

Proactive Lung Ultrasound: The Vet BLUE & the Tale of Four Felines

AAFP 2018

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INTRODUCTION

The reluctance to proactively apply lung ultrasound (LUS) to small animals with respiratory signs or distress is irrational in many respects. The overriding belief that air-filled lung creates insurmountable sonographic obstacles, and that sonographic imaging of lung is difficult, perpetuates these myths, and delays the widespread acceptance of what is true and reality, that the ultrasound probe is your new stethoscope. TFAST (Thoracic FAST) was the first standardized abbreviated veterinary ultrasound exam of the thorax and the proactive survey of lung via the TFAST Chest Tube Site (CTS) view for the diagnosis of pneumothorax.

However, because of the finding of lung pathology during TFAST, extended lung surveillance from the TFAST CTS with the addition of 6 more lung views and its applications beyond trauma to non-trauma subsets of small animal patients was logically the next step. The name of this novel pattern-based, regional LUS exam is Vet BLUE (Veterinary Bedside Lung Ultrasound Exam); and BLUE also for cyanosis implying respiratory conditions. The Vet BLUE's 8 transthoracic acoustic windows representing regional views applied bilaterally include the caudodorsal (Cd) lung region, the perihilar (Ph) lung region, the middle (Md) lung region, and the cranial (Cr) lung region. The 9th acoustic window is the FAST Diaphragmatico-Hepatic (DH) View, which is part of AFAST, TFAST and Vet BLUE. The DH View provides a deep window into lung along the diaphragm that is otherwise inaccessible via the transthoracic views. It is important to recognize that the 9 Vet BLUE acoustic windows are not anatomical per se, and that different parts of lung or different lobes of lung may dynamically enter and exit the intercostal spaces at any of these 9 views. As an example, dry lung, then wet lung, then dry lung, then wet lung may interchange during phases of respiration; or dry lung, and a shred sign, and dry lung then a shred sign, as the patient inspires and expires, where in fact 2 different parts or 2 different lung lobes are moving in and out of that respective acoustic window. This phenomenon is fairly common.

The next logical step is developing an easily understandable lung language. We have sided with a visual lung language and the explanative terms of "dry lung," "wet lung" and "lung rockets," "shred sign," "wedge sign," "tissue sign," and "nodule sign," while also acknowledging the lung ultrasound consensus statement of 2012. The terms have been adopted and modified primarily from Volpicelli and Lichtenstein with the author's additions and modifications; and our Vet BLUE system may be used in place of less visual terms of A-lines, B-lines, C-lines, and PLAP-lines. Having an easily understandable **visual** lung language facilitates communication regarding findings, making LUS immediately useful, that dispels the historical lag time of years between human and veterinary medicine.

In summary, having an easily understandable standardized method of recording findings is mandatory for interpreting and creating value for Vet BLUE and LUS. Through recording of findings, patient profiles may be compared on serial exams. Having applied Vet BLUE to >1,000 small animal patients since 2010, with >400 cases compared to thoracic radiography, we have learned expected patterns, developed an understandable lung language, and a simple procedure for recording findings. Most recently, we have been determined to define the Vet BLUE acoustic windows more accurately by embracing the pitfalls and perithoracic anatomy in order to better locate the Vet BLUE acoustic windows, its views, more consistently for better interobserver performance.

HOW TO PERFORM VET BLUE

Patient Positioning & Preparation

Although Vet BLUE may be performed in lateral recumbency, Vet BLUE is almost always performed in standing or sternal recumbency unless patients present laterally recumbent due to their disease condition and moving them is risky. Sternal and standing is safer for cats in respiratory distress, and those that are hemodynamically or respiratory fragile. For ventral views, a roll of towels or paper towels under the forelegs of a sternal recumbent feline is an easily tolerated maneuver to gain access to the lower ventral Vet BLUE and TFAST Pericardial Site views.

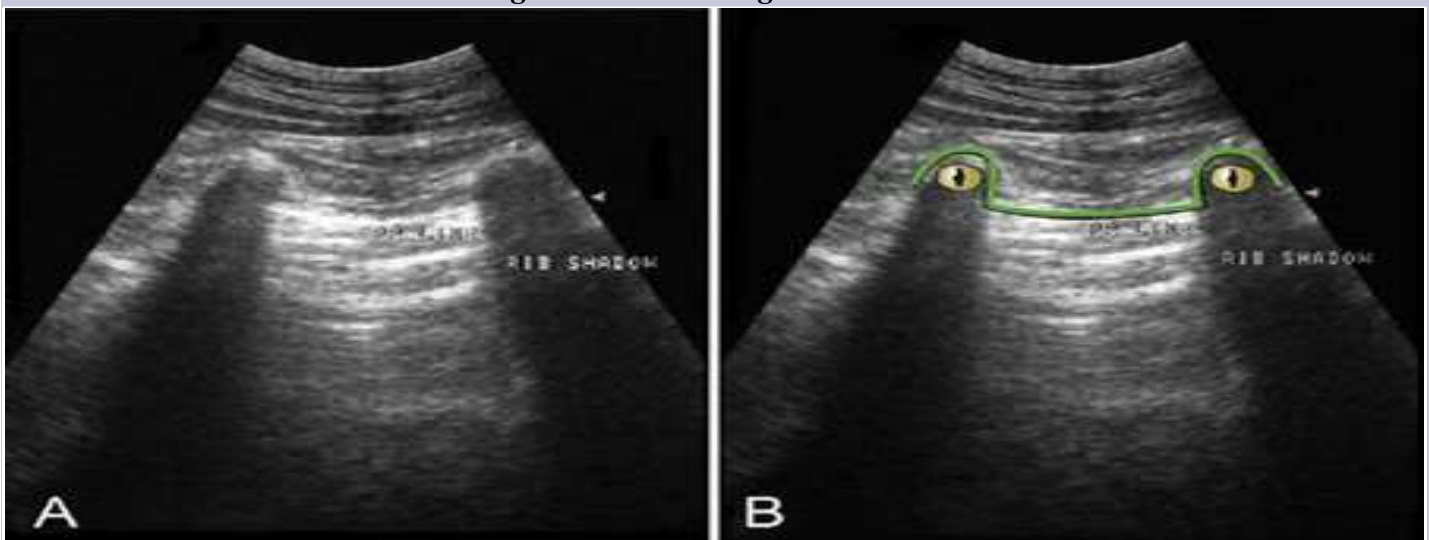
No Vet BLUE views are shaved. All images in the lecture were from unshaved cats. The fur is parted and small amounts of alcohol are applied to the skin with or without a small amount of acoustic coupling gel or alcohol-based hand sanitizer on the probe head. The author prefers small amounts of alcohol to part the fur followed by hand sanitizer. Hand sanitizer avoids the noxious coldness and fumes of alcohol and wipes off easily (and evaporates) the feline patient (especially when a cat is placed in the confines of oxygen cages). Keep in mind that most ultrasound manufacturers warn against placing alcohol directly on the probe head because of alcohol's potentially damaging effects. To maximize the image quality, the probe head should be applied as directly as possible to the skin surface without fur between the probe head and the patient's skin.

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" by the author, is properly imaged. By mistaking air reverberation artifacts or another structure for the lung line (stomach, liver, gallbladder, soft tissue and bone), makes your LUS ineffective and error prone. The probe is held stationary and perpendicular to the long axis of the ribs.

Figure. The Gator Sign orientation



A) The probe is positioned over lung perpendicular to the long axis of the ribs. B) 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. The proximal PP-line white line is the focus of all LUS. The major orientation error is looking beyond the PP-line and mistaking A-line artifacts for the PP-line, or being over the abdomen and mistaking liver, stomach (especially when air-filled), or the gallbladder for lung pathology, or being over perithoracic soft

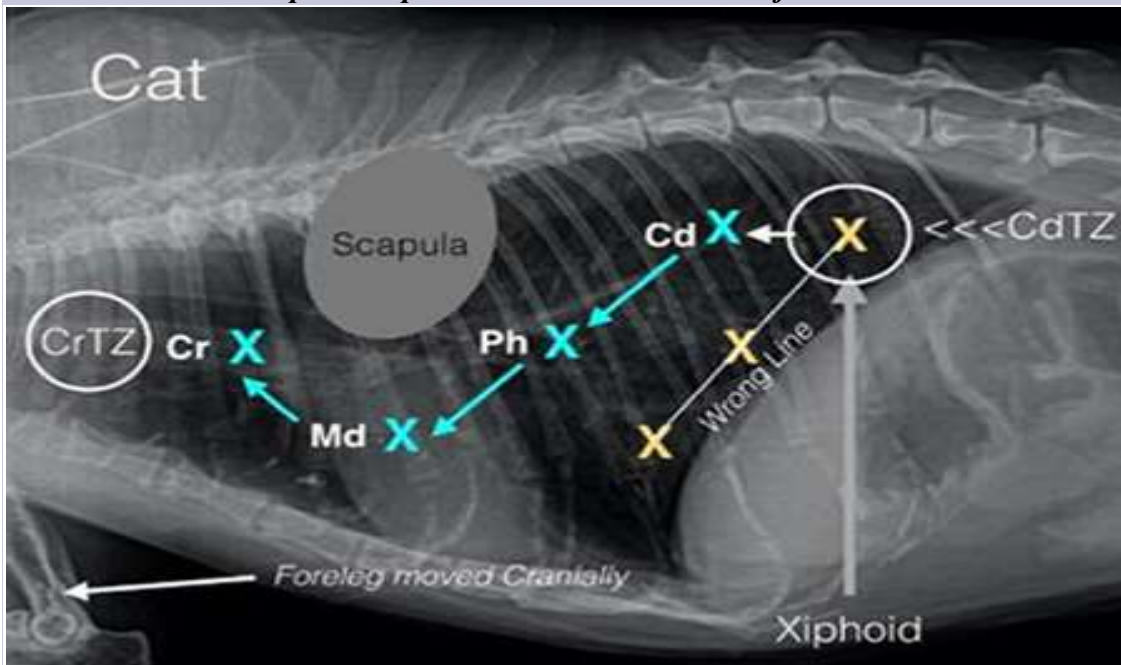
PROBE ORIENTATION, TYPE, AND DEPTH SETTINGS

LUS 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 and 8 cm depending on the size of the patient. In felines, depth is generally set between 4–6 cm. Being in 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 microconvex probe is preferred over a linear probe because the microconvex probe is acceptable for the entire Global FAST – combining AFAST, TFAST and Vet BLUE – as a whole body feline surveillance, a concept and strategy gaining momentum on the human side. A phase array or sector probe is generally not recommended because its focal point is too small, although usefulness of a phase array probe is unknown, and probably is satisfactory for cats with absent B-lines all views. A linear probe will provide superior imaging of the lung surface; however, how much is gained over a microconvex probe is unknown; and the 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. The preference is machine and user dependent. We prefer the abdominal preset for the entire Global FAST exam in the great majority of cases.

FELINE VET BLUE EXAM

How to Perform

Figure. The Vet BLUE lung examination is a screening test performed identically as the probe is positioned at the CTS view of TFAST



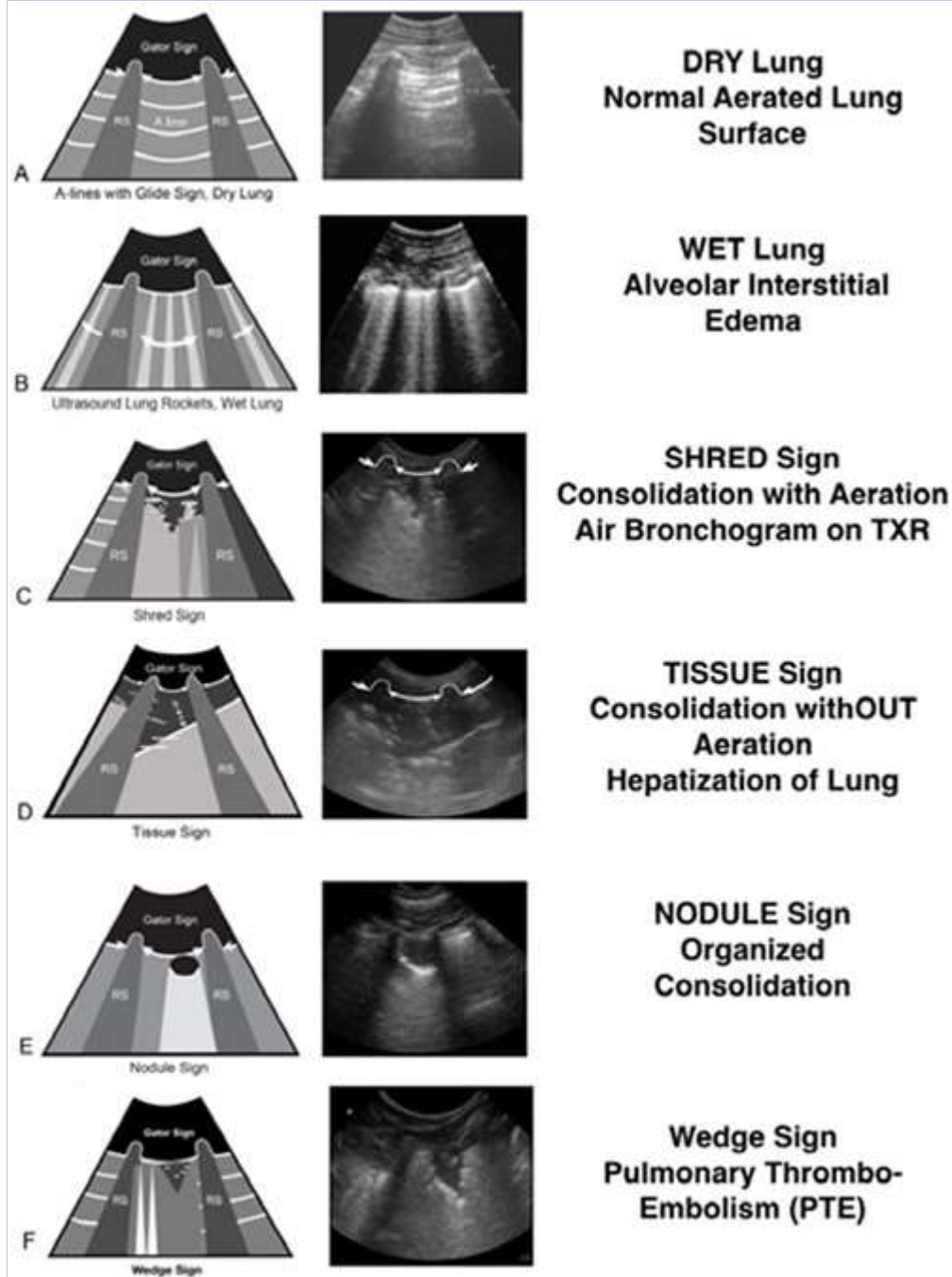
The probe is then moved through regional locations that are bilaterally applied as follows: caudodorsal lung region (Cd – same as the TFAST CTS view, upper third, 8–9th intercostal space), perihilar lung region (Ph – 6–7th intercostal space, middle third), middle lung region (Md – 4–5th intercostal space, lower third), and cranial lung region (Cr – 2nd–3rd intercostal space, lower third). These points in this order may also be referred to as point 1, 2, 3 and 4. This material is reproduced and modified with permission of John Wiley & Sons, Inc. *Focused Ultrasound Techniques for the Small Animal Practitioner*. Wiley © 2014 and FASTVet.com © 2014

THE BEST WAY TO PERFORM VET BLUE ACCURATELY

Locate the left TFAST Chest Tube Site directly above the xiphoid in the area of the 8–10th intercostal space in the upper 1/3rd of the thorax, finding the transition zone of lung and abdominal cavity, and then moving 2 intercostal spaces cranially to make sure the probe is over lung/pleural space and not over liver/stomach/abdominal contents. This is best appreciated by finding the "curtain sign" where lung dirty shadows over the abdominal structures. 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 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. In most cats, sliding caudally at the Md view often images the transition zone of lung and abdominal cavity, confounding those unfamiliar or inexperienced with the pitfall. Each of these acoustic windows has a primary view, followed by a survey one caudal and one cranial to the primary view called the secondary views. By doing this methodology a minimum of 3 intercostal spaces are imaged at each respective Vet BLUE view. The final site is the Vet BLUE cranial (Cr) view, which requires gently extending the foreleg cranially to get the probe placed in the 2nd–3rd intercostal space. If too ventral at the Cr view, you will see the striations of the pectoral muscles; and if too high 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 then sliding over the first 2–3 intercostal spaces for the Cr view. Our preference is to start high (dorsal) on the left hemithorax moving from Cd to Cr (1–4), and then performing the same routine on the right hemithorax. By always performing Vet BLUE in the same manner, findings are better remembered.

THE 6 VET BLUE SIGNS

Figure. The 6 Vet BLUE Lung Signs



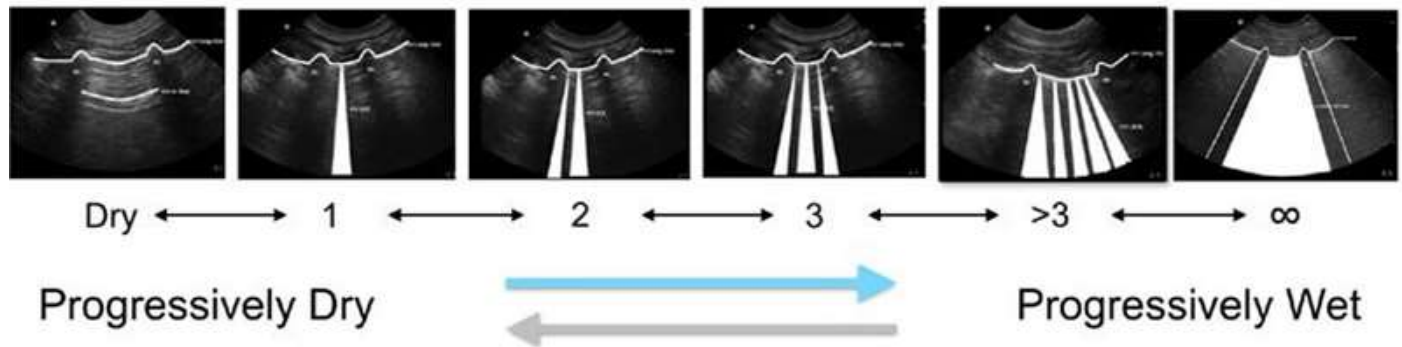
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WET VS. DRY LUNG – BASIC LUNG ULTRASOUND

Basic easily recognizable LUS findings are categorized into the wet lung vs. dry lung concept. A Glide Sign with A-lines (reverberation artifact) at the lung line is considered “Dry Lung” only to be confounded with PTX (A-lines and No Glide Sign). However, in many patients in which the probability of PTX is very low, spending additional time finding the Glide Sign becomes less important and A-lines alone suffice. Ultrasound Lung Rockets (ULRs), also called B-lines, are considered “Wet Lung” and by definition oscillate to and fro with

inspiration and expiration and must extend without fading to the far field obliterating A-lines. The numbers of ULRs also called B-lines are counted and recorded because there is evidence that numbers correlate with degree of alveolar-interstitial edema.

Figure. Counting Lung Rockets or B-lines



Numbers likely correlate with degree of alveolar-interstitial edema and our scoring system has been published in the literature in several peer-reviewed journals. The scoring is as follows: 1, 2, 3, >3, and infinity. The other Vet BLUE Signs are added next to numbers of ULRs or B-lines. Numbers help determine severity and when lung edema is present help better guide diuretic usage. In trauma, ULRs most commonly represent lung contusions until proven otherwise. Copyright 2015, 2016, 2017, 2018 Greg Lisciandro, DVM, DABVP, DACVECC, FASTVet.com and Hill Country Veterinary Specialists.

SHRED SIGN, TISSUE SIGN, & NODULE SIGN (PLUS WEDGE SIGN) – ADVANCED LUNG ULTRASOUND

These are the 3 more advanced Vet BLUE signs we have described in progressive order of increasing consolidation/infiltration. The Shred Sign is similar to an air bronchogram on TXR or rather consolidation **with** aeration of the lung; the Tissue Sign is similar to hepatization of lung or rather consolidation **withOUT** aeration; and the Nodule Sign or rather consolidation/infiltration in discrete nodules. The Wedge Sign is a subset of the Shred-Tissue Sign arranged in a triangular shape, and represents pulmonary thromboembolism (PTE), or rather infarcts at the lung periphery.

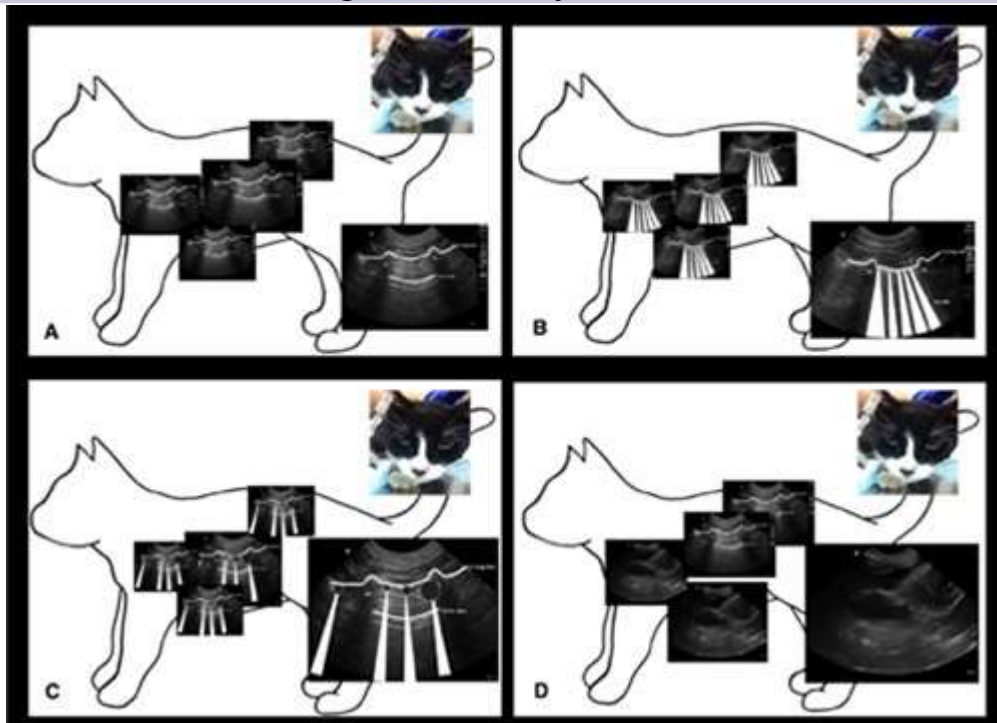
REGIONALLY-BASED RESPIRATORY PATTERN APPROACH USING VET BLUE

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 (L-CHF), and suggests upper airway obstruction, feline asthma, COPD, PTE and non-respiratory look-a-likes; 2) Wet Lung or ULRs in high numbers (>3 or infinity) in > than 2 sites bilaterally is good evidence for the likely diagnosis of cardiogenic lung edema in non-trauma; 3) Wet Lung in ventral fields with or without signs of consolidation (Shred Sign/Tissue Sign) suggest pneumonia or atelectatic lung; 4) Multiple nodules suggest metastatic disease or granulomatous disease; and 5) Wedge Sign suggests PTE.

THE TALE OF 4 FELINES

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 an incredibly powerful tool for differentiating respiratory distress in cats. Vet BLUE is a pattern-based regional approach of using our 6 described Vet BLUE visual lung ultrasound findings – Dry Lung (Glide with A-lines), Wet Lung (Ultrasound Lung Rockets also called B-lines), Shred Sign, Tissue Sign, Nodule Sign, and Wedge Sign.

Figure. The Tale of 4 Felines



A) Feline Asthma, B) CHF, C) Metastatic Disease, and D) Pleural Effusion. Copyright 2015, 2016, 2017, 2018 Greg Lisciandro DVM, DABVP, DACVECC, FASTVet.com and Hill Country Veterinary Specialists and Figure by Hannah Hey, San Antonio, Texas .

A Veterinary Cardiologist Once Said - “I Can’t Tell the Difference between Feline Asthma and CHF” – However, You Can Using Point-of-Care Vet BLUE in <60–90 Seconds

In the Tale of 4 Cats, we have Cat #1 with Left-sided CHF that is wet all Vet BLUE views; Cat #2 with Feline Asthma that is dry all Vet BLUE views; Cat #3 with pleural effusion, but don’t stop at the pleural effusion, look along the Lung Line and at the heart for pericardial effusion; and Cat #4 with Metastatic Disease that has the Nodule Sign with various-sized nodules at nearly every Vet BLUE view. On physical examination, considering auscultation and breathing patterns, **all 4 cats look exactly the same** with nostril flaring, abdominal breathing, and harsh lung sounds. We will work through these 4 cats emphasizing the evidence-based power of Vet BLUE that better directs care and diagnostic testing.

RECORDING VET BLUE FOR THE MEDICAL RECORD

Vet BLUE (Left Cd to Ph to Md to Cr THEN Right Cd to Ph to Md to Cr) – Always same order!

Left: x, x, x, x

Right: x, x, x, x

Example likely Left-sided Heart Failure:

Left: >3, >3, >3, 0

Right: >3, >3, >3, 0

DH: >3

Example likely Aspiration Pneumonia (left middle lung lobe):

Vet BLUE (Cd, Ph, Md, Cr)

Left: 0, 0, >3, 0
Right: 0, 0, 0, 0
DH: 0

Example likely Feline Asthma:

Vet BLUE (Cd, Ph, Md, Cr)

Left: 0, 0, 0, 0
Right: 0, 0, 0, 0
DH: 0

KEY: ULR = ultrasound lung rocket; **Sh=Shred Sign; Ti=Tissue Sign; Nd=Nodule Sign; Ff=Free Fluid Sign**
*The maximum number of ULRs (0, 1, 2, >3 [still recognized as individuals], ∞ [infinity, blended all together]) is counted over a single intercostal space at each respective Vet BLUE view.

Global FAST Goal-directed Templates for the Medical Record - see [Facebook.com/FASTVet](https://www.facebook.com/FASTVet)

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SPEAKER INFORMATION

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