

AFAST:
Although the protocol was originally published in right lateral recumbency, animals may be standing or in left lateral recumbency. Dorsal recumbency should be *avoided* in patients in shock, because this places increased pressure on the caudal vena cava (preventing venous return, therefore decreasing cardiac preload and cardiac output) and places increased weight on the diaphragm, impairing oxygenation and ventilation.

There are 4 classic views to AFAST:
DH: Diaphragmaticohepatic view
CC: Cystocolic view
HR: Hepatorenal view
SR: Splenorenal view

An Abdominal Fluid Score (AFS) may be generated. Each AFAST site is scored as binary (yes or no) for free fluid. 4/4 would be free fluid at all 4 sites. Higher AFS has been documented to lead to higher blood transfusion requirements in patients with hemoabdomen. Repeat AFAST and AFS should be repeated after any intravenous fluid resuscitation as new onset free fluid is not uncommon, especially in hypovolemia.

DH: Diaphragmaticohepatic view

The probe is placed caudal to the xiphoid process with the probe head facing cranially, and the ultrasonographer fans through, cranial, and caudal to the liver for free fluid. Additional structures that should be evaluated include the gall bladder, hepatic vasculature, caudal vena cava, and intrathoracic structures.

The caudal vena cava (CVC) can often be used as a surrogate for intravascular fluid status. The CVC diameter varies with inspiration and expiration. On inspiration, blood in the CVC is drawn from the abdomen into the thorax (a negative pressure space), causing the CVC to decrease in diameter. In hypovolemic patients, the CVC is deemed to be "flat;" this patient should be volume-responsive. In normovolemic patients (who still may be volume responsive), there is roughly a 50% "bounce" of the CVC with each respiratory cycle. If the CVC is "fat" or distended, this may indicate volume overload or high pressure on the right side of the heart (differential diagnoses include pericardial effusion, right-sided congestive heart failure, systolic dysfunction, pulmonary hypertension, etc.)

The gall bladder should be assessed in all AFAST exams. A gall bladder "halo" is common with anaphylaxis, an increasingly recognized condition in dogs. Gall bladder "halo" does not occur in cats, as the pathophysiology of anaphylaxis is different in this species. In dogs, histamine is released in the GI tract and enters the portal circulation, and then travels to the liver. In the liver, histamine causes increased capillary permeability, leading to an edematous gall bladder (ie. halo sign). An increase in ALT is also very common in anaphylaxis for the same pathophysiologic reason. Interestingly enough, increased ALT and gall bladder "halo" typically only occur in moderate-severe hypersensitivity reactions (acute onset vomiting, diarrhea, collapse, tachycardia, hypotension, and sometimes mild hemoabdomen), but not with mild hypersensitivity reactions (ex. post-vaccine angioedema). The interested reader is directed to Quantz et al, JVECC 2009. The gall bladder can also be assessed for mucocele, etc.

The DH view is also useful for visualizing intrathoracic structures and can be used to evaluate for pericardial or pleural effusion. This view is very useful in large, down dogs where the heart is difficult to visualize at classic TFAST views. The probe head should be angled cranially and the depth and focus properly adjusted. Don't be afraid to push hard (within reason) and angle the probe cranially in larger dogs to see into the thorax.

SR (Splenorenal, ie. left flank) view:

The spleen and left kidney should be visualized. The spleen can be evaluated for any neoplastic lesions. Free fluid is typically "triangular" in appearance. Be careful not to mistake free fluid for large blood vessels, such as the aorta or caudal vena cava.

CC (Cystocolic) view:

This view is the most basic as most novice ultrasonographers can identify the urinary bladder, and I often start with this view to "get my bearings." The urinary bladder is visualized, and the probe fanned left, right, cranial, and caudal. Free fluid is typically between the bladder and colon. A fluid-filled structure that is dorsal to the bladder and ventral to the colon is often a fluid-filled uterus, and pyometra should be considered.

HR (Hepatorenal, ie. right flank) view:

In right lateral recumbency, fluid will accumulate in this gravity-dependent area, and is therefore also sometimes termed the "home run" view. Don't be discouraged if you do not identify the right-kidney in right lateral recumbency; it is tucked by the caudate lobe of the liver.

Additional points:
The astute practitioner should *always* perform abdominocentesis when free peritoneal fluid is identified and it is safe to do so. *Never* assume that a particular fluid is present. Fluid should be evaluated grossly, cytologically, and a TS obtained. A suspected hemoabdomen may in fact have a modified transudate as free abdominal fluid secondary to pericardial effusion, significantly changing prognosis and potential treatment recommendations. Fluid that is suspected to be hemorrhagic should be spun down as a PCV as low as 10% can appear as blood to the naked eye.

TFAST:
Chest tube site (CTS), bilaterally:
This is at the dorsal most point on the chest and is best for identifying pneumothorax. With practice, one can see the pulmonary-pleural "glide sign" which is the visceral and parietal pleura touching, and moving to-and-fro with respiratory motion. With pneumothorax, this "glide sign" is absent. As the probe is moved ventrally, the "lung point" may be identified, which is where the pulmonary-pleural glide sign returns again. This can help identify how large the pneumothorax is. Many youtube videos exist on identifying the "glide sign" and M-mode can also be used, although also this takes practice. Detecting pneumothorax with POCUS is very much so a learned skill, as demonstrated in Lisciandro et al., JVECC 2008. In this study, the expert ultrasonographer diagnosed pneumothorax correctly 95.2% of the time, but novice ultrasonographers diagnosed pneumothorax 45.4% of the time. Additional veterinary studies have since been published which state that POCUS identifies pneumothorax poorly, but often the recruited ultrasonographers in the study had insufficient training (ie. practiced their skills on one dog prior to contributing to study data). Human ER physicians have become very proficient at identifying pneumothorax ultrasonographically. This is a very useful triage tool when practiced. To identify the "glide sign" better, try angling the probe dorsally and ventrally, and try placing the probe directly on the body of the rib. If there is an option on your ultrasound machine, try turning off tissue harmonics.

Pericardial site (PCS), bilaterally:
At roughly the 4^{th}-5^{th} intercostal spaces, the heart should be imaged on the left and right sides of the chest. To identify pericardial effusion, it is *essential* that the ultrasonographer view the entire heart (Zoom out! Increase depth!) and that the hyperechoic pericardium is seen in the near and far fields. Far too many novice ultrasonographers have erroneously diagnosed pericardial effusion and have mistaken pericardial effusion for a heart chamber when depth is too shallow.

The probe should be moved cranially and caudally from the heart to diagnose gravity-dependent pleural effusion.

Right-sided views are typically used to subjectively (or objectively) measure left atrial size and fractional shortening. Imaging this is beyond the scope of this lecture, but is not difficult for a novice ultrasonographer to learn. Subjective assessments of left atrial size are often just as good as a left atrial measurement in the ER setting.

DH (Diaphragmaticohepatic) view:

A useful tip for diagnosing pleural and pericardial effusion is by imaging the thorax through the abdomen and through the diaphragm. See above.

VetBLUE (Veterinary Bedside Lung Ultrasound Examination):

Lung ultrasound was previously deemed impossible because ultrasound cannot penetrate air, but recent discoveries (in the past 10-20 years) have shown that lung ultrasound is a very useful tool for identifying pulmonary pathology, albeit with limitations. In order to visualize pulmonary parenchymal pathology, pathology must extend to within 1-3mm of the visceral pleura. Interestingly, it often does.

B-lines (previously termed ultrasound lung rockets or comet tails) are hyperechoic laser-like lines originating from the pulmonary-pleural line and extend to the far edge of the screen without fading. B-lines represent interstitial-alveolar edema (ie. extravascular lung water) and are an ultrasound artifact; one we can use to our advantage. The reverberation of the ultrasound with the air-fluid interface creates this artifact. Keep in mind, B-lines only let you know that there is fluid in the lung, but differential diagnoses include hemorrhage, exudate (pus), edema (cardiogenic or non-cardiogenic), or atelectasis. B-lines can be graded as 1, 2, 3, >3, or infinity (confluent) B-lines per ultrasonographic field and may correlate with disease severity, or can be serially used to assess disease resolution (or lack thereof).

When interstitial-alveolar edema worsens to the point that air is no longer in an area of the lung, the lung appears more hypoechoic. This is termed C-lines (or shred sign). If the entire lung lobe lacks air, it appears similar to liver (an organ without air in it), and is thus termed “hepatized.” Interestingly, air bronchograms can be seen on lung ultrasound with significant enough consolidation. Anecdotally, left-sided congestive heart failure rarely manifests with ultrasonographic lung consolidation (often appears simply as many B-lines), but pneumonia and pulmonary contusions often appear as consolidation.

Lung nodules may also be seen on VetBLUE. These nodules may represent neoplasia (often metastatic), fungal granulomas, and sometimes small areas of consolidation. These findings should always be followed up with thoracic radiographs and should be correlated with case history, but may be a useful triage tool.

The original veterinary lung ultrasound studies documented that B-lines are very rare in healthy dogs and cats (roughly 9/10 healthy dogs and cats lack B-lines, and those that do have very few B-lines had them mostly in gravity-dependent lung regions). Lung ultrasound is highly sensitive and specific for left-sided congestive heart failure and could reliably (>90% sensitivity and specificity) differentiate dogs in ACVIM Class B1/B2 vs. Class C (L CHF). Remember, the presence of significant B-lines must be correlated with patient history and physical exam findings. A study has yet to be done, but anecdotally, lung ultrasound is incredibly helpful for differentiating an asthmatic cat from a heart failure cat. Unless the asthma is chronic/end-stage, there is rarely pulmonary edema (B-lines) present. Within minutes, one can correctly rule out L CHF with POCUS (no B-lines, normal left atrial size), administer a puff of albuterol and sedation to an asthmatic cat without causing undue stress obtaining radiographs. Radiographs may always be considered when the patient is stable.

In trauma, lung ultrasound is highly sensitive (90.5%) for detection of pulmonary contusions, and was more sensitive than thoracic radiographs (66.7%) compared to CT as gold standard (Dicker et al, JVECC accepted for publication). As such, I perform a full AFAST/TFAST/VetBLUE on all trauma patients, as I can usually get most of the information I need about cardiovascular status, internal hemorrhage, pneumothorax, and pulmonary contusions with a 3-5-minute POCUS. This avoids unnecessarily stressing an animal in the radiology suite with restraint. Again, radiographs can always be considered once stable.

Lung ultrasound pathology can be topographically correlated with disease process. For example, left-sided heart failure is often caudodorsal to perihilar, non-cardiogenic pulmonary edema classically caudodorsal, and aspiration pneumonia cranioventral.

Thank you to Gregory Lisciandro, DVM, DABVP, DACVECC, arguably the biggest contributor to the veterinary POCUS literature, for co-authoring a study during my residency as well as providing valuable insight and providing images for the lecture.

Additional references available on request.