

# 2017 IVPOCUS



FIRST ANNUAL INTERNATIONAL VETERINARY POINT-OF-CARE ULTRASOUND SYMPOSIUM



OCTOBER 31 - NOVEMBER 2 | AUSTIN, TEXAS

# WELCOME TO IVPOCUS 2017



## Dear Attendee,

On behalf of Hill Country Veterinary Specialists, FASTVet.com, Companion Animal Health and Oncura Partners Diagnostics, welcome to the 1st Annual International Veterinary Point-of-Care Ultrasound Symposium and to vibrant Austin, Texas!

This Symposium is a first of its kind and represents the launch of the International Veterinary Point-of-Care Ultrasound Society (IVPOCUS), an organization dedicated to the awareness and advancement of veterinary point-of-care abdominal, thoracic, pulmonary, cardiovascular, musculoskeletal, ocular, neurological and FAST ultrasound.

Over the next few days, you will have the opportunity to meet, listen to and interact with outstanding speakers that represent thought leadership in veterinary FAST and point-of-care ultrasound (POCUS) including:

- Dr. Soren Boysen, Professor, University of Calgary
- Dr. Deborah Canapp, Veterinary Orthopedic Medicine Support Group
- Dr. Terri DeFrancesco, Professor, North Carolina State University
- Dr. Greg Lisciandro, Hill Country Veterinary Specialists, CEO of FASTVet.com, editor of the textbook Focused Ultrasound Techniques for the Small Animal Practitioner

I am also pleased to welcome Dr. Nilam J. Soni, MD, Associate Professor of Medicine, University of Texas Health Science Center in San Antonio, Texas, who will be our Keynote Speaker. Dr. Nilam Soni's academic interests focus on the clinical applications of hand-carried ultrasound, including ultrasound-guided procedures and diagnostic bedside ultrasound. He is a visionary in the field, a leader in POCUS implementation within medical school curriculum, and chief editor of Point-of-Care Ultrasound, translated into 3 languages.

I, and the rest of the Founding Partners, are looking forward to meeting you and spending time not only exploring the world of POCUS, but to having the chance to network and get to know each other as passionate colleagues exploring this exciting, game-changing frontier of veterinary medicine. As I have found in my practice, POCUS and FAST ultrasound are becoming the greatest advancement for small animal veterinary medicine this decade. What better place to kick off the International Veterinary Point-of-Care Society than in Austin, emulating the courageous and independent spirit of the Lone Star State of Texas!

I am looking forward to sharing this experience with you and hope you will continue our journey as members of IVPOCUS for years to come.

Welcome!

**Dr. Greg Lisciandro, Dipl. ABVP, Dipl. ACVECC**  
**President, International Veterinary Point-of-Care Ultrasound Society**

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# MEET OUR SPEAKERS



## **Nilam J. Soni, MD, MS, FHM, FACP**

Our Keynote Speaker, Dr. Soni, received his degree from the University of Texas Health Science Center San Antonio. He is the lead author of the book, *Point-of-Care Ultrasound*, that was awarded the 2015 British Medical Association's President's Choice Award. He leads educational programs in point-of-care ultrasound locally, nationally, and internationally.

## **Dr. Gregory R. Lisciandro, DVM, Dipl. ABVP, Dipl. ACVECC**

Dr. Lisciandro received his DVM degree from Cornell University, completed an internship at The Animal Medical Center, NYC, and a residency in Emergency & Critical Care at the Emergency Pet Center, San Antonio, Texas. He developed the abdominal fluid scoring system, TFAST and Vet BLUE lung ultrasound and has practiced half his 26-year career in general practice and half in emergency and critical care. He knows what he missed every day without ultrasound the first half of his career!



## **Dr. Soren Boysen, DVM, Dipl. ACVECC**

Dr. Boysen obtained his DVM degree from the University of Saskatchewan, CA, an internship at the University of Prince Edward Island, CA, and a residency in Emergency & Critical Care at Tufts University. Dr. Boysen has lead the POC & FAST movement with the first veterinary translational FAST study in dogs and is a leader in veterinary student education.

## **Dr. Teresa DeFrancesco, DVM, Dipl. ACVIM, Dipl. ACVECC**

Dr. DeFrancesco received her DVM degree from Cornell University, an internship at Virginia Tech, and residency in Cardiology and Emergency & Critical Care at North Carolina State University. Dr. DeFrancesco has received numerous teaching and clinical awards and leads in training first line veterinarians in POC ultrasound for the cardiac/respiratory patient to better identify the cause, and better treat for survival to gold standard testing.



## **Dr. Debra Canapp, DVM, CRRT, CVA, Dipl. ACVSMR**

Dr. Canapp is certified in Canine Rehabilitation through the Canine Rehabilitation Institute in Florida in 2005, and has become a leader in small animal sports and rehabilitation medicine. She is board-certified by the American College of Veterinary Sports Medicine and Rehabilitation and leads in this new frontier of applying POC musculoskeletal (MSK) ultrasound to soft and hard tissue orthopedic conditions for diagnosis and patient monitoring.

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## **Translation of Point-of-Care Ultrasound into Veterinary Medicine**

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Point-of-care ultrasound continues to revolutionize the practice of medicine, influencing how care is provided in nearly every medical and surgical specialty. Point-of-care ultrasound is the only new technology in medicine that has taken clinicians back to the bedside to spend more time with their patients. As portable ultrasound machines continue to become more compact and available in diverse healthcare settings, more frontline clinicians have begun to integrate point-of-care ultrasound in the management of their patients.

This didactic session will dive into the myriad point-of-care ultrasound applications currently used in human medicine and discuss the potential translation of these applications to veterinary medicine. A review of the fundamental principles of ultrasound technology will precede a discussion of the clinical, educational, and research applications. This session is geared toward provoking discussion about new and innovative ways to incorporate point-of-care ultrasound in veterinary medicine.

# 1st Annual Veterinary Point-of-Care Ultrasound Symposium, Austin, Texas USA

## **AFAST® Introduction to Its Views & How to Use the Abdominal Fluid Scoring System for the Bleeding Patient and Decision Making**

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### **INTRODUCTION**

The clinical utility of AFAST® and the applied fluid scoring system trauma, triage (non-trauma) and tracking (monitoring) cases in the emergent and critical care settings will be reviewed. The T<sup>3</sup> designation encompasses these 3 subsets and avoids the onslaught of confusing acronyms in human medicine in which similar abbreviated formats are given different acronyms when applied to different subsets of human patients. Thus, AFAST<sup>3</sup> becomes a universal term that has exact clarity of the 4-acoustic windows used by the veterinary sonographer.

The AFAST<sup>3</sup> ultrasound format has greater potential to positively guide clinical course and improve patient outcome by detecting conditions and complications otherwise occult based on traditional means of physical examination, laboratory and radiographic findings, and avoiding the delay associated with more advanced imaging (jeopardizing patient care). Finally, AFAST<sup>3</sup> findings are made more clinically relevant for the clinician, client, and referring veterinarian by using a standardized ultrasound format (AFAST<sup>3</sup>), and standardized goal-directed templates for medical records (see below). The mindset for those using AFAST<sup>3</sup> is one of a ruling out test for the presence or absence of free fluid, and a ruling in of target-organ pathology; and that AFAST<sup>3</sup> is a means to better survey veterinary patients keeping them alive for gold standard testing; and that AFAST<sup>3</sup> helps better decision-making regarding medical vs. surgical cases. Finally, the Global FAST approach, AFAST, TFAST and Vet BLUE combined as a single exam, better ensures that more traditional complete studies are ordered for the correct cavity. Through the remainder of these proceedings we will use "AFAST" for "AFAST<sup>3</sup>".

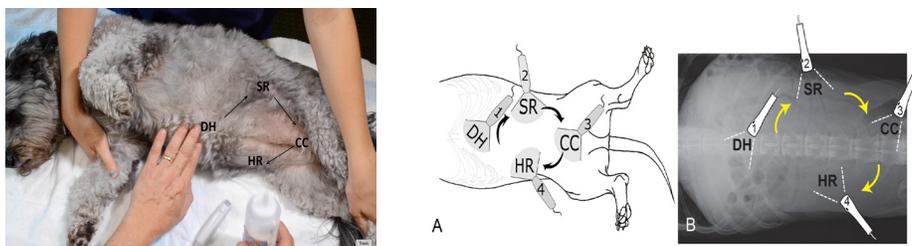
### **TERMINOLOGY**

In the human literature, there has been a confusing onslaught of multiple acronyms for similar ultrasound examinations by non-radiologists. Veterinarians would be best served by using AFAST®, TFAST® (thoracic) and Vet BLUE® (lung exam). When all 3 formats are used together the exam is referred to a Global FAST®. Because Global FAST and any of the three AFAST, TFAST and Vet BLUE ultrasound formats may be diagnostic, the author suggests that comprehensive exams of the abdomen and thorax be designated as "complete abdominal ultrasound" and "complete echocardiography" respectively, similar to the human literature. Finally, terms such as "Focused" and "Targeted" and "COAST" have been used for specific sonographic interrogation of organs in both human and veterinary medicine. However, focused organ exams and traditional complete exams may not be ordered for the correct system or cavity, thus we strongly advocate for Global FAST® as a first line screening soft tissue and free fluid exam to better pick the next best test and avoid missing potentially serious conditions.

### **PREPARATION, POSITIONING AND MOST EFFICIENT WAYS TO PERFORM AFAST®**

- Coupling medium – 70% alcohol, coupling gel, hand sanitizer
- Lighting – dimmed or ambient light
- Shaving – unnecessary for most cases
- Positioning – Right Lateral recumbency preferred over Left, Modified Sternal recumbency, Standing and Sternal recumbency, *never* Dorsal recumbency it's too risky/dangerous
- Two efficient ways to perform Global FAST and General Guidelines for Depth Setting (cm)
  1. Start Right Lateral with AFAST (8-13cm) followed by Left and Right TFAST PCS (8-13cm), then standing for Vet BLUE (4-7cm)
  2. Start Standing or Sternal and do a Vet BLUE-TFAST Blend alternating between shallow and deeper depths performing Left Vet BLUE (4-7cm), Left TFAST PCS (8-13cm) and the Left DH (8-13cm) from the patient's left side before moving to the patient's right side for Right Vet BLUE (4-7cm) and ending at Right PCS TFAST (8-13cm) then Right Lateral if safe for AFAST (8-13cm) by doing this order the most time consuming Right PCS Echo Views are done last after surveying lung and thorax for patient problems and stability.

Fur is generally *NOT* shaved but rather parted for probe to skin contact with the use of 70% isopropyl alcohol and/or gel *being sure to get the probe head directly on skin as directly as possible*. By using coupling medium you are trying to displace air so that the interface is the probe head and skin with no air. *In other words, placing the probe on a wetted or gelled mat of fur does little for image quality*. Lights are dimmed according to sonographer preference. 70% isopropyl alcohol should *NOT* be used if electrical defibrillation is anticipated because alcohol is a fire/burn hazard. Be aware that 70% isopropyl alcohol may physically cool and be noxious to some patients. 70% isopropyl alcohol may cause probe head damage so check with the probe manufacturer. To protect the probe head, it's best to use 70% alcohol on the patient and a coating of acoustic coupling gel on the probe head. Another trick from the radiologists at Mississippi State University, Drs. Jen Gambino and Erin Brinkman, is to use alcohol-based hand sanitizer because it does not have the fumes of 70% isopropyl alcohol and wipes off the patient more easily than acoustic coupling gel. By not shaving or limiting shaving to small viewing windows, the cosmetic appearance of the patient is preserved, thus happier clients and less stressed patients and technicians, the AFAST exam time is shortened, and imaging quality is sufficient with most newer ultrasound machines. *All images in our lecture/lab are from unshaved views.*

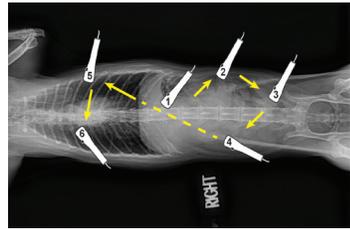
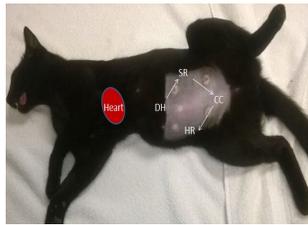


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The AFAST sites shown in right lateral recumbency. To the right of the pictorial labeled A) is a translational depiction on an abdominal radiograph of a dog. The AFAST should always be performed in a standardized counter-clockwise manner as follows: 1) Diaphragmatic-Hepatic (DH) View also used to image the pleural and pericardial spaces 2) Spleno-Renal (SR) View also used as a window into the retroperitoneal space 3) Cysto-Colic (CC) View and 4) Hepato-Renal (HR) Umbilical View which completes the AFAST exam. The HR Umbilical view in higher-scoring dogs and cats is often a favorable site for abdominocentesis. All AFAST views are performed in the longitudinal (sagittal) orientation because it is easier to appreciate the anatomy of the respective target-organs and less confusing especially for the novice sonographer. Importantly, Boysen et al. showed that when comparing longitudinal (sagittal) to transverse views, they matched 397/400 times. Thus, keeping it simple with fanning through only longitudinal expedites the learning process.

Right lateral recumbency is recommended for AFAST and the TFAST left and right PCS views because **1)** Standard positioning for electrocardiographic (ECG) and basic echocardiographic evaluation, and **2)** The left kidney, a window into the retroperitoneal space at the SR View, and the gallbladder and caudal vena cava (CVC) at the Diaphragmatico-Hepatic (DH) View are readily imaged. Left lateral recumbency may be used in cases in which injury prohibits right lateral positioning or the right retroperitoneal space warrants imaging. Either lateral recumbency is not only safer for patients over dorsal recumbency, which is never recommended, but also for imaging because gas-filled loops of gastro-intestinal tract fall away from the less gravity-dependent DH, SR and CC Views. In respiratory compromised or stressed patients, a modified sternal recumbency positioning used for AFAST where the forelegs are in sternal and hind legs moved to lateral as the patient allows or AFAST may be done in standing or sternal.

The author generally starts with a Vet BLUE-TFAST Blend in respiratory questionably stable patients in standing or sternal, whichever is best for the patient, and then proceeds with a standing or sternal AFAST or delays AFAST and calculating patient abdominal fluid score until the patient is more stable. A tip for gaining maximizing the pericardial ventral gravity-dependent views for the heart and pleural cavity is to place a rolled towel or roll of paper towels under the forelegs of a sternally recumbent dog or cat. This trick elevates the sternum off the table surface optimizing maneuverability of the ultrasound probe. *Sternal recumbency or standing is used for TFAST and Vet BLUE in all respiratory compromised patients.*

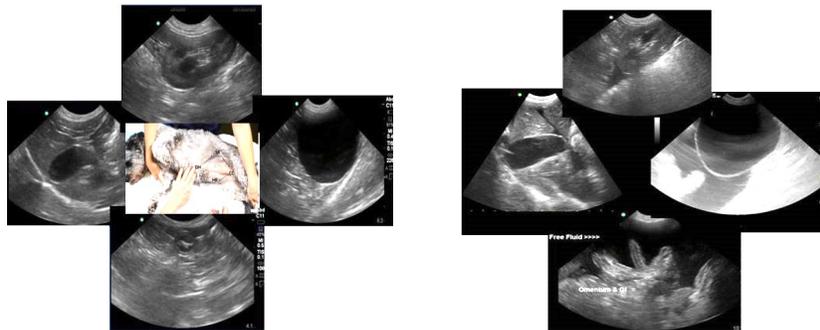


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The most 2 most efficient manners for performing Global FAST are described. **Option 1:** Global FAST is shown externally on a cat in right lateral recumbency along with a corresponding whole body radiograph. By doing the deeper imaged AFAST views first as follows in the same protocol driven order of DH (probe 1), SR (probe 2), CC (probe 3), HR Umbilical (probe 4) Views followed by the TFAST left PCS/echo (probe 5) and right PCS/echo (probe 6) views, then allowing your patient to stand and decreasing the depth (4-6cm) for the more shallow lung views of Vet BLUE (not shown). In this sequence, the depth setting is generally only changed once. **Option 2:** The patient is in standing or sternal so begin with the Vet BLUE-TFAST Blend in which depth is at 4-7cm for left Vet BLUE starting high to low (Cd to Ph to Md to Cr), then increase depth 6-13cm for left PCS and DH if you are right-handed, then go to move to the other side of the patient switching sides with the handler. Then, decrease for shallow right Vet BLUE views going from high to low (Cd to Ph to Md to Cr), and finishing at the right PCS View with increased depth 6-13cm for the left ventricular "mushroom" short-axis view (LVSA), the right ventricular to left ventricular long-axis view (RV:LV), and the left atrial to aortic ratio (LA:Ao). By starting high and going low in cases in which pneumothorax is suspected the Vet BLUE is automatically your search for the "Lung Point."

Dorsal recumbency *should never be used* for several important reasons including risking the destabilization of a hemodynamically-fragile patient. By insisting on dorsal recumbency you cause the following **1)** The weight of its abdominal organs shifts to compressing its great vessels, aorta and caudal vena cava, compromising venous return and aortic blood flow **2)** Respiratory status is negatively affected **a)** by shifting ventilation from larger, most aerated, least gravity-dependent, dorsal lung fields to much smaller ventral lung fields and **b)** the weight of the abdominal organs move against the diaphragm reducing tidal volume. In combination, these factors create a negative double- or triple-whammy effect, along with increased oxygen demand when the panicking patient struggles with restraint, which can rapidly lead to patient deterioration including death. In the human ER/EC, the axiom is never send an unstable or questionably stable patient to radiology by first doing a physical exam and FAST/EFAST, or essentially Global FAST, because as they say "death begins in radiology."

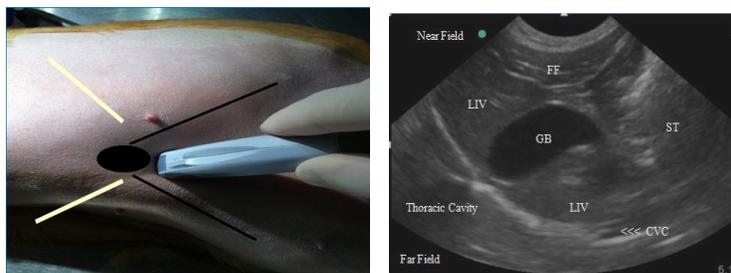
**Classic AFAST Views of Negative on the Left and Positive Scans on the Right**



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The order for AFAST should always be the same, thus in right lateral recumbency - DH to SR to CC to HR Umbilical Views with +/- an HR5th Bonus View for the right kidney vs. left lateral recumbency - DH to HR to CC to SR Umbilical Views with an SR5th Bonus View for the left kidney. The probe is oriented in longitudinal (or sagittal) fanning toward and away from the table top though the gallbladder in both directions at the DH View and then the left kidney in both directions until it disappears at the SR View, followed by doing the same for the urinary bladder at the CC View, and then ending at the HR Umbilical View (HRU). A Focused Spleen can be performed after AFAST is completed depending on the sonographer's skill set. For left lateral recumbency the analogous approach is used. Free fluid is generally recognized as black (anechoic) triangulations base on the generalization that no other normal intra-abdominal or retroperitoneal structures will appear with fluid triangulations.

## The Diaphragmatico-Hepatic (DH) View



### **Focused Ultrasound Techniques for The Small Animal Practitioner © Wiley 2014 and FASTVet.com © 2014**

The classic DH View is nicknamed the “Designated Hitter” since the DH View is a view of *both* AFAST and TFAST. Palpate the costal arch that is “V” shaped (black bars) to locate the xiphoid process (black oval). Place the probe head directly caudal to the xiphoid and *really, really* direct the probe marker toward the patient’s head in longitudinal (or sagittal) orientation searching for the gallbladder. The gallbladder should be easy to locate with the probe fanned toward the exam tabletop because the gallbladder lies on the body’s right side. Once the gallbladder (GB) is in view, attempt to direct the probe so that the gallbladder becomes immediately adjacent to the diaphragm (see ultrasound still image). Note the apex of gallbladder (GB) is immediately against the curvilinear white line representing the location of the diaphragm (not labeled). Once the classic starting point of the DH View is appreciated, fan through the liver lobes (LIV), gallbladder (GB), and the diaphragm. The angle of the fanning is away and toward the exam tabletop represented by the white bars on the dog (see picture of the external dog). There should be enough depth to have 25-33% of the distal and cranial image into the thorax (other side of the diaphragm). In dogs, the gallbladder should reliably be imaged adjacent to the diaphragm, so when the sonographer is unable to acquire this image, hepatomegaly should be considered, or if the gallbladder is not found, it may be full of debris or calculi, emphysematous, ruptured, or displaced. In normalcy, the feline gallbladder is less reliably imaged against the diaphragm; and the feline gallbladder can have a bi-lobed gallbladder and a tortuous cystic-looking common bile duct in normalcy shown in textbook in the Focused Gallbladder and Liver Chapter.

Other structures noted in the ultrasound image include the falciform fat (FF), the stomach (ST), and the caudal vena cava (CVC). Because the DH View advantageously serves as an acoustic window via the liver and gallbladder into the thorax, *always look past the diaphragm and into the thorax* for the rapid detection of pleural and pericardial effusion, and lung pathology. Questionable findings within the thorax using the DH View should be confirmed via the left and right PCS TFAST Views, or Vet BLUE or both. Thoracic radiography may also be used as a complimentary test. Echocardiography and non-cardiac thoracic ultrasound by a sonographer with more advanced training may also be indicated. Serial exams are always, always, always, another option! Even after complete abdominal and echocardiography by a radiologist/cardiologist because conditions change! Finally, in addition to these basic structures, the caudal vena cava (CVC), the hepatic veins, and lung, should become a standard part of the DH View; and volume status is best explained in Global FAST.

Ultrasound lung rockets (ULRs, also called B-lines) are uncommon but may be present to some extent (1-2) along the diaphragm in normal dogs and cats although generally expect no ULRs. The savvy sonographer will also note that acoustic enhancement through the gallbladder (GB) sometimes yields “false” ULRs if ULRs are seen only in the far field through the GB. The presence of ULRs and the Glide Sign along the diaphragm may be used to determine whether pneumothorax (PTX) is present although its sensitivity, specificity and accuracy are unknown; and this view *is not the* highest point on the thorax. The TFAST Chest Tube Site (CTS) view, being the highest point of the thorax, is the optimal site for rapidly ruling out PTX.

### **FAST DH VIEW FOR PERICARDIAL AND PLEURAL EFFUSION**

Since the canine and feline heart do not consistently rest against the diaphragm, as in humans, the heart and its pericardial sac may not be ultrasonographically visualized because of air interference from interposing lung between the heart and the diaphragm. For the savvy sonographer, a mirror image artifact of the liver and gallbladder into the thorax immediately rules out *pleural* effusion along that plane of imaging. However, in most cases of clinically-relevant *pericardial* effusion in dogs, the diagnosis is made via the DH View because the distended pericardial sac with fluid moves against the diaphragm displacing lung. Moreover, the DH View helps avoid mistaking heart chambers, the most catastrophic of mistakes if centesis is performed on the heart, for pericardial or pleural effusions because the solid muscular apex of the heart is closest to the xiphoid rather than fluid-filled heart chambers at the TFAST PCS views. Importantly, the most

common cause of pericardial effusion, generally < 3-4 mm of greatest width, in cats is heart failure; and pericardiocentesis is rarely indicated in felines.

**Table:** Diagnosis of Pericardial and Pleural Effusion

<b>Diagnosis of Pericardial Effusion</b> The Gold Standard for the Diagnosis of Pericardial Effusion is Ultrasound <i>Radiography is Poor, Insensitive</i> Pericardial Effusion is Contained in the Pericardial Sac that Attaches at One Atrium and Rounds the Apex of the Heart to Attach to the Other Atrium		
Imaging Strategy	FAST DH View	TFAST PCS View
Image toward the muscular apex of the heart where no heart chambers can be mistaken for free fluid	*FAST DH View – Racetrack Sign	*TFAST Right PCS View – Bull’s Eye Sign
*Long-axis 4-chamber view where all 4 chambers are identified		*TFAST Right PCS View
*Increase depth to view the heart in its entirety using the bright white (hyperechoic) pericardium in the far field as a landmark		
<b>Diagnosis of Pleural Effusion</b> The Gold Standard for the Diagnosis of Pleural Effusion is Computerized Tomography <i>Radiography is Generally Good</i> Pleural Effusion is Uncontained and Unrestrained Unless Compartmentalized		
Imaging Strategy	FAST DH View	TFAST PCS View
*Increase depth to image the heart in its entirety using the bright white pericardium in the far field as a landmark		*TFAST Right and Left PCS – Anechoic (Black) Triangulations
*Image toward the muscular apex of the heart where no heart chambers can be mistaken for free fluid	*FAST DH View – Anechoic (Black) Triangulations	
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**PITFALLS AT THE DH VIEW**

The DH View has many possible artifacts including mirror image, side-lobe, edge shadow, and acoustic enhancement well explained in our textbook. Furthermore, fluid-filled intra-abdominal structures including the gallbladder and common bile duct, hepatic and portal veins, and the stomach wall, may easily be mistaken for intra-abdominal free fluid by the hasty sonographer. Thus, the DH View has the most clinical information of all the AFAST views, however, at the same time it poses the challenges of the most artifacts and pitfalls. The sonographer should be familiar with these artifacts and their potential misinterpretations, and the anatomy.

**MAXIMIZING INFORMATION FROM THE DH VIEW**

Three basic questions should be asked while performing the DH View:

- 1) Is there free fluid in the abdominal or peritoneal cavity, the pleural space, or the pericardial sac?
- 2) Is the gallbladder in its expected location, are its walls and lumen normal?
- 3) What is the characterization of the CVC?
  - i) Is the CVC flat? - poor volume status/low CVP
  - ii) Does the CVC have a 50% bounce - ballpark of normal volume status/CVP
  - iii) Is the CVC FAT (overly distended)? - too much volume/high CVP - \*a FAT overly distended CVC

is always of concern and include 3 major rule outs:

- 1) Pericardial Effusion
- 2) Right-sided heart dysfunction/failure
- 3) Dilated Cardiomyopathy (DCM)
- 3) Volume overload from fluid therapy

\*Often along with a FAT CVC there will be hepatic venous distension (Tree Trunk Sign)

- 4) Can any free fluid in the abdomen or the pleural or pericardial spaces be pitfalls or artifacts?
- 5) What does the lung look like at the DH View - most advanced question?

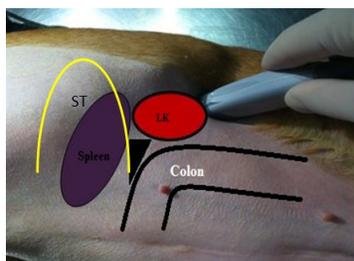
<b>Causes of Gallbladder Wall Edema (the Gallbladder Halo Sign)</b>
*Canine Anaphylaxis (acute collapse, flat caudal vena cava) – massive histamine release results in hepatic venous

congestion
<b>*Right-sided congestive heart failure/Dilated Cardiomyopathy/Pulmonary Hypertension</b> (collapse, weakness, <i>FAT caudal vena cava</i> ) – backflow of blood flow from the right heart results in hepatic venous congestion
<b>*Pericardial effusion</b> (acute collapse, weakness, <i>FAT caudal vena cava</i> ) – obstruction of blood flow to the right heart results in hepatic venous congestion and gallbladder wall edema
Cholecystitis
Pancreatitis
Hypoalbuminemia, 3 <sup>rd</sup> Spacing
Right-sided volume fluid overload (iatrogenic)
Immune-mediated Hemolytic Anemia (IMHA), unknown cause, speculate immune-mediated
Post-Blood Transfusion, unknown pathogenesis, speculate combination of immune-mediated, volume overload
<b><i>*Often Present with Acute Collapse, Weakness</i></b>
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### The Spleno-Renal (SR) View



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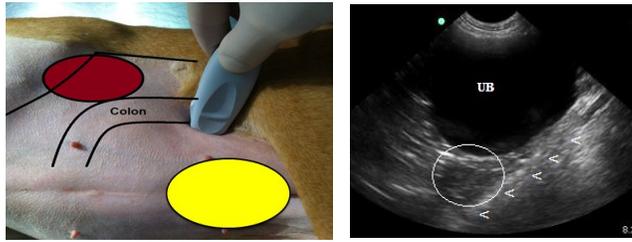
The classic SR View includes the visualization of both the spleen, which is located in the peritoneal cavity, and the left kidney (LK), which is located in the retroperitoneal space. In right lateral recumbency, the SR View target-organs, left kidney and head of the spleen, are readily imaged by placing the probe just caudal to the last rib where it meets the paralumbar muscles. Here start by fanning at that location and then generally if the left kidney is not seen directing the probe cranially under the ribs. A common imaging mistake is pushing into your patient, and by doing so you push the left kidney out of view - don't push the probe into your patient!

The spleen may be used to locate the left kidney by following it caudally because in most normal dogs the spleen extends to the left kidney. *In some cats and small dogs both left and right kidneys can be imaged through the SR View and this would rarely be a mirror image artifact.* If the right kidney needs to be imaged and is not viewed through the SR View, the patient may be rolled to dorsolateral positioning and the probe slipped under the patient. If this is not successful or the dog is large, the patient is moved to left lateral recumbency, or standing after AFAST has been completed discussed in the HR5th Bonus View. Because the canine right kidney is cupped by the renal fossa of the liver, and blends into adjacent soft tissue and liver (cortex of kidney and liver have similar echogenicity), and is more cranially located under the rib cage and obliquely positioned, it is much more challenging to image than its left renal counterpart.

### **PITFALLS AT THE SR VIEW**

SR View pitfalls commonly include gas interference from the colon because ultrasound does not transmit through air, and mistaking linear stripes of small bowel or the great vessels for free fluid remembering that linear anechoic stripes are generally not free fluid vs. anechoic sharp triangulations are free fluid. A challenge that requires some thinking is whether the free fluid at this view is peritoneal or retroperitoneal or both. Playing the odds, most of the time free fluid at the SR View is peritoneal; however, recall that the SR View is least gravity-dependent so often free peritoneal fluid will also be present at the more gravity-dependent CC and HR Views. On the other hand if only the SR View is positive then it may be retroperitoneal free fluid. Changing the position of your patient and re-scanning the SR View and Serial Exams are additional ways to further assess.

### The Cysto-Colic (CC) View



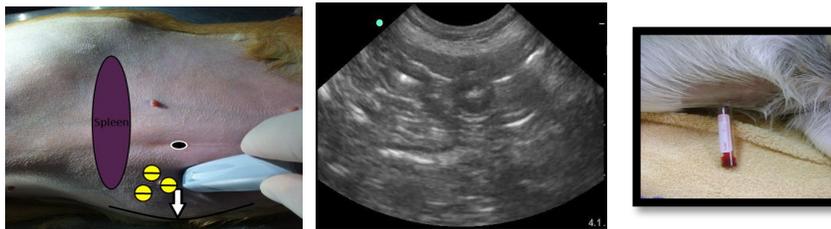
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The classic CC View includes imaging the urinary bladder (UB) immediately against the abdominal wall (<) in the deep field. Note how the probe is directed down into the most-gravity dependent region of the CC View. The CC View is slightly a misnomer because although the urinary bladder (Cysto-) is imaged, the colon (Colic) is not. However, it is important to remember that an air-filled colon will obscure imaging since ultrasound does not transmit through air. By directing the probe into the gravity-dependent CC pouch between the urinary bladder and the abdominal wall in the far field, called the "CC Pouch" (circle on the ultrasound image), you will be scanning the most likely place for free fluid to pool. By directing the probe into the CC Pouch and away from the sublumbar and retroperitoneal areas, most artifacts and confounders such as lymph nodes, great vessels, colon, and reproductive structures for free fluid not in the CC View. The bottom line, by imaging in the AFAST manner, free fluid is reliably in the "CC Pouch" (circle on ultrasound image); and will also be where urinary bladder sediment and calculi will settle. Another confounder at the CC View is the opposing thigh through the far field that may be mistaken for a mass; and may be more convincingly recognized as the thigh through the observation of its associated femoral artery and vein.

#### **PITFALLS AT THE CC VIEW**

Because the urinary bladder is fluid-filled, it is subject to fluid-associated artifacts that can be misinterpreted for abnormalities including side-lobe (mistaken for sediment) and edge shadowing (mistaken for rent in bladder); and mistaking small bowel and colon, especially when air-filled, for urinary bladder wall and urinary bladder luminal pathology. Probe pressure also can make the urinary bladder be oddly shaped. We refer to it as "dumbbelling" the bladder because of the dumbbell shape you create. Avoid excessive probe pressure. Recently we have published a urinary bladder volume estimation formula using the AFAST CC View - length x width x height (cm) x 0.625 = estimation of urinary bladder volume (ml)

### The Hepato-Renal (HR) Umbilical View



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Finally, the classic HR Umbilical (HRU) View typically includes loops of small bowel and occasionally the spleen (middle image). The liver (unless it is enlarged) and the right kidney *are not searched for* in most cases making the HR Umbilical View a misnomer from the "target-organ" standpoint since neither HR target-organ is directly imaged when the dogs are in right lateral recumbency. The probe is *not moved under the patient* but rather placed ventral to the umbilicus (image to the left, arrow and bar show the "Home Run Pouch"; and the oval shape marks the umbilicus). By imaging the HR Umbilical View in this manner, the sonographer is imaging the most gravity-dependent, mid-abdominal region called the "Home Run Pouch." The HR Umbilical view is called the "Home Run Site" because it completes the 4-view AFAST exam and is optimal for tapping accessible larger volume effusions (image on the far right, performing abdominocentesis).

#### **PEARL OF THE HR UMBILICAL VIEW (HRU)**

The HRU View is nicknamed the "Home Run Site" because it *completes* the AFAST exam and ends where abdominocentesis is often safely performed. In left lateral recumbency we would call the view the Spleno-Renal Umbilical (SRU) View.

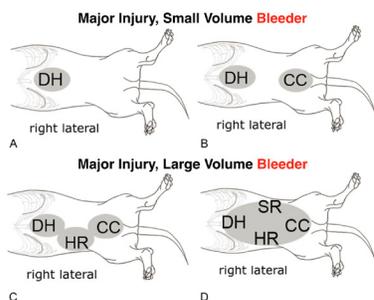
#### **PITFALLS AT THE HR UMBILICAL VIEW (HRU)**

Linear stripes from small bowel loops may be mistaken for free fluid; and mid-abdominal masses with necrotic or vascular, cavitated centers, or pyometra, are conditions that also may be mistaken for free fluid.

### **THE HR BONUS 5<sup>th</sup> VIEW (HR 5th View)**

In the event that imaging of the right kidney is warranted, e.g., right retroperitoneal injury, hematuria, or other renal pathology, the smaller sized patients may be moved dorsolaterally with the probe slid under the patient. However, the author generally prefers to look at the HR Bonus 5<sup>th</sup> View with the patient standing as the very last part of Global FAST. Standing also has advantages in that the gas-filled gastro-intestinal tract falls away from the right kidney. The canine right kidney is more difficult to readily image than the left kidney because of its more cranial location within the renal fossa of the caudate liver lobe. This poses 2 problems: 1) the right kidney lies obliquely blends into the liver sonographically because its cortex is nearly the same echogenicity of the liver in normalcy and 2) its more cranial location necessitates intercostal imaging in many larger dogs. As mentioned in the SR View section, both kidneys can usually be imaged via the SR View in most cats and many smaller dogs. In left lateral recumbency we would call the view the SR Bonus 5th View (Splenorenal View) or SR 5th View.

### **THE AFAST-Applied Fluid Scoring System**



The AFAST<sup>3</sup>-applied fluid scoring system is defined as follows (4-point scale): abdominal fluid score (AFS) of 0 (AFS 0) means negative at all 4 views to a maximum score of AFS 4 means positive at all 4 views.

Low-scoring AFS1 and 2 are considered major injury, small volume bleeders.

High-scoring AFS 3 and 4 are considered major injury, large volume bleeders.

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### **USE OF SERIAL AFAST AND DETERMINING THE AFS**

The use of serial AFAST<sup>3</sup> and serial application of the abdominal fluid score is imperative to maximize information and improve sensitivity of the exam including searching for fluid, assessing the abdominal fluid score (0-4), and evaluating the presence or absence of the urinary bladder. The author performs 4-hour post-admission serial AFAST and AFS in all stable patients (sooner if unstable); and serial FAST exams are standard of care in human medicine since 2001 by the American College of Emergency Physicians Guidelines.

### **TRAUMATIC HEMOABDOMEN**

The clinical utility of the AFAST<sup>3</sup>-applied fluid scoring system as predictor of anticipated degree of anemia and need for blood transfusion was shown in dogs with traumatic hemoabdomen. Dogs with negative fluid scores (AFS 0), and as low-scorers (AFS 1 and AFS 2) that had no other sources of blood loss apparent on physical exam and AFAST<sup>3</sup> and TFAST<sup>3</sup> imaging (no free fluid in retroperitoneal, pleural and pericardial spaces), predictably did not develop anemia. For example, in dogs with normal admission packed cell volume, low-scoring AFS 1 and 2 dogs that remained AFS 1 and 2 during their hospitalization, rarely became anemic from their intra-abdominal hemorrhage; and if anemia did occur it was mild > 30%. Therefore, a general guideline used by the author is that if the PCV < 30% in an AFS 1 or 2 dog or cat, the attending should look elsewhere for the source of bleeding, i.e. retroperitoneal and pleural spaces, fracture sites, and only then consider the possibility of hemodilution. Although not determined in the AFAST<sup>3</sup> study, clinicians should keep in mind that AFAST<sup>3</sup> does not interrogate the intra-pelvic region effectively and that significant bleeding in dogs and cats through pelvic fractures and femoral fractures is possible that could lead to anemia and missed by AFAST<sup>3</sup> and TFAST<sup>3</sup>.

On the other hand, high-scoring AFS 3 and 4 dogs are more likely to develop anemia and predictably an ~25% decrease in PCV from baseline admission PCV; and with ~25% of these high-scoring dogs becoming severely anemic defined as a PCV < 25% requiring blood transfusion in the manner the author fluid resuscitates. Bluntly traumatized dogs uncommonly require emergent laparotomy and should be treated initially with titrated fluid therapy to conservative endpoints and blood transfusion(s).

In summary, the AFAST-applied fluid scoring system is simple and easy to remember and provides a semi-quantification of the degree of hemorrhage; and analogous hemorrhage scoring systems have been shown to also helpful in clinical decision-making regarding blood transfusion and need for surgery or advanced imaging in human patients. To reiterate, bluntly traumatized dogs, i.e. hit-by-car, kicked, stepped on, falls from rooftops, uncommonly require emergent

laparotomy to control their hemorrhage and often are successfully managed with judicious fluid therapy and blood transfusion(s). Cats as a species typically do not survive large volume bleeds; and thus trauma-related large volume effusions in felines are more likely to be due to uroabdomen. Moreover, by using the abdominal fluid score and recording locations of positive sites, not only is the volume semi-quantified but the source is potentially localized.

**NON-TRAUMATIC HEMOABDOMEN AND POST-INTERVENTIONAL BLEEDING**

The same concept may be applied to non-traumatic hemoabdomen, i.e. bleeding tumor and coagulopathic cases, and to at-risk post-interventional cases, i.e. post-surgical, percutaneous biopsy/aspirate, laparoscopy, interventional radiology, etc. The abdominal fluid scoring system applied in serial manner allows for the detection of ongoing (increasing scores), static, and resolving hemorrhage (decreasing scores). Whereas bluntly traumatized dogs and cats rarely need surgical intervention, post-interventional large volume bleeding (AFS 3 and 4) commonly requires exploratory laparotomy and surgical ligation of the bleeding source.

**\*Summary of Abdominal Fluid Score (AFS 1,2 (small volume) vs. AFS 3,4 (large volume)) and Medical vs. Surgical Decision-making in Bleeding Dogs** \*Same concepts may be applied to cats

Type of Trauma	Major Injury, Small Volume Bleeder (AFS 1,2)	Major Injury, Large Volume Bleeder (AFS 3,4)
<p><b>Blunt Trauma – Think Medical 1<sup>st</sup></b></p> <p><i>*Blood rapidly defibrinates thus is seen acutely as anechoic black triangles.</i></p>	<p><i>– If stays AFS 1,2 no blood transfusion necessary if only bleeding intra-abdominally because do NOT expect anemia (PCV&gt;35%) if only bleeding intra-abdominally</i></p> <p><i>– If stays AFS 1,2 and anemic &lt;30% rule out another site of bleeding (retro-peritoneal, pleural cavity, fracture site, externally)</i></p>	<p><i>– If is an AFS 3,4 or becomes AFS 3,4 then expect anemia (&lt;35%) to develop and use graduated fluid therapy (1/3 shock dose and repeat as fluid challenge needed)</i></p> <p><i>– If becomes severely anemic &lt;25% generally need a blood transfusion FIRST because most bleeding will stop with 1 or 2 rounds of blood transfusion +/- fresh frozen plasma; and rarely need exploratory surgery</i></p>
<p><b>Penetrating Trauma – Think Surgical for Any Positive AFS</b></p> <p><i>*Blood from ripping, tearing, crushing, is often clotted and thus often missed acutely during AFAST because clotted blood looks like adjacent soft tissue; however, in time blood clots will defibrinate and become visible during AFAST, thus Serial Exams are Key in cases unsure if Medical vs. Surgical.</i></p> <p><i>*Generally best to err that is Surgical with ANY Positive</i></p>	<p><i>– Think Surgical for Any Positive</i></p> <p><i>– Combine with other Clinical Findings and Surgical Indications (hernia, free air, septic abdomen, refractory pain, etc.)</i></p> <p><i>– Serial Exams are Key!</i></p> <p><i>– Sample Fluid When Accessible!</i></p>	<p><i>– Think Surgical even for Any Positive</i></p> <p><i>– Combine with other Clinical Findings and Surgical Indications (hernia, free air, septic abdomen, refractory pain, etc.)</i></p> <p><i>– Serial Exams are Key!</i></p> <p><i>– Sample Fluid When Accessible!</i></p>
<p><b>Post-interventional Trauma – Think Medical for AFS 1,2 and Surgical for AFS 3,4</b></p>	<p><i>– If stays AFS 1,2 on Serial Exams, then generally NOT surgical</i></p>	<p><i>– If is an AFS 3,4 and not anemic, then generally it is still best to Explore Emergently and NOT</i></p>

<p><i>*Large volume bleeding (AFS 3,4) is generally not going to stop without surgical ligation of the bleeding.</i></p> <p><i>*Correct Coagulopathy if present</i></p>	<p><i>– Do Serial Exams to make sure does not change score and become a Large Volume Bleeder (AFS 3,4)</i></p> <p><i>– Sample Fluid When Accessible!</i></p>	<p><i>wait (if you wait you will likely have to transfuse your patient with its added extra cost and risk)</i></p> <p><i>– If is an AFS 3,4 and already anemic, transfuse as per patient assessment and Explore Emergently!</i></p> <p><i>– Sample Fluid When Accessible!</i></p>
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### **OTHER ABDOMINAL EFFUSIONS**

The use of the AFAST- abdominal fluid scoring system also provides a means to detect and monitor response to therapy of other non-hemorrhagic effusive conditions including for example transudates (liver/GI disease), modified-transudates (right-sided heart failure, liver disease, splenic disease) and exudates (peritonitis). The use of the AFAST-applied abdominal fluid scoring system also is helpful for the surveillance of post-operative patients at-risk for hemorrhage and peritonitis since ultrasound is superior in sensitivity to physical examination and abdominal radiography.

### **CLINICAL INDICATIONS FOR AFAST®**

The use of AFAST should be simply stated as an “extension of the physical exam” for all dogs and cats that are abnormal or suspect. Global FAST should be adopted as first line “free fluid and soft tissue screening test” just as we have been trained to perform basic blood tests. There is a long list of effusive and soft tissue conditions missed by radiography, which are potentially picked up by the AFAST Target-organ Approach. Clinical indications include **1) Blunt trauma 2) Penetrating trauma 3) Collapse, apparent collapse 4) Undifferentiated hypotension 5) Anemia 6) Respiratory distress** (since there are non-respiratory look-a-likes [hemoabdomen, cardiac tamponade, anaphylaxis, high fever, and others]) **7) Post-interventional at-risk bleeding** (surgery, percutaneous procedures, laparoscopy) **8) Post-interventional at-risk peritonitis** (surgery, percutaneous procedures, laparoscopy) **9) Patient monitoring during fluid resuscitation and during hospitalized care 10) Pre-anesthetic screening test.**

### **GOAL-DIRECTED TEMPLATES FOR AFAST®**

**Patient positioning:** right or left lateral recumbency (right preferred)  
**Gallbladder:** present or absent, contour, wall, content, unremarkable or abnormal  
**Urinary bladder:** present or absent, contour, wall, content, unremarkable or abnormal

#### **Positive of negative at the 4-views (0 negative, 1 positive)**

Diaphragmatico-Hepatic site: 0 or 1  
 Spleno-Renal site: 0 or 1  
 Cysto-Colic site: 0 or 1  
 Hepato-Renal Umbilical site: 0 or 1

**Abdominal Fluid Score: 0-4** (0 negative all quadrants to a maximum score of 4 positive all quadrants)

**HR5th Bonus View:** \_\_\_\_\_

**Focused Spleen (add-on after AFAST HR Umbilical View):** \_\_\_\_\_

**DH View:**

**Pleural effusion:** absent, present (mild, moderate, severe) or indeterminate

**Pericardial effusion:** absent, present (mild, moderate, severe) or indeterminate

**Hepatic venous distension:** present, absent or indeterminate

**Caudal vena cava characterization:** FAT, flat or bounce or indeterminate

**Comments:**

Note: The AFAST exam is a rapid ultrasound procedure used to detect the presence of free abdominal fluid, which is generally abnormal, as a screening test in order to better direct resuscitation efforts, decide on next best test(s), detect complications, and manage critically ill patients. AFAST allows rapid but indirect assessment for evidence of major internal abdominal organ injury or disease. The AFAST exam is not intended to replace a complete abdominal ultrasound exam of the abdomen.

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**Emergency Cageside AFAST Ultrasound for Critically Ill and Unstable Cases from the Trenches**

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**INTRODUCTION**

Focused emergency cageside sonography is expanding rapidly and with ultrasound machines becoming common place, they have become an integral part of the early evaluation and triage of small animal patients that present to the emergency service or that are hospitalized in the ICU. In fact, these formats, AFAST, TFAST and Vet BLUE, should be considered an extension of the physical exam for any patient critical or stable. These exams require minimal ultrasound experience to perform, can be done at the cageside concurrent with other resuscitative efforts, are non-invasive, safe, relatively inexpensive, repeatable, and can be completed in under 10 minutes. Multiple studies in the human and veterinary profession have shown focused emergency sonography can identify potentially life threatening conditions and help direct therapeutic options. Although new applications of focused emergency cageside sonography are continually being developed and applied in veterinary patients, to date there are 3 main areas of emergency cage side sonography that have been investigated in small animal patients;

- 1)** Assessment of the chest and lungs (thoracic focused assessment with sonography for trauma/triage/tracking and the Vet BLUE exam),
- 2)** Assessment of the abdomen (abdominal focused assessment with sonography for trauma/triage/tracking), and
- 3)** Estimation of intravascular volume status via assessment of the caudal vena cava.

Important factors to consider when applying focused emergency cageside sonography to small animal veterinary patients:

- Perform the obvious first. i) Obtain IV access, ii) commence fluid therapy, iii) control obvious hemorrhage, iv) ensure adequate airway and breathing, etc. prior to performing the sonographic examination.
- The ultrasound machine should be brought to the resuscitation area for unstable patients; do not move an unstable patient for the purposes of emergency sonographic evaluation!
- These exams do not assess all organs of the body and are not a replacement for formal or complete abdominal and echocardiographic sonographic exams.
- Focused emergency cageside sonography should be considered an extension of the physical exam, and not a substitute for, the triage exam or a complete physical exam; triage exams identify unstable patients while emergency cageside sonography is one tool that can help rapidly identify the underlying cause and direct therapy that is often life saving.
- When free fluid is detected, and is safely accessible, in the peritoneal, retroperitoneal, pleural, and pericardial spaces, then the pursuit of ultrasound-guided therapeutic and diagnostic centesis (pericardial, abdominal and thoracocentesis) is expedited potentially improving patient care and better directing diagnostic testing.

Although originally developed to assess blunt and penetrating trauma, these exams are now becoming standard of care for all emergent/critical care situations in which an underlying cause is not readily apparent, particularly if the patient is unstable. A recent veterinary study applied to unstable, non-traumatized dogs and cats, demonstrated that AFAST and TFAST combined, detected free fluid in the peritoneal, pleural, and/or pericardial spaces in approximately 75% of these cases presenting to the ER (See Algorithm 1).

## **ABDOMINAL FOCUSED ASSESSMENT WITH SONOGRAPHY FOR TRAUMA (AFAST)**

### **Important points to consider**

- The subxiphoid (DH) view of the AFAST exam is a shared view with the TFAST exam, and can therefore detect pericardial and pleural fluid in addition to free intra-abdominal fluid (see TFAST).
- Detection of free fluid is often instrumental in the management of critically ill patients; it helps narrow differential diagnoses, directs diagnostic steps, and guides therapeutic options.
- Identification of gallbladder wall edema (called the halo sign) has been documented to be a marker for canine anaphylaxis and is easily detected at the subxiphoid (DH) view; however, in collapsed or weak dogs, pericardial effusion and right-sided CHF and generalized systolic dysfunction (dilated cardiomyopathy), also lead to hepatic venous congestion and a gallbladder halo sign making the use of AFAST and TFAST combined a better strategy make an accurate diagnosis.

### **INDICATIONS**

- Any patient with blunt trauma. Blunt trauma patients, particularly those that are critical and/or unstable, that have a total solids of less than 60 g/L and/or a decreased PCV, or an elevated serum alanine transaminase (ALT), or a pneumothorax, or pelvic fractures have a high probability of being AFAST-positive (See Algorithm 4).
- Any patient with penetrating trauma
- Any patient in which intra-abdominal free fluid is suspected
- Any collapsed and/or unstable patient (i.e. elevated shock index, hyperlactatemia, unexplained hypotension, tachycardia, or decreased mentation) regardless of trauma, particularly if the underlying cause is uncertain (See Algorithm 1).
- Any patient with acute abdomen/abdominal pain (See Algorithm 5)
- Any patient with anemia
- Any patient with a fever
- Post-surgical patients that become unstable or in whom there is a concern for bleeding or risk of dehiscence/peritonitis. Avoid being confounded by lavage fluid which can last several days in the abdominal cavity, dry the abdominal cavity prior to closure.
- Serial AFAST exams are warranted to:
  - 1) monitor progression/resolution of intra-abdominal fluid in AFAST positive patients, and
  - 2) to re-assess AFAST negative patients, particularly those that are unstable, and/or have received significant quantities of intravascular fluids
  - 3) may be used to calculate urinary bladder volume measured in centimeters the formula length x width x height x 0.625 gives you an estimation in milliliters

### **CONTRAINDICATIONS**

- None. AFAST exams are rapid, non-invasive, do not require sedation or anesthesia, and do not compromise patient stability with special positioning or restraint.
- Patients that struggle with gentle positioning in lateral recumbency can be assessed in the standing or sternal position (standing AFAST exams negate the abdominal fluid score – see below).
- Dorsal recumbency should not be used due to the risk of decompensating hemodynamically and respiratory fragile patients by compromising venous return and ventilation through the weight of the abdominal organs on the caudal vena cava and diaphragm, respectively.

### **MATERIALS**

- Ultrasound machine capable of B-mode (ideally portable or permanently located in the triage area of the clinic).
- A curvilinear probe (also called microconvex) with a 5 MHz setting for larger patients (> 20kg) and 7.5MHz setting for smaller patients (≤ 20 kg) and a maximum capable depth of 10-20 cm is used for the abdomen, thorax and lung.

- Alcohol and/or ultrasound conducting gel or alcohol-based hand sanitizer.
- Clippers (optional).

### **Anesthesia, analgesia, sedation**

- Patients generally tolerate the procedure well without the need for sedation or anesthesia.
- Patients presenting with evidence of pain (trauma, acute abdomen, etc.) should be managed with analgesia.

### **TECHNIQUE/PROCEDURE**

- The fur does not need to be clipped although shaving a small 5 x 5 cm area may improve image quality in some patients (i.e. patients with thick undercoats).
- The probe location sites are soaked with alcohol after parting the fur keeping in mind the best image will be obtained with the probe head directly in contact with skin.
- Some images are improved with the addition of ultrasound gel, hand sanitizer, as well as alcohol.
- Left or right lateral recumbency can be used depending on operator preference, or patient's presenting position.
- Transducer depth is generally set between 5-15 cm depending on the size of the patient and the organs to be identified.
- At each site, the ultrasound probe is initially placed longitudinally to the underlying organs and fanned through an angle of 45° and moved 2.5 cm in cranial, caudal, left, and right directions.
- Fanning and moving the probe increases likelihood that abdominal fluid is detected and that target organs are properly identified.
- The AFAST scan can be done in any order, although developing a systematic approach is recommended to standardize and help ensure important structures are not overlooked. The authors suggest starting at the subxiphoid (DH) view and then imaging the least gravity-dependent (SR or HR view depending on what lateral positioning) before going to the CC view ending at the most gravity-dependent view (HR or SR depending on what lateral positioning). The advantage is that gain may be set when imaging the gallbladder as normal bile is purely anechoic (black) and ending at the most gravity-dependent site completes AFAST and is generally a favorable safe site for abdominocentesis.
- The ultrasound probe is placed at 4 focal regions of the abdomen in a consistent systematic manner. At the minimum the probe is fanned toward and away from the table top and then rocked toward the head of the patient at each of the 4 views (See Fig. 4):

**1) Subxiphoid or Diaphragmatico-hepatic (DH) site:** the probe is tucked into the "v" formed by the ribs where they join the xiphoid. Direct the probe cranially and towards the spinal column under the xiphoid process. Allows visualization of the diaphragm, liver lobes, and gallbladder (gentle pressure to slide the probe just under the xiphoid may be required). Tilting and fanning the probe to the right of midline at the subxiphoid site identifies the gallbladder. Adjust the gain until the fluid-filled gallbladder appears anechoic. This sets the gain to identify anechoic free peritoneal fluid (black triangulations) elsewhere in the abdomen. After fanning toward and away from the exam table top, rock the probe toward the sternum to pick up the "cardiac bump" where the apex of the heart is against the diaphragm for detecting or ruling out pericardial effusion. The "cardiac bump" is less reliably seen in cats in normalcy because of the interposition of air-filled lung although feline pericardial effusion often is observed as in dogs.

**2) Left paralumbar or Spleno-renal (SR) site:** the probe is placed on the left lateral side of the animal at the pocket formed where the ribs and paralumbar muscles come into contact. Allows visualization of the spleen and left kidney. Fan through the left kidney in both directions in a sagittal (or longitudinal plane mean the same thing) and then rock the probe toward the head to image the head of the spleen where it is attached to the stomach by its short gastric vascular branches.

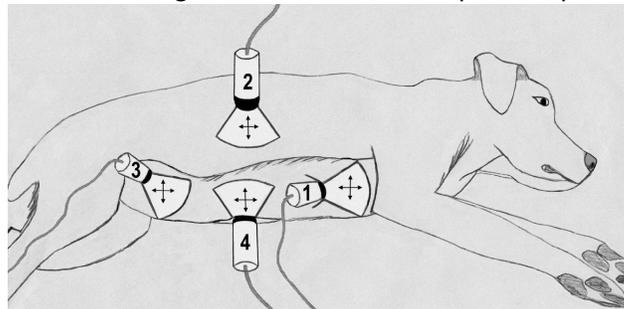
**3) Off midline over the bladder or Cysto-colic (CC) site:** the probe is placed on the upward side of the patient and directed lateral to medial towards the table top keeping in mind that free fluid is gravity-dependent. The ultrasound beam passes through the bladder, allowing visualization of the bladder apex and gravity dependent

caudal region of the peritoneum referred to as the CC pouch. Fan through the urinary bladder prior to imaging the CC pouch one final time.

**4a) Right paralumbar or Hepato-renal (HR) site:** the probe is placed on the right lateral side of the animal at the pocket formed where the ribs and paralumbar muscles come into contact. Allows visualization of the liver and right kidney. This site is difficult to find with patients in right lateral recumbency. In dogs it may be necessary to direct the probe cranially under the ribs to find the right kidney, which blends into the liver because it is cupped in the liver's renal fossa.

**4b)** A variation, which can be done in addition to or in place of the gravity-dependent paralumbar view, is to place the probe at the umbilicus and direct it laterally towards the table top. This allows the abdomen to be quickly "flashed" for the presence of fluid at the most gravity-dependent view of your patient's abdominal cavity, where large volumes of fluid are most likely to accumulate because of gravity. However, without the Right paralumbar (HR) view's target organs, detailed assessment of the right kidney and associated liver is missed.

- If results are positive for the detection of free fluid in the longitudinal orientation, the probe is moved to the next site.
- If the results are negative or equivocal with the probe placed longitudinally, then a transverse view of the organs should be obtained with fanning and movement of the probe repeated at that site.



**Figure 4:** To perform an AFAST exam the patient can be placed in right or left lateral recumbency. Left lateral recumbency is shown in this figure. The 4 sites to be evaluated include the subxiphoid or diaphragmatico-hepatic (DH) site (1), the right paralumbar or hepato-renal (HR) site (2), off midline over the bladder or cysto-colic (CC) site (3) and the left paralumbar or spleno-renal (SR) site (4). A variation of the technique whereby a "flash" scan in place of the gravity-dependent view (site 4 with the dog in left lateral recumbency or site 3 with the dog in right lateral recumbency) can be substituted if the objective is to identify free fluid and right kidney and its associated liver assessment is not vital. At each site, the ultrasound probe is initially placed longitudinally to the underlying organs and fanned through an angle of 45° and moved 2.5 cm in cranial, caudal, left, and right directions. From *Veterinary Emergency and Critical Care, 3rd ed. Mathews, 2016, Lifelearn, Guelph, Ontario, Canada; with permission*".

## INTERPRETATION

- Free fluid is hypoechoic to anechoic (black), often forming triangles or sharp angles between organs.
- Fluid identified on AFAST may be blood, urine, ascites, septic, or inflammatory; ultrasound-guided or directed fluid aspiration is necessary when fluid is safely accessible to confirm the type of fluid present.
- **An Abdominal Fluid Score (AFS)** specific to trauma has been applied to dogs. AFS is determined by recording the number of AFAST sites at which free abdominal fluid is detected.
  - a. **AFS 1** is positive for free fluid at one site;
  - b. **AFS 2:** positive at any 2 sites;
  - c. **AFS 3:** positive at any 3 sites;
  - d. **AFS 4:** positive in all 4 sites.
- **The AFS has only been validated in lateral positions.**
- **An increase in the AFS** suggests ongoing intra-abdominal hemorrhage and further patient evaluation and serial monitoring of the AFS is warranted. Blood transfusion may be required based clinical assessment of the patient.

- **A decrease in the AFS** indicates resolving hemorrhage.
- Patients with an AFS of 1 or 2 following major trauma are not expected to become anemic, particularly if the AFS remains at 1 or 2 on serial exam unless the patient is bleeding elsewhere or had preexisting anemia.
- An AFS of 3 or 4 following major trauma are considered large volume bleeders. Dogs beginning or progressing to an AFS 3 or 4, following trauma, will reliably become anemic and in the author's experience 20-25% requiring blood transfusion. Bluntly traumatized cats are much different than dogs in terms of large volume AFS 3,4 bleeds because they generally do not survive. In bluntly traumatized felines with large volume effusions (AFS 3, 4), they are more likely to have uroabdomen in contrast to dogs that are far more likely to have hemoabdomen.

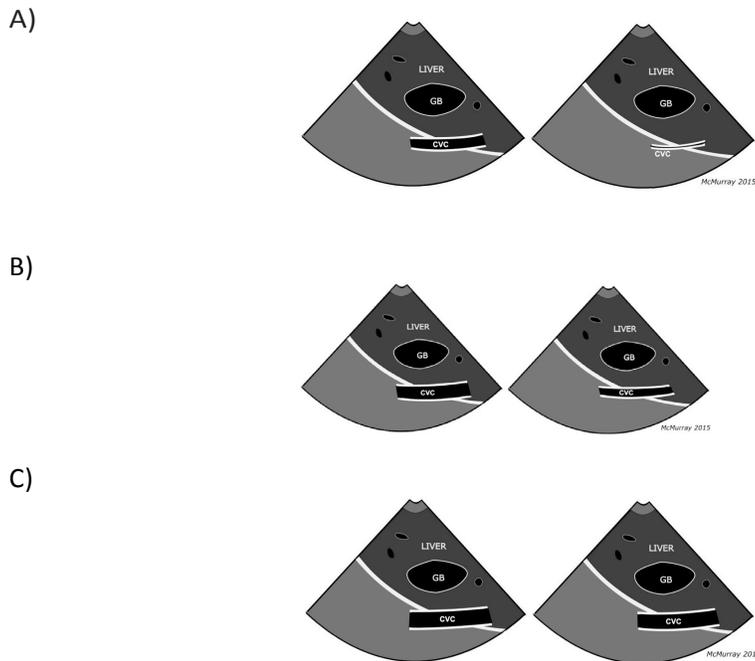
### **IMPORTANT CONSIDERATIONS**

- Not all trauma-induced abdominal injury and peritoneal diseases produce free fluid; the absence of free fluid (negative AFAST) does not imply the absence of pathology and importantly only provides indirect evidence.
- AFAST scans are not good at detecting intrapelvic injury and it is not known how reliable AFAST scans are for detecting retroperitoneal free fluid.
- AFAST scans detect the presence of fluid and help collect samples, but do not locate the source/origin of the free fluid in many cases. However, it is important to record both fluid score and location, particularly in patients that may require subsequent surgery or other interventional procedures.
- AFAST scans omit large areas of the abdomen and can easily miss localized organ injury.
- Adjusting the depth and focus at each location enhances the organs of interest and decreases the chance of missing small free fluid accumulations.
- Certain normal anatomic features within the abdomen may be mistaken for free fluid (i.e. gallbladder, hepatic veins, vena cava, GI contents, uterus, etc.). Using the transverse view in addition to the longitudinal view helps decrease false positives. Linear anechoic stripes are generally not free fluid and typically represent either small intestine or vessels.
- AFAST scans that are initially negative for fluid may become positive over time; serial AFAST scans are recommended to decrease false negatives and detect dynamic intra-abdominal pathology.
- Hemorrhage behaves differently between blunt and penetrating trauma. In blunt trauma cavity bleeding rapidly defibrinates becoming free fluid readily recognized acutely. In contrast, blood in penetrating trauma often clots, and clotted blood looks like adjacent soft tissue. Serial exams (4-hours, 8-hours, 12-hours, 24-hours, 2-days, 5-days, 7-days post-trauma) are therefore integral for decision-making in penetrating trauma cases because in time clotted blood defibrinates and becomes free fluid recognized on ultrasound and rupture of viscous organs will leak.
- Hemorrhaging blunt trauma patients uncommonly need exploratory surgery, think transfusion first; in contrast penetrating trauma cases with positive AFAST scans should be generally explored.
- Post-intervention cases (percutaneous liver/other organ biopsy, post splenectomy surgery, laparoscopy, etc) with hemoabdomen of AFS of 1 or 2 may be serially followed every 2 to 4-hours provided the patient remains stable, and monitored, however, bleeding post-intervention cases that progress to AFS 3 or 4 are unlikely to cease hemorrhaging without surgical ligation of bleeding vessel(s).

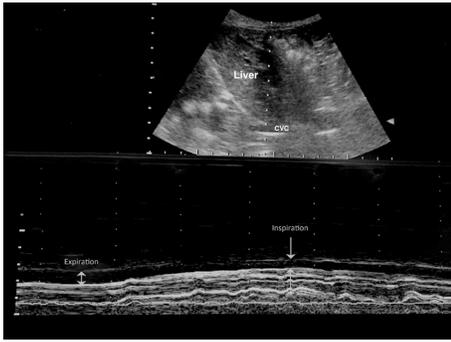
### **RAPID SONOGRAPHIC ESTIMATION OF VOLUME STATUS VIA THE CAUDAL VENA CAVA IN THE CRITICALLY ILL PATIENT**

Emergency and critical care patients are often at risk to develop hypo- and hypervolemia. Unfortunately, predicting which patient is suffering from either state is not always easy. Although further research is required, evaluating the caudal vena cava (CVC) shows promise in estimating the intravascular volume status, particularly in dogs. By placing the probe longitudinally at the subxiphoid site (DH) of the FAST exam and fanning just to the right of midline the CVC can be detected as it crosses the diaphragm. At this location the caudal vena cava diameter and its change in diameter between the expiratory and inspiratory phases of respiration can then be used to estimate the patient's volume status. In healthy euvoletic human patients the CVC has a larger diameter at the end of expiration than it does at the end of inspiration. The changes between expiration varies

but is generally in the neighbourhood of 20-60%. Similar changes in the CVC diameter during the respiratory cycle are likely in healthy dogs as well. In hypovolemic patients the CVC becomes “flatter” than normal and may show greater collapse at the end of inspiration. For example, the CVC diameter between expiration and inspiration will likely vary by >60% in the face of hypovolemia. The opposite is true in hypervolemic patients, or patients with increased right atrial pressures (i.e. pericardial effusion, right sided heart failure, etc.), where the CVC becomes “fatter” than normal, hardly changing (<20%) between expiration and inspiration. If the hepatic veins are visualized (often seen at the site they enter the CVC just caudal to the diaphragm) they are often distended as well in cases with increased right atrial pressures and/or hypervolemia (See Fig. 5). Using M mode will sometimes allow the difference in diameter of the CVC during expiration and inspiration to be more objectively assessed although the eyeball approach or fat (high CVP, hypervolemia), flat (low CVP, hypo-volemia) or having a bounce (somewhere in the ballpark of normal) is often reliable (see Image Fig 6).



**Figure 5 A,B,C:** Place the probe longitudinally at the subxiphoid location and gently fan the probe to the right of midline until the gallbladder is visible – continue gently fanning from this location, keeping a close eye on the diaphragm until the CVC is visible crossing it. **A) With hypovolemic patients** the CVC becomes “flatter” than normal and may collapse at the end of inspiration. Hypovolemic patients also have wide changes in CVC diameter between expiration and inspiration (>60%). **B) In euvolemic patients** the CVC width will vary between inspiration and expiration by roughly 20-60%. **C) The CVC becomes fat, not changing much (<20%) between inspiration and expiration in hypervolemic patients and in patients with increased right atrial pressures.** If the hepatic veins are visualized (often seen at the site they enter the CVC just caudal to the diaphragm) they are often distended as well. From *Veterinary Emergency and Critical Care, 3rd ed. Mathews, 2016, Lifelearn, Guelph, Ontario, Canada; with permission*”.



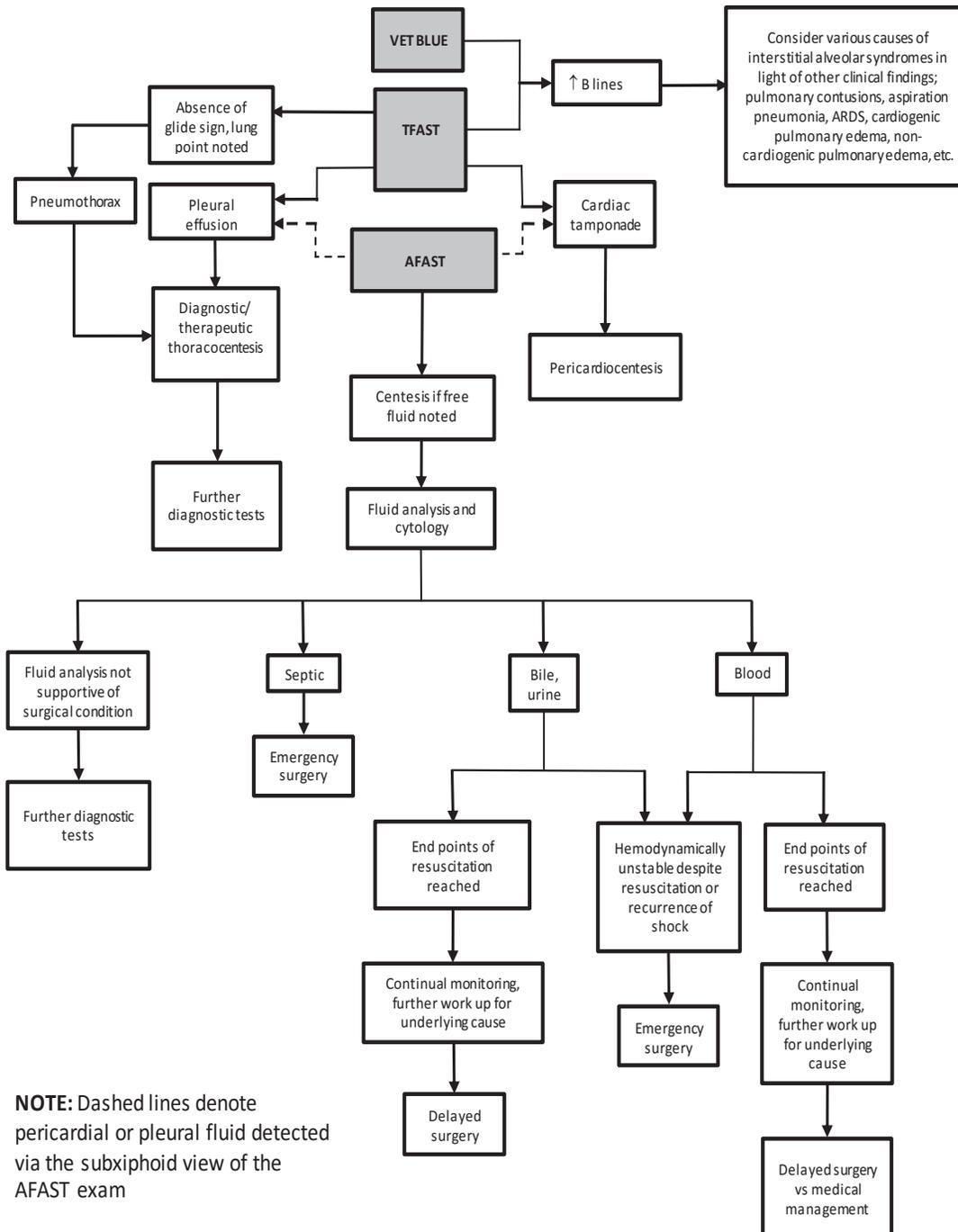
**Fig 6:** An M-mode image is shown with the ultrasound beam (dotted white within the image field) crossing the caudal vena cava (CVC) at the level of the diaphragm. At this site a more objective measurement of the change in diameter between expiration (small arrow in the lower part of the image) and inspiration (larger arrows in the lower part of the image) can be performed. From *Veterinary Emergency and Critical Care*, 3rd ed. Mathews, 2016, Lifelearn, Guelph, Ontario, Canada; with permission”.

#### **FURTHER READING AND REFERENCES:**

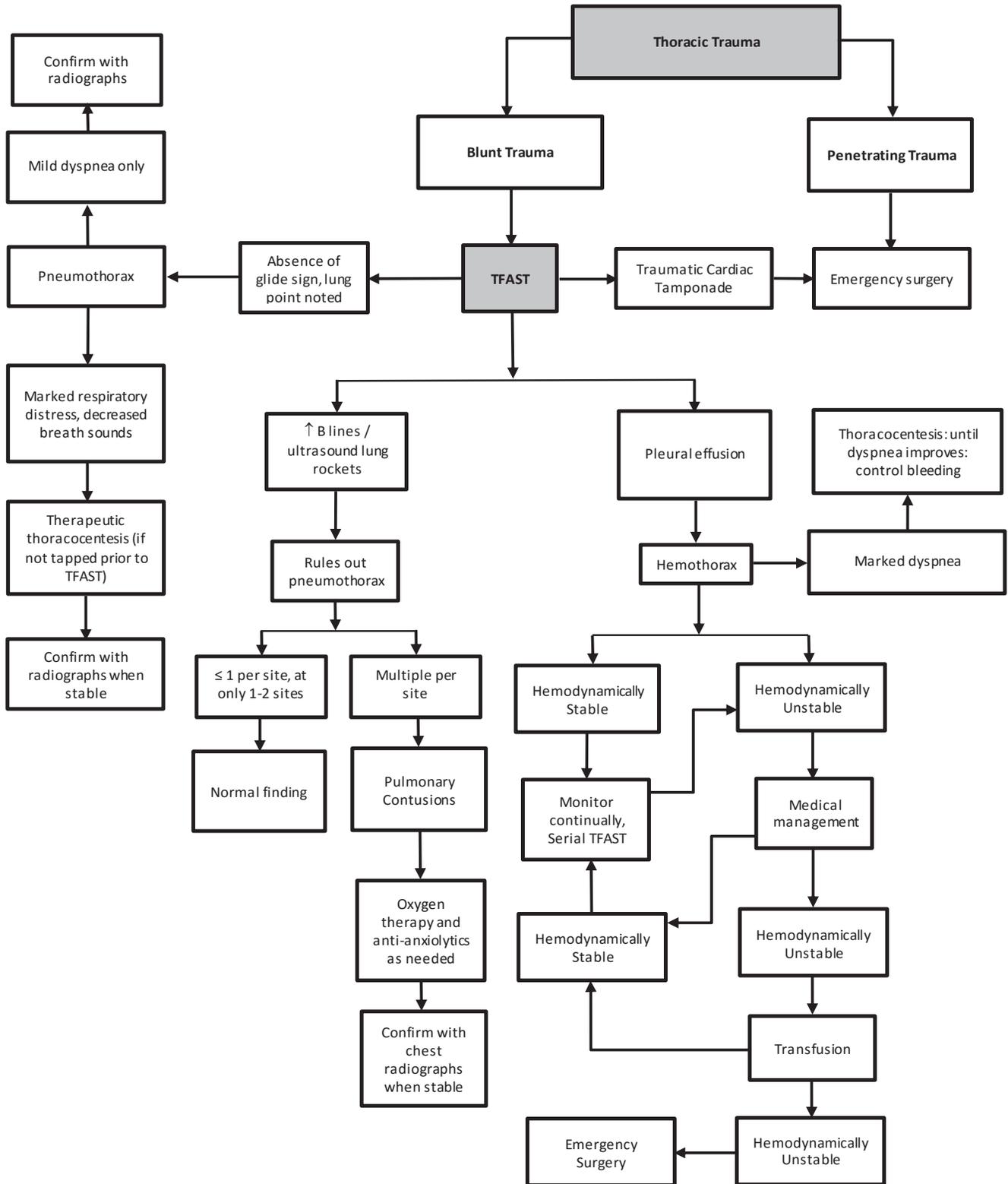
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# Algorithms for interpretation of Focused emergency cage side sonography in small animal veterinary patients

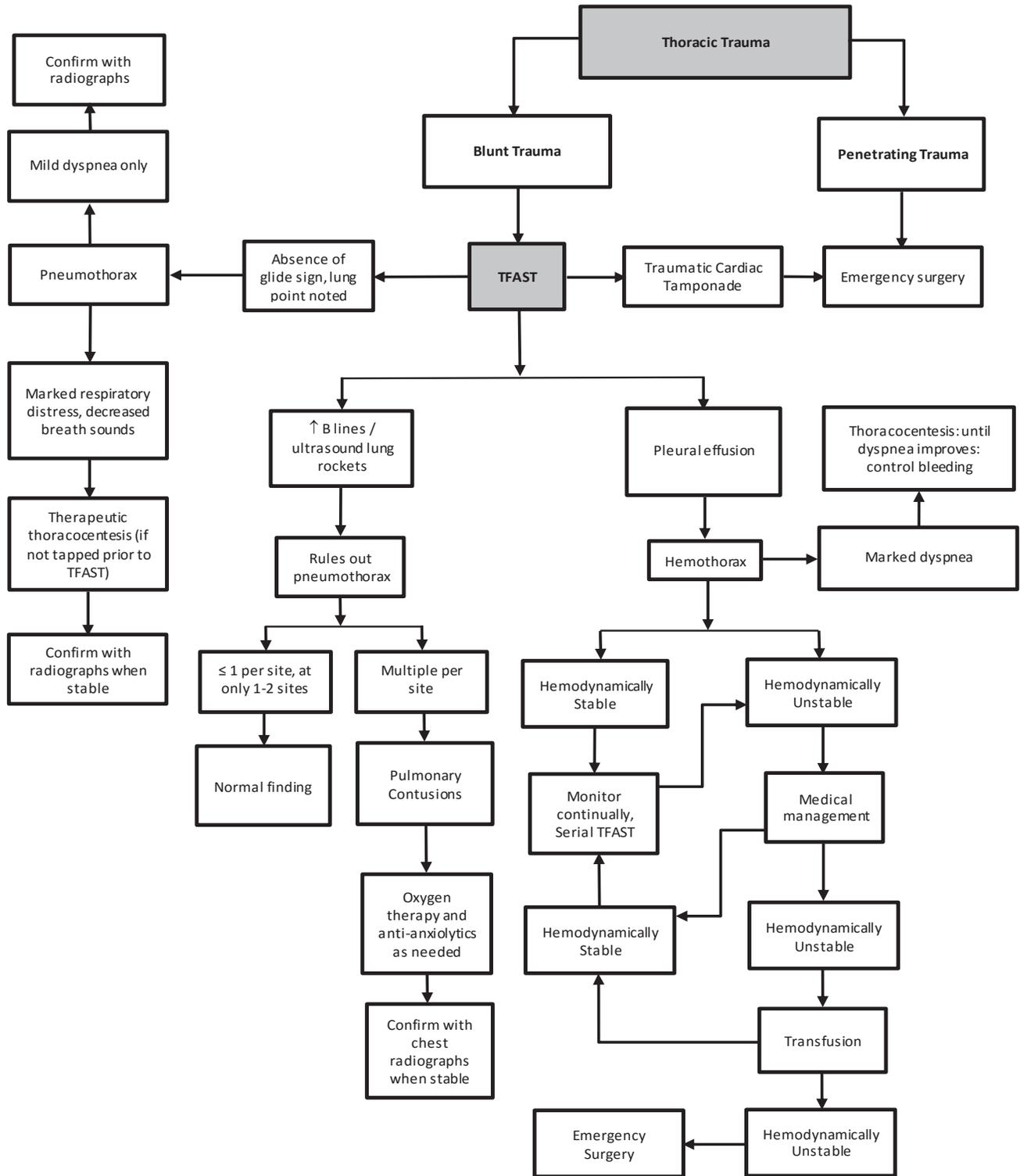
**Algorithm 1: Focused Assessment with Sonography in the Cardiovascularly and/or Respiratory Unstable Dog Presenting with Acute Collapse.** *From Veterinary Emergency and Critical Care, 3rd ed. Mathews, 2016, Lifelearn, Guelph, Ontario, Canada; with permission”.*



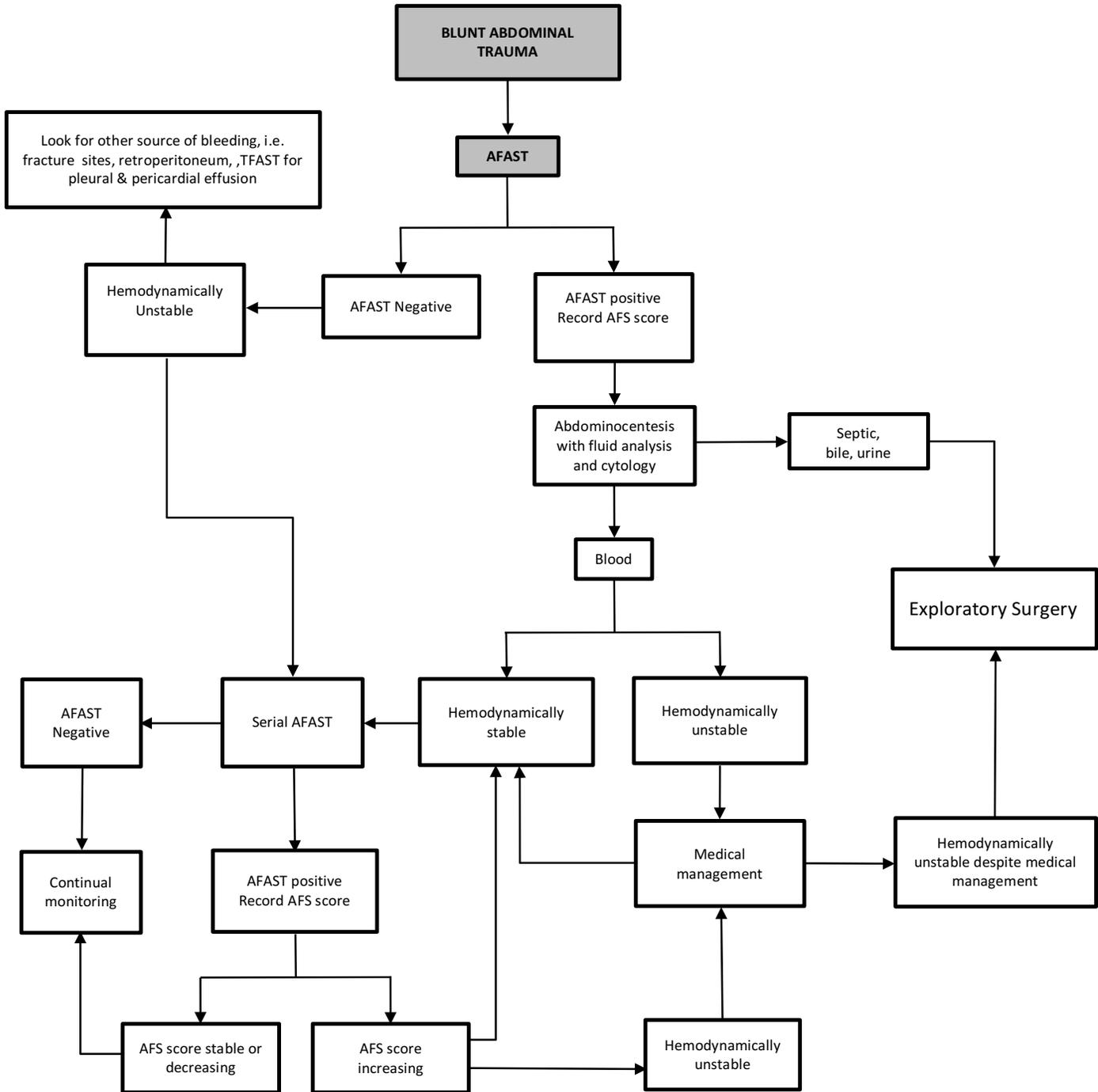
**Algorithm 2: Thoracic Focused Assessment with Sonography for Cats and Dogs with Thoracic Trauma**



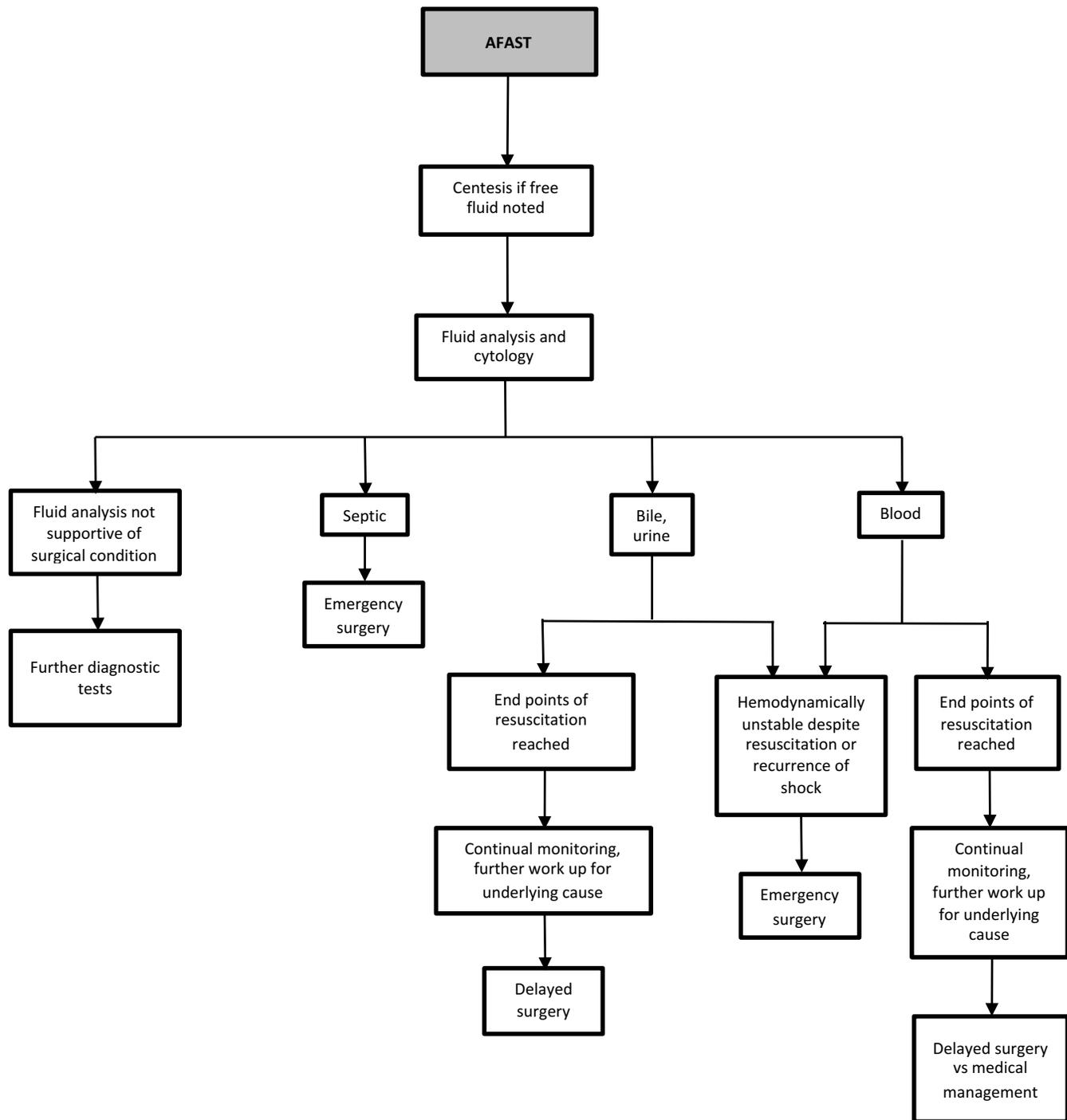
**Algorithm 3: Thoracic Focused Assessment with Sonography for Cats and Dogs with Thoracic Trauma**



**Algorithm 4: Abdominal Focused Assessment with Sonography for Cats and Dogs with Blunt Abdominal Trauma**



**Algorithm 5: Abdominal Focused Assessment with Sonography for Cats and Dogs with Acute Abdomen**



## 1st Annual Veterinary Point-of-Care Ultrasound Symposium, Austin, Texas USA

### Introduction to TFAST® - Pleural Effusion, Pericardial Effusion, Pneumothorax and Echo Views

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#### **INTRODUCTION, TERMINOLOGY, PATIENT POSITIONING AND PREPARATION**

See AFAST Proceedings.

#### **THE TFAST® EXAM - STRENGTHS AND WEAKNESSES OF THE TFAST VIEWS**

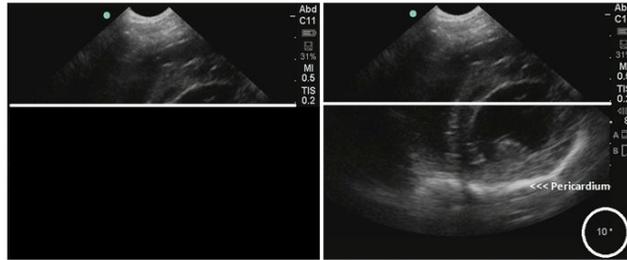
The bilaterally-applied Chest Tube Site View (CTS) is best used to rule out pneumothorax (PTX) and survey for lung pathology (see Vet BLUE® Proceedings). The CTS view is the highest reasonable point on the thoracic wall where the cap of air would rise in the event that PTX was present. Thus, if lung is observed against the thoracic wall, then PTX is ruled out. In the event that PTX is suspected then search for the "Lung Point" to determine the degree of PTX (see below). The bilaterally-applied PeriCardial Site View (PCS) is best used to screen for the presence of pleural or pericardial fluid; and is used for volume status and contractility assessment via the left ventricular short-axis "mushroom" view (LVSA), for the "quick peek" left atrial to aortic ratio (LA:Ao) to screen for left-sided cardiac conditions, and the 4-chamber long-axis view for right-sided conditions (RV:LV). However, non-echo views may be used in place of the echo views when the patient won't allow or restraint for echo views is too risky through use of the Vet BLUE® lung scan and characterization of the caudal vena cava at the FAST DH view for left- and right-sided cardiac conditions, respectively (see Vet BLUE and Global FAST Proceedings). The single DH View may be superior for the detection of pericardial and pleural effusion fluid over transthoracic TFAST<sup>3</sup> views because of the acoustic window provided by the liver and gallbladder and less air interference from the lung at the TFAST<sup>3</sup> PCS views. Our strategy taught to non-radiologist, non-cardiologist veterinarians is to image toward the solid muscular apex of the heart where a heart chamber is unlikely to be misinterpreted for pleural or pericardial effusion. The finding has been described and referred to as the "Racetrack Sign" and "Bull's Eye Sign" by the author in Focused Ultrasound Techniques for the Small Animal Practitioner. By imaging toward the muscular apex of the heart, using multiple views by combining the DH View and TFAST<sup>3</sup> PCS sites, and abiding by the sage axiom "1 view is no view", the probability of misinterpreting a fluid-filled heart chamber for pericardial and pleural effusions is lessened. We will use "TFAST" through the remainder of the proceedings in place of "TFAST<sup>3</sup>".

#### **THE DIAGNOSIS OF PERICARDIAL VS. PLEURAL EFFUSION**

When performing the TFAST left and right PeriCardial Views make it a habit to have enough depth to see the heart globally or in other words in its entirety. Your landmark is the bright white hyperechoic pericardium in the far-field. The sonographer should be aware that too shallow of depth easily leads to the possibility of mistaking heart chambers for pleural and/or pericardial effusion especially in distressed patients that provide only quick glimpses of the heart due to air interference from lung.

The error is mistaking a heart chamber especially concerns the right ventricle on short-axis views for pleural or pericardial effusion with too shallow depth as shown in the image below. The mistake was found to occur in our published retrospective study on the use of the FAST DH view for the diagnosis of pericardial effusion. Non-cardiologist sonographers should be aware that the right ventricle is crescent-shaped with it a lot of variability in its size and proportionality during TFAST in right lateral recumbency at triage on an exam table without echo cut-out window. Moreover, the crescent-shaped right ventricle also has an "ugly" papillary muscle(s) that may easily be mistaken for lung, a mass, fibrin, or combinations thereof wafting in pleural or pericardial effusion when in fact the sonographer is imaging *normal* right ventricular anatomy. It seems that this mistake would be implausible, however, when patients are in respiratory distress, and the cardiac acoustic

window is flashing with each breath, the mistake is easy to make. Thus, we have come up with the tenets for the non-cardiologist sonographer to accurately diagnose pericardial and pleural effusion in the Table below.



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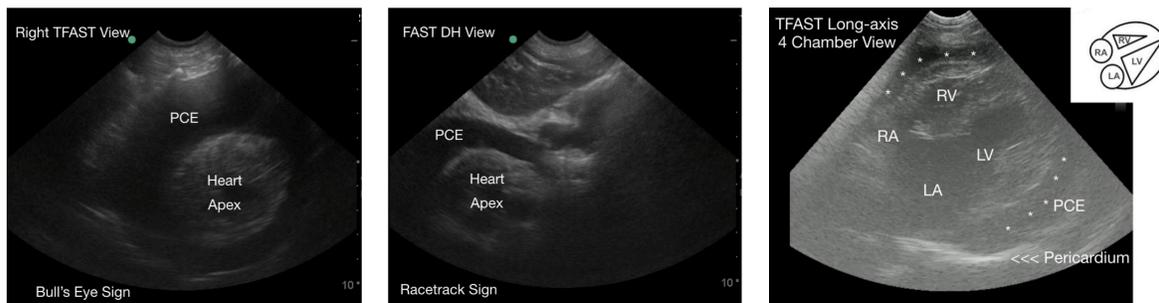
<b>Diagnosis of Pericardial Effusion</b>		
The Gold Standard for the Diagnosis of Pericardial Effusion is Ultrasound Radiography is Poor		
Pericardial Effusion is Contained in the Pericardial Sac that Attaches at One Atrium and Rounds the Apex of the Heart to Attach to the Other Atrium		
1 View is No View - Use Multiple Views		
Fallback Non-echo for Cardiac Tamponade is Use of the Caudal Vena Cava		
*AVOID the short-axis views for the diagnosis of Pericardial effusion unless directing the probe toward the heart's muscular apex		
<b>Imaging Strategy</b>	<b>FAST DH View</b>	<b>TFAST PCS View</b>
*Image toward the muscular apex of the heart where no heart chambers can be mistaken for free fluid	*FAST DH View – Racetrack Sign	*TFAST Right PCS View – Bull's Eye Sign
*Long-axis 4-chamber view where all 4 chambers are identified		*TFAST Right PCS View
*Image the heart globally in its entirety using the bright white pericardium in the far field as a landmark		
<b>Diagnosis of Pleural Effusion</b>		
The Gold Standard for the Diagnosis of Pleural Effusion is Debatably Computerized Tomography Radiography is Generally Good		
Pleural Effusion is Uncontained and Unrestrained Unless Compartmentalized		
<b>Imaging Strategy</b>	<b>FAST DH View</b>	<b>TFAST PCS View</b>
*Image the heart globally in its entirety using the bright white pericardium in the far field as a landmark		*TFAST Right and Left PCS – Anechoic (Black) Triangulations
*Image toward the muscular apex of the heart where no heart chambers can be mistaken for free fluid	*FAST DH View – Anechoic (Black) Triangulations	

Greg Lisciandro, DVM, Dipl. ABVP, Dipl. ACVECC and FASTVet.com © 2016, 2017

### Accurately Diagnosing Pericardial Effusion

- Use the FAST DH View for the "Racetrack Sign" of PCE rounding the muscular apex of the heart
- At the right PCS TFAST View direct the probe toward the muscular apex of the heart to observe the "Bull's Eye Sign" where there are no heart chambers

- Use the long-axis 4 chamber view where the 4 chambers of the heart may be clearly identified for observation of fluid present outside the heart



### **Accurately Diagnosing Pleural Effusion**

- 1 View is NO View Use Multiple Views
- Pleural effusion is uncontained and unrestrained and thus appears as triangulations
- Pleural effusion can have variability in being bilateral, unilateral, compartmentalized, and have variability in echogenicity with hemorrhage and transudates and modified transudates being anechoic (black) vs. exudates being echogenic (gray)
- Masses in the thorax can be confounders



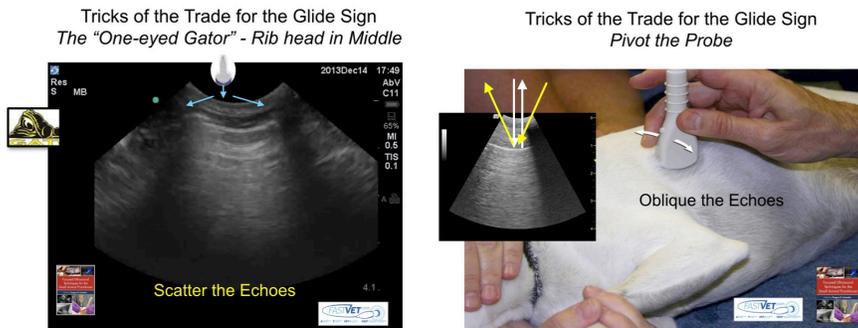
### **TFAST FOR PNEUMOTHORAX, LUNG CONTUSIONS, AND THORACIC WALL TRAUMA**

#### **BASIC LUNG ULTRASOUND FINDINGS AT THE CTS VIEW- GLIDE SIGN, PNEUMOTHORAX, LUNG ROCKETS AND STEP SIGN**

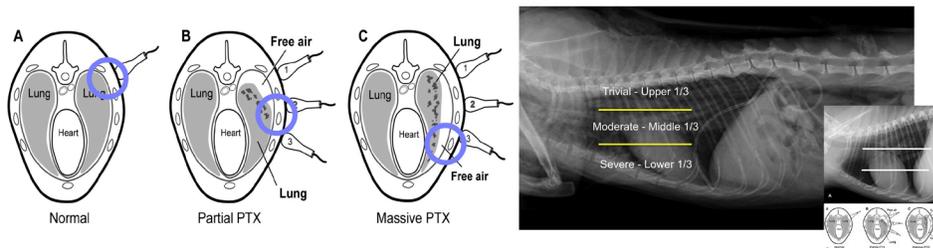
These lung ultrasound signs are well described in the textbook **Focused Ultrasound Techniques for the Small Animal Practitioner ©Wiley 2014**. They are as follows: 1) Normal dry lung (A-lines with the Glide Sign) 2) Pneumothorax (PTX) (A-lines withOUT the Glide Sign) 3) Ultrasound Lung Rockets (ULRs) are also called B-lines and are defined as hyperechoic laser-like streaks that do not fade extending to the far-field obliterating A-lines and oscillating in synchronization with inspiration and expiration. In trauma, ULRs represent lung contusions until proven otherwise; and by counting the number of ULRs at each intercostal space, semi-quantification of severity of lung contusions may be made (see Vet BLUE). 4) Step Sign representing deviation from the expected linear to and fro movement of the pulmonary-pleural interface suggesting thoracic wall trauma i.e. intercostal tear(s), fractured rib(s), subpleural hematoma; and/or pleural space conditions i.e. effusions, diaphragmatic hernia, masses. However, in non-trauma there are subsets of the Step Sign referred to as the Shred Sign, Wedge Sign (PTE), Tissue Sign, and Nodule Sign that represent forms of lung consolidation/infiltration (see Vet BLUE®). Both the presence of the Glide Sign and ULRs immediately rule out PTX at that point on the thorax because neither is present when air in the pleural space separates the lung from the thoracic wall. Importantly all lung sonographers should be aware of the limitations of lung ultrasound. Because ultrasound does not transmit through air, deeper more centrally located lung pathology that does not touch the lung surface will be missed. Thus, Vet BLUE® does not replace the need for thoracic radiography or other advanced imaging once the patient is stable or when radiology becomes available.

## TRICKS OF THE TRADE FOR IMAGING THE GLIDE SIGN ALONG THE LUNG LINE

The strategy is to make the echos work for you! There are 2 tricks of the trade we have developed: 1) place the rib head in the middle of the image to "scatter the echos." We refer to the maneuver as the "one-eyed gator." And 2) oblique the echos by pivoting the probe to a 45-60 degree angle to the lung line or in other words make the lung line more gray than bright white. Another helpful hint is turn down the gain along the lung line.



## USE OF TFAST® FOR THE "LUNG POINT" – THE DEGREE OF PTX



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Cross-sectional of the canine thorax in sternal recumbency depicting the quantification of the degree of pneumothorax (PTX) as B) partial or C) massive by searching for the "Lung Point" defined as the level at which lung re-contacts the thoracic wall. The author records as upper 3rd (trivial), middle third moderate and concerning, and lower 3rd severe; and uses this system for deciding on thoracocentesis and progressing, static or resolving PTX.

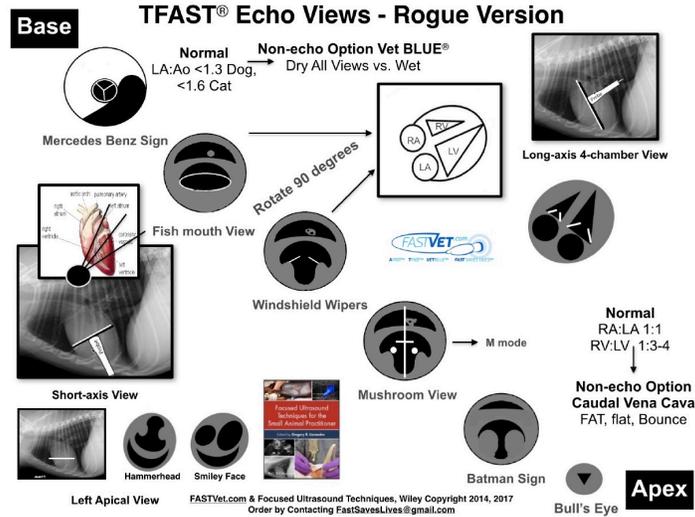
## TFAST Echo Views

- Global FAST for Volume Status
  - Volume Status & Contractility
    - Left Ventricular Short-axis "Mushroom" View (LVSA)
  - Left-sided Cardiac Status
    - Left Atrial to Aortic Ratio (LA:Ao Ratio)
    - Vet BLUE - Fallback
  - Right-sided Cardiac Status
    - Right Ventricular to Left Ventricular Ratio (RV:LV Ratio)
    - Caudal Vena Cava - Fallback



TFAST has 3 echo views from the right Pericardial Site View (PCS). They are the left ventricular short-axis "mushroom" view, the short-axis LA:Ao ratio (left atrial to aortic ratio) Ratio and the long-axis RV:LV ratio (right ventricular to left ventricular ratio). It is really important to know that there exist non-echo fallback views. For the left heart its Vet BLUE and lung (wet vs. dry). For right heart it's the caudal vena cava and hepatic venous characterization (FAT, flat or bounce to the CVC). The bottom line is don't kill you patient trying to get an echo view or a radiograph rather use the "fallback non-echo views" as called by the author. See Global FAST Proceedings for more information.

## TFAST Echo Chart



### CLINICAL INDICATIONS/APPLICATIONS FOR TFAST®

The use of TFAST<sup>3</sup> should be simply stated as an “extension of the physical exam” for all dogs and cats that are abnormal or suspect. Questionable findings within the thorax using the FAST DH View should be confirmed via TFAST<sup>3</sup> PCS View(s) or Vet BLUE or both and by serial exams by repeating TFAST<sup>3</sup> and Vet BLUE at least once 4-hours later. Global FAST should be adopted as a first line screening tests just as we have been trained to perform basic blood tests. Global FAST carries the potential to detect many effusive and soft tissue conditions of the abdomen, heart and lung missed by radiography. Indications include but not limited to 1) Blunt trauma 2) Penetrating trauma 3) Collapse, apparent collapse 4) Undifferentiated hypotension 5) Anemia 6) Acutely decompensated cardiac case, detection of left atrial tears 7) Respiratory distress (since there are non-respiratory look-alikes (i.e. hemoabdomen, cardiac tamponade, cardiac arrhythmias, anaphylaxis, high fever, and others) 8) Post-interventional at-risk bleeding (surgery, percutaneous procedures, i.e. lung lobe aspirates, pleurocentesis, pericardiocentesis) 9) Thoracoscopy, chest tube 10) Post-interventional at-risk pneumothorax (surgery, percutaneous procedures, i.e. lung aspirates, tracheal wash, pleurocentesis, pericardiocentesis, thoracoscopy, chest tube) 11) Monitoring PTX, pleural and pericardial effusions 12) Detecting and monitoring cardiogenic and non-cardiogenic pulmonary edema (see Vet BLUE Proceedings) 13) Patient monitoring during fluid resuscitation and during hospitalized care and 14) Pre-anesthetic screening test.

### Template for TFAST®

<b>Pneumothorax?</b>	Absent or Indeterm or Present: Left Right Bilateral Lung Point : Upper 1/3 Middle 1/3 Lower 1/3
<b>Pleural Effusion?</b>	Absent or Indeterm or Present: Left Right Bilateral Mild Moderate Severe
<b>Pericardial Effusion?</b>	Absent or Indeterm or Present Mild < 5mm Moderate 5mm-1cm Severe >1cm

### TFAST Echo Views

<b>Right PCS</b>	LVSA - Unremarkable or Abnormal or Indeterm LA;Ao Ratio - Unremarkable or Abnormal or Indeterm RV:LV Ratio - Unremarkable or Abnormal or Indeterm
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**Caudal Vena Cava** Unremarkable (bounce) Small (flat) Distended  
(FAT) or Indeterminant

**Hepatic Venous Distension** Absent or Present

Comments: \_\_\_\_\_

Conclusion: \_\_\_\_\_

**KEY:** CTS = chest tube site; PCS = pericardial sac; LV = left ventricle, PTX = pneumothorax, LVSA: left ventricular short-axis view, LA:AO aortic to left atrial ratio on short-axis view, RVLV: right ventricular to left ventricular ratio on long-axis view.

**Qualifier:** The TFAST exam is a rapid ultrasound procedure used to help detect major thoracic wall, lung, and pleural and pericardial space problems, and heart abnormalities as a screening test in order to better direct resuscitation efforts, expedite diagnosis, better pick the next best test(s), manage hospitalized critically ill patients, and keep alive for gold standard treatment and testing. TFAST exam is not intended to replace thoracic radiographs, or complete echocardiography.

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## 1st Annual Veterinary Point-of-Care Ultrasound Symposium, Austin, Texas USA

### Emergency Cageside TFAST® Ultrasound for Collapse & Respiratory Distress: Case-Based Discussion

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#### **INTRODUCTION**

Focused emergency cageside sonography is expanding rapidly and with ultrasound machines becoming common place, they have become an integral part of the early evaluation and triage of small animal patients that present to the emergency service or that are hospitalized in the ICU. These exams require proper training of veterinarians with minimal ultrasound experience to perform, can be done at the cageside concurrent with other resuscitative efforts, are non-invasive, safe, relatively inexpensive, repeatable, and can be completed in under 10 minutes. Multiple studies in the human and veterinary profession have shown focused emergency sonography can identify potentially life-threatening conditions and help direct therapeutic options. Although new applications of focused emergency cageside sonography are continually being developed and applied in veterinary patients, to date there are 3 main areas of emergency cageside sonography that have been investigated in small animal patients;

- 1)** Assessment of the thorax and lungs (thoracic focused assessment with sonography for trauma/triage/tracking (TFAST®) and the Vet BLUE® exam),
- 2)** Assessment of the abdomen (abdominal focused assessment with sonography for trauma/triage/tracking (AFAST®)), and
- 3)** Estimation of intravascular volume status via assessment of the caudal vena cava.

Important factors to consider when applying focused emergency cageside sonography to small animal veterinary patients:

- Perform the obvious first. i) Obtain IV access, ii) commence fluid therapy, iii) control obvious hemorrhage, iv) ensure adequate airway and breathing, etc. prior to performing the sonographic examination.
- The ultrasound machine should be brought to the resuscitation area for unstable patients; do not move an unstable patient for the purposes of emergency sonographic evaluation!
- These exams do not assess all organs of the body and are not a replacement for formal or complete abdominal or echocardiographic sonographic exams.
- Focused emergency cageside sonography should be considered an extension of your physical exam, immediately after the triage exam or your complete physical exam.
- When free fluid is detected, and is safely accessible, in the peritoneal, retroperitoneal, pleural, and pericardial spaces, then the pursuit of ultrasound-guided therapeutic and diagnostic centesis (pericardial, abdominal and thoracocentesis) is expedited potentially improving patient care and better directing diagnostic testing.
- Ultrasound cannot characterize the type of free fluid. Thus, when free fluid is safely accessible for sampling via centesis, characterization through biochemical analysis, cytology, and culture leads to more rapidly gained evidence-based diagnosis over traditional means without the use of FAST ultrasound.
- Although originally developed to assess blunt and penetrating trauma, these exams are now becoming standard of care for all emergent/critical care situations in which an underlying cause is not readily apparent, particularly if the patient is unstable. A recent veterinary study applied to unstable, non-traumatized dogs and cats, demonstrated that AFAST and TFAST combined, detected free fluid in the peritoneal, pleural, and/or

pericardial spaces in approximately 75% of these cases presenting to the ER (See Algorithm 1).

## **THORACIC FOCUSED ASSESSMENT WITH SONOGRAPHY FOR TRAUMA (TFAST) AND EMERGENCY CAGESIDE LUNG ULTRASOUND (VET BLUE)**

### **Important points to consider**

- The two protocols used most widely in small animal emergency medicine at this time are probably TFAST and Vet BLUE. The two are really complementary and overlap each other to some degree with regards to identifying underlying thoracic pathology.
- TFAST has been validated for detection of pleural space disease (pleural effusion and pneumothorax) as well as pericardial effusion in dogs.
- Vet BLUE is an extension of TFAST and focuses more specifically on lung pathology, particularly interstitial/alveolar conditions through the identification of B-lines and their distribution using a regionally-based approach.
- B-lines (often referred to as lung rockets, comet tail artifact, or ring down artefact) are hyperechoic vertical lines extending from the pleural line to the edge of the far field image (See Image Fig. 2B).
- B-lines move in a to-and-fro fashion with inspiration and expiration, synchronous with the glide sign.
- Pneumothorax poses challenges for rapidly, shallow breathing or panting dogs and cats; however, through the use of some probe maneuvers that scatter or oblique the ultrasound beam (one-eyed gator, and fanning the probe) and use of the lung point concept, help improve its diagnosis.
- Cardiac performance including volume and contractility, right- and left-sided problems, can be assessed with these TFAST and Vet BLUE protocols but requires proper training and generally more experience to master.

### **INDICATIONS**

- Any small animal trauma patient (See Algorithm 2).
- Any small animal patient presenting for dyspnea, particularly if the underlying cause is uncertain: perform after/concurrent to providing oxygen +/- anxiolytics, IV access, lifesaving intubation, etc. (See Algorithm 3)
- Any patient suspected to have pneumothorax (dyspnea with decreased breath sounds dorsally).
- Any patient in which pericardial effusion is suspected (pulses paradoxus, muffled heart sounds, electrical alternans), or detection of an overly distended caudal vena cava, hepatic veins and/or gallbladder wall edema (the halo sign) at the FAST DH view.
- Any patient suspected to have pleural effusion (dyspnea with decreased breath sounds ventrally).

### **CONTRAINDICATIONS**

- None. TFAST and Vet BLUE exams are rapid, non-invasive, do not require sedation or anesthesia, and do not compromise patient stability with special positioning or restraint.
- Dyspneic patients can be assessed in sternal recumbency or the standing position concurrent with oxygen therapy +/- sedation.
- Dorsal recumbency should not be used due to the risk of decompensating hemodynamically and respiratory fragile patients by compromising venous return and ventilation through the weight of the abdominal organs on the caudal vena cava and diaphragm, respectively.

### **MATERIALS**

- An ultrasound machine capable of B-mode (ideally portable or permanently located in the triage area of the clinic).
- A curvilinear (also called microconvex) probe within a range 5-7.5MHz setting and a maximum capable depth of 10-20 cm is used for the abdomen, thorax and lung
- Linear array probes may be used to identify the glide sign but are not required.
- Phase-array probes may be used for cardiac evaluation but are not required.
- Alcohol and/or ultrasound conducting gel or alcohol-based hand sanitizer.

- Clippers (optional).

### **Anaesthesia, analgesia, sedation**

- Patients tolerate the procedure well without the need for sedation or anaesthesia.
- Patients presenting with evidence of pain (trauma, acute abdomen etc) should be managed with analgesia.

### **TECHNIQUE/PROCEDURE: TFAST EXAM**

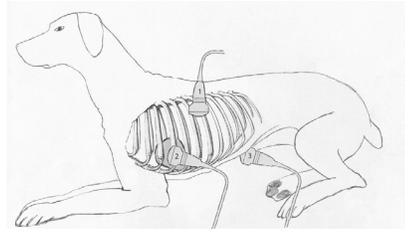
- Fur does not require clipping, although shaving a small 5 x 5 cm area may improve image quality in some patients (i.e. patients with thick undercoats).
- The probe location sites are soaked with alcohol after parting the fur keeping in mind the best image will be obtained with the probe head directly in contact with skin.
- Some images are improved with the addition of ultrasound gel, hand sanitizer, as well as alcohol (if a good image is not obtained with alcohol, try adding gel or hand sanitizer on top of the alcohol - if this still fails to provide a good image try clipping the fur and using gel).
- Patients that are not dyspneic can be scanned in lateral recumbency as an extension of the AFAST exam.
- The subxiphoid site, non-gravity dependent chest tube site (CTS), and pericardial site (PCS) are obtained following the AFAST exam with the animal in right or left lateral recumbency. The animal is rolled into sternal recumbency to obtain the contra-lateral CTS and PCS sites.
- Alternatively, all 5 sites can be obtained with the patient standing or in sternal recumbency, particularly if the patient demonstrates signs of respiratory distress.
- Transducer depth is generally set between 10-20 cm for the subxiphoid view, 5-15 cm for the PCS views, and 2-6 cm for the CTS views, depending on the patient size and body condition score.

The ultrasound probe is placed at 5 focal regions of the chest in a consistent systematic manner; **1) Subxiphoid (DH) site:** the probe is placed just caudal to the xiphoid and the depth adjusted to allow visualization of the pleural and pericardial spaces via the liver and diaphragm (liver and diaphragm remain visible in the near field). It helps to angle the probe cranially at this site (direct the probe almost parallel to the spine with the head of the probe just tucked under the xiphoid process), and it may be necessary to gently but firmly push the probe under the xiphoid process in larger dogs, particularly deep-chested breeds. The probe is moved 2.5 cm in several directions and rocked or fanned at this site to improve the chances of finding free pericardial and/or pleural fluid. The targets of the subxiphoid (DH view) are the liver, gallbladder, diaphragm, heart against the diaphragm (difficult in to see the cardiac bump in normalcy in cats), pleural and pericardial spaces, and the caudal vena cava as it traverses the diaphragm. The subxiphoid (DH view) should look almost identical whether performed in lateral recumbency or in sternal or standing positioning.

**2) Left and right chest tube site (CTS):** the probe is placed at the 7<sup>th</sup>-9<sup>th</sup> intercostal spaces on the dorsolateral thoracic wall (closer to vertebrae). The "classic" view, referred to as the gator sign, involves holding the probe perpendicular to the long-axis of the ribs, at the intercostal space (See Fig. 1). It is important to hold the probe static at this site through several respiratory cycles, as iatrogenic movement of the probe can create the illusion of a false glide sign. Fanning the probe slightly off perpendicular such that the ultrasound beam passes through the pleural line at an angle, referred to as obliquing the echoes, often enhances visualization of the glide sign. Another technique is called the one-eyed gator by placing the rib head in the center of the image to scatter the echoes (see Lisciandro TFAST Proceedings for illustrations). An intercostal view with the probe held parallel to the long-axis of the ribs can also be used and may facilitate identification of the lung point, although the landmarks associated with the rib are lost with this orientation. The lung point is the site where the lung begins to come in contact with the parietal surfaces when pneumothorax is present (see Lisciandro TFAST Proceedings for illustrations).

**3) Left and right pericardial sites (PCS):** These sites are used to detect pleural and pericardial effusions, to evaluate volume and contractility, and to screen for right- and left-sided heart conditions through 3 echocardiography views (short-axis left ventricular "mushroom" view, short-axis LA:AO ratio, long-axis 4-chamber view for the RV:LV ratio). The probe is placed to visualize the heart, pericardial sac, and pleural spaces.

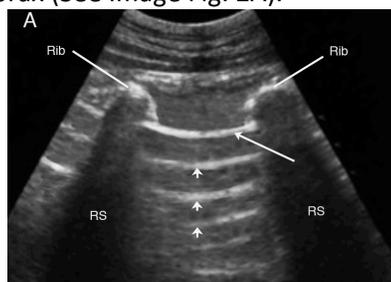
The probe is placed over the heart at the level of 5<sup>th</sup>-6<sup>th</sup> intercostal space on the ventrolateral thoracic wall (closer to the sternum). The probe is moved 2.5 cm in several directions (may need to move between rib spaces) and is rocked and fanned at this site to improve the chances of finding free pericardial and/or pleural fluid. Increasing the ultrasound depth to include the entire heart within the image field, particularly in the short-axis view, improves the likelihood of differentiating pericardial from pleural fluid and not mistaking a heart chamber for either. Also comparing the PCS view and the subxiphoid (DH) view helps in differentiating pericardial from pleural fluid.



**Figure 1:** Sites to be examined during the TFAST exam include placement of the probe perpendicular to the ribs at the left and right chest tube site (CTS) (probe labeled 1), the left and right pericardial sites with the probe in both longitudinal and transverse orientation to the heart (PCS) (probe labeled 2), and the subxiphoid site with the probe initially placed in a longitudinal orientation (probe labeled 3). In this figure the dog is in sternal recumbency with the hind end shifted into a more right lateral position. This allows both side of the chest to be evaluated while still leaving access to the subxiphoid site. From *Veterinary Emergency and Critical Care, 3rd ed. Mathews, 2016, Lifelearn, Guelph, Ontario, Canada; with permission*”.

### **INTERPRETATION: TFAST EXAM**

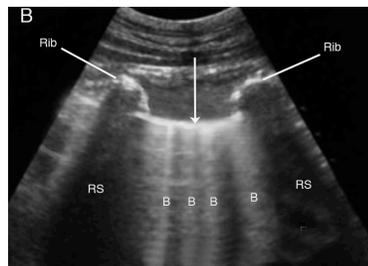
- Free fluid is hypoechoic (black) and may be located in the pleural and/or pericardial spaces.
- Fluids identified on TFAST may be blood, septic, chylous, or other; ultrasound guided fluid aspiration is recommended with fluid cytology and analysis to confirm the type of fluid present.
- In cases of pneumothorax, air in the pleural space obliterates the normally present glide sign. Healthy patients have their visceral and parietal linings in contact with each other. Together these linings sonographically form a single visible white line referred to as the pulmonary-pleural line. The pulmonary-pleural line is located between two adjacent ribs when the ultrasound probe is placed in the “classic” CTS orientation referred to as the gator sign (See Image Fig. 2A).
- As the visceral and parietal pleura slide back and forth across each other during inspiration and expiration, they form a dynamic pulmonary-pleural interface. This dynamic process creates a continuous speckling along the white pleural line referred to as the glide sign.
- With pneumothorax, the glide sign is absent even during inspiration and expiration. The loss of the glide sign during respirations implies the presence of air in the pleural space. The loss of the glide sign occurs because air separates the parietal from the visceral lining and prevents the gliding or sliding from being seen during the dynamic phases of respiration. Note: a white pleural line is still sonographically visible when pneumothorax is present (composed of only the parietal lining); the pleural line is indistinguishable between healthy patients and those with pneumothorax, except the pleural linings no longer move back and forth against each other (absent glide sign) in cases of pneumothorax (See Image Fig. 2A).



**Figure 2A:** Sonographic image obtained when the ultrasound probe is placed perpendicular to the ribs at the chest tube site (CTS) referred to as the gator sign with the rib heads the two eyes, and the line in between the

bridge of its nose, likened to a partially submerged alligator looking at you. The ribs appear as the curvilinear white lines to either side of the image with rib shadowing (RS). The first white line that appears distal to the rib, connecting the two ribs, is the pleural line (identified by the long white arrow). This is the area that is assessed for the back and forth shimmering or glide sign. The reverberation artifact that causes the pleural line to be repeated in the far field of the image are known as A-lines (short arrows). Note that the pleural line and A-lines are both present in patients with normal peripheral lung and patients with pneumothorax. It is the back and forth motion, the glide sign, along the pleural line that differentiates normal peripheral lung (glide sign present) from patients with a pneumothorax (glide sign absent). From *Veterinary Emergency and Critical Care*, 3rd ed. Mathews, 2016, Lifelearn, Guelph, Ontario, Canada; with permission”.

- The CTS sites can also allow detection of B-lines; reverberation artifacts originating from the pulmonary-pleural line extending to the edge of the far field image that move to-and-fro with inspiration and expiration (See Image Fig. 2B). B-lines serve two purposes: 1) their presence definitively rules out the possibility of pneumothorax, and 2) if they are increased in number they represent a variety of interstitial-alveolar pathology.
- A single B-line at a single probe site can be normal in healthy dogs and cats. Numerous to converging B-lines indicate significant interstitial-alveolar pathology is present. With a history of trauma B-lines most likely indicate pulmonary contusion. The number of B-lines semi-quantitates the severity of lung contusions by the larger the number, the more severe the contusions.



**Figure 2 B:** Sonographic image obtained when the ultrasound probe is placed perpendicular to the ribs at the chest tube site (CTS) in a patient in respiratory distress with crackles noted on auscultation. The ribs appear as the curvilinear white lines to either side of the image with rib shadowing (RS). The first white line that appears distal to the rib, connecting the two ribs, is the pulmonary-pleural line (long white arrow). In patients with interstitial/alveolar disease (e.g. pulmonary edema, contusions, etc.) vertical white lines known as B-lines (B) may be noted. These originate at the pulmonary-pleural line, extend to the far field of the image, obliterating A-lines, and will move back and forth with respirations similarly to the glide sign. From *Veterinary Emergency and Critical Care*, 3rd ed. Mathews, 2016, Lifelearn, Guelph, Ontario, Canada; with permission”.

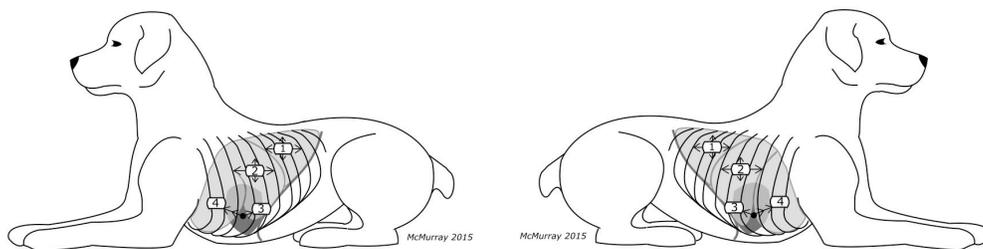
#### **TECHNIQUE/PROCEDURE: VET BLUE EXAM**

The Vet BLUE protocol involves examination of the thorax at 4 bilateral sites; caudo-dorsal, peri-hilar, middle, and cranio-ventral lung regions (See Fig. 3). It is often done in conjunction with the TFAST exam because it's an extension from the TFAST Chest Tube site for more information regarding the lung. Depth is set between 4 (smaller)-6cm (larger) for most dogs and cats. It is important to avoid diagnosing pleural and pericardial effusion during Vet BLUE because depth is too shallow, and it is easy to confuse heart chambers for either. TFAST PCS and subxiphoid (DH) views with increased depth avoid this mistake.

The four sites evaluated with the Vet BLUE exam on each hemithorax (8 sites total) include:

- 1) Upper third of the thorax at the 8<sup>th</sup>-9<sup>th</sup> intercostal space** called the dorsal caudo-dorsal (Cd) lung region (this is the CTS of the TFAST exam)
- 2) 6<sup>th</sup>-7<sup>th</sup> intercostal space in the middle third of the thorax** called the perihilar (Ph) region
- 3) Lower third of the thorax near the costochondral junction at the 4<sup>th</sup>-5<sup>th</sup> intercostal space** called the middle (Md) lung region
- 4) The lower third of the thorax near the costochondral junction at the 2<sup>nd</sup>-3<sup>rd</sup> intercostal space** called the cranial (Cr) lung region.

The probe is placed at each site and initially moved 1-2 rib spaces cranially and caudally to rapidly look for B-lines and other described lung ultrasound signs (shred sign, tissue sign, nodule sign, and wedge sign [PTE]) not covered here (See Lisciandro Vet BLUE Proceedings). In larger dogs, the probe can also be moved 1-2 cm dorsally and ventrally. If B-lines are visualized, the probe is held stationary and the number of B-lines are counted and recorded over the most representative view at that Vet BLUE location. If no B-lines are found, the probe is held stationary and the presence/absence of a glide sign is evaluated. At the middle lung site (3), the probe is initially placed over the 4<sup>th</sup>-5<sup>th</sup> intercostal space just above the level of the costochondral junction; if the heart obscures the field of view and prevents visualization of the lung field, the probe is moved 1-2 rib spaces caudally or dorsally just enough until the heart is out of view or is no longer visible and the lung can be evaluated. At the cranial lung site (4), the probe is placed over the 2<sup>nd</sup>-3<sup>rd</sup> intercostal space. The heart may be used as a landmark so that when the heart is visible, the probe is then moved cranially one rib space at a time until the heart is no longer visible and the lung can be evaluated. In the cranial direction, the thoracic inlet may be used as a landmark and the probe moved caudally counting to the 2<sup>nd</sup> and 3<sup>rd</sup> intercostal space. The patient's forelimb often need to be advanced cranially to facilitate probe positioning at this site. Once pneumothorax is ruled out, record the presence or absence and number of B-lines other described lung ultrasound signs (shred sign, tissue sign, nodule sign, and wedge sign [PTE]) at each site. Numbers of B-lines likely correlate with the degree alveolar-interstitial edema. The counting system over the most representative intercostal space at each Vet BLUE view that has been published is 1, 2, 3, >3 (more than 3 but still split into individual B-lines) and infinite B pattern (confluent having so many that no B-lines can be recognized individually). Expect dogs and cats to have predominately dry lung or absent B-lines at all Vet BLUE views.



**Figure 3:** Four sites are evaluated on each hemithorax: upper third of the thorax at the 8-9th intercostal space, or caudo-dorsal (Cd) lung region (1), 6-7<sup>th</sup> intercostal space in the middle third of the thorax or perihilar (Ph) lung region (2), lower third of the thorax near the costochondral junction at the 4<sup>th</sup> to 5<sup>th</sup> intercostal space or middle (Md) lung region (3), and the lower third of the thorax near the costochondral junction at the 2<sup>nd</sup> to 3<sup>rd</sup> intercostal space or cranial (Cr) lung region (4). From *Veterinary Emergency and Critical Care*, 3rd ed. Mathews, 2016, Lifelearn, Guelph, Ontario, Canada; with permission".

The probe is placed at each site and initially moved 1-2 rib spaces cranially and caudally to rapidly look for B-lines. In larger dogs, the probe can also be moved 1-2 cm dorsally and ventrally. At the middle lung site (3), the probe is initially placed over the 4<sup>th</sup>-5<sup>th</sup> intercostal space just above the level of the costochondral junction; if the heart obscures the field of view and prevents visualization of the lung field, the probe is moved either caudally 1-2 rib spaces until the heart is no longer visible and the lung can be evaluated, or if abdominal contents are immediately caudal to the heart, then move dorsally just enough until the heart is out of view. At the cranial lung site (4), the probe is initially placed over the 2<sup>nd</sup> to 3<sup>rd</sup> intercostal space 1-3 cm (depending on the size of the patient) near the costochondral junction. If the heart is visible, then the probe is then moved cranially one rib space at a time until the heart is no longer visible and the lung can be evaluated. In the cranial direction, the thoracic inlet may be used as a landmark and the probe moved caudally counting to the 2<sup>nd</sup> and 3<sup>rd</sup> intercostal space. The patient's forelimb is advanced cranially to facilitate probe positioning at this site.

#### **INTERPRETATION: VET BLUE EXAM**

- The VET BLUE protocol detects pulmonary pathology in cats and dogs, and the presence or absence of a glide sign (see TFAST).

- Pulmonary pathology (most often interstitial/alveolar edema) is identified on Vet BLUE via the identification of B-lines, defined as artifacts (most commonly created by fluid next to air) originating from the pulmonary line extending to the edge of the far field image without fading that move to-and-fro with inspiration and expiration obliterating A-lines (See Image Fig. 2B).
- A single B-line at a single Vet BLUE site may be a normal finding in dogs and cats without respiratory disease but in general you should expect dogs and cats to have absent B-lines ALL Vet BLUE views.
- A B-line or the glide sign effectively rules out pneumothorax at that specific site along the thoracic wall.
- Multiple B-lines (>3) or those that coalesce (infinite) over a single intercostal space may indicate different underlying pathology depending on their distribution (See Algorithm 3).
  - A preponderance of B-lines present in the upper caudo-dorsal and peri-hilar regions generally supports left-sided congestive heart failure and forms of non-cardiogenic pulmonary edema. Advanced left-sided congestive heart failure often involves 3 or more positive views bilaterally.
  - A preponderance of B-lines present in the middle and cranial lung regions generally supports bacterial and aspiration pneumonia. The use of the shred sign (an air bronchogram on radiographs) gives more credence to pneumonia.
  - By using the lung ultrasound signs of consolidation and infiltration described as the shred sign, tissue sign, nodule sign and wedge sign, a better working diagnosis may be established during Vet BLUE (see Vet BLUE Proceedings by G Lisciandro).
- When B-lines are numerous they create what is called a *B-pattern*, which is indicative of advanced interstitial-alveolar disease. Importantly, B-lines are non-specific and may represent different types of alveolar/interstitial edema created by fluid next to air at the lung periphery, e.g., water/air (CHF), blood/air (contusions, coagulopathy), pus/air (pneumonia) *immediately* adjacent to air, thus the regionally-based Vet BLUE approach and its 6 basic lung ultrasound signs help better interpret findings during lung ultrasound.

### **IMPORTANT CONSIDERATIONS**

- Patients that have a negative initial TFAST and/or Vet BLUE scan that fail to stabilize or have persistent clinical signs should have at least one 4-hour post-admission serial exam if stable and sooner if not stable.
- A negative TFAST or Vet BLUE scan does not exclude internal injury or pathology. Pathology located more than a few mm within the lung that does not extend to the lung periphery is unlikely to be seen during lung sonography making thoracic radiography and other advanced imaging important once the patient is stable. Serial Vet BLUE/TFAST should also be repeated at least once 4-hour post-admission serial exam if stable and sooner if not stable.
- Vet BLUE can help better interpret radiographical findings because lung ultrasound is very sensitive for detecting lung surface pathology possibly exceeding the limits of thoracic radiography.
- Patients that are panting or have rapid shallow respirations can be difficult to assess for a glide sign if B-lines are not present. As this can also be opioid-induced, titration of the opioid IV or administering a lower dose of the selected drug IM helps avoid this phenomenon.
- The glide sign is only visible during the dynamic phases of inspiration and expiration and thus cannot be observed between breaths (static phases of respiration and during periods of apnea).
- Movement of your hand, the probe, or the patient may cause a false positive glide sign; keep your hand, the patient, and the ultrasound probe still when looking for the glide sign.
- Scattering the echoes by placing the rib head in the center of the image (one-eyed gator), or by obliquing the echoes by directing the probe at an angle to the pulmonary-pleural line are helpful tricks to more effectively and rapidly observe for the glide sign.
- A linear array probe and changing the angle of the probe from perpendicular to a 45 degree angle may help identify the glide sign (oblique the echos).

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#### **Algorithms for interpretation of Focused emergency cage side sonography in small animal veterinary patients**

-See Boysen and Lisciandro AFAST Proceedings

**Focused Echocardiography for the Non-Cardiologist Veterinarian**

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**Focused ECHO – The why, when, what and how?**

A joint consensus statement by the American Society of Echocardiography and the American College of Emergency Physicians supported the use of the focused cardiac ultrasound exam to expedite the diagnosis and management of life-threatening conditions in the emergency room setting (Labovitz 2010). With minimal didactic and hands-on echocardiography training, non-cardiologist or non-radiologist veterinarians can achieve proficiency in identifying pleural and pericardial effusions, and detect the presence of left atrial enlargement (Tse 2012). The technologic miniaturization and improvement in transducer technology, reduced price and educational opportunities such as this training session, have facilitated the integration of focused cardiac ultrasound into emergency practice. **In the emergency setting, focused cardiac ultrasound has become a fundamental tool to expedite the diagnostic evaluation of the patient at the cage-side and to initiate emergent treatment and triage decisions by the emergency clinician.**

**When to perform a Focused ECHO:**

- Dog or cat with respiratory distress, tachypnea or dyspnea
- Dogs or cats with clinical signs suggestive of congestive heart failure (left- and right-sided)
- Dog or cat with clinical signs suggestive of pericardial effusion
- Uncharacterized persistent or intermittent hemodynamic instability or collapse.
- Uncharacterized syncope, collapse or generalized weakness.
- Uncharacterized tachycardia (rapid heart rate) or arrhythmia with clinical signs.
- Feline aortic thromboembolism (ATE).
- Cardiovascular assessment of volume status and heart contractility.
- Re-assessment for recurrence of either pericardial or pleural effusions post-centesis or during course of therapy.
- Assessment of pulseless electrical activity or asystole in cardiopulmonary resuscitation (CPR)

The superior diagnostic accuracy of abbreviated echocardiography in certain conditions over the cardiac physical examination is the reason why point-of-care thoracic ultrasound has been coined the “visual stethoscope of the 21st century” (Moore 2011).

**What are achievable goals for the non-cardiologist performing a Focused ECHO?**

- Detection of **pleural and pericardial effusion**. Also estimation the amount of pleural and pericardial fluid, its location(s), identify site for centesis, and assess for recurrence of effusion. For pericardial effusion, determine the presence of **cardiac tamponade** and likely cardiac mass.
- Identification of an **obvious cardiac mass** usually located at the heart base or right atrium.
- Identification of **severe left atrial enlargement** providing supportive evidence of left-sided heart failure.
- Detection of **obviously thickened mitral or tricuspid valves**; and possibly ruptured chordae tendineae.

- Identification of **severe right atrial and ventricular enlargement** providing supportive evidence for right-sided heart failure or pulmonary hypertension (cor pulmonale).
- Assessment of **left ventricular contractility** typically by “eyeball” assessment (or by measurement of the fractional shortening). Assessment of cardiac standstill in CPR.
- Assessment of **severe left ventricular concentric hypertrophy** (thickening); providing supportive evidence for the diagnosis of hypertrophic cardiomyopathy in cats.
- In cats with ATE, detection of left atrial enlargement, **left atrial thrombus or “smoke”**.
- In dogs with suspect caval syndrome, detection of **heartworms in the right atrium or ventricle**.
- Detection of **severe hypovolemia** by initial or serial assessments of cardiac chamber size and degree of respiratory variation of the caudal vena cava.

### **Focused ECHO Exam: TRANSDUCER POSITIONS and VIEWS:**

The focused ECHO should not be used as a stand-alone test for the definitive diagnosis of heart failure and should not replace a more complete and diagnostic echocardiogram by a cardiologist or other expert specialist. The sonographer should know their limitations and be cautious with their findings. That being said, there is no doubt that the focused ECHO provides a tool that is portable, point-of-care, less stressful (than radiographs), non-invasive, and rapid assessment of patients and is indicated in dogs and cats presenting with respiratory signs or distress, suspect heart failure, persistent or episodic hemodynamic collapse especially to rapidly rule out cardiac tamponade and heart failure.



Despite the practical value and benefits of point of care ultrasound (US), there are some inherent limitations. These limitations often relate to suboptimal imaging conditions that are often associated with the critically ill patient and due to the constraints of the physical environment of the ICU. Obtaining a “good” acoustic window is required to allow an accurate assessment. However, finding a good acoustic window for the heart can be quite difficult in an animal in respiratory distress. For this reason, the examiner must have a thorough knowledge of the anatomy and instrumentation (gain, depth, gray scale, Doppler) as well as the ability to adjust transducer positioning to adequately obtain and interpret the images. Other limitations relate to surgical wounds and dressing, tubing, obesity and telemetry patches. Additionally lack of patient cooperation and difficulty in moving the patient into the optimal position contributes too many technically poor studies. When appropriate, mild sedation may improve patient cooperation. Care must be taken when positioning the critically ill patient. Sternal recumbency is the most comfortable for animals with respiratory distress, however images of the heart are best obtained from the right side ideally in right lateral recumbency while imaging from the down side.

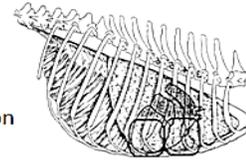


## Images from the Right Hemithorax

- Long axis parasternal images
  - Four chamber view
  - Optimize for LV outlet and ascending aorta
  - Optimize for RA and tricuspid valve
- Short axis parasternal at level of:
  - LV at chordae tendoniae
  - LV at mitral valve
  - Heart base (Aorta, LA)
- Sub- costal for LVOT doppler study or caudal vena cava/hepatic vein assessment

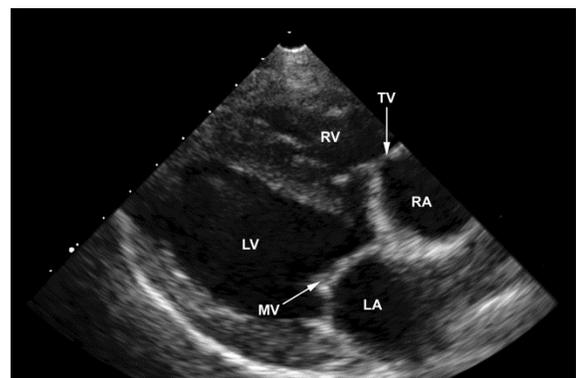
## Images from the Left Hemithorax

- Left apical transducer position
  - 4 chamber view
  - 5 chamber view (aorta – “5<sup>th</sup>” chamber)
- Left cranial transducer position (short and long axis)
  - Right ventricular inlet and tricuspid valve view
  - Right auricular view
  - Aorta and pulmonary artery views



## RIGHT PARASTERNAL LONG AXIS VIEWS: 4 Chamber and LV Outflow Tract Views

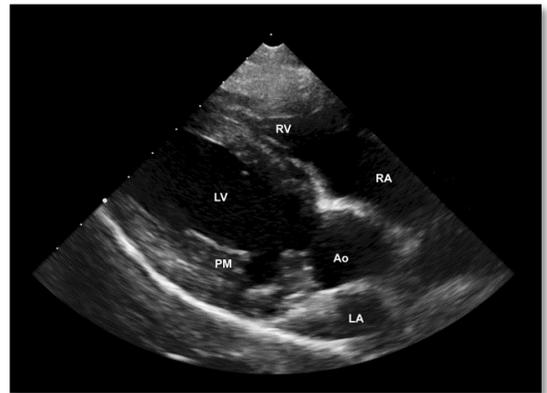
- With patient in right lateral recumbency, start imaging at the site where you feel a palpable heart beat (place your hand on the patient’s thorax) on the recumbent or right side. If patient in respiratory distress, echo in sternal recumbency.
- The probe is held with either your thumb or index finger on the marker. **The marker and the corresponding image is oriented such that the atria are on the right side of the image.** To obtain the 4-chamber long-axis view with the probe is held so that your index finger (either on or off the marker) is oriented towards the spine. From the 4 chamber view, slightly angulate the probe towards the animal’s head to image the ascending aorta, aortic valves, left atrium and the left ventricular outflow tract.
- Once the initial image is obtained, adjust ultrasound settings to optimize the image. You should educate yourself or have the ultrasound vendor educate you about the knobs on your ultrasound unit to improve image quality. In general, you want your echocardiographic images to have more contrast (more black and white, less shades of grey) than abdominal ultrasound images to allow for clearer visualization of motion of the ventricular walls, endocardial border contour and valvular structures. Vendors can possibly make a preset on your ultrasound unit for cardiac studies. Common basic adjustments include:
  - Depth adjustment. You want to see the entire heart if possible. Some smaller units only go to a maximum depth of 13 cm that won’t allow visualization of the entire heart in a big dog. Adjust the depth so that heart fills the view to avoid mirror image artifact.
  - Gain adjustment. Adjust gain to allow good visualization of the heart. Sometimes, poor visualization is often related to poor coupling of the transducer to the patient which may be remedied with more alcohol or gel or a firmer application of the transducer to the body wall.
  - Frequency adjustment. Most new units have a range of frequencies within a transducer that can be adjusted. Select the frequency that looks the best.
  - Focal zone adjustment. Move focus to just inside the posterior wall of the heart to optimize the image.
  - Image contrast setting adjustments. Increase the contrast of the image by adjusting (or turning down) the grey scale or persistence settings.
- In general, once you have found the best image or “acoustic window” of the heart between the ribs, the probe generally is not moved much (maybe one intercostal space forward or backwards) other than rotated and fanned to visualize the various cardiac chambers. Image quality may be improved in obese animals by pressing a little bit without causing discomfort.



- The right parasternal long-axis views are most helpful to estimate the size and relative proportions of the right and left heart as well as an ‘eyeball’ assessment of LV contractility. Mitral valve anatomy, pericardial effusion and pleural effusion are generally best seen in these views.

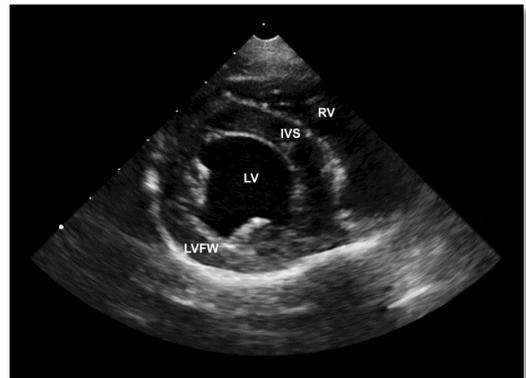
**INTERPRETATION:**

- Normally the left ventricle (LV) should be 3-4 times bigger than the right ventricle (RV) in the right parasternal 4-chamber view. The interventricular septum is generally straight. The perimembranous IVS can be very thin and echolucent. If the RV is same size as LV, >>>>severe right ventricular enlargement.
- Normally, the left and right atria are approximately the same size (1:1) with a straight interatrial septum. The left atrium is usually a little bigger but not by much. Look for “bowing” of the interatrial septum to suggest atrial enlargement. For example, if the right atrium is larger than the left with the interatrial septum bowing to the left, then the right atrium is enlarged.
- The left atrium (LA) and aorta (Ao) in the LVOT view should be the same size (LA:Ao should be 1:1). If ratio greater than 1.3:1>>>> LA enlargement.



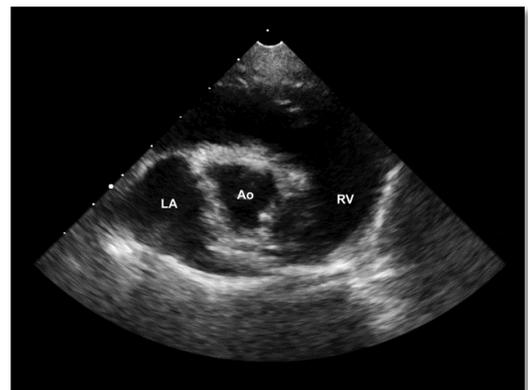
**Right Parasternal SHORT-AXIS Views: LV, Mitral Valve and Heart Base**

- To obtain the LV short-axis views, start with the long-axis view and simply rotate the probe about 90 degree so that your index finger or thumb is pointing towards the elbow.
- Now, rotate the probe slightly until the image of the LV short-axis “mushroom” view is as symmetrical as possible.
- Within this acoustic window, angulate or fan the probe just below and then through and above the mitral valve to get the various views. When you fan, you are essentially only moving the “tail” of the probe while keeping your transducer head stationary.



**Interpretation:**

- The LV “mushroom view” should normally have a circular appearance and the RV should be crescent shaped. Flattening of the interventricular septum (IVS) suggests right ventricular volume or pressure overload
- The views at the heart base are helpful in assessing left atrial, pulmonary artery size and the presence of a heart base mass. The aorta and main pulmonary artery are normally the same diameter.
- Be cautious not to over-interpret normal fat at the heart base as a mass lesion. Adipose or fat tissue is quite hyperechoic with irregular borders. A heart base mass usually has a smooth border and is less echogenic.

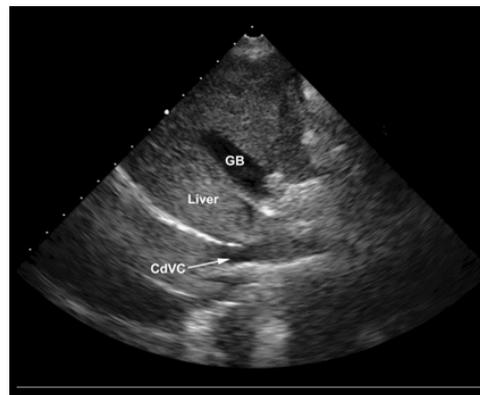
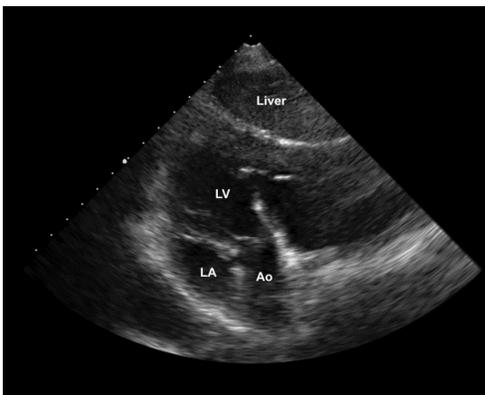


- In the short axis heart base view, normally, the diameters of left atrium (LA) and aorta (Ao) are similar in size (LA:Ao is 1:1) If the left atrium is greater than 1.3 times the aorta in dogs, then the left atrium is enlarged and greater than 1.6 in cats (LA:Ao > 1.3 dogs; LA:Ao > 1.6 cats).
- A left atrial diameter that is twice the aortic diameter is very suggestive of left-sided heart failure in an animal with consistent clinical signs.
- To obtain cardiac chamber dimensions, freeze a loop and scroll between systole (when the LV lumen is smallest) and diastole (when LV lumen is biggest) to obtain a fractional shortening (FS %) using 2-dimensional B-mode and to measure LV wall thicknesses.
- Alternatively, M-mode echocardiography can be used. The M-mode view is an “ice pick” view with the cursor placed in the center the LV short-axis “mushroom” view. Use of M-mode enhances assessment of both LV contractility and its wall thickness.

**Fractional Shortening Values (FS %).** Keep in mind that normal FS% can vary by breed and loading (i.e., volume status) conditions. In general, normal FS% is between 28 to 45% in the dog; and 30-50% in the cat. A FS% below 20% is suggestive of severe myocardial systolic failure; and a FS% above 55% would be considered hyperdynamic LV function. (See section below on assessment of LV systolic function)

### SUBCOSTAL Views: LV Outflow tract, Caudal Vena Cava and Hepatic Veins

- The transducer is positioned just caudal to the xyphoid typically with the patient in right lateral recumbency.
- For these subcostal views, my thumb in on the marker and my thumb is essentially parallel with the sternum to get the LVOT views. Adjust the depth and rotate the probe until a 4 chamber or 5 chamber view is seen.
- From the subcostal cardiac views, angulate the probe and decrease the depth to visualize the liver and hepatic veins.
- To image the caudal vena cava near the diaphragm, the probe is angulated towards the spine with slight upward tilting of the tail of the probe as the caudal vena cava is slightly to the right of midline.



#### **Interpretation:**

-**Hepatic venous distention** is a somewhat subjective assessment. Look for the large anechoic vessels, first the larger branches and then smaller branches, extending peripherally into hepatic tissue.

-If these large hepatic veins are seen with concurrent findings of ascites, and an enlarged and hypoechoic liver, a diagnosis of right-sided heart failure is suggested.

-Usually, hepatic veins can be differentiated from portal veins in the liver because they have much less echogenic (less bright) vessel walls than the portal veins.

-Additionally, when measured at the same depth, portal veins and hepatic veins should be about the same size.

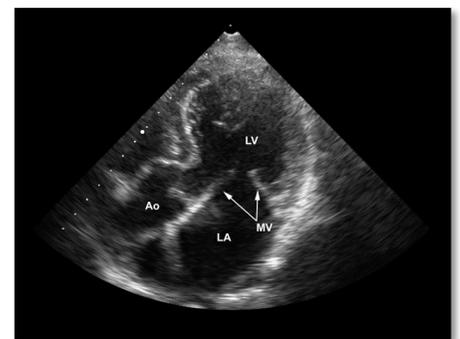
**-The caudal vena cava can be assessed for respiratory fluctuation and in size as an indicator of volume status.**

-Respiratory fluctuations are greater in animals that are volume depleted or fluid responsive (generally > 50% fluctuation). No respiratory fluctuations, only static distention, of the caudal vena are seen in animals that have high right atrial pressure and are fluid intolerant.

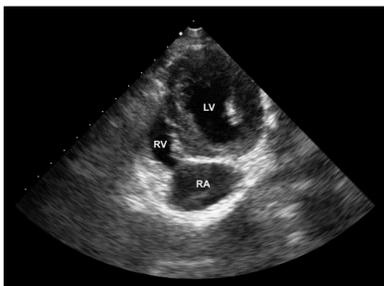
The caudal vena cava and aortic comparison can be visualized from the right side just behind the ribs just below the epaxial muscles in a dog in left lateral recumbency. The vena cava will be at the level of the kidneys. By fanning towards the dorsum one can also visualize the aorta.

### LEFT PARASTERNAL VIEWS: Left apical (4 and 5- chamber), Left cranial

- The main reasons to image from the left side are to further assess the right heart, great vessels, valvular anatomy and function, to help discriminate pleural from pericardial effusions when present, and to search for possible right atrial or auricular mass when indicated.
- The left sided views also allow a good line up for quantitative Doppler studies for both MV and TV.
- The left cranial views allow the best visualization of right auricle (rule out hemangiosarcoma), good visualization of RA, RV and TV apparatus as well as Aorta and PA (which are perpendicular to each other).
- These views are obtained with the probe positioned at the 3-4<sup>th</sup> intercostal spaces **on the left side (or recumbent side) with the patient ideally in left lateral recumbency**. Alternatively, one can obtain some of these views from the left side with the patient in right lateral recumbency.
- The left four and five chamber apical views are obtained with the probe marker pointing towards the spine with the probe angulated up towards the neck about the fifth intercostal space near the costochondral junction.
- The left five chamber apical view is obtained with a slight angulation toward the head and a slight rotation of the marker towards the head until the aorta comes into view



#### Left Parasternal Cranial View



-From the left apical view, the probe is moved one or two intercostal spaces cranially with the probe marker towards the spine angulated slightly to optimize the visualization of the right atrium and ventricle.

-The left cranial view allows for optimal visualization of the right heart, including the right atrium and tricuspid valve.

**-This is the best view to visualize a small right auricular mass in a dog with pericardial effusion and cardiac tamponade.**

## Normal Mean Echocardiographic Values (cm) in Dogs.

BW(kg)	LVEDD	LVESD	IVSD	LVFWD	Ao	LA
3	2.0	1.1	0.5	0.6	1.1	1.3
5	2.4	1.3	0.6	0.7	1.3	1.5
10	3.0	1.8	0.7	0.8	1.6	1.8
15	3.4	2.1	0.8	0.8	1.9	2.0
20	3.8	2.4	0.9	0.9	2.1	2.2
25	4.0	2.6	0.9	0.9	2.1	2.4
30	4.3	2.8	1.0	1.0	2.4	2.5
35	4.5	3.0	1.0	1.0	2.5	2.6
40	4.7	3.1	1.0	1.0	2.6	2.7
45	4.9	3.3	1.1	1.1	2.7	2.8
50	5.0	3.4	1.1	1.1	2.8	2.9

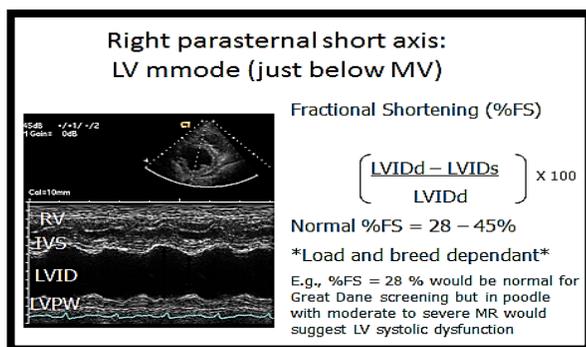
Kittleson MD and Kienle RD. 1998. *Small Animal Cardiovascular Medicine*, Mosby:St. Louis, MO. Table 6-2, p 104. Available on VIN

\*Please note that normal canine cardiac chamber dimensions vary based on body weight and breed.

## Normal Ranges of Echocardiographic Values (cm) in Cats

Cardiac parameter	Normal range
LVEDD	11.0 – 17.5
LVESD	0.40 – 1.0
IVSD	0.35 – 0.55
LVFWD	0.35 – 0.55
Ao	0.7 – 0.13
LA	0.9 – 0.15
FS%	33 – 66%

## Assessment of Left Ventricular (LV) Systolic Function and LV Failure



Global assessment of left ventricular contractility can be a qualitative “eyeball” assessment and/or a quantitative assessment by fractional shortening or ejection fraction. The eyeball assessment of LV function should not be underestimated. An experienced clinician can make real-time assessments of LV wall kinetics and chamber dimensions to make an immediate diagnosis. The simplest quantitative approach is to measure the LV end diastolic dimension and the LV end systolic dimension for determination of the fractional shortening. This can be done in 2-D or via M mode echo.

**Fractional Shortening Values (FS %).** Keep in mind that normal FS% can vary by breed and loading (i.e., volume status) conditions. In general, normal FS% is between 28 to 45% in the dog; and 30- 50% in the cat. A FS% below 20% is suggestive of severe myocardial systolic failure; and a FS% above 55% would be considered hyperdynamic LV function.

One may also assess LV systolic function with either fractional area change or ejection fraction as fractional shortening may either under- or over-estimate global ventricular function especially in the setting of regional LV wall motion abnormalities. Normal Fractional area change is 36 to 60 % and normal ejection fraction is 55 – 75%.

**Fractional area change =**

$$\frac{\text{LV end diastolic area} - \text{LV end systolic area}}{\text{LV end diastolic area}}$$

These measurements require good image quality as endocardial border contours need to be determined and/or traced.

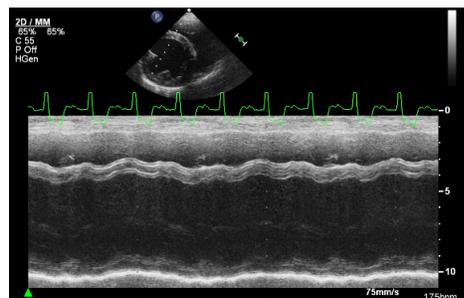
LV Failure in human ICU's is a common cause of unexplained hemodynamic instability. The causes of LV failure in veterinary ICU's may be related sepsis induced myocardial depression or possibly due to a breed associated cardiomyopathies (boxers, Dobermans), cardiomyopathy of volume overload in dogs with advanced mitral valve disease and end stage hypertrophic cardiomyopathy in cats.

### **Sepsis Induced Myocardial Dysfunction:**

Classically sepsis had been considered to be a “hyperdynamic” state in which the cardiac output is either maintained or increased. However, the term hyperdynamic is not an appropriate term as it relates to the cardiac contractility because in fact the heart is often hypodynamic. Studies in human ICU's suggest that most if not all patient with septic shock experience **LV hypokinesia and LV dilation.**

Sepsis induced myocardial depression is a global (systolic and diastolic) biventricular dysfunction that, in survivors, is **reversible.**

Human echocardiographic studies suggest that 40% to 60% of patients with prolonged severe sepsis (> 3 days) and septic shock develop myocardial depression, as defined by a reduced ejection fraction. The degree of myocardial structural derangement and functional impairment relates to the severity of illness. Myocardial depression is a major contributor to mortality and morbidity in patients with sepsis. In a small cases series of dogs with critical illness, the identification of left ventricular dysfunction was associated with a high death rate (75%) suggesting a poor prognostic indicator similar to humans. There are relatively few patient studies in humans with sepsis induced myocardial dysfunction. Based on human clinical observational studies, those who do not survive sepsis had lower peripheral vascular resistance, reduced inotropic response to dobutamine, and less LV dilation. Full recovery of cardiac function is seen in survivors at 7–10 days.



In the septic patient, repeat cage side point of care US exams are valuable for identification of LV systolic dysfunction, LV dilation or contraction allowing optimization of fluid administration, as well as inotropic or vasoconstrictor therapy.

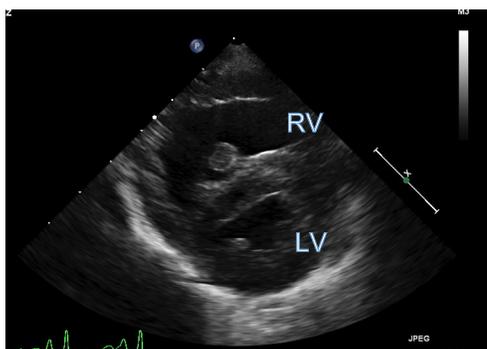
LV diastolic dysfunction may also be suspected in the setting of elevated filling pressures (see below), signs of congestion with normal or even supranormal LV systolic function parameters. Evaluation of diastolic properties of the ventricle are mostly done with Doppler echo of mitral valve inflow and pulmonary venous flow. These techniques are beyond the goals for this educational experience, but simply assessing for LA dilation and LV concentric hypertrophy may provide collaborative evidence for diastolic dysfunction. Hypertrophic

Cardiomyopathy (HCM) in cats is primarily a disease of diastolic dysfunction. **An LV wall thickness of either the interventricular septum or LV free wall of > 6 mm is suggestive of HCM.** Remember that there are other causes of LV hypertrophy. Other causes of LV hypertrophy include systemic hypertension, hyperthyroidism, congenital aortic stenosis, acromegaly, infiltrative disease and importantly pseudo-hypertrophy associated with volume contraction.

### Assessment of Right Ventricular (RV) Function and RV Failure

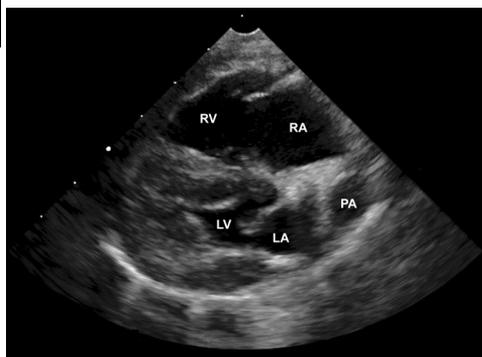
Right ventricular dysfunction is likely much more common than we recognize in critically ill patients. In human ICUs, the most common causes of Acute Cor Pulmonale (Right heart failure secondary to primary lung disease) are massive pulmonary embolism and Acute Respiratory Distress Syndrome (ARDS). Other causes of RV dysfunction include sepsis, high levels of PEEP (positive end expiratory pressure), and increased pulmonary vascular resistance due to chronic lung disease.

There are several common causes of right sided heart failure in the dog, including congenital diseases (pulmonic stenosis, tricuspid valve dysplasia), and acquired diseases such as heartworm disease, other causes of pulmonary hypertension, neoplasia, valvular heart disease or cardiomyopathy. Although most dogs with valvular heart disease progress to have left sided heart failure, some may manifest with right sided or biventricular failure. Similarly, cats and dogs with cardiomyopathies may have manifest with biventricular failure. A common presenting sign for dogs with pulmonary hypertension is syncope in addition to respiratory compromise.

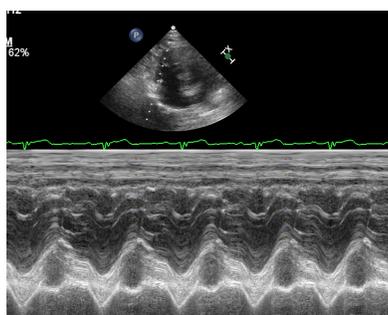


Echocardiographic assessment of the right heart in both size and kinetics can be challenging. RV size and kinetics are typically compared to the LV. Normally, the RV chamber is relatively flat as it wraps around the more cylindrical LV. As the RV dilates, the apical region of the RV becomes more rounded. In the short axis view, normally the RV is shaped like a crescent. As the RV dilates, the RV lumen grows ultimately displacing the interventricular septum and causing a flattening of the septum in severe cases.

Flattening of the result from either volume or pressure. Furthermore, the motion of the be distorted with conditions of high motion of the septum. Because both within a relatively stiff pericardium, ventricular dimensions has to remain or RV dilation will cause a reduction way of quantifying the RV dilation is to measure the ratio between the RV end diastolic area and the LV end diastolic area. Moderate RV dilation corresponds to a ratio of  $\geq 0.6$  where as severe RV dilation usually has a ratio of  $\geq 1$ . RV end diastolic dilation is usually associated with tricuspid valve regurgitation, right atrial and caudal vena caval dilation.



interventricular septum can overload of the RV. interventricular septum can strain, causing paradoxical ventricles are contained the sum of diastolic constant. Thus any acute RV in the opposite ventricle. One



In terms of RV function, there is no commonly accepted “fractional shortening” parameter of RV function. One could do a fractional area change or ejection fraction but obtaining an acceptable image with point of care echo can be challenging. One technique accessing RV function that is worth mentioning is Tricuspid Annular Systolic Excursion (TAPSE). TAPSE is obtained by m-mode in the left sided apical four chamber view. It measures the distance moved by the TV annulus from end diastole to end systole. It is gaining popularity because it is

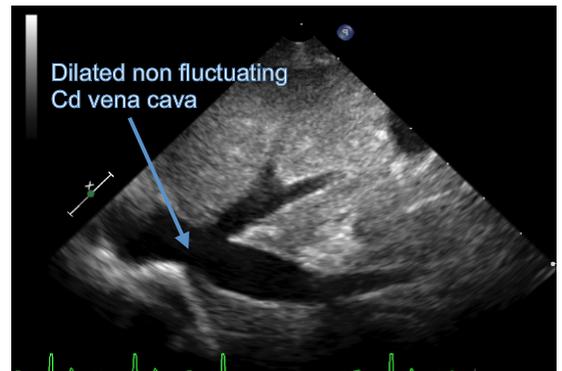
easy to perform, highly reproducible, correlates well to RV ejection fraction and fractional area change, requires no geometric assumptions and can be measured even when the image quality is relatively poor. Normal values have been established for dogs based on body weight. TAPSE will be reduced with RV systolic dysfunction.

### Assessment of Filling Pressures and Volume Status

Assessment of LV and RV filling pressures and intravascular volume status are “holy grail” in management of critically ill patients. Invasive measurements of pressure (pulmonary arterial occlusion pressure) can be used to estimate preload but these pressure measurements may not correlate with volume status and are most often not feasible in veterinary critical care patients. Various echocardiographic parameters have been evaluated as surrogate markers of volume status including LV end diastolic volume/area, Doppler echo of diastolic filling patterns, respiratory variation of aortic blood velocity and caudal vena caval assessment, caudal vena cava: aortic ratio.

“Eyeball” assessment of LV volume in short and long axis views are often sufficient to guide initial fluid therapy at the extremes of cardiac filling abnormalities, i.e., the patient with severe hypovolemia or severe hypervolemia. For example, systolic obliteration of the LV lumen is considered a sign of severe hypovolemia. However, on the opposite extreme, a very large end diastolic LV area may or may not indicate adequate preload in a patient with concurrent LV systolic dysfunction. Outside of the extremes of cardiac filling abnormalities, more precise quantitative measurements are desirable for most situations assessing preload. LV end diastolic diameter or area measured in the right parasternal short axis view at the level of the papillary muscles is commonly used to estimate volume status. Serial measurements and response to therapy such as fluid administration is more valuable than a single assessment.

Patients on positive pressure ventilation pose different challenges when assessing volume status. Positive pressure ventilation decreases venous return during inspiration resulting in decreased preload and subsequently decreased aortic velocities. Studies in humans have shown that magnitude of respiratory variation of peak aortic velocity measured by pulse wave Doppler at the aortic annulus is superior to static measurements of LV end diastolic area to predict fluid responsiveness. In one study of humans with septic shock, an aortic pulse variation of > 12% predicted a fluid responsive state. It's important to emphasize that although practical and reliable, this technique should only be assessed in patients receiving mechanical ventilation who are synchronized well and have no cardiac arrhythmias.



Volume status can also be assessed on 2D echocardiography by indirectly estimate RA pressure. This is often done by assessing the size and change in diameter of the caudal vena cava with inspiration usually in a subcostal view as the cava crosses the diaphragm. In adult humans, a normal sized inferior vena cava (< 21 mm) with a respiratory fluctuation of > 50% suggests a RA pressure of 5 mmHg or less where as a dilated vena cava (> 21 mm) with no respiratory fluctuation suggests a RA pressure of 20 mmHg. IVC diameter has also been used to assess acute blood loss in adults. In these studies, contraction of the intravascular volume resulted in measurable decreases in IVC diameters. Conversely, research has shown that the diameter of the descending aorta (Ao) remains mostly constant, despite intravascular volume depletion. Because dogs vary in size, assessing the vena cava size may be difficult unless normalized to body weight but may be helpful to assess in the extremes of cardiac filling abnormalities. A severely hypovolemic animal will have an obviously small caudal vena cava with > 50 % respiratory fluctuation (decreases during inspiration) where as an animal with severely elevated RA pressures will have a dilated vena cava that does not fluctuate with respirations. This dilated vena cava is often accompanied by dilated hepatic veins and ascites. Additionally, the gall bladder wall can become

edematous in severely increased right heart filling pressures. This abnormality is often coined the “gall bladder halo” sign as the edematous submucosa of the gall bladder is contrasted against the outer layer of the gall bladder. The comparison of the caudal vena cava to the aorta may be a useful measure to assess hypovolemia in dogs and cats as the aorta can be used as its own reference for size. Because the aorta is stiff walled, its diameter does not change significantly with changes in volume status. Normally, the caudal vena cava and aorta have similar diameters. In humans, a caudal vena cava: aortic ratio of  $< 0.8$  suggests hypovolemia and need for more preload.

Lastly, 2D assessment of the size of the atria, the curvature of the interatrial septum, dilation of pulmonary veins, and presence of pericardial effusion (in the cat) can all be helpful in assessing high LV or RV filling pressures as is seen in right or left heart failure. Critically ill cats in particular are prone to volume overload if occult heart disease is present. Occult heart disease in cats is not uncommon as most cats with asymptomatic HCM may not have a cardiac murmur.

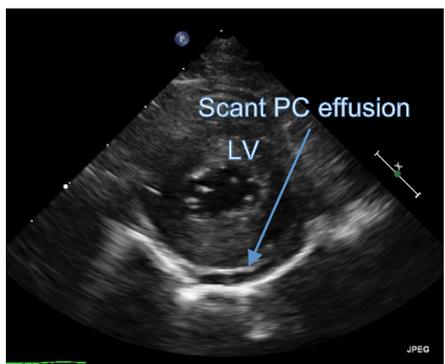
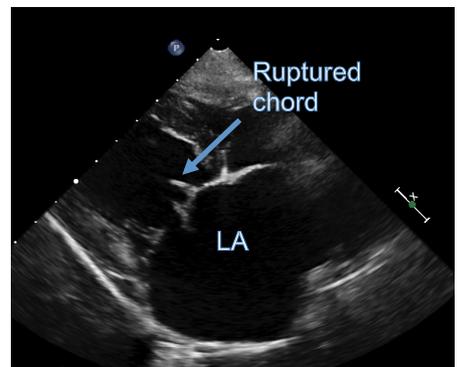
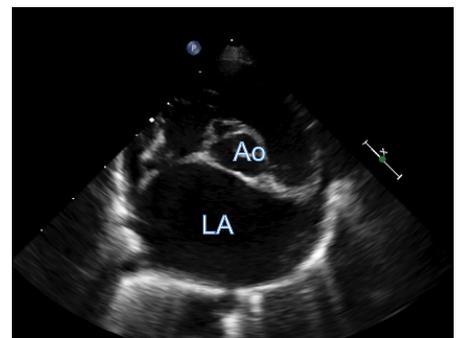
## ECHO FINDINGS IN COMMON CARDIAC EMERGENCIES

### LEFT-SIDED CONGESTIVE HEART FAILURE:

The most common cause of heart failure in the dog by far is mitral valve disease (MVD). Second most common cause of heart failure in the dog is dilated cardiomyopathy (DCM) usually affected large or giant breed dogs. In the cat the most common disease associated with congestive heart failure is hypertrophic cardiomyopathy (HCM).

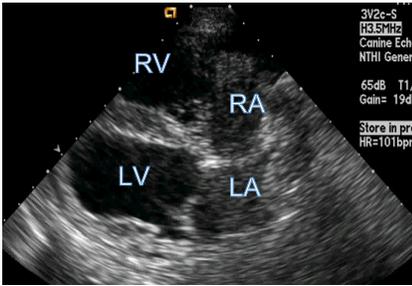
### ECHOCARDIOGRAPHIC FINDINGS ASSOCIATED with left heart failure:

- Generally in all cases of left heart failure, the left atrium and ventricle will be severely enlarged (except in peracute chord rupture case). The LA:Ao ratio is usually  $> 2:1$ .
- In a dog with MVD, the mitral valve will be thickened with possible prolapsing of a leaflet.
- Pericardial effusion seen in a dog with congestive heart failure and cardiogenic shock may be a result of left atrial rupture as a complication of severe mitral valve disease and left atrial dilation.
- In a dog with DCM, in addition to a dilated left ventricle (with spherical appearance), the left ventricular systolic function will be markedly hypodynamic. Fractional shortening (FS %) is typically  $< 20\%$ .
- In a cat with heart failure secondary to HCM, concentric LV hypertrophy will be seen. The LV hypertrophy can be either symmetrical or segmental. (LV diastolic wall measurement  $> 6$  mm) is generally considered hypertrophic. In some cats with chronic disease, LV walls may be high normal thickness because of a phenomenon referred to as LV remodeling.
- Slight to large amounts of pleural effusion is not uncommon as a manifestation of left heart failure in cats.
- Low volume pericardial effusion (typically  $< 5$  mm) is commonly associated with congestive heart failure in cats.
- Possible left atrial thrombus, most commonly within the left auricle, may be present. The thrombus can be adhered to the atrial wall or freely mobile. Shadow artifacts can often be over-interpreted as thrombus. A thrombus usually has sharply defined edges.
- Spontaneous echo contrast, or “smoke”, may be seen in ATE or cat at



high risk for thromboembolism.

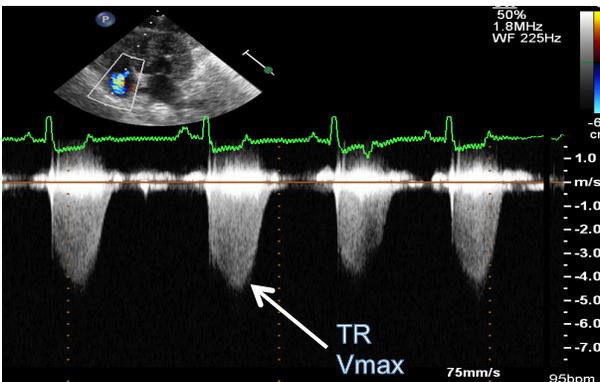
## **RIGHT SIDED HEART FAILURE AND/OR PULMONARY HYPERTENSION (PHT)**



There are several common causes of right sided heart failure in the dog, including congenital diseases (pulmonic stenosis, tricuspid valve dysplasia), and acquired diseases such as heartworm disease, other causes of pulmonary hypertension, neoplasia, valvular heart disease or cardiomyopathy. Although most dogs with valvular heart disease progress to have left sided heart failure, some may manifest with right sided or biventricular failure. Similarly, cats and dogs with cardiomyopathies may have manifest with biventricular failure. A common presenting sign for dogs with pulmonary hypertension is syncope in addition to respiratory compromise.

### **ECHOCARDIOGRAPHIC FINDINGS ASSOCIATED with right heart failure and/or PHT:**

- RV and RA dilation. RV is same size or larger than the LV in long axis views. Flattening of the IVS in the LV short-axis view. The RA is larger than the LA and the interatrial septum is bowing into the left atrium.
- Caudal vena caval and hepatic venous distention with concurrent ascites.
- For PHT, main pulmonary artery enlargement (larger than the aorta). Also in severe PHT cases, the LV is small and suggests poor filling of the LV and low cardiac output.
- The tricuspid regurgitation velocity can be measured to estimate systolic pulmonary arterial pressure.



The tricuspid regurgitation maximum velocity (TR Vmax) obtained with Doppler echo can be measured to estimate systolic pulmonary arterial pressure.

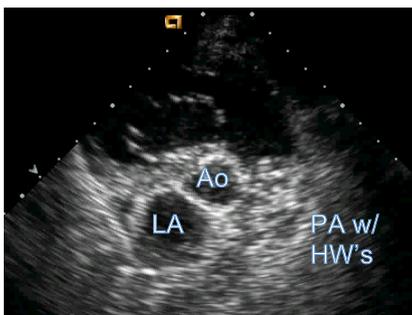
Estimated PA pressure =

$$(TR V_{max})^2 \times 4 + \text{est. RA pressure}$$

Estimated PA pressure =

- 5 mmHg if not in heart failure (normal)
- 10 mmHg if impending right heart failure
- 15 mmHg if in right heart failure

Normal PA systolic pressure is ~ 20 to 30 mmHg (older dog 35 mmHg)



Mild pulmonary hypertension: > 35 to 50 mmHg

Moderate pulmonary hypertension: > 50 – 80 mmHg

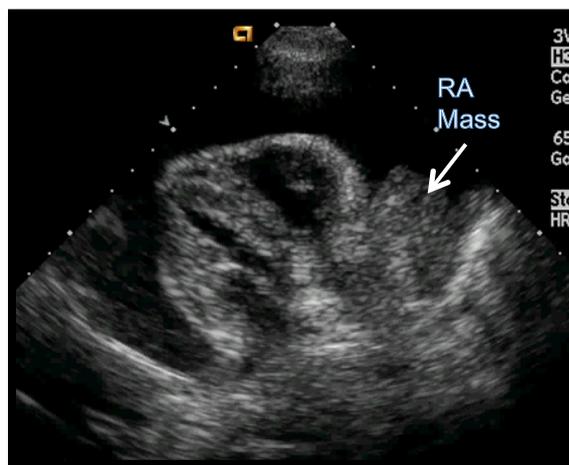
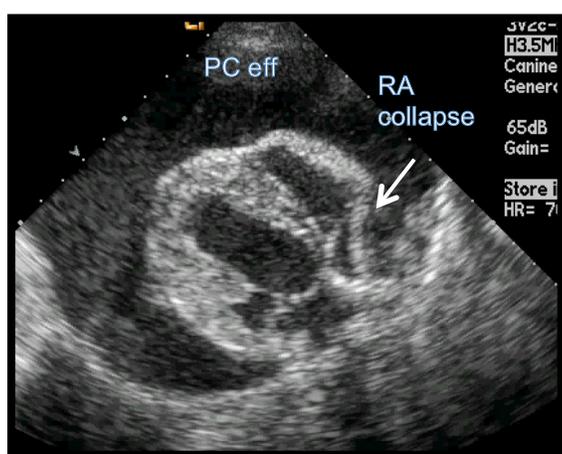
Severe pulmonary hypertension: > 80 mmHg

In dogs with severe heartworm disease, heartworms may be seen as double-lined structures within the pulmonary artery, right atrium and ventricle and even the caudal vena cava with caval syndrome.

## PERICARDIAL EFFUSION

The most common cause of pericardial effusion in the older dog is neoplasia with hemangiosarcoma and chemodectoma (heart base tumor) being most common. Other neoplasia such as mesothelioma, metastatic carcinoma, and lymphoma are other consideration. Idiopathic pericardial effusion can also be seen in middle aged large breed dogs. Less commonly, pericardial effusion may be caused by coagulopathies, left-atrial tear (mitral valve disease dogs), foreign bodies, and trauma. In cats, the most common cause of pericardial effusion is congestive heart failure. Neoplasia and FIP are other less common causes in the cat.

Cardiac tamponade occurs when the pericardial effusion has caused the intrapericardial pressure to be higher than the right ventricular filling pressure. This causes diminished right ventricular filling, signs of low cardiac output (collapse), and right heart failure (ascites). It's important to recognize that even a small amount of effusion can cause cardiac tamponade if the effusion developed quickly. This is most common with an acute bleeding hemangiosarcoma of the right atrium.



## **ECHOCARDIOGRAPHIC FINDINGS ASSOCIATED with Pericardial Effusion**

- **It's important to view fluid around the heart in multiple views and to increase your depth of field to image as much of the heart as possible.** It can be difficult to distinguish pericardial from pleural effusion. Pericardial effusion should not be visible above the left atrium. Pleural effusion is gravity dependent and moves with patient repositioning and often surrounds lung lobes.
- Use caution in over-interpreting pericardial effusion in obese cats, as they usually have an excessive amount of pericardial fat.
- Anechoic fluid around the heart that is surrounded by the pericardium which appears as a bright white linear echo. The pericardium is typically one of the brightest structures in the chest.
- Echocardiographic criteria for cardiac tamponade are right atrial and right ventricular diastolic collapse.
- If patient is stable, evaluate for the presence of a cardiac mass prior to pericardiocentesis as the pericardial fluid will enhance your ability to identify a possible mass.
- Chemodectoma is usually best visualized in the right-sided short-axis parasternal view at the heart base with the aorta in the center.
- A right atrial or auricular hemangiosarcoma is typically best seen from a left-sided parasternal view optimized for the right atrium and auricle. If a mass is very large, it can be seen in any view and may compress the atria or great vessels impinging the inflow or outflow of blood.
- ECHO can help with choosing an optimal site for pericardiocentesis, typically on the right side (cardiac notch) above the costochondral junction and with a clear shot to the pericardial fluid with no lung interference.

## **HOW TO PERFORM A PERICARDIOCENTESIS:**

- The patient is placed in sternal or lateral recumbency depending on the demeanor of the patient and the preference of the veterinarian performing the procedure. Sedation may or may not be needed.
- ECG should be performed during the procedure to monitor for ventricular arrhythmias. Have lidocaine ready to go if needed.
- Pericardiocentesis site over the right hemithorax is prepared aseptically. Ultrasound or thoracic radiography is helpful to find the best site for the centesis. Human studies show that ultrasound-guided pericardiocentesis is associated with a reduced complication rate.
- Lidocaine is infused at the puncture site on the right hemithorax between 3-6 th intercostal spaces just above the costochondral junction.
- In large dogs, a large catheter (e.g., 16 or 14 gauge, 3-5 in length), often with one or two side-hole fenestrations, is inserted through a stab incision in the skin.
- A 3-cc syringe or extension set with syringe is attached to the end of the catheter and constant negative suction is applied. A flash of pericardial effusion into the syringe will signal entry into the pericardial space. Watch carefully for any ventricular arrhythmias as you advance the catheter.
- Once in the pericardial space, the catheter is advanced over the needle stylet and extension tubing, a 3-way stop cock, and 35 - 60 cc syringe are attached, and drainage of the fluid begins.
- Most pericardial effusions are hemorrhagic and can be similar in appearance to blood. If there is concern for possible intracardiac puncture, a sample of the fluid should be obtained and visualized for clot formation. Pericardial effusion should not clot.
- Complications of pericardiocentesis include death (rare) resulting from a lethal arrhythmia or coronary artery laceration, transient arrhythmias (common), pneumothorax, or intracardiac puncture.
- Unfortunately, analysis of the pericardial effusion is often not helpful in determining the underlying cause. Analysis of the effusion is still recommended in most cases.
- After the centesis, monitoring for possible re- effusion is advised, especially in a dog with presumed hemangiosarcoma.

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# Diagnostic Musculoskeletal Ultrasound: A Guide in Rehabilitation of Canine Soft Tissue Injuries



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Rehabilitation  
Certified Canine Rehabilitation Therapist  
Certified Veterinary Acupuncturist

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## Musculoskeletal Ultrasound

- Great Soft Tissue
- Quick, Non-Invasive
- No Anesthesia
- Lower Cost vs MRI
- Allow for Rechecks
- Monitoring Rehab
- Dynamic Evaluations



Excellent Tool For Diagnosing Soft Tissue Injury and  
Monitoring Regenerative Medicine Treatment

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## Musculoskeletal Ultrasound Disadvantages

- Limited # of practitioners/radiologists performing SA MS US
- Limited # of practitioners/radiologists fluent in SA MS US
- Operator dependent
  - Image
  - Interpretation




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## Small Animal Sports Medicine/Rehab Applications

- Localization of Injuries
  - Tendon, Ligament and Muscle Injuries
  - Joints
- Accuracy of Diagnosis
  - US >= MRI on tendon/lig
    - More Convenient
    - Allows Injury Detection Earlier
  - US 2X more likely to correctly determine presence or absence of meniscal pathology than MRI
- US guided Injections
  - Superior to fluoroscopy
  - Accuracy and Ease
- Monitor lesions
  - Cost Effective
  - No sedation needed



Prospective Assessment of MRI vs. Ultrasound for Diagnosis of Meniscal Pathology  
Cook R, Cook, James P, Stannard, Gavin M, Vaughn, Nichole Wilson, Branstetter J, Strube, MD, Noyes, Florida  
Aaron M, Stekler, Prakash S, Jayabalan, Kelci Kuraki, James L, Cook, DVM, PhD, Columbia, Missouri

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# MSK Ultrasound

- Objectively Withstands Scientific Rigor
- Valid/Reliable Method
  - Muscle size
  - Indicator of Muscle Activity
  - Tendon/Ligament Cross Integrity



Bunce SM, Moore AP, Hough AD. M-mode ultrasound: A reliable measure of transversus abdominis thickness? Clin Biomech 2002;17:315-317.  
 Hodges PW. Ultrasound imaging in rehabilitation: Just a fad? J Orthop Sports Phys Ther 2005;35:333-337.

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# Image Interpretation

## GENERAL GUIDELINES

- Tendon, ligament, muscle
  - Size
  - Texture
    - Homogenous
      - Smooth, even
    - Non-homogenous
      - Mottled
  - Echogenicity
    - Normal
    - Hyperechoic
      - More white
    - Hypoechoic
      - More black
    - Anechoic
      - Absent

## USUAL FACTS




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# Tendon Injury

- Gross Findings
  - Rupture
  - Dynamic Function
- Tendon Ligament Grading System
  - Ligament – Sprain
  - Tendon - Strain
- Tissue Stiffness
  - Elastography
- Vascularity
  - Fine flow color doppler




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# Dynamic Function

## NORMAL BICEP

## BICEP RUPTURE




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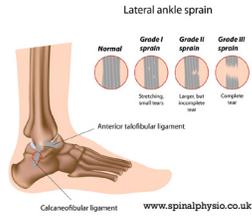
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## Tendon/Ligament Standard Grading Scale

- Grade 1
  - Minimal Structural Involvement
  - Microscopic Tears
  - Mostly Inflammation
- Grade 2
  - Partial Tear
  - Partial Fiber Disruption
  - Possible minor/partial instability
  - Painful
- Grade 3
  - Complete Tear
  - Complete Fiber Disruption
  - Unstable




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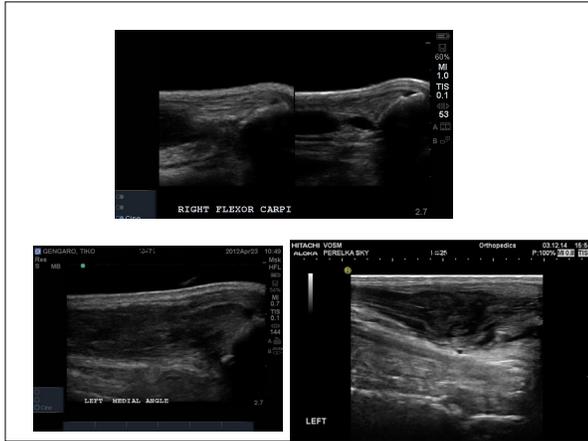
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## Ultrasound Shoulder Pathology Rating Scale (USPRS) Canine

- **I. Biceps Tendinosis/Tendinopathy**
  - 0 = Normal fibrillar pattern and echogenicity
  - 1 = Mild loss of fibrillar pattern and/or echogenicity
  - 2 = Moderate loss of fibrillar pattern and/or echogenicity
  - 3 = Calcified area of tendon
  - 4 = Clear longitudinal tear
  - 5 = Partial rupture
  - 6 = Full rupture/absence of tendon
- **II. Supraspinatus Tendinosis/Tendinopathy**
  - 0 = Normal fibrillar pattern and echogenicity
  - 1 = Mild loss of fibrillar pattern and/or echogenicity
  - 2 = Moderate loss of fibrillar pattern and/or echogenicity
  - 3 = Calcified area of tendon
  - 4 = Clear tear partial thickness
  - 5 = Clear tear full thickness
- **III. Biceps Groove Humeral Cortical Surface**
  - 0 = Smooth hyperechoic cortical surface
  - 1 = Mild cortical irregularity
  - 2 = Moderate cortical irregularity
  - 3 = Marked cortical irregularity or pitting
- **IV. Static/Dynamic Biceps Impingement by Supraspinatus**
  - 0 = No evidence of impingement
  - 1 = Mild impingement: supraspinatus contact biceps, no change in motion
  - 2 = Moderate impingement: mild to moderate irregularity in motion with mild to moderate supraspinatus impingement of the biceps (changing shape of biceps on cross section view)

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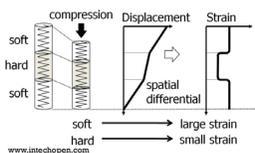
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## Diagnostic Ultrasound Elastography (EUS)



- Assess Mechanical Properties of Tissue
  - Apply Stress
  - Measure tissue displacement
- Strain/Compression
  - Free Hand EUS
- Elastogram
  - Strain readings superimposed over US image

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# Iliopsoas Tendinopathy

- "Stella"
- Right Iliopsoas Insertionopathy
  - Dx MSK US
  - Grade 2 Strain
  - Acute on Chronic
- Right(BMAC)StemCell/PRP
  - US guided injection
- Rehab Plan
  - Restricted activity
    - 8-12 weeks
    - Laser Therapy
    - Manual Therapy
    - Home Exercise Program



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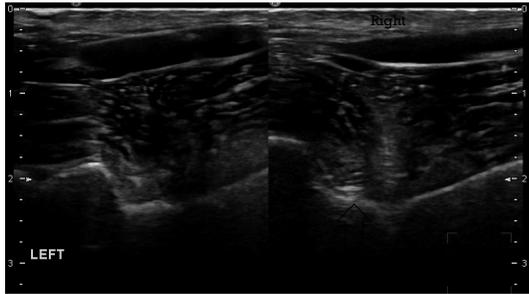
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## Initial MSK US Scan



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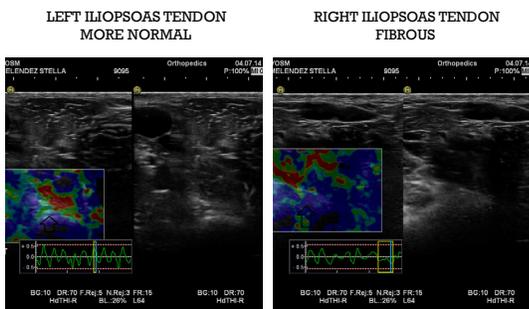
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## Initial MSK US Scan



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## Initial MSK Scan



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# BMAC/PRP Tendon Injection



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## 45 days Post Stem cell Injections

### EXPECTED

- Restricted Activity
  - Leash Walks Only
- Weekly laser/manual therapy
- Reduced Lameness
- MSK US
  - Expect better fiber pattern
  - Less Inflammation
  - Less Hypoechoic Changes
  - Trend to Fibrosis Reduction

### REALITY

- Non Compliant!!
- No laser modality treatment
- Exercise Restriction
  - Less than Ideal
    - Swimming
    - Dock Diving
- No improvement in lameness on gait analysis
- Persistent R iliopsoas discomfort
- Additional L iliopsoas discomfort

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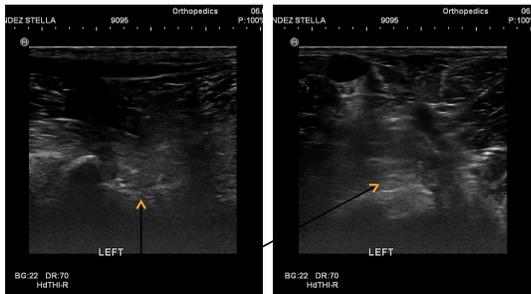
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## 45 days Post Stem cell Injections

Left side initially NORMAL



Moderate Inflammation

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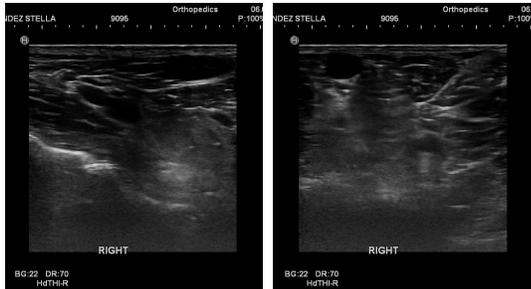
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## 45 days Post Stem cell Injections

No reduction in inflammation  
No signs of healing  
No tendon regeneration



Generalized Increased Inflammation and Fiber Disruption  
**NOT EXPECTED!!**

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## Change(REMINDER) Rehabilitation Plan

- Modality Usage
  - Laser therapy 2X week
- Manual therapy
- Strict Home Exercise Program
  - Isometric to build support muscles
- NO running, jumping, playing, swimming etc




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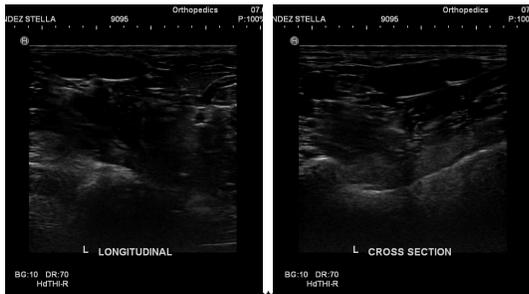
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### 60 days Post Stem Cell Injection With Compliance!



Left Compensatory meniscus  
Tx with Laser Therapy  
Resolution of Inflammation

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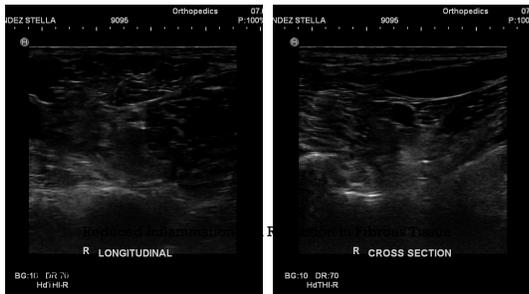
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### 60 days Post Stem Cell Injection With Compliance!



Improved Fiber Pattern  
Resolution of Inflammation  
12 weeks Post Injection

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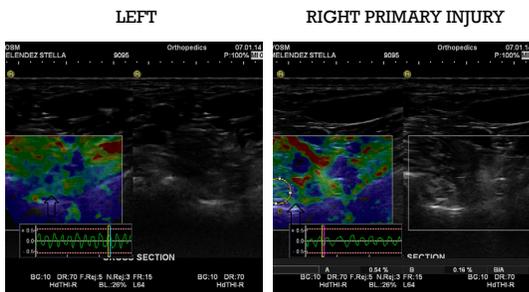
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### 60 days Post Stem Cell Injection With Compliance!



Bilateral Return to Normal Tendon Consistency/Elastography

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## Biceps Tendinopathy with Medial Shoulder Syndrome Hobble

- "Cap"
  - 5 yr old border collie
  - Agility
- Poor performance
- Short Strided
  - L front
- Diagnosis/Treatment
  - L MSS
  - Shoulder arthroscopy/RF
  - L biceps tendinopathy
  - Stem cell/PRP inj
- Post op Hobbles




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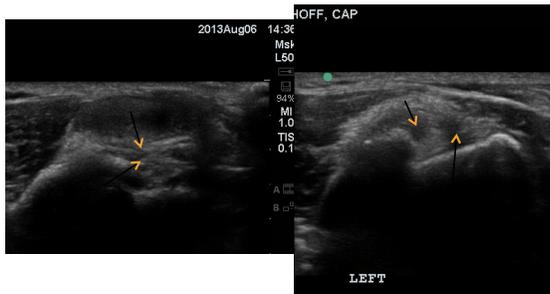
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## Left Shoulder Initial MSK Scan




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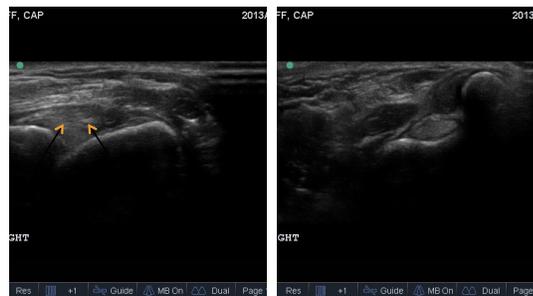
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## Right Shoulder Initial MSK Scan

**Normal**




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## 90 days Post Treatment/Rehab

### STATUS

- Tendinopathies should be healed
- Equal muscle mass
- Controlled conditioning performed
- Now
  - Gradual return to function/free activity/sport

### LEFT BICEPS HEALED




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## 90 days Post Treatment/Rehab

INITIAL NORMAL R BICEP



CURRENT R BICEP



Remember, initial symptoms were subtle but represented significant underlying issues and resulted in poor performance issues

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## Rehabilitation Plan Changed



- Did not “release” to full activity
- Continued restricted activity
- Initiated therapeutic ultrasound to R biceps
- Returned in 6 wks with improvement and then returned to sport

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## Conclusion

- Canine Musculoskeletal Ultrasound
  - Excellent soft tissue diagnostic tool
  - Valuable in precise regen med applications
  - Excellent tool to monitor healing
  - Available and economical when compared to other similar diagnostic tools
  - **INDISPENSABLE TOOL**
    - Guide in Canine Rehabilitation
    - Aid in Documentation of Benefits of Modality Therapies
    - Aid in Documentation of Benefits of Regenerative Medicine

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# Ultrasound Guided Injections For Soft Tissue Injuries



Debra Canapp, DVM, CCRT, CVA  
Diplomate, American College of Veterinary Sports Medicine and  
Rehabilitation  
Certified Veterinary Rehabilitation and Acupuncture Therapy

## Data Driven Audience

Comparing the accuracy and efficacy of ultrasound-guided versus blind injections of steroid in the glenohumeral joint in patients with shoulder adhesive capsulitis.

**Article** - Journal of Clinical Ultrasound 4(3):204-5 - January 2012

**Accuracy of blind versus ultrasound-guided suprapatellar bursal injection**

**Accuracy of ultrasound-guided intra-articular injections in Guinea pig knees.**

**Effectiveness of Blind & Ultrasound Guided Corticosteroid Injection in Impingement Syndrome.**

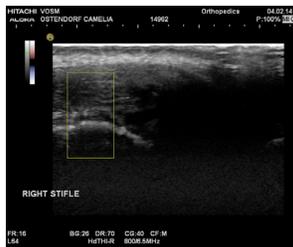
**Extensive Research & Publications**

# Ultrasound Guided Injections Musculoskeletal System

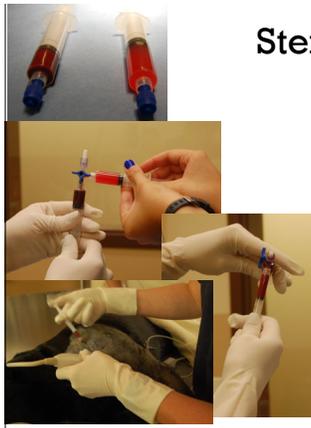
- Proven Accurate Method to Delivery Treatments
  - Visualization of Needle
  - Proven Reliable Needle/Tx Placement
  - Tendon
  - Ligament
  - Bursa
  - Joint
  - Direct Away from Other Structures
- Improve/Increase Effectiveness Of Treatment
  - Experienced Sonographer
  - Reported 90-100% Accurate

# Pre-Injection Diagnostic Assessment

- Identify target
  - Identify local structures to AVOID
    - Nerves
    - Vessels
  - Color Doppler
    - Clearly identify vessels to avoid
  - Determine needle trajectory



# Sterility

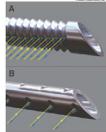


- Aseptic surgical prep
  - Injection Site
  - Hair clip
  - Chlorhex/Alcohol
- Transducer
  - Chlorhex/Alcohol
- Sterile US jelly
- Sterile Gloves
- Aseptic technique
- Treatment Prep

5

# Needle Selection

- US visualization
  - Dihedral & Tetrahedral Echogenic Etching
- Product Care
- Viability of Stem Cells
- Tissue Trauma
- 22g 1.5" needle
  - Most tendon and ligaments
- 22g 2-3" spinal needle
  - Deeper structures
  - Iliopsoas
  - Coxofemoral joint
  - Nerve Blocks



Impact of passing mesenchymal stem cells through smaller bore size needles for subsequent use in patients for clinical or cosmetic indications

Murali Krishna Mamidi, Gurbind Singh, Sujati Mamin Husni, Kavitha Ganesan Nathar, Gopinath Sathisharan, Zubairah Zakaria, Ramesh Bhonde, Anish San Majumdar III and Anjan Kumar Das III

**OBJECTIVE:** To assess the biological effects of passage through directly relevant needles on the viability and metabolic activity of cells required for clinical and cosmetic applications using MSCs.

**DESIGN:** Prospective observational pilot study.

**SETTING:** Academic medical center.

**PARTICIPANTS:** Patients consented about prior informed written consent.

**INTERVENTIONS:** MSCs were passed through passage through directly relevant needles, with an 18 gauge (20 mm) needle placed in a 18 gauge (15 mm) needle, placed at a certain position for use and control of concentrations. Each needle number was compared to a control.

**MAIN RESULTS/MEASUREMENTS:** Cell count and viability, metabolic activity, and gene expression as measured by qPCR, respectively, were compared and analyzed with the control. The results showed that the viability of MSCs was significantly affected by needles, and each professional normally regardless of study group.

**CONCLUSIONS:** MSCs viability was significantly affected by needles, and each professional normally regardless of study group. Therefore, MSCs viability was significantly affected by needles, and each professional normally regardless of study group.

6

# Needle Trajectory

- In-plane
  - Most common
  - Easiest
  - Needle parallel to transducer
  - Best full needle visualization
- Out of Plane
  - Arc-TOA technique
    - Much More Difficult For Novices



The arcTOA Technique for Out-of-Plane Ultrasound-Guided Injections.

**OBJECTIVE:** To assess the biological effects of passage through directly relevant needles on the viability and metabolic activity of cells required for clinical and cosmetic applications using MSCs.

**DESIGN:** Prospective observational pilot study.

**SETTING:** Academic medical center.

**PARTICIPANTS:** Patients consented about prior informed written consent.

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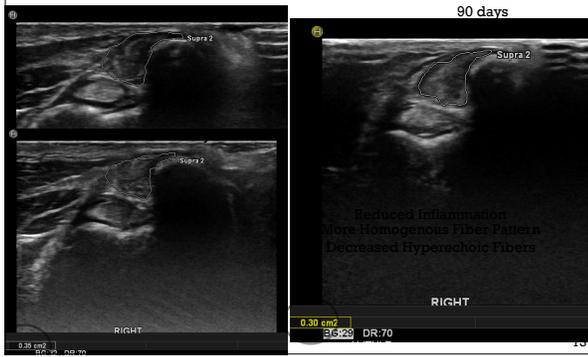
# Technical Tips

- Free Hand Technique
  - Direct/Dynamic Needle Visualization
  - Dominant Hand
  - Injects
- Needle Entry
  - Parallel to transducer
  - Close to transducer
- Identify approach to target
  - Shortest distance
  - Move either transducer or needle





# Supraspinatus Tendinopathy




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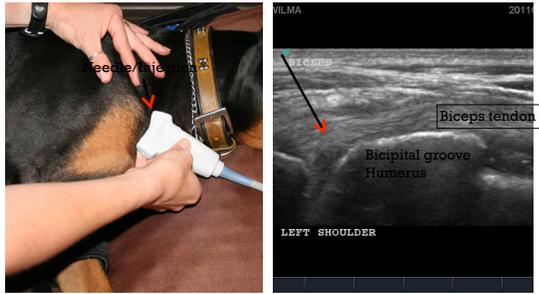
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## Biceps Tendon Probe/Needle Placement




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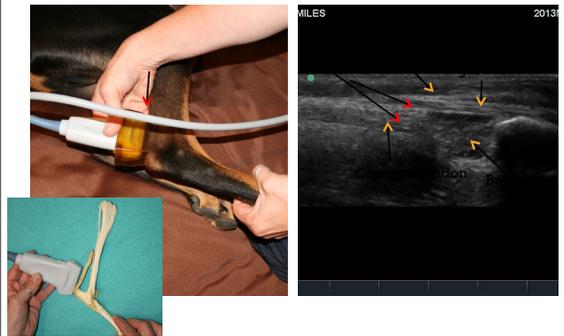
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## Achilles Tendon Probe Placement-Longitudinal




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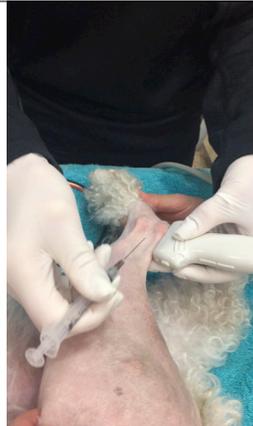
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### US Guided Injection Achilles Tendon Technique

- Identify Lesion
- Slightly raise end of probe
  - Seat needle into skin
  - Stay parallel and center to probe
- Place probe back in contact to original image
- Advance into lesion




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## Iliopsoas New Approach for Injection




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## “Ranger”

- 3yr old M(c) Border Collie
  - Professional child & squirrel chaser
- Right Hind Limb Lameness
- Right Iliopsoas Strain
  - Chronic
  - Grade 2 Strain
- Right Achilles Tendon
  - Grade 3 Strain
  - Common Tendon
  - Gastroc Tendon




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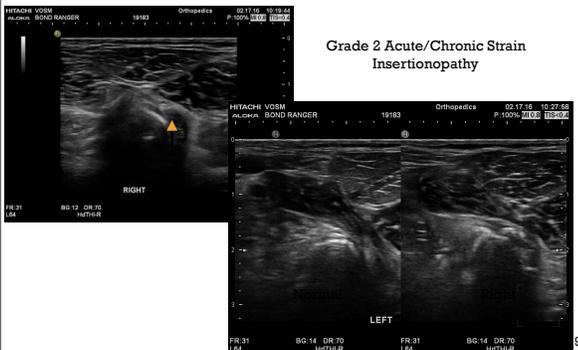
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## Initial Iliopsoas Injury

Grade 2 Acute/Chronic Strain  
Insertionopathy




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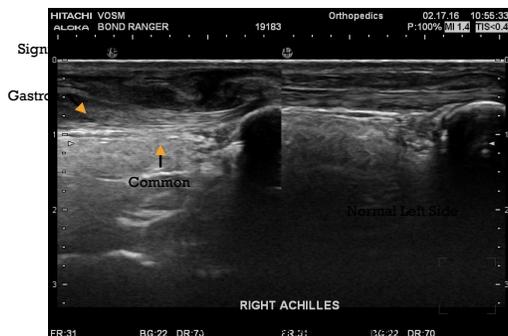
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## Initial Achilles Injury




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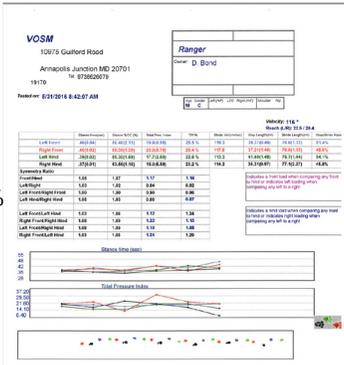
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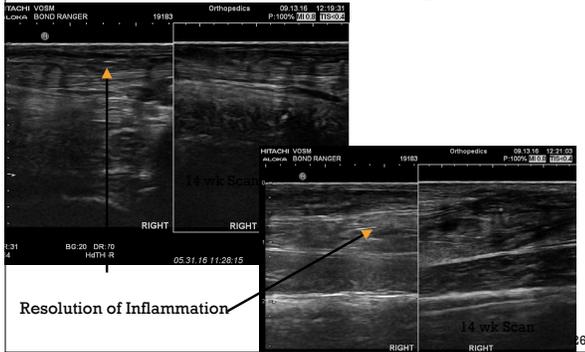
# 14 week Gait Analysis

Left Hind 22.8%  
Right Hind 23.2%



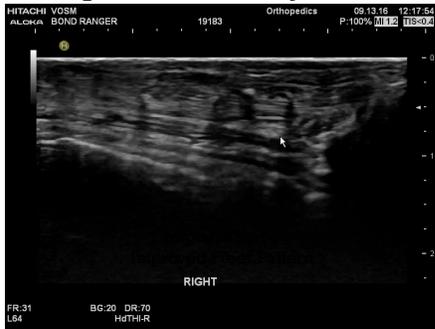
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# 29 wks Post Injection Achilles Tendon Repair



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# 29 wks Post Achilles Tendon Repair Regen Med US Injections



27

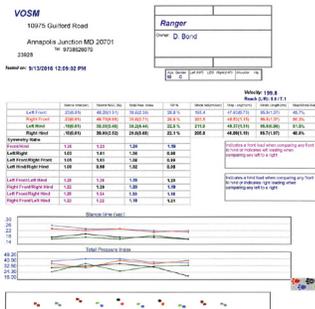
# 29 Week Gait Analysis

Left Hind 22%  
Right Hind 22%

Start Free  
Activity with  
Brace On

Gradually Wean  
Off Brace for All  
Activity

Objective Data  
US and Gait Analysis  
Helped Very Concerned Owner  
Allow Return to Full Daily Activity



28

## Conclusions

### Small Animal Diagnostic MSK Ultrasound

- Increased Accuracy of Injury Diagnosis
- Real-Time Imaging
- Increased Accuracy of Treatment Delivery
- Diagnostic Modality Safe & Widely Available

SPECTRUM OF MUSCULOSKELETAL INTERVENTIONS  
DONE UNDER ULTRASOUND GUIDANCE  
BOTH DIAGNOSTIC AND THERAPEUTIC PURPOSES  
POSITIVE IMPACT POTENTIAL in SM AN MED  
IS ENDLESS

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## SA MSK US WEBSITE Membership only

- Comprehensive Resource for Small Animal MSK Ultrasound
- Lecture Notes, Technique Videos, US Images, Pathology
  - Case Management Recommendations
  - Technique/US Image Acquisition Recommendations
- Case of the Month Series
- Access to Exclusive MSK US Webinars (MORNING)
  - Troubleshooting
  - Pathology
  - New Developments in MSK US
- Access to Remote US Image Read Program
  - Detailed US Image/Case Submission Guidelines
  - Specific Lecture Notes
  - Written Descriptions
  - Video Technique

Sign Up Now  
Email [eschlimm@vosm.com](mailto:eschlimm@vosm.com)  
Cost  
Introductory Rate  
\$799/year

30

## DISTANCE LEARNING Diagnostic MSK Ultrasound Course

- Delivered Online
    - Live Webinar Based
    - Interactive
  - 4 units
    - Intro to MSK US
    - Shoulder
    - Carpal/Tarsal
    - Illopoas/Stifle
  - US Anatomy
    - Normals
    - Image Acquisition Techniques
  - Conditions
    - US Pathology
    - Treatments
    - US guided Injections
    - US Rechecks
    - Tendon/Ligament Healing
  - Extensive Case Series for Each Unit
  - Requirements
    - Linear Probe
      - >10MHz
    - Image Capture & Video Capabilities
    - Reliable Internet Access
    - Image/Video Upload Capabilities
  - Homework
    - Probe Technique Videos
    - US Image Submission
    - Technique & Image Critiques
  - Registration
    - Includes 1 yr Access to DX MSK US Online Library/Website
    - Membership/Fee Based Waived
    - If Member then Access fee Credit Applied
  - Access to Remote MSK US Case Submission/ Reads
- 5,5 week Course  
For More Information  
Email [dcnapp@vosm.com](mailto:dcnapp@vosm.com)  
Subject Line : DX MSK US COURSE

## 1st Annual Veterinary Point-of-Care Ultrasound Symposium, Austin, Texas USA

### Lung Ultrasound in Small Animals: The Vet BLUE® and The 5 Basic Lung Ultrasound Signs

Gregory R. Lisciandro, DVM, Dipl. ABVP, Dipl. ACVECC

Hill Country Veterinary Specialists & FASTVet.com, Spicewood, Texas USA

Email [FastSavesLives@gmail.com](mailto:FastSavesLives@gmail.com)

Cell 210.260.5576

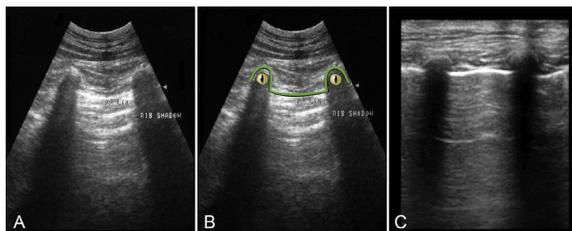
#### USE OF LUNG ULTRASOUND IN SMALL ANIMALS - THE VET BLUE

The reluctance to pro-actively apply LUS to small animals with respiratory distress is irrational in many respects. The overriding belief that air-filled lung creates insurmountable obstacles, and the continued belief in small animal medicine that imaging lung is difficult to perform leading to mistakes, perpetuate LUS delayed use in small animal veterinary medicine. Thoracic FAST called TFAST (2008) was the first standardized abbreviated veterinary ultrasound exam of the thorax that included the Chest Tube Site (CTS) for lung surveillance for detection of PTX and lung contusions. However, because of the finding of lung pathology found during TFAST, the author extended lung surveillance from the TFAST CTS with the addition of 6 more lung views applied to non-trauma subsets of small animals. The name of this novel regionally-based LUS exam has been studied and published by Lisciandro and colleagues in 2014 as the Vet BLUE Protocol (“Vet” for veterinary and “BLUE” blue for cyanosis and bedside lung ultrasound exam or in emergency).



#### THE BASICS OF VET BLUE

Patient Preparation Generally no Vet BLUE sites are shaved! All images shown by the author are unshaved sites at which the fur is parted and alcohol is applied to the skin and a small amount of acoustic gel or alcohol-based hand sanitizer to the probe head. No images from cases in this talk were shaved. Patient Positioning Vet BLUE is performed in sternal recumbency or standing and is safer for dogs and cats in respiratory distress. A roll of towels or paper towels under the forelegs of a cat is an easy tolerated maneuver to gain access to the lower ventral Vet BLUE and TFAST Pericardial Site views. Vet BLUE may also be performed in dogs and cats in lateral recumbency. Probe Orientation and Type LUS orientation is always the same with the visualization of the “Gator Sign” to properly identify the pulmonary-pleural interface or the “Lung Line”, actual surface of the lung. The probe is held perpendicular to the long-axis of the ribs; depth is generally set between 4-7 cm; frequency is generally set between 5-10 MHz; and a microconvex probe is preferred over a linear probe because the probe is acceptable for all 3 formats - AFAST, TFAST and Vet BLUE – combined called Global FAST. A phase-array or sector probe is generally not recommended because its focal point is too small, although this is unknown. A linear probe may be used, however, it is generally not ideal for the AFAST and TFAST portions of Global FAST.

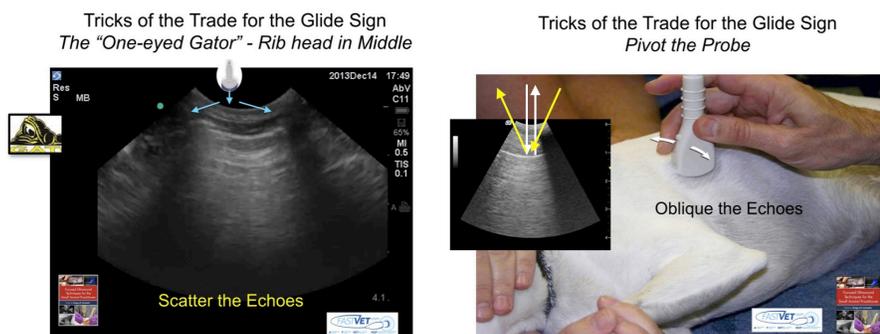


### **THE “GATOR SIGN” – BASIC LUNG ULTRASOUND ORIENTATION**

The rounded rib heads are likened to the eyes, and the pulmonary-pleural (PP-line) interface to the bridge of its nose, as a partially submerged gator (alligator) peers at the sonographer. The proximal white line is the focus of all LUS. Didactic descriptive illustrations may be found in Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley ©2014.

### **TRICKS OF THE TRADE FOR IMAGING THE GLIDE SIGN ALONG THE LUNG LINE**

The strategy is to make the echos work for you! There are 2 tricks of the trade we have developed: 1) place the rib head in the middle of the image to "scatter the echos." We refer to the maneuver as the "one-eyed gator." And 2) oblique the echos by pivoting the probe to a 45-60 degree angle to the lung line or in other words make the lung line more gray than bright white. Another helpful hint is turn down the gain along the lung line.



### **HOW TO PERFORM THE VET BLUE® - 8 ACOUSTIC WINDOWS ACTUALLY 9!**

How to Perform 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<sup>3</sup> CTS view, upper third, 8-9<sup>th</sup> intercostal space), perihilar lung region (Ph – 6-7<sup>th</sup> intercostal space, middle third), middle lung region (Md – 4-5<sup>th</sup> intercostal space, lower third), and cranial lung region (Cr – 2<sup>nd</sup>-3<sup>rd</sup> intercostal space, lower third). Key Point Best way to perform Vet BLUE accurately is to locate the left TFAST Chest Tube Site directly above the xiphoid in the area of the 8-10<sup>th</sup> intercostal space in the upper 1/3<sup>rd</sup> of the thorax, find the transition zone where lung and abdomen interface, then by move 2 intercostal spaces cranially to make sure the probe is over lung/pleural space and not over liver/stomach/abdominal contents. From the left TFAST CTS, which is the same as the left Vet BLUE Cd view (point 1), draw a line with your alcohol or acoustic coupling gel to the elbow, and halfway to the elbow is the Vet BLUE Ph view (point 2), and near the elbow is the Vet BLUE Md view (point 3). If the heart is in view at the Vet BLUE Md view, slide above the heart until you see the lung line or in larger dogs you may slide caudally toward the diaphragm until the heart is lost and a lung line is seen. The final site is the Vet BLUE Cr view (point 4), which requires extending the foreleg cranially to get the probe placed in the 2<sup>nd</sup>-3<sup>rd</sup> intercostal space. Define the Cr view by finding its transition zone of the thoracic inlet and lung then sliding caudally over intercostal spaces 1 and 2. If too ventral at the Cr view, you will see the striations of the pectoral muscles. The author’s preference is to start high (dorsal) on the left moving from Cd to Cr, and then do the same on the right hemithorax. Although not published, the FAST DH View is a 9th acoustic window as a deep window into lung for

lesions not accessible by the transthoracic Vet BLUE views. Didactic descriptive illustrations may be found in Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley ©2014.

How to Do a Vet BLUE Correctly? - Picking the "Vet BLUE® Line" to the Elbow

- 1) Find the "Transition Zone" of lung and abdomen at the Cd view which is the same as the TFAST Chest Tube Site (X)
- 2) Slide 2 Intercostal Spaces toward the Head ←
- 3) Draw a Line with Your Alcohol or an Imaginary Line to the Elbow (✓)
- 4) Half Way to the Elbow is the Ph view and at the Elbow is the Md view
- 5) If over the heart at the Md view. If over the Heart, Slide toward the Spine until you See the Gator Sign, or a Lung Line - Do NOT Slide Caudally as in our VRUS 2014 Manuscript
- 6) Gently Pull the Foreleg toward the Head. Slide Probe in the Axillary Area and into Thoracic Inlet (TI), then Slide over the First and Second Intercostal Spaces so Your Cr view is more accurate - **caudal** to the Thoracic Inlet and in **cranial** to the Heart →
- 7) Shows Common Mistake (X line) of being over the Transition Zone - confusing abdominal contents with Shred, Tissue and Nodule Signs

\* Embrace the Pitfalls of the Transition Zone (X) of Lung and Abdomen and the Thoracic Inlet (TI)

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### VET BLUE® FOR RESPIRATORY DISTRESS— THE 5 BASIC LUNG ULTRASOUND SIGNS

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, many patients in which the probability of PTX is very low, then spending additional time finding the Glide Sign becomes less important and A-lines alone suffice. Ultrasound Lung Rockets (ULRs) are considered "Wet Lung" and oscillate to and fro with inspiration and expiration and must extend to the far field obliterating A-lines. Shred Sign, Tissue Sign, and Nodule Sign (plus Wedge Sign) – Advanced Lung Ultrasound. These are the 3 more advanced LUS signs we have created 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 discreet nodules. The Wedge Sign is a subset of the Shred Sign and represents pulmonary thrombo-embolism (PTE) or rather infarcts at the lung periphery. Didactic descriptive illustrations may be found in Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley ©2014.

The [FASTVet.com](http://FASTVet.com) Vet BLUE® Lung Ultrasound Language

**DRY Lung**  
Normal Aerated Lung Surface

**WET Lung**  
Alveolar Interstitial Edema

**SHRED Sign**  
Consolidation with Aeration  
Air Bronchogram on TXR

**TISSUE Sign**  
Consolidation withOUT Aeration  
Hepatization of Lung

**NODULE Sign**  
Organized Consolidation

**The "Vet BLUE 6 Lung Ultrasound Signs" and "Vet BLUE Counting Lung Rockets or B-lines"**

\*Counting Lung Rockets or B-lines - 1, 2, 3, >3, infinite (&)

**Wedge Sign**  
Pulmonary-ThromboEmbolism

**A** A-line with Glide Sign, Dry Lung

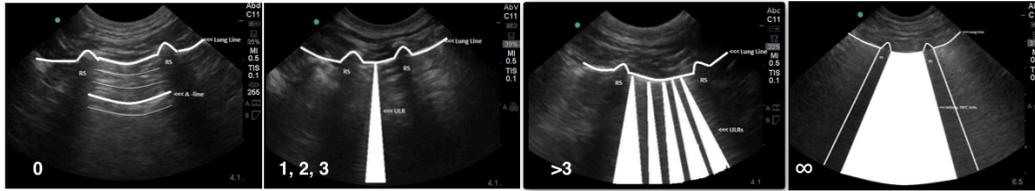
**B** Wet Lung Rockets, Wet Lung

**C** Shred Sign

**D** Tissue Sign

**E** Nodule Sign

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Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley © 2014  
 Counting Lung Rockets or B-lines Published in Lisciandro et al. VRUS 2014, Ward et al. JAVMA 2017, Lisciandro et al. JVECC 2017 and Focused Ultrasound Techniques for the Small Animal Practitioner Wiley 2014



Greg Lisciandro, DVM, Dipl. ABVP, Dipl. ACVECC and FASTVet.com ©2015, 2016, 2017

**Figure. A)** No ULRs **B)** A single ULR scored as “1” or 2 or 3 not shown **C)** >3 ULRs where there are more than 3 but ULRs are still recognized as individual ULRs and **D)** ∞ or infinity ULRs. The maximum number of ULRs over a single representative intercostal space at each respective Vet BLUE view is recorded. The counting system is as follows: 0; 1; 2; 3; >3, when ULRs are still recognized as individuals; and ∞ or infinity, when the ULRs blend into one another becoming confluent. FASTVet.com ©2015, 2016

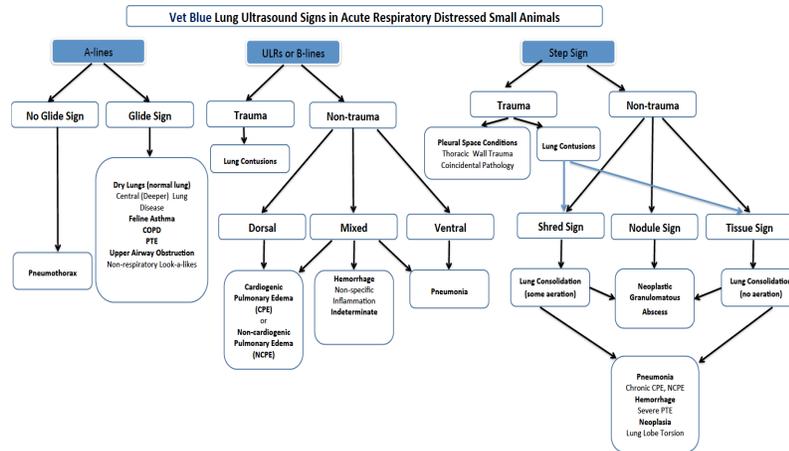
### THE 6 BASIC VET BLUE® FINDINGS

Vet BLUE	Lung Ultrasound Findings	Thoracic Radiography	Notes
Dry Lung	Glide Sign with A-lines	Normal Aerated Lung Surface	Outer 1-3 mm of Lung
Wet Lung	B-lines	Alveolar-Interstitial Edema	Created by Outer 1-3 mm of Lung
Shred Sign	Consolidation with Aeration	Air Bronchogram	
Tissue Sign	Consolidation withOUT Aeration	Consolidated Lung	Hepatization of Lung in Ultrasound Texts
Nodule Sign	Anechoic Circular Structure often with Acoustic Enhancement with a B-line	Nodular Pattern	
Wedge Sign	"V-shaped" Shred Sign	Likely Occult	V-shaped area of infarction and necrosis

### REGIONALLY-BASED PATTERN APPROACH OF VET BLUE®

Clinical Cases Examples of Vet BLUE regionally-based patterns within lecture will emphasize the following: **1)** Dry Lung all fields rules out clinically relevant Left-sided Congestive Heart Failure, suggests upper airway obstruction, Feline Asthma, COPD, PTE and non-respiratory look-a-likes. **2)** Wet Lung or ULRs in dorsal, perihilar, and middle lung regions suggests Cardiogenic Lung Edema (left-sided congestive heart failure, volume overload from intravenous fluids). **3)** Wet Lung in dorsal lung regions suggests forms of Non-cardiogenic Lung Edema. **4)** Wet Lungs in ventral fields with or without signs of consolidation (Shred Sign/Tissue Sign), suggest Pneumonia. **5)** Solitary nodule. **6)** Multiple nodules suggest Metastatic Disease or Granulomatous Disease. Didactic descriptive illustrations may be found in Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley ©2014.

## VET BLUE® DIAGNOSTIC ALGORITHM FOR FINDINGS AND PATTERNS



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<b>Rule Outs for DRY All Fields on Vet BLUE®</b>	
<b>RESPIRATORY</b>	
Pulmonary Thrombo-embolism (PTE)	
Dynamic Upper Airway Conditions (e.g., Collapsing Trachea, Laryngeal Paralysis)	
Upper Airway Obstruction (e.g., Mass, Oropharyngeal Swelling)	
Chronic Obstructive Pulmonary Disease (COPD)	
Feline Asthma	
Tracheobronchitis (e.g., Infectious, Inflammatory, Irritant)	
Centrally located lung pathology away from the lung line (missed by Vet BLUE)	
<b>CARDIAC</b>	
Pericardial Effusion / Cardiac Tamponade	
Cardiac Arrhythmia	
Dilated Cardiomyopathy (DCM)	
Right-sided CHF	
Pulmonary Hypertension	
<b>UNDIFFERENTIATED HYPOTENSION</b>	
Canine Anaphylaxis	
Hemoabdomen	
Hemothorax	
Hemoretroperitoneum	
Cavitary or hemorrhage in a space	
GDV / Bloat	
Sepsis	
<b>OTHER NON-RESPIRATORY</b>	
Pyrexia / Heat Stroke	
High Fever	
Severe Metabolic Acidosis	
Severe Anemia	
<i>NOTE: Dry Lungs ALL Fields also called Absent B-lines ALL Views (ABAV) is Rapid (&lt;90 seconds), Point-of-care, Minimal Restraint</i>	

### **ADVANTAGE OF VET BLUE® OVER THORACIC RADIOGRAPHY**

Ultimately proactive Vet BLUE lung ultrasound will prove itself as a more sensitive test than radiography for lung surface pathology including pneumothorax, alveolar-interstitial edema (Ultrasound Lung Rockets, also called B-lines), lung consolidation (Shred Sign, Tissue Sign, Wedge Sign for PTE) and nodules (Nodule Sign). We have several clinical studies accepted, in the process of being written that support this statement. We have been advocating for Vet BLUE as both a screening test and a complimentary test to better interpret pulmonary radiography and refer to the latter as "RADBLUE."

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## 1st Annual Veterinary Point-of-Care Ultrasound Symposium, Austin, Texas USA

### The Tale of Four Felines: Use of Proactive VET BLUE® Lung Ultrasound - A Colossal Change

Gregory R. Lisciandro, DVM, Dipl. ABVP, Dipl. ACVECC

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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 the 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. Because of the finding of lung pathology during TFAST, the author extended lung surveillance 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 (**V**eterinary **B**edside **L**ung **U**ltrasound **E**xam); and BLUE also for cyanosis implying respiratory conditions. The Vet BLUE 8 regional sites are applied bilaterally and include the caudo-dorsal (Cd) lung region (point 1), the peri-hilar (Ph) lung region (point 2), the middle (Md) lung region (point 3), and the cranial (Cr) lung region (point 4). It is important to recognize that the Vet BLUE views are not anatomical per se, and that different parts or different lobes may dynamically enter and exit the intercostal spaces of each of these 8 views or acoustic windows. The regional concept is important to appreciate because 2 parts of a lung lobe or 2 different lung lobes may be coming into view over the same intercostal space during Vet BLUE imaging. 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. This Vet BLUE phenomenon is fairly common.

The next logical step is developing a Lung Language that is easy to understand. We have sided with the visual and explanative terms of Dry Lung, Wet Lung (alveolar-interstitial edema), Shred Sign (air bronchogram/consolidation with aeration), Wedge Sign (PTE), Tissue Sign (hepatization/consolidation withOUT aeration), 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. In 2017, many medical doctors default to these easily understandable terms over less descriptive A-lines, B-lines, A-, B-, and C-profiles. Having an easily understandable lung language allows for easy communication regarding findings, and thus, LUS use can accelerate over the next several years bucking the lag time between human and veterinary medicine. Finally, having an easily understandable standardized method of recording findings is mandatory for interpreting LUS and establishing patient profiles that may be compared on serial exams. Having applied Vet BLUE to over 1,000 small animal patients since 2010 including >400 cases of Vet BLUE compared to thoracic radiography, we have learned expected patterns, perfected a lung language, and a perfected a simple procedure for recording findings. Most recently, we have been determined to define the 8 Vet BLUE views; and by "embracing the pitfalls" and peri-thoracic anatomy we are more accurate locating the Vet BLUE views for better inter-observer performance.

#### **HOW TO PERFORM VET BLUE®**

##### **Patient Positioning & Preparation**

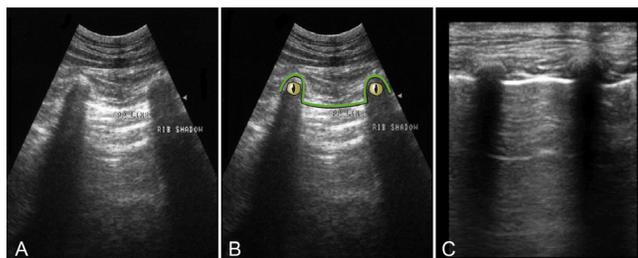
Although Vet BLUE may be performed in lateral recumbency, Vet BLUE is generally performed in standing or sternal recumbency, which is safer for dogs and cats in respiratory distress, or those that are hemodynamically or respiratory fragile. Generally no Vet BLUE sites are shaved. All images in the lecture were from unshaved sites. The fur is parted and alcohol is applied to the skin with or without a small amount of acoustic coupling gel or alcohol-based hand sanitizer on the probe head. To maximize the image quality, the probe head

should be applied as directly as possible to the skin surface without fur in 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, is properly imaged. By mistaking air reverberation artifacts (A-lines) or another structure for the lung line, Vet BLUE is less accurate and erroneous. The probe is held stationary and perpendicular to the long-axis of the ribs.

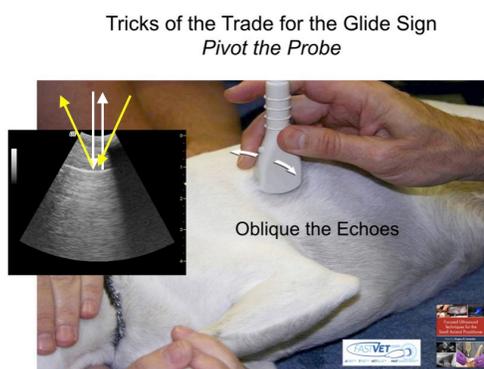


### **Probe Orientation, Type, and Depth Settings**

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 4-8 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 Global FAST - combining AFAST, TFAST and Vet BLUE – as a whole body surveillance of the patient, 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. 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.

### **TRICKS OF THE TRADE FOR IMAGING THE GLIDE SIGN ALONG THE LUNG LINE**

The strategy is to make the echoes work for you! There are 2 tricks of the trade we have developed: 1) place the rib head in the middle of the image to "scatter the echoes." We refer to the maneuver as the "one-eyed gator." And 2) oblique the echoes by pivoting the probe to a 45-60 degree angle to the lung line or in other words make the lung line more gray than bright white. Another helpful hint is turn down the gain along the lung line.



## The Best Way to Perform Vet BLUE® Accurately - 8 Transthoracic Views plus the FAST DH View

Locate the left TFAST Chest Tube Site directly above the xiphoid in the area of the 8-10<sup>th</sup> intercostal space in the upper 1/3<sup>rd</sup> of the thorax, finding the transition zone of lung and abdominal cavity, and then moving 1 or 2 intercostal spaces cranially to make sure the probe is over lung/pleural space and not over liver/stomach/abdominal contents. From the left TFAST CTS view, which is the same as the Vet BLUE Caudo-dorsal (Cd) view (point 1), 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 Peri-hilar (Ph) view (point 2), and near the elbow is the Vet BLUE Middle (Md) view (point 3). If the heart is in view at the Vet BLUE Md view, slide above the heart until you see the lung line. In most cats and dogs, sliding caudally at the Md view often images the transition zone of lung and abdominal cavity, confounding those unfamiliar or inexperienced with the pitfall. The final site is the Vet BLUE Cranial (Cr) view (point 4), which requires gently extending the foreleg cranially to get the probe placed in the 2<sup>nd</sup>-3<sup>rd</sup> 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 caudally over the first 2 intercostal spaces for the Cr view. Our preference is to start high (dorsal) on the left hemithorax moving from Cd to Cr (points 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, and findings better processed for common respiratory conditions. Although not published, the FAST DH View provides a deep window into lung for lesions that may be missed trans-thoracically and is actually the 9th Vet BLUE View. See Vet BLUE Introduction & Canine Proceedings for additional illustrations.

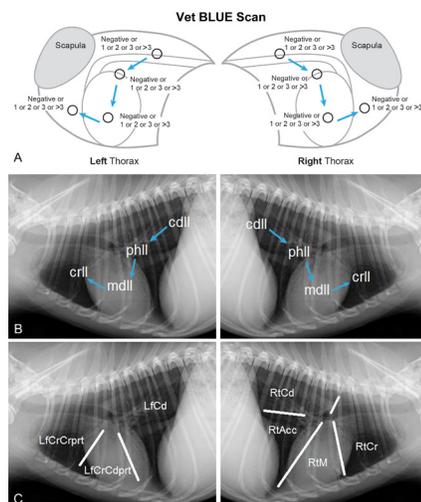
How to Do a Vet BLUE Correctly? - Picking the "Vet BLUE® Line" to the Elbow

- 1) Find the "Transition Zone" of lung and abdomen at the Cd view which is the same as the TFAST Chest Tube Site (X)
- 2) Slide 2 Intercostal Spaces toward the Head (←)
- 3) Draw a Line with Your Alcohol or an Imaginary Line to the Elbow (↙)
- 4) Half Way to the Elbow is the Ph view and at the Elbow is the Md view
- 5) If over the heart at the Md view. If over the Heart, Slide toward the Spine until you See the Gator Sign, or a Lung Line - Do NOT Slide Caudally as in our VRUS 2014 Manuscript
- 6) Gently Pull the Foreleg toward the Head. Slide Probe in the Axillary Area and into Thoracic Inlet (TI), then Slide over the First and Second Intercostal Spaces so Your Cr view is more accurate - **caudal** to the Thoracic Inlet and in **cranial** to the Heart (→)
- 7) Shows Common Mistake (X line) of being over the Transition Zone - confusing abdominal contents with Shred, Tissue and Nodule Signs

\* Embrace the Pitfalls of the Transition Zone (X) of Lung and Abdomen and the Thoracic Inlet (TI)

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## FELINE VET BLUE® EXAM



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**THE 6 BASIC VET BLUE® FINDINGS**

Vet BLUE	Lung Ultrasound Findings	Thoracic Radiography	Notes
Dry Lung	Glide Sign with A-lines	Normal Aerated Lung Surface	Outer 1-3 mm of Lung
Wet Lung	B-lines	Alveolar-Interstitial Edema	Created by Outer 1-3 mm of Lung
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Tissue Sign	Consolidation withOUT Aeration	Consolidated Lung	Hepatization of Lung in Ultrasound Texts
Nodule Sign	Anechoic Circular Structure often with Acoustic Enhancement with a B-line	Nodular Pattern	
Wedge Sign	"V-shaped" Shred Sign	Likely Occult	V-shaped area of infarction and necrosis

**Wet vs. Dry Lung – Basic Lung Ultrasound**

Basic easily recognizable Vet BLUE 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, many patients in which the probability of PTX is very low, then 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 oscillate to and fro with inspiration and expiration and must extend without fading to the far field obliterating A-lines.

The FASTVet.com Vet BLUE® Lung Ultrasound Language

**DRY Lung**  
Normal Aerated Lung Surface

**WET Lung**  
Alveolar Interstitial Edema

**SHRED Sign**  
Consolidation with Aeration  
Air Bronchogram on TXR

**TISSUE Sign**  
Consolidation withOUT Aeration  
Hepatization of Lung

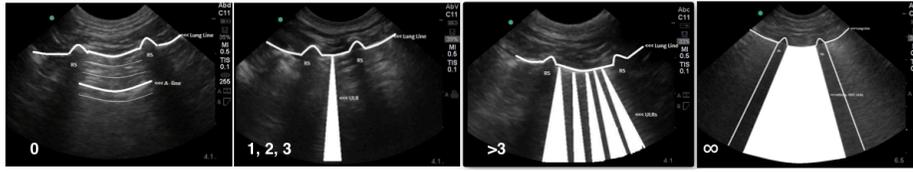
**NODULE Sign**  
Organized Consolidation

**Wedge Sign**  
Pulmonary-ThromboEmbolism

The “Vet BLUE 6 Lung Ultrasound Signs” and “Vet BLUE Counting Lung Rockets or B-lines”

\*Counting Lung Rockets or B-lines - 1, 2, 3, >3, Infinite (&)

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Greg Lisciandro, DVM, Dipl. ABVP, Dipl. ACVECC and FASTVet.com ©2015, 2016, 2017

### Shred Sign, Tissue Sign, & Nodule Sign (plus Wedge Sign) – Advanced Lung Ultrasound

These are the 3 more advanced LUS 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 Sign and represents pulmonary thrombo-embolism (PTE) or rather infarcts at the lung periphery.

**Regionally-based Respiratory Pattern Approach Using Vet BLUE** The clinical relevancy of a Vet BLUE patterned-based regional approach includes the following: 1) Dry Lung all fields rules out clinically relevant left-sided congestive heart failure, 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 even more reliably in felines than canines, especially when involving upper Vet BLUE views 3) Wet Lung in ventral fields with or without signs of consolidation (Shred Sign/Tissue Sign) suggest pneumonia 4) Multiple nodules (Nodule Sign) suggest metastatic disease or granulomatous disease and 5) Wedge Sign suggests PTE.

### THE TALE OF 4 FELINES

**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 Lung all fields; Cat #2 with Feline Asthma that is Dry Lung all fields; Cat #3 with pleural effusion, but don’t stop at the pleural effusion, look at the Lung Line; 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.

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## **1st Annual Veterinary Point-of-Care Ultrasound Symposium, Austin, Texas USA**

### **AFAST®, TFAST® and Vet BLUE® Point-of-care Ultrasound for Traditionally Difficult Conditions**

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#### **INTRODUCTION**

We will discuss traditionally difficult conditions treated based on more often based suspicion rather than evidence-based information. The Global FAST Ultrasound Approach of using AFAST, TFAST and Vet BLUE in combination can tackle many of these traditional conundrums.

#### **TRADITIONALLY DIFFICULT CONDITIONS ADDRESSED BY AFAST, TFAST AND VET BLUE**

##### **Where Is My Patient Bleeding?**

Global FAST - AFAST, TFAST and Vet BLUE survey 4 spaces and lung. Global FAST should be applied to all coagulopathic and at risk for bleeding cases. The abdominal cavity, retroperitoneal space, pleural space, pericardial sac, and lung are surveyed and interventions may take place to better treat the patient prior to overt signs.

##### **Is It Feline Asthma or Left-sided Congestive Heart Failure?**

The use of VET BLUE lung ultrasound rapidly answers this historically difficult question in <90 seconds because the Vet BLUE Profiles are radically different.

##### **Does My Patient Have Pulmonary Thrombo-Embolism?**

Better evidence may be gained for the presence of PTE by using the TFAST long-axis 4-chamber view and evaluating the right ventricular to left ventricular ratio (RV:LV); and through the use of Vet BLUE and the finding of the Wedge Sign representative of small infarcts on the lung surface.

##### **Does My Patient Have Pulmonary Hypertension?**

The respiratory case being treated for pneumonia that in fact has pulmonary hypertension. Using the TFAST long-axis 4-chamber view and evaluating the right ventricular to left ventricular ratio (RV:LV); and characterizing the caudal vena cava are means to support the presence of PHT, explaining why your patient is not improving on antibiotics and triggering an echo in an otherwise occult condition.

##### **Left Atrial Tears in Mitral Valve Disease More Common than You Think?**

Using Vet BLUE and TFAST first line and during hospitalized care as part of your cardiac evaluation helps detect this otherwise missed condition.

##### **Does Your Collapsed Dog have Anaphylaxis?**

Gallbladder wall striation due to gallbladder intramural edema is a marker for canine anaphylaxis. How to recognize the sonographic finding and why you should look beyond the diaphragm for other important rule outs will be discussed; and briefly discuss the canine anaphylaxis-related heparin-induced hemoabdomen.

##### **How to Better Interpret the Nebulous Thoracic Radiograph?**

You are missing pulmonary disease by not using proactive Vet BLUE lung ultrasound. Use Vet BLUE to complement thoracic radiography and better help pick your next best respiratory test to more accurately and expediently diagnose and treat.

##### **Why You Should Do Vet BLUE in All Vomiting Patients?**

Aspiration pneumonia may be detected point-of-care in your hospitalized patients using Vet BLUE.

### **How to Monitor Pneumothorax by Using the Lung Point?**

Pneumothorax cannot only be diagnosed point-of-care using TFAST but may also be monitored through the use of the Lung Point.

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# 1st Annual Veterinary Point-of-Care Ultrasound Symposium, Austin, Texas USA

## Global FAST® - AFAST®, TFAST® and Vet BLUE® for Patient Monitoring

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### **INTRODUCTION**

The evolution of veterinary abbreviated ultrasound formats has extended beyond the abdominal format as a simple "flash exam" of fluid positive or fluid negative since the landmark publication by Boysen et al. in 2004. In 2008, the thoracic FAST format was developed by Lisciandro et al. and referred to as TFAST for the rapid diagnosis of pneumothorax and other thorax-related injury. In 2009, the abdominal FAST referred to as AFAST was a modification from the original FAST study. AFAST renamed the views with a target-organ approach rather than naming of external sites so that sonographer would be more aware anatomically about the actual organs and structures at each of the AFAST views; and AFAST directed the probe more strategically into the gravity-dependent regions of each view; and AFAST has its applied fluid scoring system to make more sense of a positive scan; and the same study advocated for 4-hour serial exams with repeat scoring for all hospitalized patients. In 2014, a 3rd abbreviated lung ultrasound format was published by Lisciandro et al. named Vet BLUE to complement AFAST and TFAST. In combination, these 3 formats are called Global FAST. Global FAST provides a huge amount of clinical information (< 6-8 minutes) regarding your patient by taking advantage of basic echo views of the heart, and non-echo views that reflect left- and right-sided cardiac status; and determining if your patient is losing volume internally because the abdominal cavity, retroperitoneal space, pleural cavity, pericardial sac and lung are also surveyed for free fluid and edema, respectively; and urinary bladder volume may be estimated and serial exams using our AFAST Cysto-Colic formula can non-invasively estimate urine output. A similar strategy has evolved referred to as the RUSH Exam (**R**apid **U**ltrasound in **S**hock) in emergent patients, although the RUSH exam does not have a fluid scoring system, lacks a lung screening component other than ruling in or out pneumothorax, and does not evaluate urinary bladder volume. Most recently, the analogous global approach as a screening test is gaining some momentum on the human side because focused exams are dangerous, and traditional complete abdominal ultrasound and complete echocardiography are often not in the right cavity. We advocate for a baseline Global FAST recorded on goal-directed templates for all admitted patients prior to intervention; and with proper training Global FAST takes <6-8 minutes with no shaving, minimal restraint.

### **GLOBAL FAST FOR PATIENT MONITORING**

#### **The Abdominal Fluid Scoring System**

Small animals are placed in preferably right lateral recumbency because it facilitates the right TFAST PeriCardial Views for TFAST basic echo views; however, either lateral recumbency is validated for the AFAST abdominal fluid scoring system. The abdominal fluid score (AFS) of 1 is given to any positive AFAST views so the scoring system ranges from 0-4. The use of the abdominal fluid scoring system gives more value to effusions over mild, moderate and severe, and allows for better tracking of resolution or worsening of effusions. In cases of hemorrhage, the fluid scoring system helps categorize intra-abdominal bleeding as small volume bleeding, AFS 1 and 2, and large volume bleeding, AFS 3 and 4. Small volume AFS 1 and 2 dogs and cats do not have enough intra-abdominal hemorrhage for anemia, so if they are or become anemic then pre-existing anemia existed or they are losing blood somewhere else, i.e. retroperitoneal, pleural, pericardial, lung, intrapelvic, fracture sites, gastro-intestinal tract, or externally, respectively. On the other hand, large volume bleeders of AFS 3 and 4, considered life-threatening, have enough intra-abdominal hemorrhage to become anemic and many require blood transfusions dependent on the subset of patient and the degree of fluid resuscitation. The use of the AFAST-applied AFS is also a monitoring tool for all at-risk for bleeding, post-interventional cases, including those with percutaneous needle and Tru-cut biopsies. Patient AFS helps better make decisions regarding ongoing bleeding, resolving bleeding, and need for blood transfusion and/or exploratory laparotomy.

### **TFAST RIGHT PERICARDIAL ECHO VIEWS**

#### **Left Ventricular Short-axis View for Volume and Contractility**

The left ventricular short-axis view (LVSA) is acquired just below the mitral valves at the level where the chordae tendinae come off the left papillary muscles referred to as the LV short-axis "mushroom" view. The filling and size of the "mushroom" is a reflection of patient volume status as long as the sonographer is aware of how to locate the proper level on short-axis. Contractility is also assessed subjectively using the eyeball approach. It does not take a whole lot of training to be able to screen for poor filling and poor contractility. Poor filling indicating poor volume can be supported or refuted

by assessing the caudal vena cava; and contractility by triggering a complete echocardiography. In the meantime though, a patient thought to have poor contractility, i.e., dilated cardiomyopathy, may be treated and better stabilized during the delay of acquiring complete echocardiography.

### Long-axis 4-chamber View for the Right Ventricular to Left Ventricular Ratio (RV:LV)

The normal RV:LV ratio is 1:3-4 with the RV being a small triangle when compared to the LV. When the RV is nearly the same size of the LV then right heart problems and pulmonary hypertension should be suspected, and complete echocardiography is indicated until proven otherwise. However, by recognizing the abnormality, patient therapy may be adjusted to better head off complications. In an acutely respiratory distressed cat or dog that develops acute RV dilation, massive PTE has likely occurred. Your non-echo fallback view for right-sided heart problems is the caudal vena cava at the FAST DH View (see below).

### Left Ventricular Short-axis View for the Left Atrial to Aortic Ratio (LA:Ao)

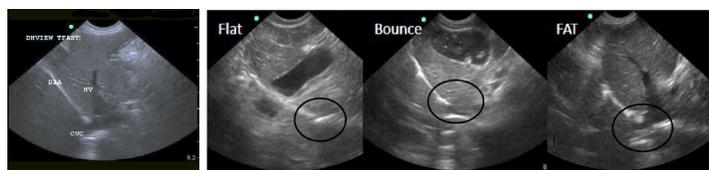
The normal LA:Ao Ratio is <1.3 in dogs and <1.6 in cats. This is the most challenging view to obtain. Your non-echo fallback strategy is performing the easier, less stressful, Vet BLUE lung exam. Absent B-lines in All Views (ABAV) is an effective means to rapidly rule out left-sided congestive heart failure (see below).



## THE NON-ECHO FALLBACK VIEWS FOR LEFT- AND RIGHT-SIDED CARDIAC PROBLEMS

### Characterizing the Caudal Vena Cava and Hepatic Veins

The caudal vena cava (CVC) where it traverses the diaphragm rapidly reflects preload and is your new non-invasive central venous pressure (CVP). In fact, central lines have been debunked in human medicine since 2013; and it is common practice to use the analogous view of the inferior vena cava (IVC). We simply eyeball and characterize the CVC as being 1) FAT or distended with < 10% change in diameter (high CVP), or 2) flat (collapsed with < 10% change in diameter, low CVP), or 3) having a bounce (~50% change in diameter, in the ballpark of normal). The normal “bounce” reflects the dynamic changes in CVC diameter during inspiration and expiration as blood is drawn/squeezed into the heart in spontaneously ventilating dogs and cats. Measuring the CVC using M-mode can be challenging and difficult with a lot of patient movement. However, by visually characterizing the CVC at the FAST DH view, called the “eyeball approach”, and correlating with clinical impression and other findings (blood pressure, physical exam findings, blood lactate), the clinician has a much better idea of patient preload (CVP) and right-sided cardiac status. Moreover, if the sonographer wants a numeric value, then imaging the CVC in B-mode and freezing and rolling the cine ball to get minimal and maximal diameter is another approach. These measurements can then be used to calculate its distensibility index. Because of the great differences in sizes in dogs absolute measurements are less likely to be as reliable. The hepatic veins are not normally seen in lateral or sternal/standing, so their distension is another clue that CVP is high.

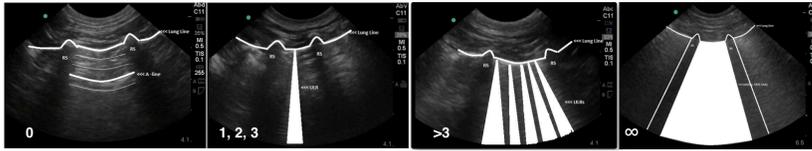


**Figure.** Far left image shows the classic FAT or distended CVC as it traverses the diaphragm with associated hepatic venous distension likened to tree trunks and branching referred to as the “Tree Trunk Sign.” The 3 images labeled FAT, Bounce and flat represent a high CVP, a ballpark normal CVP, and a low CVP, respectively. This material is reproduced with permission of John Wiley & Sons, Inc, Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley ©2014.

### Use of Vet BLUE – “Wet Lung” vs. “Dry Lung”

Because the “wet lung” vs. “dry lung” concept is easily recognized during Vet BLUE, the presence or absence of ultrasound lung rockets (ULRs), also called B-lines, provides important clinical information regarding left-sided cardiac status and left-sided volume overload. Moreover, Volpicelli et al. showed that numbers of ULRs correlate with the degree of alveolar-interstitial edema when compared to CT; and Vet BLUE requires minimal patient restraint, is rapid (<60-90

seconds), safe and point-of-care. Thus, acquire a baseline Vet BLUE prior to fluid therapy on all hospitalized dogs and cats. ULRs have been shown to correlate with extravascular lung water, and thus are sentinels for worsening respiratory status and pulmonary failure. If treatment strategy is not adjusted, then alveolar-interstitial edema may progress to alveolar flooding, which is much more difficult to treat. Using the regionally-based Vet BLUE patterned approach, other causes of wet lung artifacts, such as pneumonia, can often be discriminated. Moreover, the use of Vet BLUE potentially triggers additional testing and imaging.



**Figure.** Showing the counting scheme published by the author for counting ULRs as 1,2,3 or >3 and infinite ∞.

### The Urinary Bladder Volume Formula

At the AFAST Cysto-Colic View the urinary bladder is imaged in longitudinal (sagittal) and the best oval is acquired in this plane and measured followed by transverse orientation and acquiring the largest oval and measured. Measurements in cm will give you an estimation of urinary bladder volume in ml by using Length x Width x Height x 0.625. With measurements over time, urine output can be non-invasively estimated.

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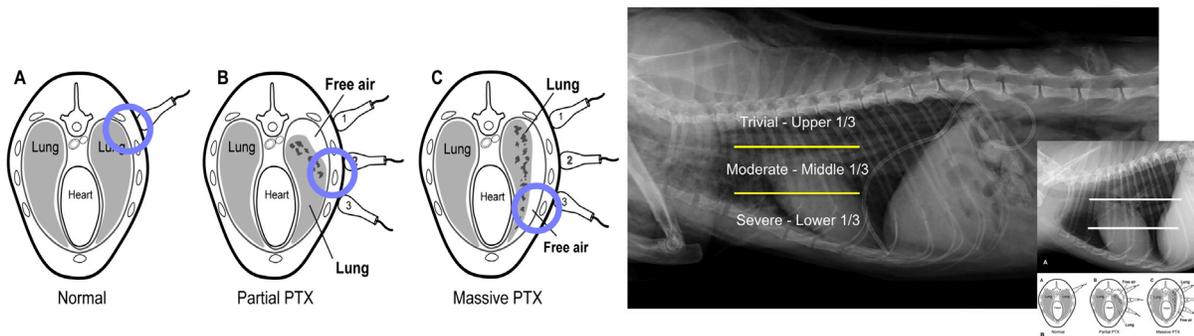
Brief Clinical Communication

**Use of urinary bladder measurements from a point-of-care cysto-colic ultrasonographic view to estimate urinary bladder volume in dogs and cats**

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Length x Height x Width (cm) x 0.625 = Est. Urinary Bladder Volume (ml)

### Use of the Lung Point for Monitoring Pneumothorax (PTX)



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The use of the Lung Point, the transition zone of where there is pneumothorax (PTX) and lung re-contacting the thoracic wall is a means to increase the sensitivity for the diagnosis of PTX and to track worsening, or resolving PTX. Post lung lobe aspirate, chest tube placement/removal, or other invasive thoracic procedures, the Lung Point qualifies the PTX, point-of-care with minimal patient restraint and stress, as follows: 1) upper 1/3 of the thorax, trivial or 2) middle 1/3 of

thorax moderate and concerning warranting thoracocentesis or 3) lower 1/3 of thorax as severe/massive warranting thoracocentesis (author's experience). Clinical judgment is required to maximize decision-making.

#### **BASELINE ADMISSION GLOBAL FAST AND SERIAL EXAMS ARE KEY**

The repeating of Global FAST exams, serial exams, cannot be overemphasized. Minimally a 4-hour post-admission Global FAST exam should be performed in all admitted patients; and the author incorporates Global FAST as part of daily rounds immediately after a complete physical exam.

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## 1st Annual Veterinary Point-of-Care Ultrasound Symposium, Austin, Texas USA

### The Gallbladder Halo Sign: More than Canine Anaphylaxis

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#### **INTRODUCTION**

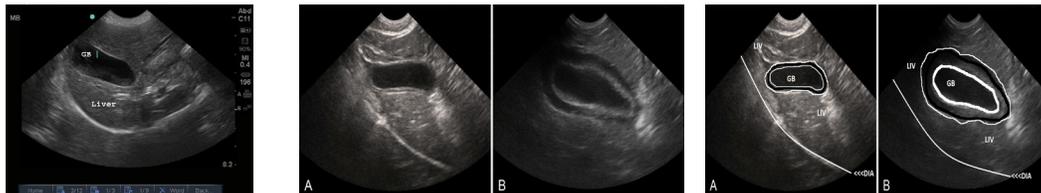
The lecture will not cover detail regarding the pathophysiology of anaphylaxis of which there exist many excellent published descriptions. Rather, the lecture will focus on how to rapidly gain supportive evidence for the diagnosis of canine anaphylaxis, including the sonographic marker of gallbladder wall edema; and important rule outs for sonographically-detected gallbladder wall edema that can confound the diagnosis at the expense of the patient; and a newly described fascinating complication referred to by the author as canine "anaphylaxis-related, heparin-induced hemoabdomen" that is medically-treated.

The major reason for this lecture is that many veterinarians are now using point-of-care ultrasound, specifically FAST exams, as a life-saving first line, screening test. As a result, ultrasound detects free-fluid and other soft tissue changes that are not recognized without ultrasound; and many triaged collapsed dogs with anaphylaxis have no cutaneous signs nor witnessed inciting envenomation. The focus of the source of anaphylaxis in this lecture disregards the obvious canine with classic cutaneous signs of angioedema, pruritus and urticaria, but focuses on the single Hymenoptera envenomation that is often unwitnessed. All veterinarians need to recognize the strengths and limitations of sonographically-detected gallbladder wall edema since its presence is not pathognomonic; and that AX-related, heparin-induced hemoabdomen is a medically treated canine complication, because without this knowledge gallbladder wall edema will be misinterpreted and surgical intervention will likely lead to a fatal exploratory surgery with the findings of hepatic swelling, intra-abdominal blood, and non-specific histopathology.

#### **The FAST DIAPHRAGMATICO-HEPATIC (DH) VIEW**

##### **Imaging the Gallbladder and Detecting Intramural Edema**

In normalcy, the gallbladder sonographically is generally oval in longitudinal (sagittal) orientation with a lumen that is homogeneously anechoic (black). The gallbladder wall is quite reliably and seen sonographically as a thin hyperechoic (white) line in both canines and felines despite normal thickness reported to a thickness of 2-3 mm. In summary, the sonographic features of the canine and feline gallbladder are easy to appreciate by non-radiologist sonographers when imaging the FAST DH view. In a 2009 study, Quantz et al. published in JVECC a brilliant study that correlated the presence of a thickened, edematous, striated gallbladder wall, referred to as the gallbladder halo sign, with canine anaphylaxis (AX). Their study design was a result of recognizing that in a canine AX research model, gallbladder wall edema was commonly present.



**Figure.** Normal expected sonographic appearance of the gallbladder wall in canines. Unlabeled middle figure with A and B shows more subtle gallbladder wall striation/intramural edema in A and more obvious gallbladder wall striation/intramural edema in B. Far right image is now outlined. This material is reproduced and modified with permission of John Wiley & Sons, Inc, Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley ©2014

##### **Gallbladder Wall Edema as a Sonographic Marker for Canine Anaphylaxis (AX)**

AX-related gallbladder edema is specific to canines because their shock organ, where the highest concentration of mast cells are located, is their liver and gastro-intestinal tract. In contrast, the shock organ of felines and humans is the lung, thus gallbladder wall edema is not a hallmark of AX in these species. The cause of gallbladder wall edema is the result of massive histamine release causing hepatic venous sphincter constriction and massive generalized hepatic venous congestion. Simply put, when the liver swells, so does the gallbladder wall. This is important to remember when considering other rule outs for canine gallbladder wall edema. The AX-related intramural gallbladder edema is recognized sonographically as sonographic striations. These striations appear as a hyperechoic (white) lines representing the inner

and outer aspects of the gallbladder wall, and a sonolucent anechoic (black) line striation representing the intramural edema. In other words, the gallbladder wall becomes layered as white, black, and white, (sometimes it is white, gray, white), and thus has been dubbed the “gallbladder halo sign.” In the Quantz et al. study, it was found that AX-induced gallbladder edema is an immediate occurrence within seconds/minutes that lasts up to 24-48 hours post-insult.

### Serum Alanine Transaminase as a Serum Marker for Canine Anaphylaxis (AX)

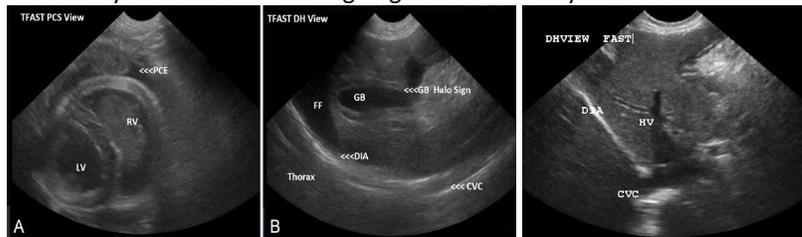
Because the liver and gastro-intestinal tract are the shock organ for the canine species, traditionally serum alanine transaminase (ALT) has been used as supportive evidence for canine AX. However, in the Quantz et al. study, it was stated that serum ALT marker was not as immediate as gallbladder wall edema; and that the ALT may not spike in value for up to 2-4 hours post-insult. Quantz et al. documented a mean ALT of ~ 400 IU/L for their case study population of canine AX.

### The Classic Constellations of Signs for Canine Anaphylaxis

Keeping in mind the canine shock organ, traditional means of diagnosing anaphylaxis have relied on a history of acute collapse often associated with gastro-intestinal signs in a previously healthy dog. The collapse is often associated with gastro-intestinal signs, i.e. vomiting and defecation. The great majority of these dogs have no obvious cutaneous signs. Upon presentation due to massive fluid shifts caused by histamine release and likely other factors that increase vascular permeability, dogs with AX are commonly hemoconcentrated with packed cell volumes in the 50% range and even higher (in contrast dogs with a hemoabdomen from a bleeding tumor are not hemoconcentrated); and as previously mentioned, the serum ALT is likewise a marker because of the hepatic insult. The weather should also be considered because many warm days and cool nights make Hymenoptera species lethargic and less likely to move away from the dog walking and sniffing in the grass in the cool evenings and mornings (author's experience).

### Gallbladder Wall Edema is Not Pathognomonic for Canine Anaphylaxis - It's also a "Cardiac Gallbladder"

In the collapsed or acutely weak hypotensive canine triaged with the finding of gallbladder wall striation/edema, other important rule outs include pericardial effusion, right-sided heart and generalized systolic dysfunction (DCM). The pathophysiology of gallbladder wall edema in these cases is mechanical obstruction of blood, in which backflow of blood leads to a distended caudal vena cava (CVC), and hepatic venous congestion. Simply put, when the liver swells, so does the gallbladder. These rule outs are addressed by looking past the diaphragm for pericardial effusion, the classic racetrack sign of pericardial effusion rounding the muscular apex of the heart; and adding the right TFAST PeriCardial (PCS) view to assess contractility at the left ventricular short-axis view. Moreover, the really savvy sonographer always, always looks at the caudal vena cava (CVC) where it traverses the diaphragm at the FAST DH view. The CVC is a marker for central venous pressure (CVP) and its human counterpart, the inferior vena cava at the analogous location, is being taught to medical doctors. The CVC in AX is flat (no volume, low CVP) with no variation in its diameter vs. the CVC characterization in pericardial effusion and cardiac cases is diametrically opposed as FAT (too much volume, high CVP), or distended with minimal variation in its diameter. When the CVC is FAT from a high CVP, hepatic veins, not normally obvious in lateral or standing/sternal recumbency, are obvious branching structures from venous downstream obstruction. The upshot is that gallbladder wall edema is not pathognomonic for canine anaphylaxis in the collapsed or weak canine; that veterinarians must resist satisfaction of search error and minimally look past the diaphragm for pericardial effusion and the TFAST right PeriCardial View to evaluate contractility before administering large volumes of crystalloids.



**Figure.** The gallbladder halo sign and FAT (distended) CVC in a dog with pericardial effusion (PCE) in A and B. PCE should be ruled out in collapsed, weak dogs suspected of having AX. The single figure on the right showing the FAT (distended) caudal vena cava (CVC) as it traverses the diaphragm (DIA); and the associated distended branching hepatic veins appearing as tree trunks (referred to as the Tree trunk Sign). The character of the CVC is completely different between canines with AX (flat CVC) and canines with pericardial effusion or right-sided heart failure/DCM (FAT CVC). LV: left ventricle; RV: right ventricle; PCE: pericardial effusion; DIA: diaphragm; GB: gallbladder; CVC: caudal vena cava; FF: free abdominal fluid. This material is reproduced with permission of John Wiley & Sons, Inc, *Focused Ultrasound Techniques for the Small Animal Practitioner*, Wiley ©2014.

<b>Causes of Gallbladder Wall Edema (the Gallbladder Halo Sign)</b>
Anaphylaxis (acute collapse, flat caudal vena cava) – massive histamine release results in hepatic venous congestion
Right-sided heart failure/dysfunction (collapse, weakness, FAT caudal vena cava) – backflow of blood to the right heart results in hepatic venous congestion
Pericardial effusion (acute collapse, weakness, FAT caudal vena cava) – obstruction of blood flow to the right heart results in hepatic venous congestion
Cholecystitis
Pancreatitis
Hypoalbuminemia, 3 <sup>rd</sup> Spacing
Right-sided Volume Overload (iatrogenic), from intravenous fluid therapy
Immune-mediated Hemolytic Anemia (IMHA), unknown cause, speculate immune-mediated
Post-Blood Transfusion, unknown pathogenesis, speculate immune-mediated, volume overload
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Other potential causes for gallbladder wall edema that are generally present in non-collapsed dogs include 3<sup>rd</sup> spacing from hypoalbuminemia and vasculitis, primary gallbladder disease including cholecystitis, pancreatitis, and iatrogenic right-sided volume overload. Gallbladder wall edema is often observed in dogs with immune-mediated hemolytic anemia and post-blood transfusion. Its presence in these subsets of patients does not necessarily indicate canine AX, so it is important to look at the complete clinical profile of these canine patients.

### **Canine Anaphylaxis-related, Heparin-induced Medically-treated Hemoabdomen**

Dogs with anaphylaxis commonly develop abdominal effusion often scored as an abdominal fluid score (AFS) 1 or 2 using the AFAST-applied fluid scoring system; and most commonly positive at the FAST DH view. These low-scoring effusions are often self-resolving, the canine patient is non-coagulopathic, and the volume too small for safely performing abdominocentesis. Serial AFAST with AFS, minimally one repeat AFAST 4-hours post-admission, is justified to detect worsening (increasing score) or resolution (decreasing score) of the AX-related effusion; and depending on clinical course, a repeat PCV/TS and Coagulation Profile; and AFAST with AFS again after daily patient rounds until the attending veterinarian is certain that AX has resolved. In fact, Global FAST -AFAST with AFS, TFAST and Vet BLUE - is an even better format over AFAST alone because Global FAST provides information on volume status, lung status, and other potential complications occult by physical exam, blood and urine testing, radiography, and vital signs.

Abdominocentesis should be performed if the free fluid is safely accessible, generally at the most gravity-dependent regions of the abdominal cavity, when your patient is in lateral recumbency. In our experience, these effusions are hemorrhagic with a comparative abdominal PCV of minimally  $\geq 50\%$  of the peripheral PCV. In canine AX cases with abnormal coagulation profiles, clotting factors should be replaced as soon as possible, e.g., fresh frozen plasma (FFP). As a crude guideline, 1 in 5-7 canine AX cases require FFP, and 1 in 20 canine AX cases require pRBCs. Some of the coagulopathic canines require repeated FFP over several days. However, it appears from the author's experience over the past 8-years that withholding steroids is the greatest risk factor for persistent coagulopathy that results in greatly inflated financial client cost, use of practice blood bank resources, and patient risk for death. Other cases of canine AX have large volume effusions of AFS 3 and 4. Even in these large volume effusions, the coagulation profile may be close to normal and stay close to normal (<25% above baseline) on repeat Coagulation Profile 4-hours post-admission along with AFAST with AFS and PCV/TS. These large volume effusions will likewise generally self-resolve within 24-hours if the patient responds favorably to initial resuscitation and therapy for AX including IV crystalloid fluid resuscitation +/- low dose epinephrine as needed as often as every 10 minutes, histamine 1 blocker (0.5 mg/kg i.m. once avoiding i.v.), histamine 2 blocker (famotidine 0.5 mg/kg q 24-hours while on glucocorticoids), and glucocorticoids (Dexamethasone Sodium Phosphate 0.15-0.3 mg/kg i.v. then repeated 12-hours post-admission if not taking oral Prednisone), and continued Prednisone 0.25 mg/kg q 12-hours for 2-3 days and then q 24-hours for 2-3 days.

In summary, the author treats canine AX cases initially with IV crystalloid fluid therapy 30 ml/kg repeated until a low normal mean arterial pressure, +/- low dose epinephrine depending on immediate response to balance crystalloid resuscitation repeated as often as every 10 minutes as needed to stabilize, dexamethasone 0.15-0.3 mg/kg i.v. repeated in 12-hours if the patient is unable to take oral anti-inflammatory prednisone, plus histamine 1 blocker (diphenhydramine i.m. once avoiding i.v.), histamine 2 blocker (famotidine). After initial resuscitation, anti-inflammatory tapered prednisone and famotidine are continued over the next several days as generally a 5-7-day tapering regimen to mitigate the second wave of AX-related inflammation that likely perpetuates coagulopathy. Fresh frozen plasma is administered if the aPTT is > 25%

baseline. Packed red blood cells are rarely needed because anemia does not occur with the described treatment including initially using glucocorticoids.

### **Pathophysiology of Canine AX-related Heparin-induced Medically-treated Hemoabdomen**

In theory, the aPPT is more affected by heparin, a natural component of the mast cell granule; thus, PT and aPTT times should be discordant with the aPTT far more prolonged than the PT (opposite of the warfarin or coumadin effect). So when the PT is near normal or mildly elevated with an out of range aPTT, a flag should be raised that the coagulopathy is a result of AX and heparin and tryptase release by mast cells. However, the discordance seems unreliable and the entire clinical picture must be considered. In our case series of 11 dogs from nearly 4-years ago, all survived without surgery with complete resolution of their hemorrhagic effusion; and of the clients that responded to long-term follow-up, all 7 said AX had not recurred in their dog. The data from this case series is available off our FASTVet Facebook page or may be requested.

### **CONCLUSION**

It is important to recognize the limitations and additional rule outs for the sonographic finding of a striated gallbladder wall, the so-called gallbladder halo sign; and that dogs have a unique AX-related, Heparin-induced Medically-treated Hemoabdomen complication, and not over-react to stable patients with normal to relatively normal clotting times (<25% over baseline) since many will self-resolve with standard AX therapy. In other words, many dogs with mildly abnormal coagulation profiles will resolve without transfusion products. Equally important is to know not to take an AX-related canine hemoabdomen to surgery, which could be catastrophic for the dog likely resulting in death. Larger case studies and more sophisticated coagulation assessment are needed to fully understand this perplexing canine AX-related phenomenon.

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## INTERVENTIONAL PROCEDURES

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### INTRODUCTION

When performing interventional procedures using ultrasound-guidance, the procedures are generally classified as 1) indirect, 2) free-hand and 3) mechanical-guided. Furthermore, pending the procedure to be performed, ultrasound guidance can be performed “in plane” or “out of plane.” We will go through these 3 techniques.

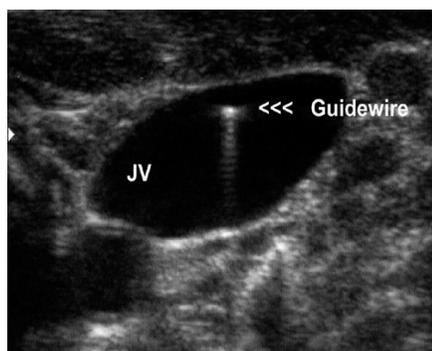
**Indirect procedures:** The ultrasound probe helps identify the widest/deepest section of the target structure to be aspirated (e.g. largest area of free fluid accumulation or widest aspect of a vessel), where there is the least risk of complications (e.g. location of adjacent vital structures). An “imaginary” needle trajectory is envisioned, which will be used to “free hand aspirate”, but the actual aspiration is performed without real-time ultrasound visualization of the. Pericardiocentesis, thoracocentesis and abdominocentesis are often performed using an indirect technique in veterinary patients, particularly when complications of aspirating nearby structures are low, and time is of the essence (e.g. large pleural effusions in patients with evident respiratory distress).

**Free-hand ultrasound-guided procedures:** The target is first identified, the widest/deepest area with the least risk of complication is determined and real-time ultrasound is used to visualize and assist in tracking the needle tip into the desired structure to be aspirated. Free-hand ultrasound guidance is inexpensive, allows the operator to move and alter the angle of the needle through multiple planes, and to change the needle location while performing the technique. Care should be taken to not needle the probe's foot print resulting in probe head damage.

**Mechanical ultrasound guided procedures:** This technique incorporates a rigid attachment to the ultrasound probe, which mandates the needle trajectory in plane with the ultrasound probe. This allows the needle/needle tip to enter the target using real-time visualization. A disadvantage of mechanical guided techniques is the limited number of needle/needle tip entry angles that can be utilized, however, the device prevents in advertent probe head damage that is possible with the free-hand technique.

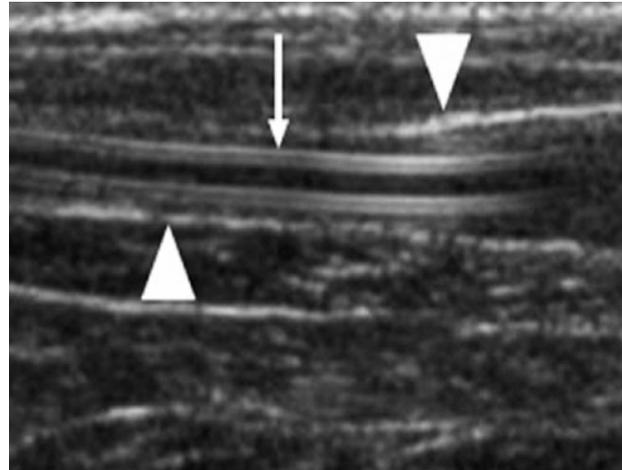
Ultrasound guidance may be performed in one of two ways: 1) Out of plane and 2) In plane as illustrated in the following figures.

**Figure. Out of Plane:** The ultrasound probe is orientated perpendicular to the needle. Out of plane techniques are often used to aspirate vessels for blood collection and/or to assist with vascular access techniques. *With permission Boysen SR. Chapter 17: Ultrasound Guided Procedures in Focused Ultrasound Techniques for the Small Animal Practitioner, Ed. Lisciandro GR, Wiley 2014.*



**Figure. In Plane:** In plane techniques are often used when there are numerous surrounding structures and visualizing the tip of the needle relative to those surrounding structures is important. With the exception of

vascular access techniques, in plane ultrasound guidance tends to be more common. *With permission Boysen SR. Chapter 17: Ultrasound Guided Procedures in Focused Ultrasound Techniques for the Small Animal Practitioner, Ed. Lisciandro GR, Wiley 2014.*



## **INTERVENTIONAL PROCEDURES**

### **Pericardiocentesis**

Traditionally, in veterinary medicine pericardiocentesis is performed using indirect ultrasound or blind techniques. In contrast, human medicine is moving towards ultrasound guided pericardiocentesis as several studies have demonstrated reduced complications with free-hand US-guided pericardiocentesis compared to blind techniques. This may be particularly relevant in cases of small volume pericardial effusion associated with tamponade. Given anatomic differences between humans and veterinary patients it is uncertain if US-guided pericardiocentesis would result in fewer complications. However, using ultrasound is advantageous by locating the optimal location for pericardiocentesis through the location of the pericardial effusion against the thoracic wall at the level of or slightly above the costochondral junction (CCJ); and estimating the distance from the body wall to the myocardium. Penetrating the thorax below the CCJ should be avoided due to the internal thoracic artery.

See DeFrancesco Focused Echo Proceedings for a description on how to diagnose, determine if cardiac tamponade is present and for performing pericardiocentesis as well as Boysen SR. Chapter 17: Ultrasound Guided Procedures *in Focused Ultrasound Techniques for the Small Animal Practitioner*, Ed. Lisciandro GR, Wiley 2014 for additional details on how to perform step-by-step, indications, and diagnosing cardiac tamponade.

### **Thoracocentesis**

In patients with life-threatening pleural effusion and/or pneumothorax blind thoracocentesis has been traditionally recommended to facilitate more rapid stabilization of the patient. However, with experience the time it takes to place an ultrasound probe on the thorax for patient evaluation is minimal and a less risky strategy than the blind approach.

**Pleural effusion:** Ultrasound guidance helps locate fluid pockets and loculated fluid accumulations which may require multiple centesis at several locations within the pleural space for therapeutic and diagnostic benefit. Furthermore, using real time ultrasound guidance during aspiration allows the tip of the needle to be monitored during aspiration and helps identify when lung will abut against the tip of the needle. Finally, the remaining fluid in the thorax can be measured with ultrasound, which helps predict resolutions and recurrence. Human studies have demonstrated higher success rates for pleural effusions when using US-guided compared to blind thoracocentesis; and the success rate of guided techniques is up to 88% in cases of failed blind thoracocentesis. Thoracocentesis for pleural effusion is generally performed in the lower 1/3 of the thorax at the level of the costochondral junction (CCJ) because fluid falls being gravity-dependent. Performing thoracocentesis below the CCJ should be avoided due to the internal thoracic artery.

**Pneumothorax:** Because ultrasound does not transmit through air, structures generally cannot be identified in the presence of pneumothorax; therefore there is little advantage of performing ultrasound guided centesis over blind centesis for pneumothorax. However, using ultrasound and the lung point concept resolution of pneumothorax may be made point-of-care and monitoring performed using the lung point concept (see Lisciandro TFAST Proceedings). Thoracocentesis for pneumothorax is generally performed in the upper to middle 1/3 of the thorax because air rises.

More specific details on how to perform step-by-step, indications, and more may be found in Boysen SR. Chapter 17: Ultrasound Guided Procedures *in Focused Ultrasound Techniques for the Small Animal Practitioner*, Ed. Lisciandro GR, Wiley 2014.

### **Abdominocentesis**

The biggest advantage of using real-time ultrasound guided abdominocentesis is that abdominal organs can be avoided as they are directly visualized during the procedure. The trajectory path of the needle is tracked and adjusted as needed to enter the target fluid for aspiration while avoiding organs. The accuracy of abdominocentesis and avoidance of false positive and negative results can be reduced with real-time US-guided abdominocentesis; and US-guided abdominocentesis has a higher success rate when compared to blind abdominocentesis. This is especially true when there are small volumes of peritoneal fluid and when peritoneal fluid is compartmentalized. In larger volumes of peritoneal fluid abdominocentesis is generally best performed immediately caudal and ventral to the umbilicus in either lateral recumbency avoiding the mesenteric fat pad generally located from the umbilicus to the xiphoid and avoiding the urinary bladder.

More specific details on how to perform step-by-step, indications, and more may be found in Boysen SR. Chapter 17: Ultrasound Guided Procedures *in Focused Ultrasound Techniques for the Small Animal Practitioner*, Ed. Lisciandro GR, Wiley 2014.

### **Modified Ultrasound-guided Diagnostic Peritoneal Lavage (MUG-DPL)**

Diagnostic peritoneal lavage (DPL) has essentially been replaced by ultrasound in most setting because DPL introduces free fluid into the peritoneal cavity and likely some amount of free air. By doing so, subsequent imaging is confounded. In humans, ultrasound detection of free fluid has a similar sensitivity and specificity to DPL for diagnosing intra-abdominal injury without the risk and iatrogenic introduction of fluid and likely air. Moreover, ultrasound has the advantage of being less invasive, is associated with fewer complications, and allows for collection of undiluted fluid samples when real time ultrasound guided abdominocentesis is performed. Fluid accumulations may become more prominent following fluid therapy and serial ultrasound may allow smaller fluid accumulations noted at presentation to be obtained via real time guidance following serial scanning.

However, in rare instances ultrasound-guided abdominocentesis may not be feasible where peritoneal fluid is present in very small quantities, is walled off, or is located in proximity to vital organs. In these situations, DPL may still prove diagnostically useful. Given the complications and possibility of failure to obtain fluid samples in and veterinary and human patients undergoing traditional DPL, the author prefers to use a modified US-guided diagnostic peritoneal lavage (MUG-DPL) technique if DPL is deemed necessary. MUG-DPL is minimally invasive, may reduce complications and increase the success rate of obtaining a fluid sample compared to blind traditional DPL techniques but does require some experience and proficiency. MUG-DPL is generally reserved for use in patients with acute abdominal pain or peritonitis with only small quantities of peritoneal fluid that cannot be aspirated by direct US-guided abdominocentesis, are unlikely to have advanced imaging, and samples of the fluid are urgently needed and cannot wait for serial US exams. In these patients, the quantity of peritoneal fluid is too small to tap or is located in proximity to vital organs that preclude direct US-guided abdominocentesis. By adding additional sterile fluid to the peritoneal cavity, it may be possible to identify and characterize small amounts of pre-existing peritoneal fluid or inflammation.

More specific details on how to perform step-by-step, indications, and more may be found in Boysen SR. Chapter 17: Ultrasound Guided Procedures *in Focused Ultrasound Techniques for the Small Animal Practitioner*, Ed. Lisciandro GR, Wiley 2014.

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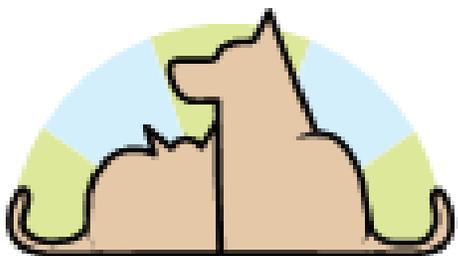


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