Global FAST Ultrasound: Patient Monitoring & Detecting Treatable Forms of Shock

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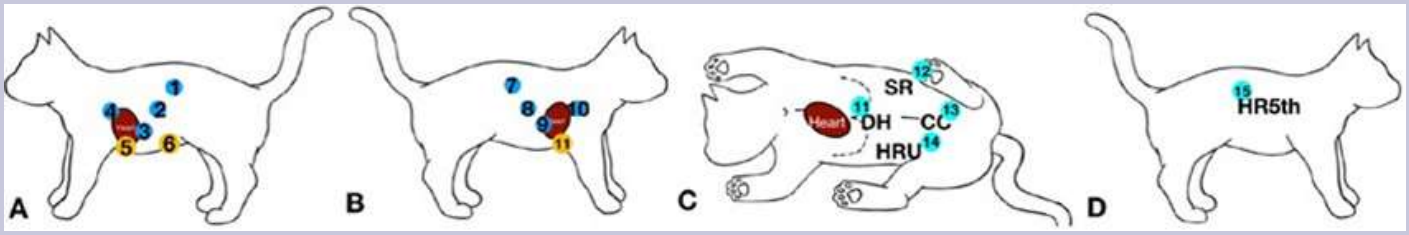
INTRODUCTION

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. TFAST was published with the use of the Diaphragmatico-Hepatic (DH) View in 2011 by the author. The DH View should always be included since avoids transthoracic air interference from lung. 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. The AFAST directs the probe more strategically into the gravity-dependent regions of each view and has its applied fluid scoring system to make more clinical relevance to a positive scan. In the same study, AFAST was performed with 4-hour serial exams with repeat AFAST scoring in all hospitalized patients (sooner if unstable). In 2014, a 3rd abbreviated lung ultrasound format was published by Lisciandro *et al*. named Vet BLUE to complement AFAST and TFAST.

Figure. Showing how to rapidly perform Global FAST on a cat and the clarity of its respective acoustic windows

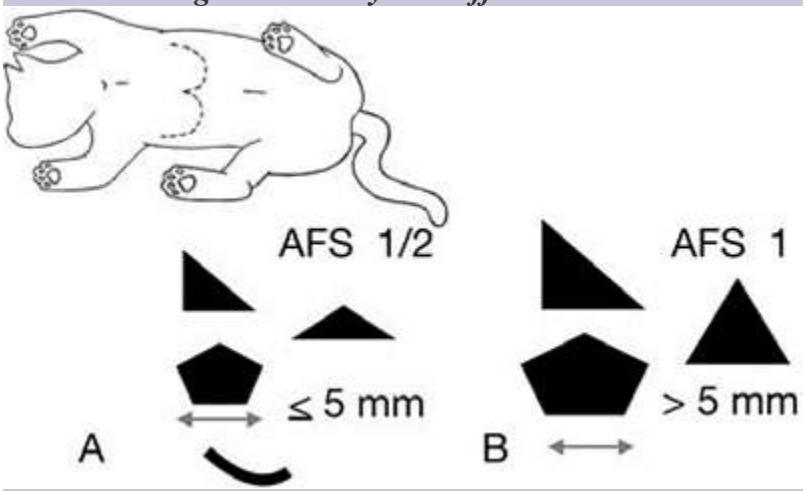


The use of this approach is standardized, and extends beyond the flash exam providing a huge amount of clinical information by properly trained sonographers. Copyright 2017, 2018 Greg Lisciandro, DVM, DABVP, DACVECC, FASTVet.com and Hill Country Veterinary Specialists and figure provided by Hannah Hey, San Antonio, Texas.

In combination, these 3 formats are called Global FAST. Global FAST provides a huge amount of clinical information (<6–9 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. The urinary bladder volume may be estimated and serial exams using our AFAST Cysto-Colic formula, and thus, with serial exams over time, non-invasively estimate urine output. A similar strategy has evolved referred to as the RUSh Exam (**R**apid **U**ltrasound in **Sh**ock) 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. In other words, Global FAST does more. 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 ordered for 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 is rapid (<6–9 minutes) with no shaving, minimal restraint (low-impact stress), an especially forgiving ultrasound imaging format for the feline patient.

GLOBAL FAST FOR PATIENT MONITORING

Figure. The abdominal fluid scoring system may be used for bleeding cats and any with effusive conditions

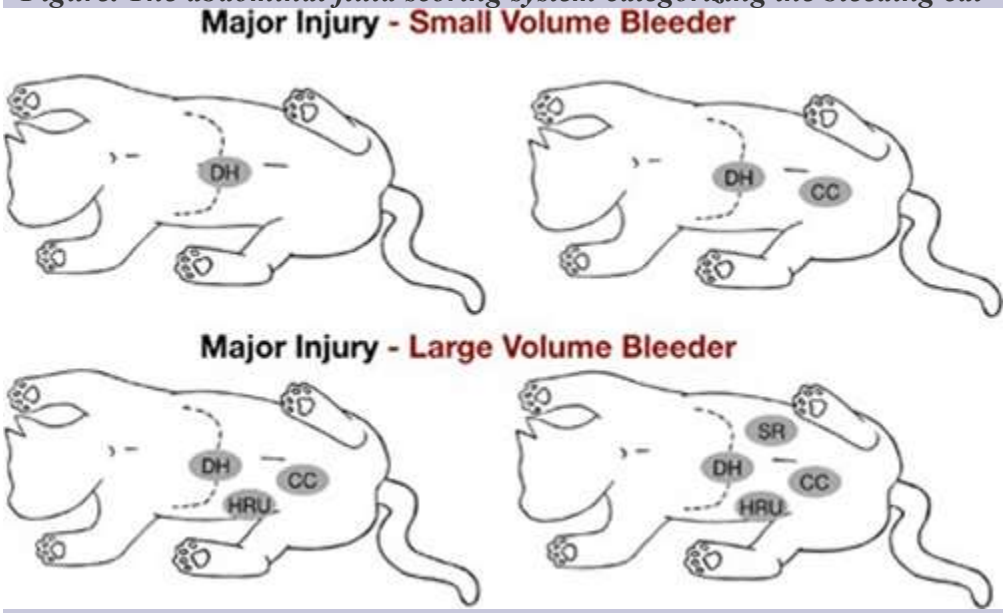


The author has published a 0–4 scoring system. Recently, the abdominal fluid scoring system has been modified assigning a score of "1/2" to smaller pockets <5 mm or thin linear fluid pockets. Copyright 2017, 2018 Greg Lisciandro, DVM, DABVP, DACVECC, FASTVet.com and Hill Country Veterinary Specialists and figure provided by Hannah Hey, San Antonio, Texas.

THE ABDOMINAL FLUID SCORING SYSTEM

Cats 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 and in many cats the entire Global FAST could be performed in standing or sternal. 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 or effusions. More recently from experience, the author has modified the AFS as a 0 or 1/2 or 1 for free fluid based on the largest dimension with an under or over 5 mm rule. Under 5 mm is a "1/2" and over a "1" with the same original AFS 1 and 2 as small volume effusions vs. AFS 3 and 4 large volume effusions.

Figure. The abdominal fluid scoring system categorizing the bleeding cat



In cases of feline hemorrhage, the fluid scoring system helps categorize intra-abdominal bleeding as major injury/pathology, small volume bleeding of AFS 1 and 2 vs. major injury/pathology, large volume bleeding, AFS 3 and 4. Small volume AFS 1 and 2 cats as a rule do not have enough intra-abdominal hemorrhage for anemia, so if they are or become anemic as an AFS 1 or 2, then preexisting anemia existed or they are losing blood somewhere else, retroperitoneal, pleural, pericardial, lung, intrapelvic, fracture sites, gastrointestinal 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 administered during 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

Figure. The TFAST Echo Views

A) Left ventricular short-axis "mushroom" view (LVSA), B) long-axis 4-chamber view (LA4CV) for the right ventricular to left ventricular ratio (RV:LV), and C) short-axis left-atrial to aortic ratio view (LA:Ao). Fallback views are also listed below each view.

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 tendineae 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; however, in real-time this can be error prone in the feline that has a higher heart rate than in dogs. Freeze the image and roll the cine ball to move through captured frames is the best way to "eyeball" chamber sizes and volume and contractility in cats. Generally, 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 status (hypovolemia) can be supported or refuted by assessing the caudal vena cava (CVC) and helps direct fluid resuscitation. Poor contractility and thickened myocardial walls trigger a complete echocardiography; however, therapy is better directed than without TFAST. Your non-echo fallback view for volume status is the caudal vena cava (CVC) and its associated hepatic veins at the FAST DH View (see below).

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 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 (CVC) and its associated hepatic veins at the FAST DH View (see below).

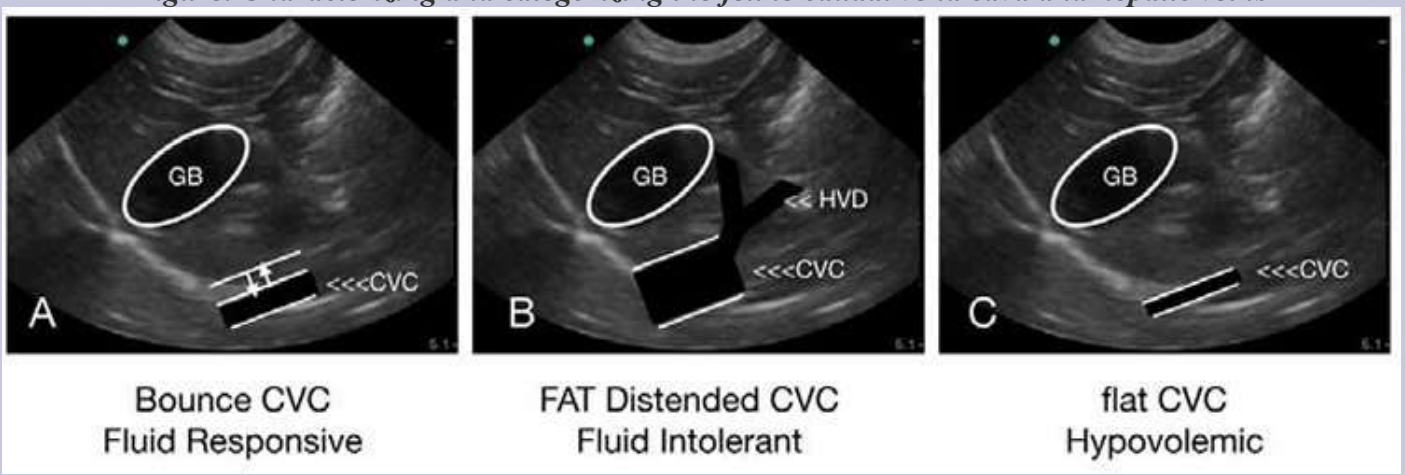
Left Ventricular Short-Axis View for the Left Atrial to Aortic Ratio (LA:Ao)

The normal LA:Ao Ratio is <1.6 in cats. This is the most challenging view to obtain, especially because the cardiac acoustic window is so tight in felines. Freeze the image and roll the cine ball to move through captured frames is the best way to "eyeball" chamber size. Your non-echo fallback strategy is performing the easier, less stressful, Vet BLUE lung ultrasound 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

Fallback Right-sided Cardiac - Characterizing the Caudal Vena Cava and Hepatic Veins

Figure. Characterizing and categorizing the feline caudal vena cava and hepatic veins



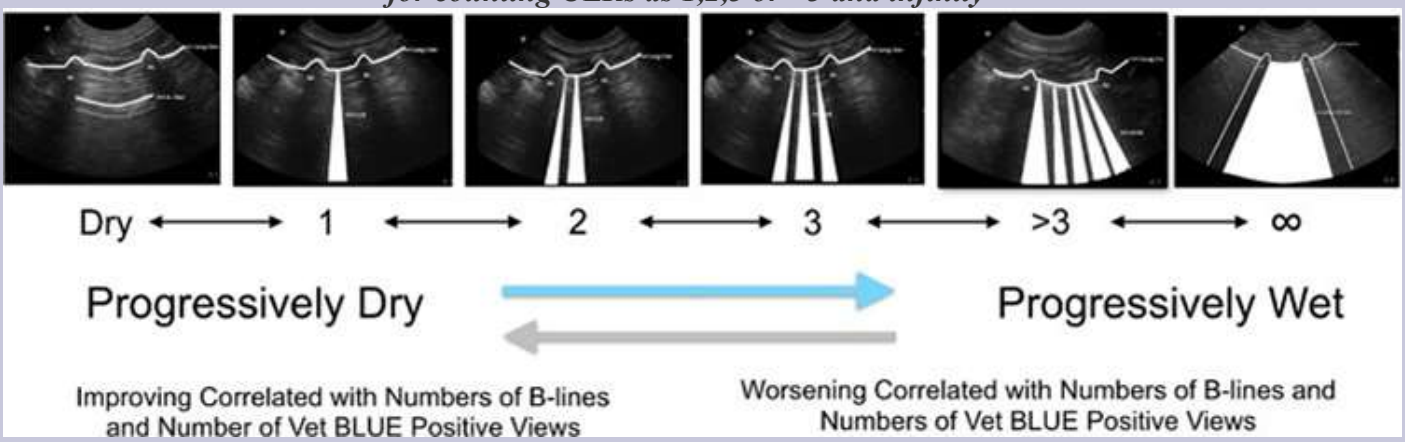
The caudal vena cava (CVC) where it traverses the diaphragm rapidly reflects preload and is your new non-invasive central venous pressure (CVP). In fact, central lines to guide fluid resuscitation have been debunked in human medicine since 2013. It is common practice in human medicine to use the analogous 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, body weight, 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 (absolute measurements and distensibility index), 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 determine maximum and minimum diameters, and calculate its distensibility index (CVCmax - CVCmin/CVCmax x 100%). The hepatic veins are not normally seen in lateral or sternal/standing, so their distension is another clue that CVP is high and that the right heart is experiencing failure/overload.

Fallback View Left-Sided Cardiac - Use of Vet BLUE – "Wet Lung" vs. "Dry Lung"

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. If you can place your stethoscope on your feline patient, you can place an ultrasound probe. Thus, acquire a baseline Vet BLUE prior to fluid therapy on all hospitalized cats.

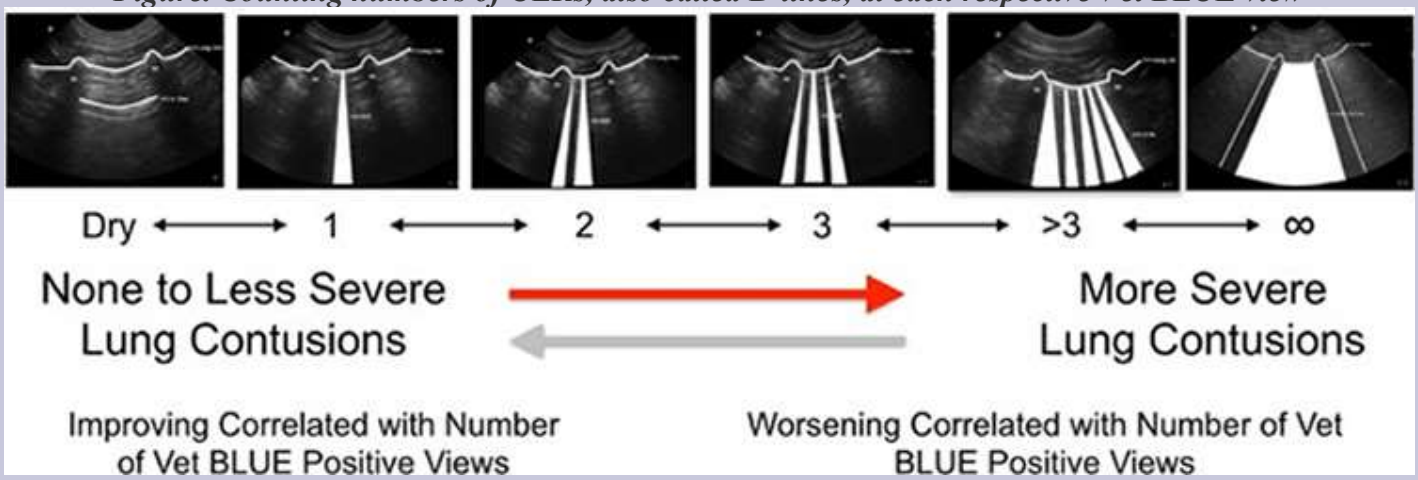
ULRs have been shown to correlate with extravascular lung water in people; thus, ULRs are sentinels for worsening respiratory status and pulmonary failure. If treatment strategy is not adjusted, then alveolar-interstitial edema may progress to alveolar flooding, which is much more difficult to treat. Using the regionally based Vet BLUE patterned approach, other causes of wet lung artifacts, such as pneumonia, PTE, can often be discriminated. Moreover, the use of Vet BLUE potentially triggers additional testing and advanced imaging.

Figure. Showing the counting scheme published by the author in several different peer-reviewed journals for counting ULRs as 1,2,3 or >3 and infinity ∞



ULRs in Trauma are Lung Contusions Until Proven Otherwise

Figure. Counting numbers of ULRs, also called B-lines, at each respective Vet BLUE view



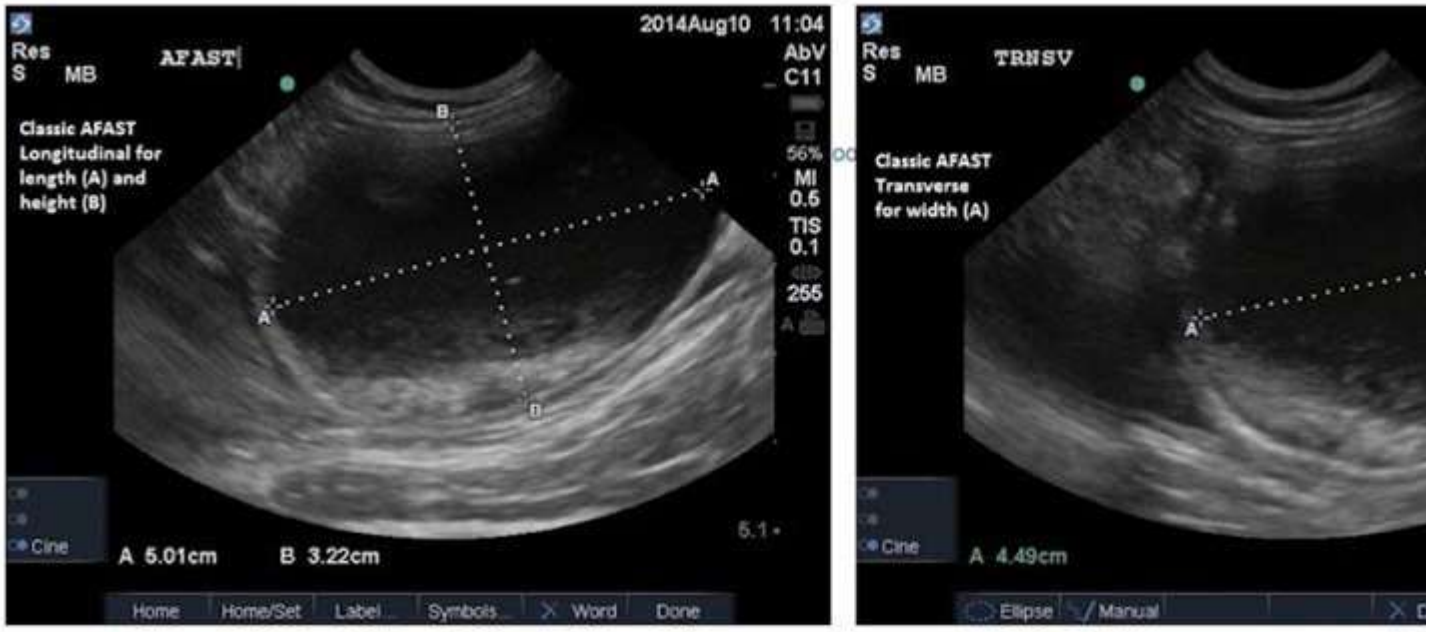
Counting numbers of ULRs, also called B-lines, at each respective Vet BLUE view and numbers of views with ULRs gives the feline patient a lung contusion score that may be monitored for progression and resolution (or static). Copyright 2014, 2018 Greg Lisciandro, DVM, DABVP, DACVECC, FASTVet.com and Hill Country Veterinary Specialists.

Figure. ULRs evident at the FAST Diaphragmatico-Hepatic (DH) View

Counting numbers of ULRs (see Figure above) and total positive Vet BLUE Views allows for a "lung contusion score." Copyright 2012, 2018 Greg Lisciandro, DVM, DABVP, DACVECC, FASTVet.com and Hill Country Veterinary Specialists.

THE URINARY BLADDER VOLUME FORMULA

Figure. AFAST Cysto-Colic (CC) View

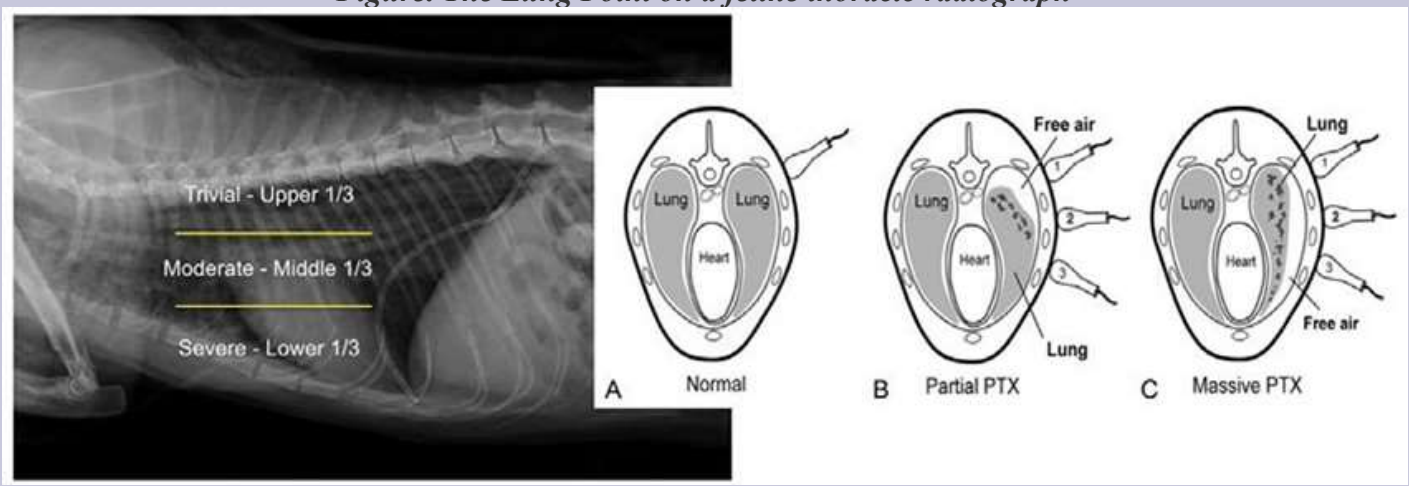


AFAST Cysto-Colic (CC) View showing the acquired measurements of L x H and then W using the longitudinal (sagittal) and transverse planes. Copyright 2012, 2018 Greg Lisciandro, DVM, DABVP, DACVECC, FASTVet.com and Hill Country Veterinary Specialists. Lisciandro and Fosgate, *JVECC* 2017.

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 centimeters (cm) will give you an estimation of urinary bladder volume in milliliters (ml) by using Length x Width x Height x 0.625. With measurements over time, urine output can be non-invasively estimated in cats that are often problematic in placing urinary collection systems (require sedation/anesthesia, require more expertise - more in females than males, invasive, stressful).

USE OF THE LUNG POINT FOR MONITORING PNEUMOTHORAX (PTX)

Figure. The Lung Point on a feline thoracic radiograph



The Lung Point on a feline thoracic radiograph showing how the 1/3s concept helps categorize as trivial, moderate and severe and serves as a point-of-care monitoring tool. Copyright 2012, 2016, 2017, 2018 Greg Lisciandro, DVM, DABVP, DACVECC, FASTVet.com and Hill Country Veterinary Specialists. This material is reproduced and modified with permission of John Wiley & Sons, Inc. *Focused Ultrasound Techniques for the Small Animal Practitioner*. Wiley © 2014. Lisciandro *JVECC* 2011.

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, thoracostomy (chest) tube placement/removal, or other invasive thoracic procedures, the Lung Point in the author's experience 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. Clinical judgment is required to maximize decision-making; however, in cats with increased work of breathing why delay the thoracocentesis?

GLOBAL FAST FOR RAPID DETECTION OF TREATABLE FORMS OF SHOCK AND CPR

Figure. The Hs and Ts for rapidly detecting treatable forms of shock and CPR

The Hs Evaluated for Using Venous Blood Gas, Physical Exam, Vital Signs and Global FAST·	The Ts Evaluated for Using Global FAST·
Hypothermia	**Tension PTX**
Hypotension	**Trauma, Hemorrhage**
Hypovolemia	**Thrombo-Embolism (PTE, DVT, ATE)**
Hyperkalemia, Hypokalemia	**Tamponade, PCE**
Hypoglycemia	**Toxin, Anaphylaxis**
Hydrogen Ion (Acidosis)	
Hypertension, Pulmonary (PHT)	
Hypocontractility, DCM	
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Modified from the American Heart Association Guidelines.

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 cats (sooner is unstable or questionable status); and the author incorporates Global FAST as part of daily rounds immediately after a thorough complete physical exam.

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