Global Fast℠ Use for Patient Monitoring During Resuscitation and for the Rapid Detection of Treatable Causes of Shock and CPR

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Gregory R. Lisciandro, DVM, DABVP, DACVECC
Hill Country Veterinary Specialists and FASTVet.com, Spicewood, TX, USA

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; AFAST directed the probe more strategically into the gravity-dependent regions of each view; 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® and has been part of 4 published peer-reviewed clinical studies at this time. In combination, these 3 formats, AFAST®, TFAST®, and Vet BLUE® 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 or 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, gastrointestinal tract, or externally, respectively. On the other hand, large-volume bleeders of AFS 3 and 4 are 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 and post-interventional cases, including those with percutaneous needle and Tru-Cut biopsies. Patient AFS helps make better decisions regarding ongoing bleeding, resolving bleeding, and need for blood transfusion and/or exploratory laparotomy.

TFAST Right Pericardial Echo Views - Volume, Contractility, Right- and Left-Sided Problems

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" are 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) - Right-Sided Problems

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).

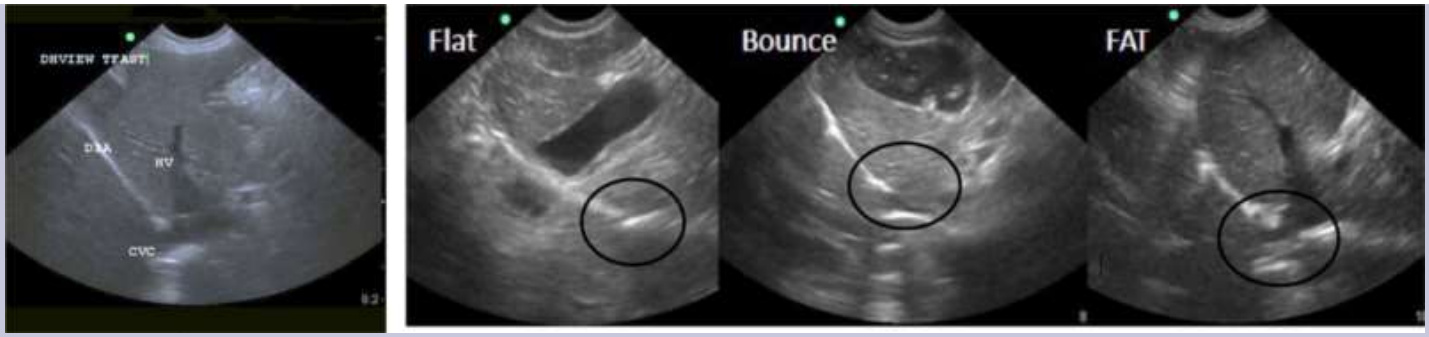
Left Ventricular Short-Axis View for the Left Atrial to Aortic Ratio (LA:Ao) - Left-Sided Problems

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 noninvasive 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; however, this is unknown. The hepatic veins are not normally obvious in lateral or sternal/standing, so their distension is another clue that CVP is high <10 cm H_2O).



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. © 2015 Gregory Lisciandro, Hill Country Veterinary Specialists and FASTVet.com

Use of Vet BLUE - "Wet Lung" vs. "Dry Lung"

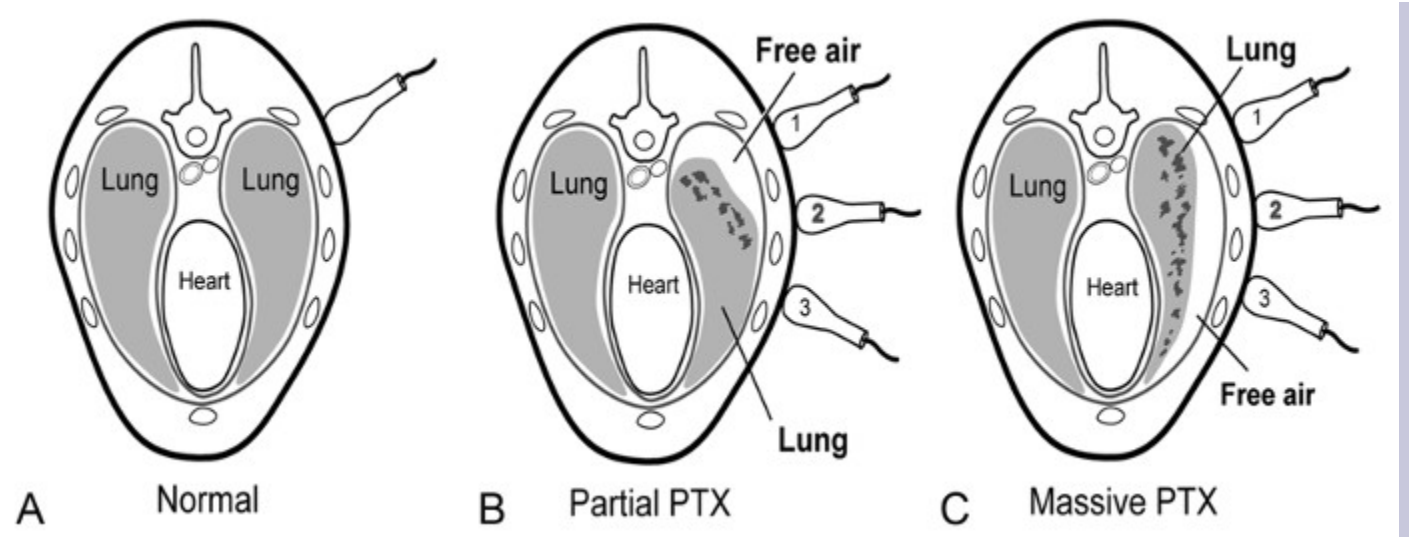
Because the "wet lung" vs. "dry lung" concept is easily recognized during Vet BLUE, in other words the presence or absence of ultrasound lung rockets (ULRs) also called B-lines, it provides important clinical information regarding left-sided cardiac status and left-sided volume overload. Moreover, Volpicelli *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, the savvy clinician acquires a baseline Vet BLUE prior to fluid therapy and any interventions on all small animal patients. ULRs have been shown to correlate with extravascular lung water, and thus are sentinels for worsening respiratory status, volume overload, 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 otherwise missed, optimizing patient care.

Showing the counting scheme published by the author for counting ULRs as 1, 2, 3, or >3 and infinity ∞. © 2015 Gregory Lisciandro, Hill Country Veterinary Specialists and FASTVet.com

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 (length and height), followed by transverse orientation and acquiring the largest oval (width) and measuring it. Measurements in cm will give you an estimation of urinary bladder volume in ml by using length x width x height x 0.625 (Lisciandro and Fosgate, *JVECC* 2016). With measurements over time, urine output can be noninvasively estimated.

Use of the Lung Point for Monitoring Pneumothorax (PTX)



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, chest tube placement/removal, or other invasive thoracic procedures, the Lung Point quantifies 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 in addition to the location of the Lung Point.

Baseline Admission Global FAST and Serial Exams are Key

The repeating of Global FAST exams, referred to as 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.

PARADIGMS ARE CHANGING WITH THE USE OF GLOBAL FAST

The New Central Venous Pressure is Via Ultrasound

In 2013 (4 years ago!), measurement of central venous pressure (CVP) via central venous catheters for guiding fluid therapy was debunked in human medicine, because the practice is unreliable (Marik *et al*. *CCM* 2013). The noninvasive use of ultrasound for volume assessment has become an accepted and popular means to assess preload and is our new central venous pressure assessment. During AFAST or TFAST, both use the subxiphoid, diaphragmatico-hepatic (dh) view, at which the caudal vena cava (CVC) is readily imaged as it traverses the diaphragm. The use of the characterization of the CVC and its associated hepatic veins for hepatic venous distension now screen for right-sided heart problems - e.g., right-sided failure, pulmonary hypertension, and pericardial effusion.

The New Way to Assess Patients with Imminent Cardiopulmonary Arrest (CPA) and During CPR is Ultrasound

The use of ultrasound to prevent CPA in patients that have unexplained or undifferentiated shock has been developed and called the RUSh exam (RUSH=**R**apid **U**ltrasound in **Sh**ock). Global FAST accomplishes everything RUSh does and more, through its abdominal fluid scoring system, more comprehensive lung evaluation (Vet BLUE), and a urinary bladder volume estimation formula gained at the AFAST cysto-colic (CC) view.

Knowing Your American Heart Association Hs and Ts for Rapidly Detecting Treatable Conditions During CPR or Imminent CPA

The veterinary profession should be well commended for standardizing CPR guidelines through RECOVER. However, the reason why your patient is going to experience CPA, or why you are doing CPR in the first place, has been overlooked. Global FAST can rapidly detect treatable causes for imminent CPA and help rapidly detect treatable causes for CPR when minutes count and decisions need to be made over traditional assessment without ultrasound. In other words, Global FAST is an approach that rapidly detects treatable conditions that point-of-care easily missed or only suspected based on traditional means of physical exam, laboratory testing, and radiography. The RUSh exam in human medicine was developed for these same reasons.

Global FAST Rapidly Evaluates the Hs & Ts of the American Heart Association Guidelines for Treatable Causes of CPR

The author has modified the AHA Hs and Ts to fit small animal veterinary medicine. The Ts are ruled out as follows: **T**ension PTX by presence of A-lines without a Glide Sign and the search for the Lung Point; **T**rauma Hemorrhage through the detection of free fluid in the intra-abdominal cavity, the retroperitoneal space, the pleural cavity and the pericardial sac, and the presence of ULRs during Vet BLUE in trauma patients; P**T**E is diagnosed by the severe dilation of the RV during TFAST and the RV:LV Ratio, and/or the presence of the Wedge Sign during Vet BLUE; and **T**amponade at the FAST DH View with or without additional PCS views; and **T**oxin-Anaphylaxis by the observation of the gallbladder halo sign, intramural edema causing striation of the gallbladder wall. However, gallbladder wall edema is not pathognomonic for canine anaphylaxis. A chart with the causes for gallbladder wall edema is available at the FASTVet Facebook page (Facebook.com/FASTVet). If you use a pensive mind in reviewing the chart below, all these Hs and Ts may be addressed with a thermometer, a venous blood gas, and Global FAST in less than minutes. Global FAST changes CPR teaching paradigms.

Use of Global FAST for rapidly ruling out your Hs and Ts in patients nearing CPA and during CPR modified from AHA CPR guidelines

Knowing Your Hs and Ts During Cardio-Pulmonary Arrest and Advanced Life Support	
The Hs Evaluated for Using Venous Blood Gas, Physical Exam, Vital Signs	**The Ts** Evaluated for Using Global FAST
Hypothermia	**Tension PTX** (TFAST)
Hypotension (AFAST, TFAST, Vet BLUE)	**Trauma, Hemorrhage** (AFAST, TFAST, Vet BLUE)
Hyperkalemia, Hypokalemia	**Thrombo-embolism (PTE)** (TFAST, Vet BLUE)
Hypoglycemia	**Tamponade, PCE** (TFAST, FAST DH View)
Hydrogen Ion (Acidosis)	**Toxin, Anaphylaxis** (FAST DH View)

THE USE OF GLOBAL FAST FOR PATIENT VOLUME STATUS AND MONITORING

Breaking it Down to Volume and Contractility, Right-Sided and Left-Sided Cardiac Function

The Global FAST strategy for left- and right-sided cardiac function is accomplished through both echo and non-echo views. Non-echo strategies are especially important because echo views can be difficult to acquire in many critically unstable patients.

General Cardiac Function and Status

- Left ventricular short-axis view by observing at the level immediately below the mitral valves where M-mode is used for cardiac measurements contractility and left ventricular filling.

Left-Sided Heart Function

- **Echo view**: the left atrial to aortic ratio (LA:Ao) on short-axis view referred to as the "quick peek" view. In dogs the ratio should be <1.3 and in cats <1.6.

- **Non-echo view**: the use of Vet BLUE and finding of absent B-lines all fields or no ULRs all fields, which we refer to as "dry lung all fields." The use of the Vet BLUE strategy is very helpful in critical and fragile patients in which it is initially too risky to obtain the echo view(s).

Right-Sided Heart Function

- **Echo view**: the right ventricular to left ventricular ratio (RV:LV). In dogs and cats, the ratio should be 1:3–4.

- **Non-echo view**: the use of the FAST DH view and characterization of the caudal vena cava (CVC) and hepatic veins. In dogs and cats, the hepatic veins should not be obvious at the FAST DH view. The CVC should have a dynamic change to its diameter we refer to as a "bounce" when central venous pressure (CVP) is in the normal range; flat and of small diameter with no dynamic change in hypovolemia or low CVP; and fat or distended with no dynamic change along with distended hepatic veins in hypervolemia or high CVP.

THE USE OF GLOBAL FAST FOR SHOCK AND THE HYPOTENSIVE PATIENT

Use of Global FAST for rapid assessment and monitoring of the critical dog and cat modified from the RUSH exam[14]

Global FAST Evaluation	Hypovolemic Shock	Cardiogenic Shock	Obstructive Shock	Distributive Shock
Pump – How Contracting? **Inotropy**	**Works** Hypercontractile Heart Small Chamber Size Dry Lung	**Deficient** Hypocontractile Heart Dilated Heart Wet Lung	**Works -Overloaded** Hypercontractile Heart PCE/Tamponade RV Strain (Increased RV:LV) When PTE, Cardiac thrombus Dry >> Wet Lung	**Works – Deficient** Hypercontractile Heart (early sepsis) Hypocontractile Heart (late sepsis) Dry > Wet Lung
Tank – How Full? **Volume**	**Empty** Flat CVC Flat jugular veins Dry Lung	**Overfilled** Distended CVC Distended jugular vein ULRS (lung edema) Wet Lung	**Overfilled** Distended CVC Distended jugular PTX (A-lines and no Glide Sign) Dry or Wet Lung	**Empty or Overfilled** Normal or small CVC (early sepsis) Peritoneal fluid (exudate/sepsis source) PE (exudate/ sepsis source) Dry or Wet Lung
Pipes – Leaky?	**Leaky** Peritoneal fluid (loss) PE (loss) *Splenic or other intra-abdominal bleeding tumor	**Normal** Peritoneal fluid (ascites) PE	**Obstructed** Thrombo-embolism	**Leaky Or Distended** ARDS 3rd Spacing
Comments	Use Vet BLUE and AFS	Use Vet BLUE and AFS	Vet BLUE Can Detect PTE	Vet BLUE and TFAST Can Detect Non-cardiogenic Edema

WHAT THE GLOBAL FAST APPROACH HAS OVER THE RUSH EXAM

Abdominal Fluid Scoring System

The abdominal fluid scoring system is a 0–4 system in which negative for fluid at all 4 AFAST views is a 0, and positive based on numbers of views ranges from 1–4. Abdominal fluid score (AFS) helps in discriminating

between small volume bleeders that will not become anemic (AFS 1,2 - not enough blood volume in the abdominal cavity) and large volume bleeders (AFS 3,4 - marked blood volume in the abdominal cavity) that predictably become anemic. The use of the AFS is very helpful in the following terms: an AFS 1,2 that remains an AFS 1,2 on serial exams will not bleed to death if there are no other sites of bleeding; and AFS 1,2 that is anemic is bleeding somewhere else or has preexisting anemia; and an AFS 3,4 has significant bleeding and will usually become anemic in time and, depending on fluid resuscitation strategies, may need blood transfusion and depending on what subset of patients, may need exploratory surgery.

The Vet BLUE Exam

The rapid pattern-based regional approach of Vet BLUE helps detect lung problems that may be occult on physical exam and radiography. Vet BLUE is an 8-view extension off the TFAST chest tube site view and has been shown to be an effective means to accurately diagnose many common respiratory conditions point-of-care upon presentation, safely without the stress and delay of radiographic imaging. In the human emergency and critical care the axiom is no unstable patient goes to radiology because death begins in radiology. TFAST, Vet BLUE help minimize such patient risk and better direct care with evidence-based information through point-of-care with minimal restraint patient imaging.

The Use of Our AFAST CC Urinary Bladder Volume Estimation Formula

By measuring the urinary bladder in centimeters during the AFAST CC view, the formula, length x width x height x 0.625 will give you an estimation of urine volume; thus, over time, urinary output may be estimated (Lisciandro and Fosgate, *JVECC* 2016).

Baseline Admission Global FAST and Serial Exams Are Key

The repeating of Global FAST exams, called serial exams, cannot be overemphasized. Minimally a 4-hour post-admission exam should be performed in all hospitalized patients, and the author incorporates Global FAST as part of daily rounds immediately after a complete physical exam. It's standard of care in human medicine for at-risk bleeding patients since 2001.

Summary of Global FAST for Patient Volume Status and CPR and ALS

The use of the Global FAST is an effective, point-of-care evaluation that is noninvasive and low risk for critical patients providing invaluable information for patient volume status during resuscitation and during advanced life support (ALS) post-CPR. Furthermore, Global FAST should be used as standard of care for rapidly surveying for treatable and reversible causes of uncharacterized hypotension/shock and CPR. By incorporating Global FAST, many conditions missed by traditional training without ultrasound are detected, and clinical course is modified and adjusted earlier in their course, and as a result, lives are saved, complications better avoided, and next best tests are better determined.

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Gregory R. Lisciandro, DVM, DABVP, DACVECC
Hill Country Veterinary Specialists & FASTVet.com
Spicewood, TX, USA