

Lung Ultrasound

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INTRODUCTION

The reluctance to proactively apply lung ultrasound to small animals with respiratory signs or distress is irrational in many respects. The overriding belief that the air-filled lung creates insurmountable sonographic obstacles and that its imaging is difficult, perpetuates these myths and delays its widespread acceptance. Dr. Roy Filly dubbed the ultrasound probe the “modern stethoscope” 30-years ago, and he was remarkably and absolutely right!

TFAST (thoracic FAST) was the first standardized abbreviated veterinary ultrasound exam of the thorax. TFAST includes the proactive survey of lung via the TFAST chest tube site (CTS) for the detection of pneumothorax. However, with the finding evidence of lung pathology in trauma and non-trauma cases during TFAST, an extended lung scan from the TFAST CTS was developed by the author and named Vet BLUE (Veterinary Bedside Lung Ultrasound Exam and BLUE also for cyanosis implying respiratory distress). Vet BLUE has 9 acoustic windows with 8 transthoracic regional views applied bilaterally named: the caudodorsal (Cd) lung region, the perihilar (Ph) lung region, the middle (Md) lung region, and the cranial (Cr) lung region. It is important to recognize that the views are not anatomical per se, and that different parts or different lobes may dynamically enter and exit the intercostal spaces of any of these 8 views. As an example, dry lung, then wet lung, then dry lung, then wet lung may interchange during phases of respiration; or dry lung, a nodule sign, and dry lung, then a nodule sign, at another view as the patient inspires and expires. This phenomenon is fairly common. The 9th unpublished view is the FAST DH view, which is part of AFAST (abdominal), TFAST (thoracic), and Vet BLUE (lung), and provides a deep acoustic window of lung along the diaphragm.

The next logical step was developing an easily understandable lung language. The author has sided with a visual nomenclature over A-lines, B-lines, C-lines, and PLAP lines with the following lung ultrasound signs of dry lung (A-lines with lung sliding), wet lung (B-lines also called lung rockets), shred sign, wedge sign, tissue sign, and nodule sign, while also acknowledging the international lung ultrasound consensus statement of 2012. These terms have been adopted and modified primarily from Volpicelli and Lichtenstein. The visual system appears at least in part in the human literature (Lichtenstein) and point-of-care ultrasound textbooks as well (Soni). In addition to having an understandable lung ultrasound signs language, and a standardized exam named Vet BLUE, a simple easily understandable, standardized method for recording findings is likewise mandatory. Without recording findings on Vet BLUE, patient information is lost and is likened to performing a physical exam without recording your findings.

HOW TO PERFORM VET BLUE

Patient Positioning and Preparation

Although Vet BLUE may be performed in lateral recumbency, Vet BLUE is generally performed in standing or sternal recumbency, which is safer for dogs and cats in respiratory distress, or those that are hemodynamically-respiratory fragile. For acquiring ventral views of Vet BLUE (and TFAST) in a respiratory distressed or fragile patient, a rolled-up towel or a roll of paper towels under the forelegs is a well-tolerated maneuver in a sternally recumbent feline or canine to gain access to the Vet BLUE middle and cranial lung regions and the TFAST pericardial site views.

Generally, no Vet BLUE sites are shaved. All images in the lecture were from unshaved sites. The fur is parted and alcohol is applied to the fur to wet and help part fur thus exposing underlying skin. Acoustic coupling gel or alcohol-based hand sanitizer may additionally be placed on the skin and/or probe head. Keep in mind that many ultrasound manufacturers warn against placing alcohol directly on the probe head because of alcohol's potentially desiccating and damaging effects to the probe head. To maximize the image quality, the probe head must be applied as directly as possible to the skin surface without air-trapping fur in between the probe head and the patient's skin. A common mistake is to apply coupling medium to the fur and then place the probe on the wetted or gelled mat of fur full with trapped air. Eliminating air in between the probe head and skin optimizes your ultrasound image.

Basic Vet BLUE Orientation - The Gator Sign

The gator sign typically gets some chuckles; however, the concept is important to understand to ensure that the pulmonary-pleural interface, also referred to as the lung line, is properly imaged. By mistaking air reverberation artifacts or another structure such as the surface of the scapula for the lung line, lung ultrasound is inaccurate. The probe is held stationary perpendicular to the long-axis of the ribs to create an orientation where rib heads are interposed by the intercostal space for accurate identification of where to expect the lung line. The rounded rib heads are likened to the eyes and the interposed intercostal space the bridge of the nose of a partially submerged alligator peering at you over the water's surface.

Figure 1

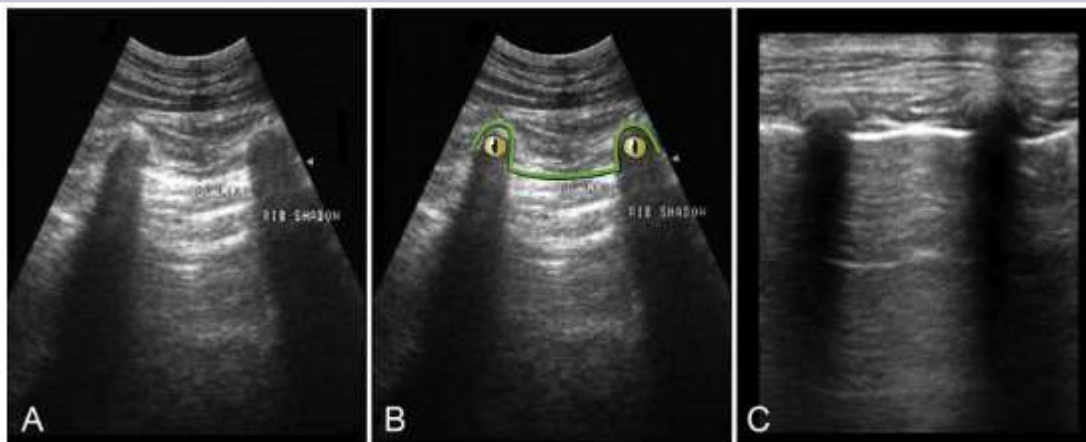


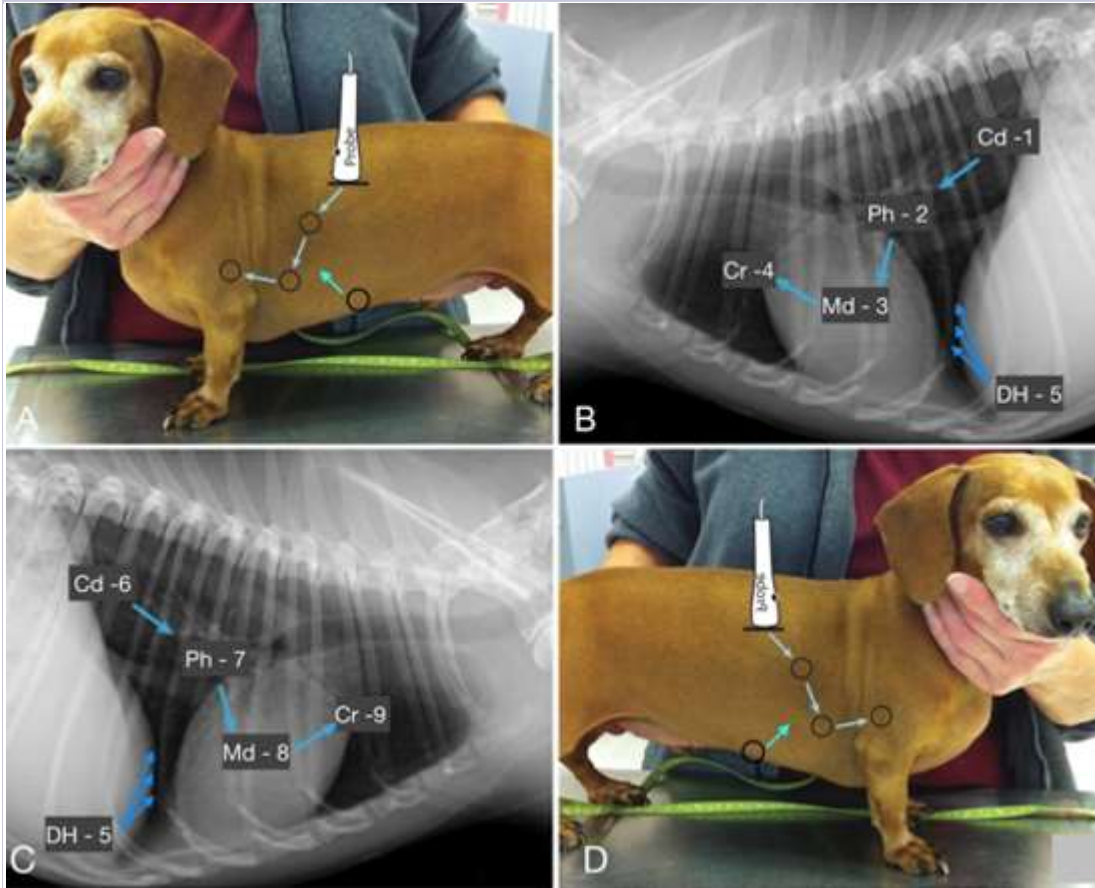
Figure 1. The probe is positioned over lung perpendicular to the long-axis of the ribs. The rounded rib heads are likened to the eyes, and the pulmonary-pleural (PP-line) interface, also called the lung line, to the bridge of its nose, as a partially submerged gator (alligator) peers at the sonographer (middle image, B). The overlay of eyes and a connecting green line delineates proper beginning orientation for all lung ultrasound called the gator sign, and C) showing the same orientation with a linear probe, which is unnecessary for Vet BLUE. The convex probe is preferred since it is used for AFAST, TFAST, and Vet BLUE due to its versatility. Reproduced with permission of John Wiley & Sons, Inc., *Focused Ultrasound Techniques for the Small Animal Practitioner*, Wiley©2014 and Greg Lisciandro, FASTVet.com.

Probe Orientation, Type, and Depth Settings

Lung ultrasound orientation always begins with establishing the gator sign so that the sonographer has properly identified the pulmonary-pleural interface or lung line for confident imaging and assessment of the surface of the lung. The depth is generally set between 4–8 cm depending on the size of the patient. In larger patients setting depth closer than 4 cm lends itself to missing pathology that extends from the lung surface deeper than your depth setting. Frequency is generally set between 5–10 MHz. A linear probe will provide superior imaging

of the lung surface, however, how much is gained is unknown; and a linear probe is not ideal for the AFAST and TFAST portions of global FAST. Either the abdominal preset or cardiac preset may be used for Vet BLUE; however, presets generally are dependent on sonographer preference and the machine's software. The author prefers the abdominal preset for the entire global FAST exam, combining AFAST, TFAST, and Vet BLUE, in the majority of cases.

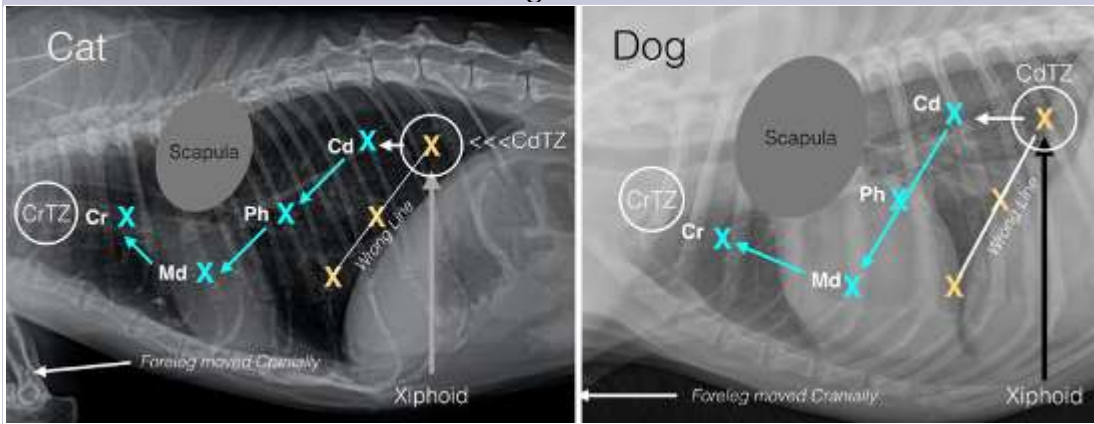
Figure 2



Vet BLUE Regional Views

Figure 2. The Vet BLUE lung exam is a screening test performed identically as the probe is positioned at the CTS view of TFAST. The probe is then moved through regional locations that are bilaterally applied as follows: caudodorsal lung region (Cd - same as the TFAST CTS view, upper third, 8–9th intercostal space), perihilar lung region (Ph - 6–7th intercostal space, middle third), middle lung region (Md - 4–5th intercostal space, lower third), and cranial lung region (Cr - 2nd–3rd intercostal space, lower third). Reproduced with permission of John Wiley & Sons, Inc, *Focused Ultrasound Techniques for the Small Animal Practitioner*, Wiley©2014 and Greg Lisciandro, FASTVet.com.

Figure 3



The Best Way to Perform Vet BLUE Accurately - Finding Your Acoustic Windows

Figure 3. Showing the manner in which to consistently and repeatably perform the Vet BLUE. Each view surveys an intercostal space cranial and caudal from the “X” mark on the ideal Vet BLUE line.

Locate the left TFAST chest tube site view directly above the xiphoid in the area of the 8–10th intercostal space in the upper 1/3rd of the thorax. At this location find the caudodorsal transition zone (CdTZ) of pleural and abdominal cavity by sliding the probe generally caudally if the CTZ is not evident at the CTS view by looking for the curtain sign moving to and fro with inspiration and expiration dirty shadowing through the far field. Once the CdTZ is located slide the probe cranially 2 intercostal spaces (ICS) moving away from the abdominal cavity and its liver/stomach/gallbladder. Air and fluid in the stomach can easily mimic B-lines (lung rockets); and rugal folds of the stomach are easily mistaken for the shred sign and liver for the tissue sign. This location 2 ICSs cranial to the CTZ is the Vet BLUE caudodorsal view (point 1), and an ICS both cranially and caudally is scanned from this focal point.

From the left TFAST CTS view, which is the same as the Vet BLUE caudodorsal (Cd) view, draw an imaginary line or an actual line with your alcohol or acoustic coupling gel to the elbow. Halfway to the elbow is the Vet BLUE perihilar (Ph) view, and near the elbow is the Vet BLUE middle (Md) view. If the heart is in view at the Vet BLUE Md view, slide dorsal to the heart until you see the lung line; and at the Ph and Md views an ICS both cranial and caudal are surveyed as at the Cd view. In most cats and dogs, sliding caudally at the Md view often images the transition zone of pleural and abdominal cavities, confounding those unfamiliar or inexperienced with the pitfall of mistaking abdominal structures for lung pathology. The final acoustic window is the Vet BLUE cranial (Cr) view, which requires gently extending the foreleg cranially to get the probe placed in the 1st–3rd intercostal spaces. If imaging too ventral at the Cr view, you will see the striations of the pectoral muscles; and if dorsal and cranial at the Cr view, you will be in the thoracic inlet with soft tissue and vessels. We use the thoracic inlet as a landmark for defining the Cr view referred to as the cranial transition zone (CrTZ). From the CrTZ slide the probe caudally over the first 3 intercostal spaces for the Cr view.

Our preference for Vet BLUE is to start high (dorsal) on the left hemithorax moving from Cd to Ph to Md to Cr views, and then performing the same routine on the right hemithorax.

THE 6 VET BLUE LUNG SIGNS AND REGIONAL APPROACH

Wet vs. Dry Lung - Basic Lung Ultrasound

Basic easily recognizable lung ultrasound signs are categorized into the wet lung vs. dry lung concept. A-lines, reverberation artifact as horizontal lines parallel with the lung line, with lung sliding, also called the glide sign, is considered “dry lung” only to be confounded with PTX (A-lines with absent lung sliding). For those patients in which the probability of PTX is very low, spending additional time observing lung sliding becomes less

important and observing A-lines alone suffice. In order to maximize observation of A-lines and the lung surface, the angle of insonation should be 90 degrees; and for lung sliding the angle of insonation is changed to 65–75 degrees along with placing the rib head in the center of the screen (one-eyed gator sign). Wet lung consists of B-lines, also called ultrasound lung rockets (ULRs), that are vertical hyperechoic lines moving to and fro with inspiration and expiration that must extend without fading to the far field obliterating A-lines.

Shred Sign, Tissue Sign, Nodule Sign, and Wedge Sign - Advanced Lung Ultrasound

There are 4 more advanced lung ultrasound signs we have described in progressive order of increasing consolidation/infiltration. The shred sign represents an air bronchogram or consolidation **with** aeration of the lung; the tissue sign is similar to hepatization of lung or consolidation **without** aeration; and the nodule sign is organized infiltrate such as neoplastic or granulomatous or consolidation/infiltration in discrete nodules. The wedge sign is a subset of the shred sign and represents pulmonary thromboembolism (PTE) or infarcts at the lung periphery.

Regionally-Based Respiratory Pattern Approach Using Vet BLUE

The clinical relevancy of Vet BLUE's patterned-based regional approach includes the following:

1. Dry lung all fields rules out clinically relevant left-sided congestive heart failure, and suggests such conditions as upper airway obstruction, feline asthma, PTE and non-respiratory look-a-likes.
2. Wet lung or ULRs in high numbers (>3 or infinity) in > than Vet BLUE 2 views that includes a dorsal view (Cd and/or Ph) bilaterally is good evidence for the diagnosis of cardiogenic lung edema in non-trauma, especially in cats.
3. Wet lung in ventral fields with or without signs of consolidation (shred sign/tissue sign) suggests pneumonia.
4. Multiple nodules suggest metastatic disease or granulomatous disease.
5. The observation of the wedge sign suggests PTE.

SUMMARY

The use of thoracic auscultation and breathing patterns for respiratory distress is insensitive and prone to error, coupled with the dangers of transport and restraint in radiology and thoracic radiographic interpretation, making the proactive use of Vet BLUE lung ultrasound incredibly powerful for differentiating causes of respiratory distress in cats.

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SPEAKER INFORMATION

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