CHAPTER TWO

The Abdominal FAST^3 (AFAST^3) Exam

Gregory R. Lisciandro

Introduction

A focused assessment with sonography for trauma (FAST) exam was prospectively validated in traumatized dogs by Boysen in 2004. The Boysen (2004) study documented that intra-abdominal injury, and more specifically, hemoabdomen, was far more frequent than previously reported prior to FAST (38%–45% with FAST vs. 12%–23%) (Boysen 2004). The abdominal FAST exam was again prospectively studied in dogs in 2009 (Lisciandro), and findings supported the conclusions of the 2004 study (Boysen) when a higher rate of intra-abdominal injury was again detected (hemoabdomen rate of 27%). The term “AFAST” (abdominal FAST) was coined to better designate the performed FAST scan because the same group was concurrently developing a novel thoracic FAST scan, which they named “TFAST” (thoracic FAST) (Lisciandro 2008). The same prospective AFAST study (Lisciandro 2009) validated an AFAST-applied abdominal fluid scoring system used initially and serially (four hours post admission) in all hospitalized dogs for semi-quantitating volume of intra-abdominal hemorrhage.

Additionally, the Lisciandro (2009) study found that the initial and serial AFAST-applied fluid scoring system reliably predicted the degree of anemia in dogs with hemoabdomen, differentiating lower-scoring “small bleeders” from higher-scoring “big bleeders.” They also found that abdominal radiographic (AXR) serosal detail was a poor predictor for the presence of free fluid. In fact, 24% of cases with normal AXR serosal detail were AFAST positive, and 32% of decreased AXR serosal detail were AFAST negative.

Moreover, AFAST and the use of the patient’s abdominal fluid score (AFS) were invaluable for detecting developing hemoabdomen (initially negative turned AFAST positive), ongoing hemorrhage (increasing fluid score), and resolution of hemoabdomen (decreasing fluid score). Finally, higher-scoring big bleeder (AFS 3, 4) dogs not only predictably became anemic vs. lower-scoring small bleeder dogs (AFS 1, 2), but they were also were more likely to need blood transfusions. The investigators, comparing their results to the 2004 study, surmised that because of the lower transfusion rates in their case population of hemoabdomen dogs, attending veterinarians were likely more judicious in administering fluid therapy during the resuscitation phase of treatment by knowing that their dog had a positive score consistent with hemoabdomen within minutes of presentation at triage. It has been clearly shown in bleeding humans that graduated fluid therapy titrated to more conservative end points minimizes exacerbation of hemorrhage, reducing the probability of the “pop the clot” or re-bleeding phenomenon.

It is noteworthy that dogs with pneumothorax, pelvic fractures, and high alanine transaminase (ALT) were more likely to concurrently have or develop hemoabdomen on either their initial or serial AFAST examinations than dogs without these findings (Lisciandro 2009). AFAST was additionally used to survey for intrathoracic trauma through the acoustic window of the liver and gallbladder via the diaphragmatico-hepatic (DH) view, as previously found (Boysen 2004). The serial use of AFAST was also helpful in determining the integrity of the urinary bladder; both FAST studies found that when the urinary bladder was imaged with a normal contour, it was unlikely to be ruptured. Using AFAST imaging of the urinary bladder, pre and post resuscitation, proved very helpful because the presence of a urinary bladder without using

Focused Ultrasound Techniques for the Small Animal Practitioner, First Edition. Edited by Gregory R. Lisciandro.

ultrasound has been traditionally difficult to determine by physical examination, catheterization, and with plain radiography in trauma patients (Boysen 2004, Lisciandro 2009).

Since studying AFAST applied to trauma, the clinical utility of the AFAST scan and its applied fluid scoring system have been found to be helpful for many non-traumatic and post-interventional subsets of patients including those suffering from anaphylaxis, pericardial effusions and tamponade, pleural effusions, and non-traumatic hemoabdomen; for early detection of hemorrhage; and for all forms of peritonitis in presenting and post-interventional cases. Thus, the proposed nomenclature for the AFAST exam has morphed to AFAST^3—a beyond-trauma ultrasound scan that rapidly provides important clinical information to better treat our veterinary patients. The "T^3" now signifies AFAST^3 use for trauma, triage, and tracking (monitoring) (Lisciandro 2011).

In conclusion, FAST is the standard of care for blunt trauma and non-traumatic uncharacterized hypotensive subsets of human patients. A local trauma surgeon a few years ago remarked that he performed 12–18 FAST exams on most busy weekend nights. Likewise, AFAST^3 and its sister techniques of TFAST^3 and Vet BLUE (chapters 9 and 10) need to be moved to the forefront of veterinary trauma and triage algorithms (Lisciandro 2011).

What AFAST^3 and AFS Can Do

- Detect free fluid in small amounts superior to physical examination and abdominal radiography and comparable to the gold standard of computerized tomography (CT)
- Anticipate the degree of anemia in traumatized hemorrhaging dogs without pre-existing anemia by applying an abdominal fluid score (AFS). AFS of 1 and 2 = "small bleeders"; AFS 3 and 4 = "big bleeders." (AFS acquired by using the AFAST^3–applied abdominal fluid scoring system [0–4])
- Anticipate the degree of anemia in dogs with non-traumatic hemoabdomen (ruptured mass, coagulopathic) using the same principles of "small bleeder" (AFS 1 and 2) vs. "big bleeder" (AFS 3 and 4). The AFS works similar to bluntly traumatized dogs in predicting the degree of anemia in this subset of canine patients
- Predict the degree of anemia using the "small bleeder" vs. "big bleeder" concept in post-interventional (percutaneous biopsy, laparoscopy) and post-surgical (ovariohysterectomy, splenectomy, adrenalectomy, liver lobectomy, nephrectomy, gastrointestinal surgery, bladder surgery, etc.) subsets of small animal patients. AFS helps with decision making regarding re-exploration and other supportive (blood transfusions) and corrective interventions (ligate the bleeder[s])
- Be used serially post-interventionally (percutaneous biopsy, laparoscopy) and post-surgically (ovariohysterectomy, splenectomy, adrenalectomy, liver lobectomy, nephrectomy, gastrointestinal surgery, bladder surgery, etc.) in cases at-risk for peritonitis and other effusive conditions
- Be used serially to monitor for development of previous occult hemorrhage (AFS negative turned positive), ongoing worsening hemorrhage (increasing AFS), or resolution (decreasing AFS) of hemorrhage by tracking AFS over time in all at-risk cases or clinically affected small animals
- Detect clinically significant pleural and pericardial effusions in most instances through the AFAST^3 diaphragmatico-hepatic (DH) view
- Detect retroperitoneal effusion through the spleno-renal (SR) and hepato-renal (HR) views
- Be used to screen for anaphylaxis in dogs by observation of the gallbladder double rim or "halo sign"; however, the sonographer should have a working understanding of the causes of false positives
- Be used to assess volume status and right-sided cardiac function by subjectively evaluating caudal vena caval size and for the presence of hepatic venous distension via the AFAST^3 diaphragmatico-hepatic (DH) view
- Increase the sensitivity of AFAST in all subsets of patients via serial examinations; a four-hour post-admission exam is minimally warranted in all at-risk hospitalized cases

What AFAST^3 and AFS Cannot Do

- Cannot ultrasonographically characterize fluid; thus, sample acquisition via abdominocentesis or diagnostic peritoneal lavage or modified ultrasound-guided (MUG) peritoneal lavage (Chapter 17) is needed when appropriate
- In penetrating trauma, AFAST^3 lacks sensitivity (in contrast to blunt trauma where sensitivity is high) but is probably very specific for intra-abdominal and retroperitoneal injury, similar to human studies

- AFAST³ potentially may miss peritonitis in dehydrated or hypotensive patients and thus should always be used in serial fashion post-resuscitation and rehydration out to 12–24 hours post admission
- AFAST³ cannot reliably predict the degree of anemia in bluntly traumatized cats, and large volumes of intra-abdominal fluid are more likely to be due to uroabdomen

Indications for the AFAST³ and AFS Exam

- All blunt trauma cases as standard of care for screening for intra-abdominal injury
- All collapsed (both recovered and unrecovered cases) with unexplained hypotension, tachycardia, or mentation changes
- All anemic cases
- All "ain't doing right" (ADR) cases
- All post-interventional, post-surgical cases at-risk for bleeding
- All post-interventional, post-surgical cases at-risk for peritonitis and other effusions
- All peritonitis suspects for expedient diagnosis through the detection of free fluid (and sampling, testing as deemed appropriate)
- Add-on for abdominally-related focused or COAST³ Exams to ensure that forms of peritonitis and pleuritis, or presence of bleeding, is not missed by traditional means

Objectives of the AFAST³ and AFS Exam

- Perform the classic AFAST³ views and apply the fluid scoring system
- Apply the "small bleeder" vs. "big bleeder" concept to non-traumatic and traumatic hemoabdomen cases to better direct definitive therapy (medical vs. surgical)
- Recognize the gallbladder "halo sign" and recognize the major causes of false positives
- Recognize pleural and pericardial effusion via the diaphragmatico-hepatic (DH) view
- Recognize retroperitoneal free fluid
- Recognize caudal vena caval size and distended hepatic veins at the DH view
- Be familiar with false positives and false negatives at each AFAST³ site

How to Do an AFAST³ Exam

Ultrasound Settings and Probe Preferences

Standard abdominal settings with depth adjustment to visualize the standardized views are outlined below. A curvilinear (or linear) probe with a range of 5–10 MHz is usually acceptable for most dogs and cats.

Patient Positioning

Fur is generally not shaved but rather parted for probe-to-skin contact with the use of alcohol and/or gel. Alcohol should not be used if electrical defibrillation is anticipated (poses serious fire hazard). The clinician should be aware that alcohol may physically cool and be noxious to some patients, and cause probe head damage (Figure 1.13).

> By not shaving (or limiting shaving to small viewing windows), the cosmetic appearance of the patient is preserved (happier clients), the exam time is lessened, and imaging quality is sufficient with most newer ultrasound machines (median time less than three minutes) (Lisciandro 2009, 2011).

Right lateral recumbency is generally preferred for AFAST³ because it is standard positioning for electrocardiographic and echocardiographic evaluation (Figure 2.1). Moreover, the left kidney (a window into the retroperitoneal space) at the SR view, and the gallbladder at the DH view (by directing the probe slightly downward toward the table top), are readily and consistently imaged on nearly every exam. Right lateral recumbency is arguably better for abdominocentesis because the spleen lies anatomically on the left side of dogs and cats. Left lateral recumbency may be used in cases in which injury prohibits right lateral positioning, or the right retroperitoneal space warrants imaging.

> Modified sternal recumbency positioning may be used for AFAST³ in stressed patients by allowing the forelegs to be in sternal position and moving the hind legs together (placed on the same side as the sonographer) laterally.

Dorsal recumbency should never be used for several important reasons including (Sigrist 2011, Lisciandro 2011):

- The lack of validation of the AFAST-applied fluid scoring system (not validated in either dorsal or sternal recumbency)

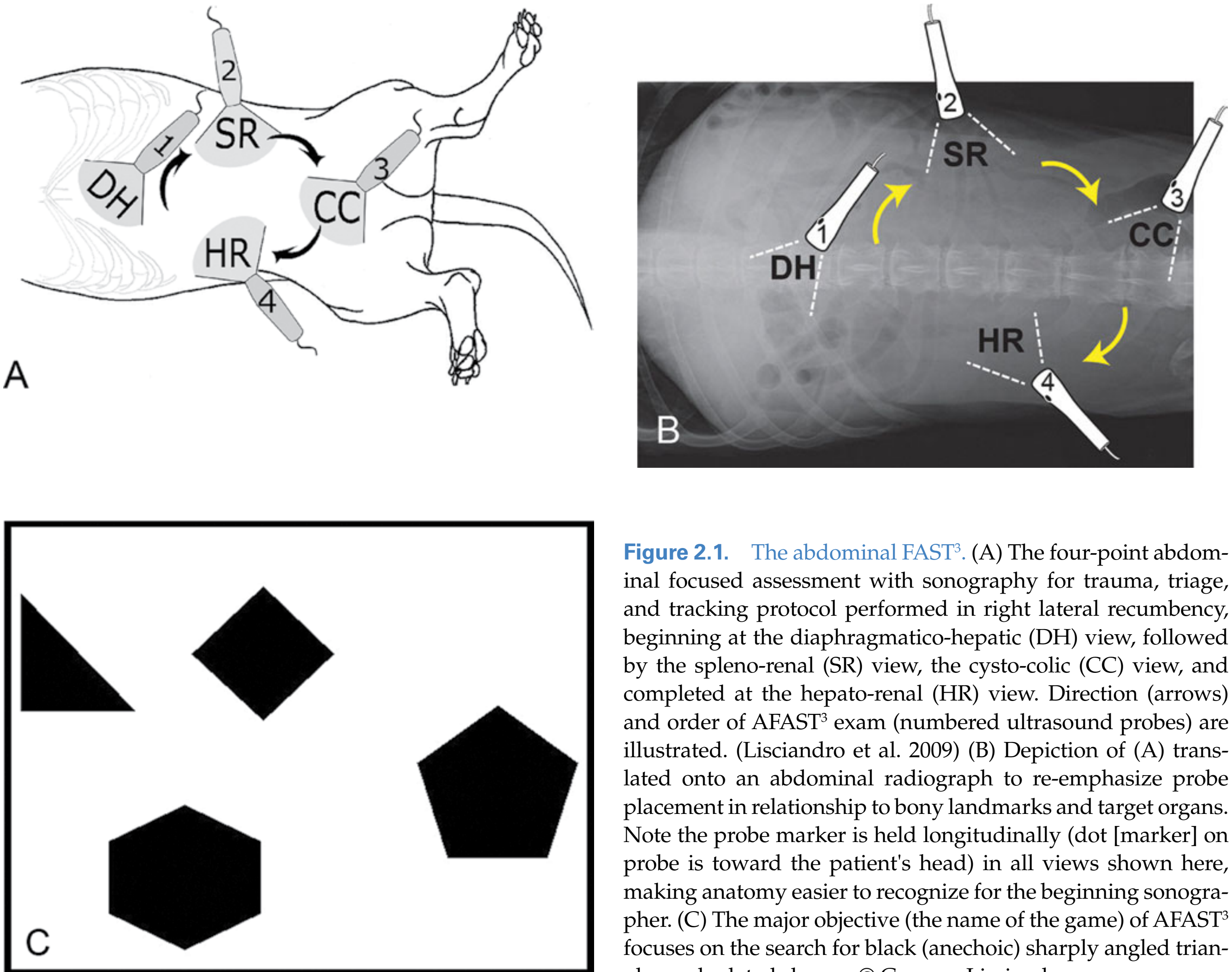


Figure 2.1. The abdominal FAST^3. (A) The four-point abdominal focused assessment with sonography for trauma, triage, and tracking protocol performed in right lateral recumbency, beginning at the diaphragmatico-hepatic (DH) view, followed by the spleno-renal (SR) view, the cysto-colic (CC) view, and completed at the hepato-renal (HR) view. Direction (arrows) and order of AFAST^3 exam (numbered ultrasound probes) are illustrated. (Lisciandro et al. 2009) (B) Depiction of (A) translated onto an abdominal radiograph to re-emphasize probe placement in relationship to bony landmarks and target organs. Note the probe marker is held longitudinally (dot [marker] on probe is toward the patient's head) in all views shown here, making anatomy easier to recognize for the beginning sonographer. (C) The major objective (the name of the game) of AFAST^3 focuses on the search for black (anechoic) sharply angled triangles and related shapes. © Gregory Lisciandro

- The high risk to compromised trauma patients (prevalence of thoracic injury and hemoabdomen is high, approximately 50%–60% and 27%–45%, respectively, in dogs with vehicular trauma)
- The stress it causes in respiratory-compromised and hemodynamically fragile non-trauma patients

Naming and Order of the AFAST^3 Views

The AFAST^3 sites in preferred right lateral recumbency are named according to target organs and are pursued in a counterclockwise order as follows (Figure 2.1):

1. Diaphragmatico-hepatic (DH) view, or "designated hitter" site, because the DH view is part of both the AFAST^3 and TFAST^3 exams for intra-abdominal and intrathoracic imaging, serving as an acoustic window into the pleural and pericardial spaces
2. Spleno-renal (SR) view, also used as a window into the retroperitoneal space
3. Cysto-colic (CC) view
4. Hepato-renal (HR) view, or "home run" site because it completes the AFAST^3 exam and is a favorable site for abdominocentesis

Internal ultrasonographic anatomy is better appreciated by imaging using the target-organ approach, and thus the sonographer is building focused ultrasound skills on every AFAST^3 exam.

For beginners, all AFAST^3 sites are imaged in longitudinal view with the marker of the probe directed toward the patient's head. In longitudinal orientation, target organs appear in a more recognizable view (than transversely) for the novice. Furthermore, the single longitudinal view is supported by a previous FAST study in which longitudinal and transverse views matched 399 out of 400 views (Boysen 2004).

Stay in longitudinal orientation while fanning with your probe when learning AFAST^3 because abdominal organs are more recognizable (than transverse orientation).

AFAST^3 Diaphragmatico-Hepatic View

The classic DH view (nicknamed the "designated hitter" because the DH is part of AFAST^3 and TFAST^3 and is used for intra-abdominal and intrathoracic imaging) initially begins with longitudinal placement of the probe (marker toward the head) immediately caudal to the xiphoid process. The probe is directed toward the patient's head (Figure 2.2A) and the gallbladder "kissing" the diaphragm is imaged by keeping the probe toward the head and scanning slightly downward toward the table top (Figure 2.2B).

The gallbladder wall and its shape should be noted, and the gain may be adjusted based on the echogenicity of its luminal contents for the remainder of the AFAST^3 exam.

In the event the gallbladder is not visualized, its rupture or displacement (diaphragmatic herniation) should be considered in light of the patient's history, presenting complaint, other diagnostic findings, and major rule outs (see Figures 3.2E and F, 3.14D, and 9.21).

Once this classic DH view is appreciated, fanning upward away from the table top through the liver lobes while keeping the diaphragm in view and maintaining its depth into the thorax during the scanning is optimal (Figure 2.2C). In low-scoring dogs, one of the most common positive sites is the DH view (along with the CC view).

Small volumes of fluid are typically between the liver and diaphragm and between liver lobes; this is seen by fanning upward away from the gallbladder (but you should also fan downward [toward the table top] as well) (Figure 2.2C and D).

The sonographer should now use the DH view advantageously (less lung [air] interference) as an

Keep 25%–33% of the far field as a window into the thorax as you fan through the DH view. This may not be possible in large dogs because the distance exceeds the maximal imaging (distance) window of the ultrasound machine (Figure 2.2E).

acoustic window (via the liver and gallbladder) into the thorax.

Always look into the thorax. If pleural or pericardial effusion is suspected, the TFAST^3 pericardial site (PCS) views should be added (see Chapter 9) for confirmation or refutation of the AFAST^3 DH view's intrathoracic suspicion, unless, however, the DH view clearly shows the distinction between pleural and pericardial effusion (Figures 2.2E and 2.3; also see Figures 9.17 and 9.18).

Always look into the thorax for pleural and pericardial effusions. A recent retrospective review showed that 88% of clinically relevant pericardial effusions were detected by the DH view (Lisciandro 2012, unpublished data) (Figure 2.3A and B; also see Figure 9.17).

Diaphragmatico-Hepatic View and Pericardial Imaging

The canine and feline heart and pericardial sac do not normally rest on the diaphragm (as in humans). Thus, these structures may be unreliably visualized in normalcy in dogs and cats because of the air-filled gap (lung) which lies between the diaphragm and heart (ultrasound does not transmit through air). In most cases of clinically relevant pericardial effusion, however, diagnosis may be made via the AFAST^3 DH view, especially in cats and small to medium-sized dogs (Figure 2.3). If an adequate discriminatory DH view is not possible, the pericardial sites of TFAST^3 should be used in combination with the DH view for clarity (see Figures 9.18 and 9.19).

The axiom "One view is no view" should be taken seriously if pleural vs. pericardial fluid cannot be clearly discriminated because it is possible to mistake normal or dilated cardiac chambers for pleural and pericardial effusions, thus potentially leading to the most catastrophic of mistakes of performing centesis on a heart chamber (see Figure 9.14 as well as Chapter 11).

The reader should additionally review the section DH View for Pericardial Effusions in this chapter and the section on the TFAST^3 pericardial site (PCS) and its pitfalls in Chapter 9.

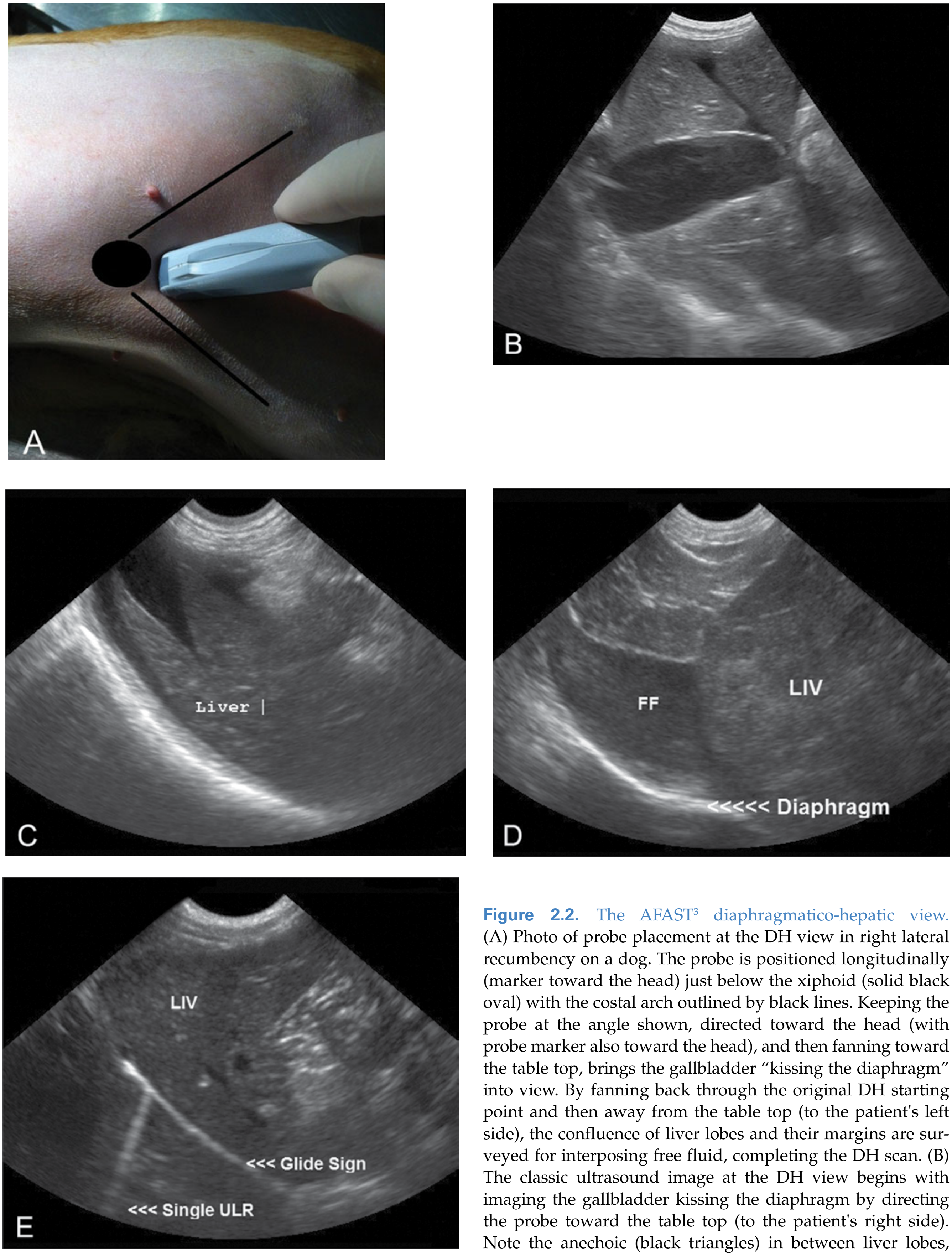


Figure 2.2. The AFAST[3] diaphragmatico-hepatic view. (A) Photo of probe placement at the DH view in right lateral recumbency on a dog. The probe is positioned longitudinally (marker toward the head) just below the xiphoid (solid black oval) with the costal arch outlined by black lines. Keeping the probe at the angle shown, directed toward the head (with probe marker also toward the head), and then fanning toward the table top, brings the gallbladder "kissing the diaphragm" into view. By fanning back through the original DH starting point and then away from the table top (to the patient's left side), the confluence of liver lobes and their margins are surveyed for interposing free fluid, completing the DH scan. (B) The classic ultrasound image at the DH view begins with imaging the gallbladder kissing the diaphragm by directing the probe toward the table top (to the patient's right side). Note the anechoic (black triangles) in between liver lobes,

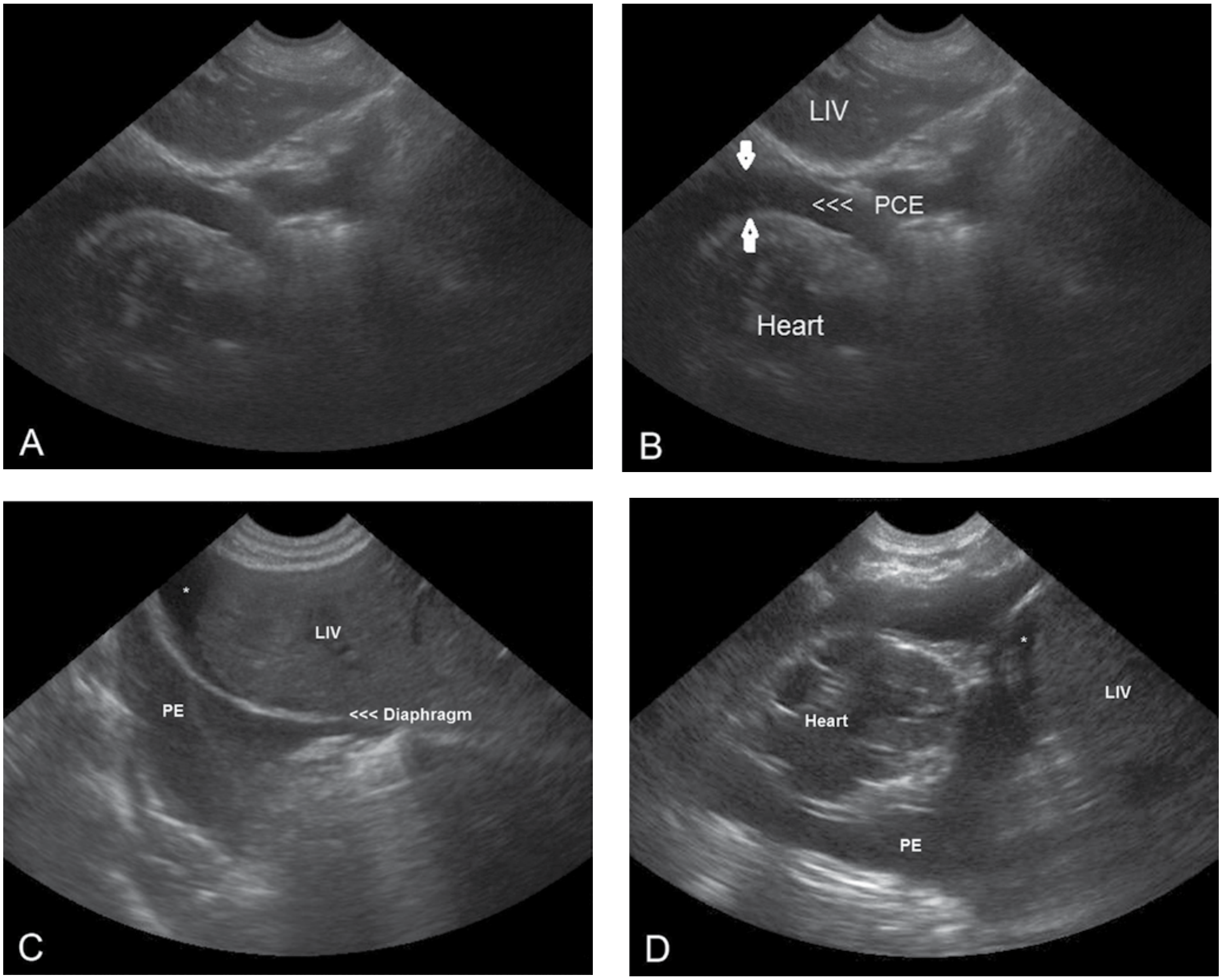


Figure 2.3. The diaphragmatico-hepatic view is part of both the AFAST[3] and TFAST[3] exams. (A) The image shows a DH view into the thorax of a dog revealing pericardial effusion (PCE). (B) The same image as in (A) but labeled with arrows showing the borders to the circular rim of contained pericardial fluid (PCE) within the pericardial sac (called the "race track sign" by the author). The liver (LIV) and heart are labeled. In most clinically relevant cases of PCE, the DH view will be diagnostic. In contrast, (C) and (D) show pleural effusion in a cat. (C) Pleural effusion (PE) from the DH view is suspected. Note there is also a small volume of intra-abdominal free fluid (*) in between the diaphragm and liver lobes (LIV). The fluid is not contained within a rim of anechoic fluid as compared to pericardial effusion in (B), but rather a large anechoic triangle of free fluid typical of pleural effusion is evident. (D) Pleural effusion (PE) is confirmed by adding the TFAST[3] pericardial site (PCS) showing that the intrathoracic free fluid is not contained from a second confirmatory (TFAST[3] PCS) view (again revealing irregular fluid borders) (pleural effusion, PE; free intra-abdominal fluid [*]; liver, LIV). Adhering to the axiom "One view is no view" by using the DH and at least a single PCS view prevents mistaking dilated (or normal) heart chambers for pericardial or pleural effusion. Keep in mind that the presence of both pericardial and pleural effusion occurs in some patients. © Gregory Lisciandro

making this image positive. (C) Next, fan back through the DH starting point and away from the table top (to the patient's left side) through the confluence of liver lobe margins, looking for free fluid. This image is also AFAST[3]-positive. Note the tips of liver lobes highlighted by the free fluid. (D) Typical free fluid (FF) positive as a large anechoic (black) triangle in between the falciform fat and ligament (near cranial field) and the liver (LIV) and diaphragm. (E) A single ultrasound lung rocket extends from the lung's surface normally positioned against the diaphragm. There is a "glide sign" along the lung-diaphragm interface similar to the "glide sign" of lung along the thoracic wall (see TFAST[3], Chapter 9). Each of these images shows a good depth into the thorax for detecting pleural and pericardial effusions, and each hints of mirroring the liver into the thorax (mirror artifact), especially (E). © Gregory Lisciandro

The axiom "One view is no view" should be taken seriously because it is possible to mistake normal or dilated cardiac chambers for pleural and pericardial effusions, potentially leading to the most catastrophic of mistakes of performing centesis on a heart chamber.

Diaphragmatico-Hepatic View and Ultrasound Lung Rockets

Ultrasound lung rockets (ULRs) are typically present to a small extent (none to one or two ULRs) along the diaphragm in normal dogs and cats (Figure 2.2E; also see Figures 9.15 and 10.14). Their presence and the glide sign along the diaphragm may be used to determine whether pneumothorax (PTX) is present. The sensitivity and specificity for PTX using the DH view is unknown, however, and it should be kept in mind that the DH view does not represent the highest point (where air would accumulate) on the thorax as does the preferred and documented reliability of the TFAST[3] chest tube site (CTS) view (highest point) (Lisciandro 2008).

Diaphragmatico-Hepatic View and Preload Volume Status, Indirect Right-Sided Cardiac Assessment

Finally, the "advanced" DH view includes evaluating patient volume status by generally directing the probe slightly further downward (it may also be slightly upward depending on the patient's anatomy, concurrent conditions) from the gallbladder (in right lateral recumbency) and imaging the caudal vena cava (CVC) as it passes through the diaphragm (Figure 2.4; also see Figures 11.8, 11.9, and 16.2). The CVC looks like a large "equal sign" created by the near field and far field venous walls. Furthermore, the CVC wall in the far field appears as a bright white line because of the acoustic enhancement of the ultrasound beam as it travels through its lumen, helping to rapidly identify the CVC (Figure 2.4, also see Figure 11.9). Subjectively, caudal vena caval diameter and hepatic venous distension may be assessed, the latter by tracing the hepatic veins as they branch into the CVC (Nelson 2010) (see Figures 16.8 and 11.8 and 11.9). Generally speaking, if the hepatic veins are obvious, often appearing as tree trunks (hepatic veins are not readily seen during the DH scan in normalcy), the patient's volume status and right-sided cardiac function should be questioned and appropriately investigated (volume overload, right-sided heart failure, obstructive conditions between the right atrium and liver, i.e., caval syndrome, Budd-Chiari-like conditions, hepatic cirrhosis (also see Figures 3.3, and 3.10A, B, and E).

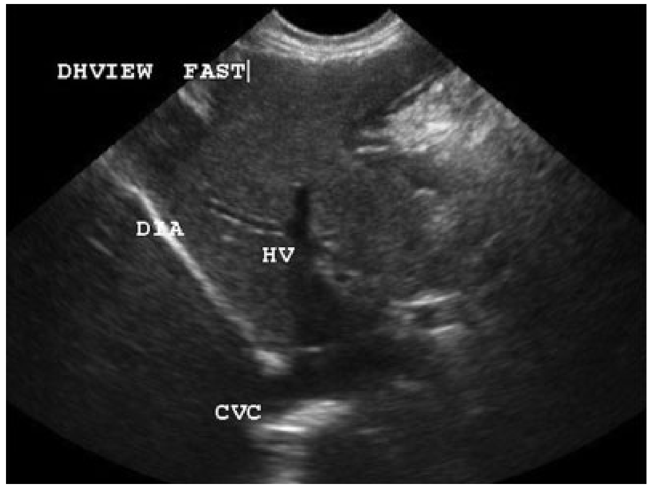


Figure 2.4. The DH view may be used for right-sided volume status (preload) during resuscitation and in at-risk patients for volume overload during fluid therapy. After imaging the classic starting point of the gallbladder kissing the diaphragm, direct the probe slightly more downward toward the table top (to the patient's right side) searching deeper (the far field along the diaphragm) while maintaining the same original longitudinally held probe angle. You should be able to achieve the image shown with the caudal vena cava (CVC) passing through the diaphragm and its branching hepatic veins. Especially note the brightness from acoustic enhancement of the CVC's far field wall (the two walls look like an equal sign as they traverse the diaphragm). Shown here is a dog with right-sided heart failure and its caudal vena cava as it passes through the diaphragm (CVC) and the liver with overly distended hepatic veins (HV) draining into the CVC. Normally, the hepatic veins are not obvious; thus, when hepatic veins are overtly obvious (as shown here) as they branch into the CVC (appear like tree trunks), clinical suspicion should be raised regarding right-sided heart status, volume overload, and the possibility for obstructive lesions between the right atrium and liver as applicable to the patient's clinical picture (also see Figures 11.8 and 11.9 and 16.2 in chapters 11 and 16, respectively). © Gregory Lisciandro

Additionally, volume status may be further assessed using the TFAST[3] PCS view for contractility and left ventricular (LV) filling (the LV short-axis "mushroom view") (see Figures 9.12, 9.14, 9.16, and 16.2, and Chapter 11) and its CTS view for presence of pulmonary edema (ULRs) (Figures 9.6; 10.7, 10.14, and 10.16; and 16.2).

Once the acquisition of the gallbladder kissing the diaphragm view is mastered, the sonographer should add on the right-sided cardiac volume status evaluation by generally directing the probe slightly downward (in some patients slightly upward) toward the table top (right lateral recumbency). This builds skills in evaluating for caudal vena caval diameter (as it passes through the diaphragm) and associated hepatic venous distention, using them as markers for right-sided heart status and patient volume status including use in pre- and post resuscitation.

Classic Diaphragmatico-Hepatic Positives

The classic intra-abdominal positives at the DH view are usually seen while moving upward (away from the table top) from the gallbladder, typically in between the divisions of the liver lobes, between the liver and the diaphragm, or between the liver lobes and the falciform ligament and fat. It is important to recognize that the falciform ligament and fat are typically hyperechoic (bright) in the near field and have coarser echotexture relative to the liver (Figure 2.2B through D; also see Figure 3.2).

The most common AFAST^3-positive sites in low-scoring (AFS-1 and –2 dogs) are the non-gravity dependent DH and CC views, so pay special attention to the presence of anechoic triangles (free fluid) while fanning through liver lobes (Figure 2.15).

The classic pleural and pericardial positives are clearly located on the other side of the diaphragm, and should be confirmed with the TFAST^3 PCS views if the sonographer is not able to confidently interrogate the effusion via the DH view (Figures 2.3 and 2.17; also see Figures 9.17 and 9.18).

Pitfalls of the Diaphragmatico-Hepatic View

The DH view has many artifacts including mirror image (Figures 1.7 and 3.9D), acoustic enhancement (Figures 1.6 and 3.6A and C), side-lobe, and edge shadowing (Figure 1.5). It is very important to be familiar with these artifacts as well as false positives (listed after artifacts) at the DH site because it is the most common positive (along with the CC site) in low-scoring AFS-1 and –2 dogs (see Chapter 1).

Artifacts

The DH view is the classic site for the creation of the mirror image artifact. The strong air-soft tissue interface between the lung-diaphragm and liver is misinterpreted, so to speak, by the ultrasound machine, which displays the liver and its structures flipped into the thoracic cavity (Figure 2.2C and E; also see Figures 1.7, 3.9D). The classic misdiagnosis of a diaphragmatic hernia has occurred by the novice; and odd-shaped mirroring of the gallbladder into the thorax may be mistaken for pleural effusion.

The gallbladder will make the soft tissues distal through its fluid-filled luminal contents appear much brighter (hyperechoic) than soft tissues adjacent to this ultrasound path. Typically this includes the liver and lung in the far field (see Figures 1.6 and 3.6A and C).

Side-lobe and edge shadowing artifacts result in loss of interpretative clarity by the ultrasound machine along any luminal borders, falsely making it appear that the lumen contains sediment or other intraluminal abnormalities, or has defects in its wall, respectively (see further explanation in Chapter 1 and Figures 1.5 and 1.10). A good way to remember that side-lobe artifact mimics sediment is that "side" may be rearranged to spell "sedi."

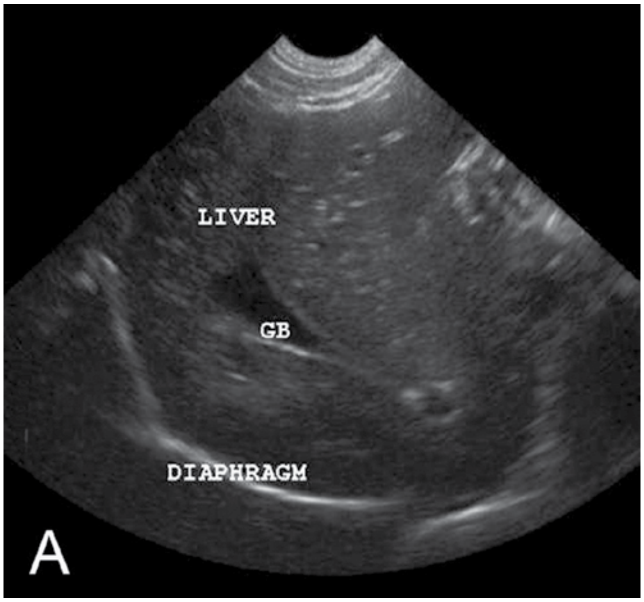
False Positives

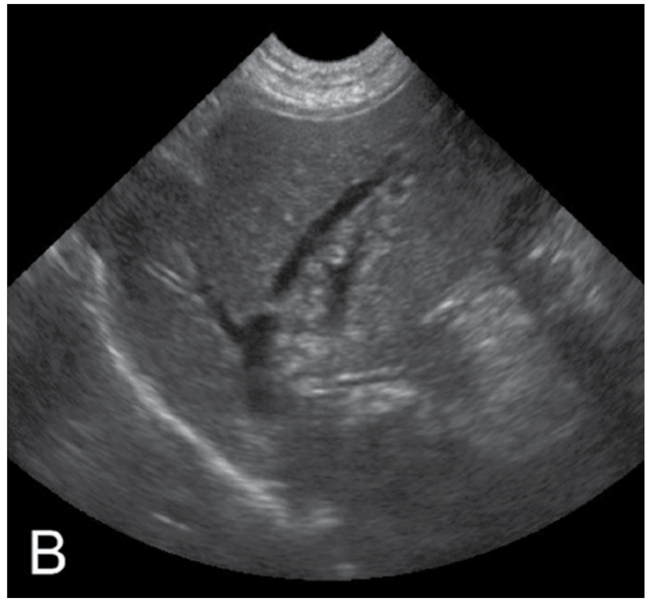
The gallbladder and its biliary system can look like free fluid and anechoic sharp angles. This false positive is easily avoided by fanning and connecting the gallbladder to its biliary tree (Figure 2.5A; also see Figures 3.2A and B).

Hepatic and portal veins (not normally obvious) can look like free fluid and anechoic sharp angles. This false positive may be easily avoided because most free fluid is not as linear as the venous system, and the venous system in most instances can be traced and seen branching (Figure 2.4; see also Figure 11.8). Color flow Doppler may be used to distinguish the venous system from free fluid but is rarely needed (Figure 2.5B).

Differentiating hepatic from portal veins may be done a couple of ways. Portal veins have more hyperechoic (brighter) walls when compared to hepatic veins (and often appear as hyperechoic [bright white] equal [=] signs, Figure 3.10A and B); hepatic veins branch into the caudal vena cava (Figure 2.4; also see Figures 11.8, 13.1D, and 16.2).

The stomach wall may look like free fluid. Typically the sonographer should stay away from this area during the DH view. The stomach has a sonolucent (dark or black) component to its wall, which typically





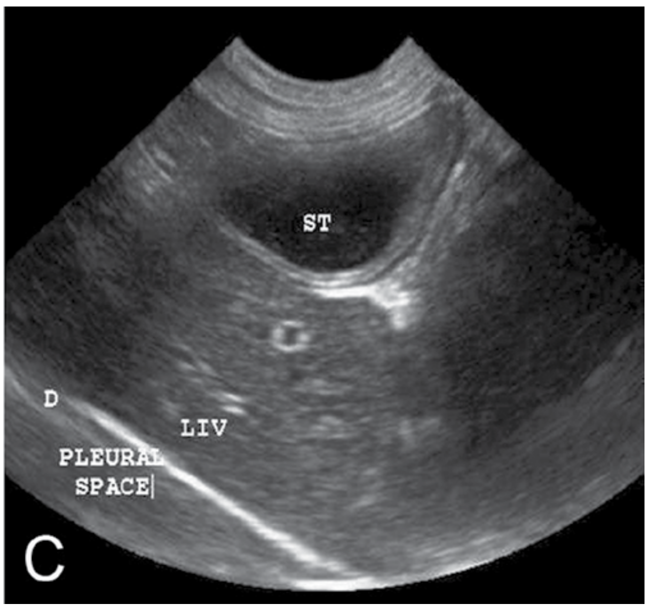


Figure 2.5. False positives at the DH view. (A) Mistaking the gallbladder and its ductal system for free fluid. Shown is an anechoic triangle (GB) that is actually part of the bile-filled gallbladder and not free fluid. Fanning through the DH view avoids this error because the gallbladder and its ductal system are more fully appreciated in real-time imaging. (B) Hepatic and portal veins can be mistaken for free fluid. Fanning through the DH view allows for tracking the venous system and prevents this error. Color flow Doppler may be used but is rarely needed. In general, portal veins have hyperechoic (bright white) walls when compared to hepatic veins; the latter can be identified as they branch from the caudal vena cava (Figures 2.4, 11.8, and 11.9). (C) Margins of the stomach wall (ST) may appear anechoic and be mistaken for free fluid. Note the stomach's lumen is fluid-filled (anechoic). In general, recognize this stomach wall error as such and avoid it by directing your attention to areas between the liver lobes and diaphragm, which are the most common DH locations for free fluid. Serial exams are key to increasing the sensitivity of all FAST^3 exams, especially when small amounts of free fluid are suspected. © Gregory Lisciandro

appears linear in real-time imaging. The stomach wall is also subject to artifacts such as edge shadowing (see Figure 1.5). Both related artifact(s) and the sonolucency of the stomach wall can be mistaken for free fluid (Figure 2.5C).

> Stay away from the stomach area; it is generally too far caudally for the DH view.

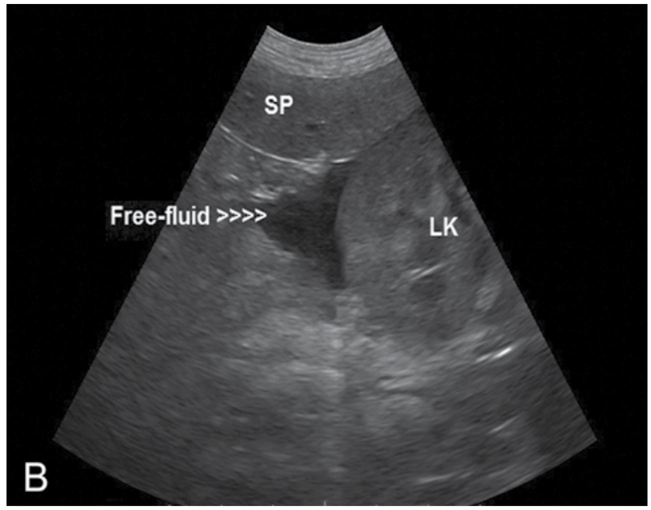
False Negatives

Serial AFAST^3 exams increase sensitivity. Don't sweat questionable small pockets of free fluid. Serially repeat the AFAST^3 exam at least a second time four hours later.

> Repeat AFAST^3 serially in four hours post-admission (sooner as clinical course dictates), or after resuscitation and rehydration. The four-hour post-admission rule of thumb is supported by the American College of Emergency Physicians (ACEP) guidelines (www.acep.org) as standard of care.

The AFAST^3 Spleno-Renal View

The classic spleno-renal (SR) view includes the visualization of both the spleen (peritoneal cavity) and the left kidney (retroperitoneal space) (Figure 2.6A).



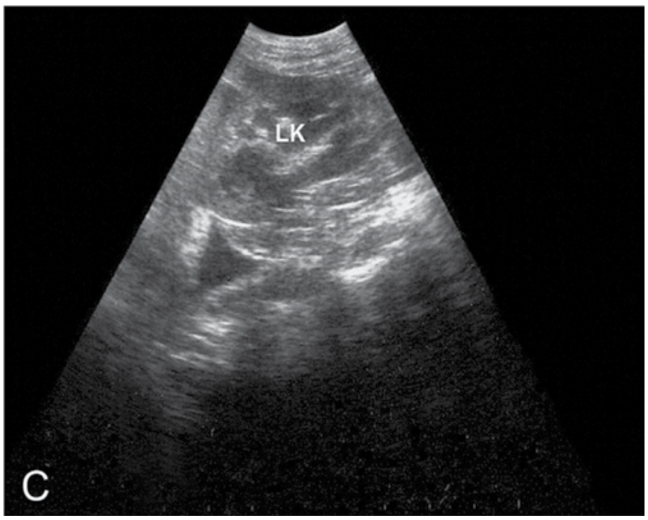


Figure 2.6. The classic AFAST[3] spleno-renal view includes the spleen and the left kidney. (A) Photo of the SR view in right lateral recumbency on a dog. The probe is positioned longitudinally (marker toward the head) more or less parallel to the spine just caudal to the costal arch because the kidney is more recognizable in longitudinal orientation. By keeping the probe at the angle shown and the probe marker directed toward the head, fanning toward the table top often brings the left kidney and spleen into almost immediate view. After doing so, fan back through the original starting point and then away from the table top to further image the retroperitoneal space and its great vessels (aorta and caudal vena cava). (B) The spleen normally runs its course with its tail just reaching the left kidney. Use this trick to help find the left kidney (follow the spleen caudolaterally to help find the left kidney). Shown is the spleen (SP) in the near field and the left kidney (LK), with a classic positive image of free fluid (anechoic triangle) in between. (C) The left kidney is obvious with an associated classic anechoic (black) triangle of free fluid (typically the triangle of free fluid is located between the left kidney and wall of the colon). (D) SR positive with an anechoic (black) triangle (or diamond) of free fluid located in an area where the spleen and left kidney are not obvious. (E) A final SR positive with free fluid as an anechoic (black) triangle shape again as in (D) without a recognizable spleen or left kidney. © Gregory Lisciandro

The SR target organs are readily imaged in the preferred positioning of right lateral recumbency by placing the probe longitudinally just caudal to the last rib and fanning cranially under the rib and then moving caudally.

The spleen may be used to locate the left kidney by following it caudally and laterally because of its anatomical association with the left kidney (Figure 2.6B).

Fanning dorsally is also recommended to screen for any pathology associated with the great vessels (aorta and caudal vena cava). The great vessels are common confounders and cause false positives, which may be easily overcome by remembering that positives are rarely anechoic (black) stripes (vessels and intestinal tract) but rather anechoic (black) triangles (free fluid) (Figure 2.8C and D, below).

The great vessels may be discriminated by the anechoic (black) linear stripe in longitudinal view as well as by observing for pulsation. Turning your probe transversely (turn left or counterclockwise) should change the linear stripe to an anechoic (black) circle representing the vessel's lumen in cross section.

Retroperitoneal fluid in this area should raise the suspicion for hemorrhage, urine, and sterile and septic effusions. Cranially, fluid sources would include the kidneys, vertebral bodies, and the great vessels and adrenal gland, and caudally, the kidneys, ureters, vertebral bodies, and pelvis (Figure 2.9A and B below; also see Figures 5.6, 5.8, and 5.14).

Retroperitoneal fluid is not part of the abdominal fluid score (AFS) but should be noted and its widest depth measured by either the eyeball method (using the centimeter scale on the far right of the US image) or using the caliper function on your machine.

Classic Positives

The majority of positives at the SR view are classically anechoic (black) triangles formed between the spleen and colon (Figure 2.6B through E).

Artifacts

Generally the SR view has few artifacts, most of which are colon related.

The colon's air-causing interference (cannot image through air) is usually not problematic because dogs and cats in right lateral recumbency have their colon (by gravity) fall away from the SR view. However, it is not uncommon for the air-filled colon to cause a "dirty" shadow in the far field (Figure 2.7; also see Chapter 7).

False mirror image in cats. Especially in cats and rarely in small dogs, both kidneys will be apparent in the SR view. It is unlikely to be a mirror image artifact (Figure 2.7).

False Positives

Linear anechoic stripes rarely represent free fluid and are more likely small intestine (intra-abdominal) or the great vessels (retroperitoneal). Color flow Doppler is rarely needed to decipher between these structures and free fluid but may be used (Figure 2.8C and D). Also, small intestine will look like small hamburgers when the bowel segment is viewed in cross section by rotating the probe (Figure 2.8B; also see Figures 7.3 and 7.4).

Figure 2.7. The SR view is from a cat and shows both left (LK) and right (unlabeled) kidneys in the same view. This is not a mirror artifact. In some small dogs both kidneys may also be imaged from the SR view. Commonly, the descending colon, which runs along the left side of dogs and cats, is gas-filled, which obscures distal or far-field imaging and causes a "dirty shadow" artifact. Lateral recumbency is advantageous in that the often air-filled (US does not transmit through air) small and large intestine fall away from the kidney at the non-gravity dependent site (SR in right lateral; HR in left lateral), facilitating ultrasound imaging. © Gregory Lisciandro

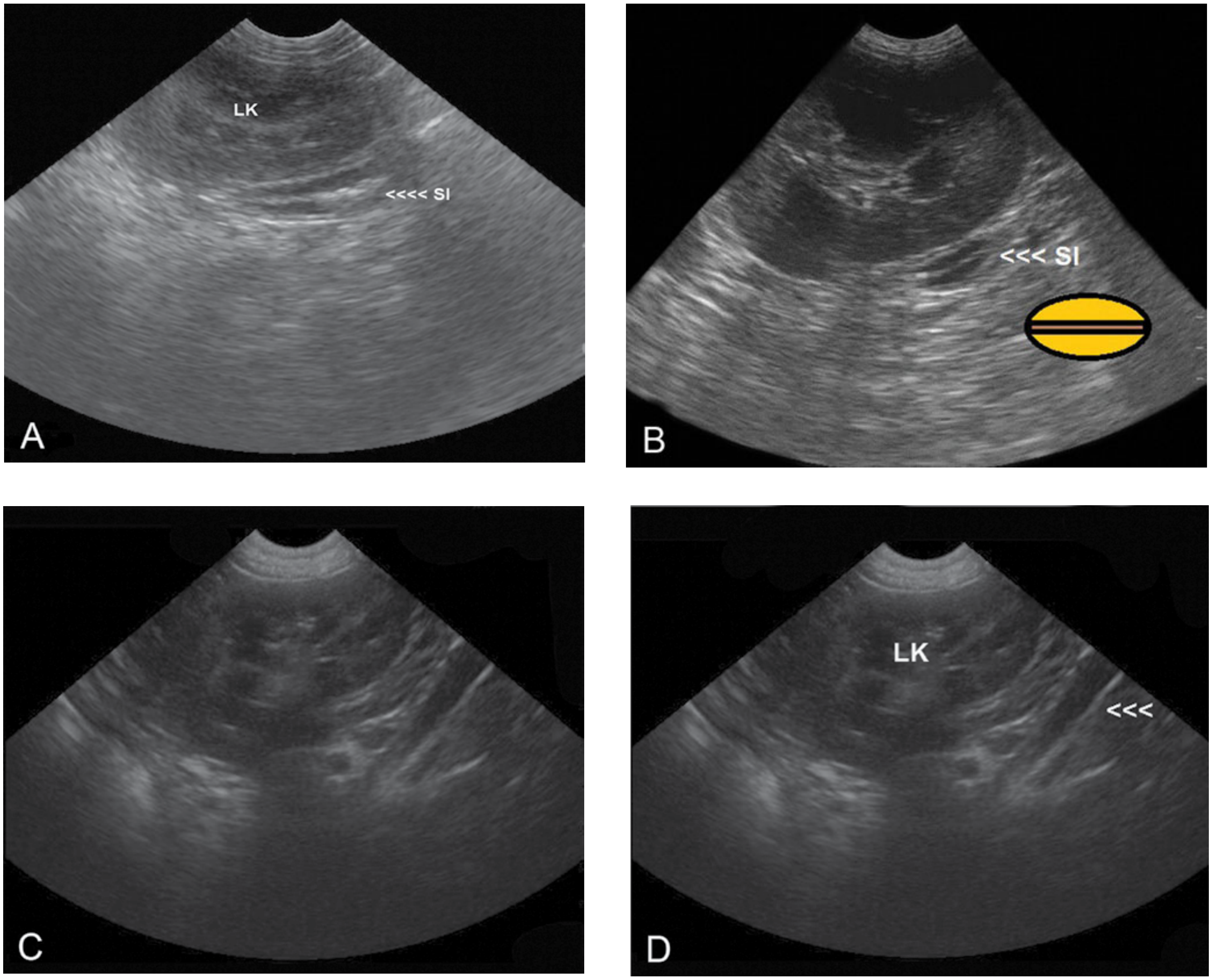


Figure 2.8. False positives at the SR view typically involve the small intestine (ventral to SR) and the great vessels (dorsal to SR, aorta and caudal vena cava). Typically they appear as anechoic stripes (linear), which is atypical of free fluid (free fluid is classically revealed as anechoic [black] triangles). (A) Shown here is a linear stripe in the immediate far field to the kidney which is not free fluid but rather a loop of small intestine (SI). (B) By turning (the probe) left (counterclockwise) the SI is imaged in standard transverse orientation and appears as a classic "hamburger" (see Chapter 7). (C) The great vessels (also linear stripes) as false positives are recognizable in the majority of instances without color flow Doppler by observing for pulsation (aorta) and considering the probe direction (dorsal to the SR starting point), and turning (the probe) left for standard transverse imaging (normal flowing vessels become anechoic [black] circles) (see Chapter 12). (D) The same image labeled as left kidney (LK) and cursors (<<<) to the anechoic (black) linear stripe coursing at a 45-degree angle as a great vessel (linear anechoic [black] stripe) and not free fluid (typically anechoic [black] triangles). © Gregory Lisciandro

> Remember, classic positives at the SR view are anechoic (black) triangles, not linear stripes.

The problem of retroperitoneal fluid vs. peritoneal fluid in people differs from our veterinary patients that are generally less obese and have a suspended (vs. attached) colon by its mesocolon. In lateral recumbency, retroperitoneal fluid will remain static and not fall away from the field of view. Zooming out, or increasing depth, also helps interrogate the two spaces (Figure 2.9A and B; also see Chapter 5).

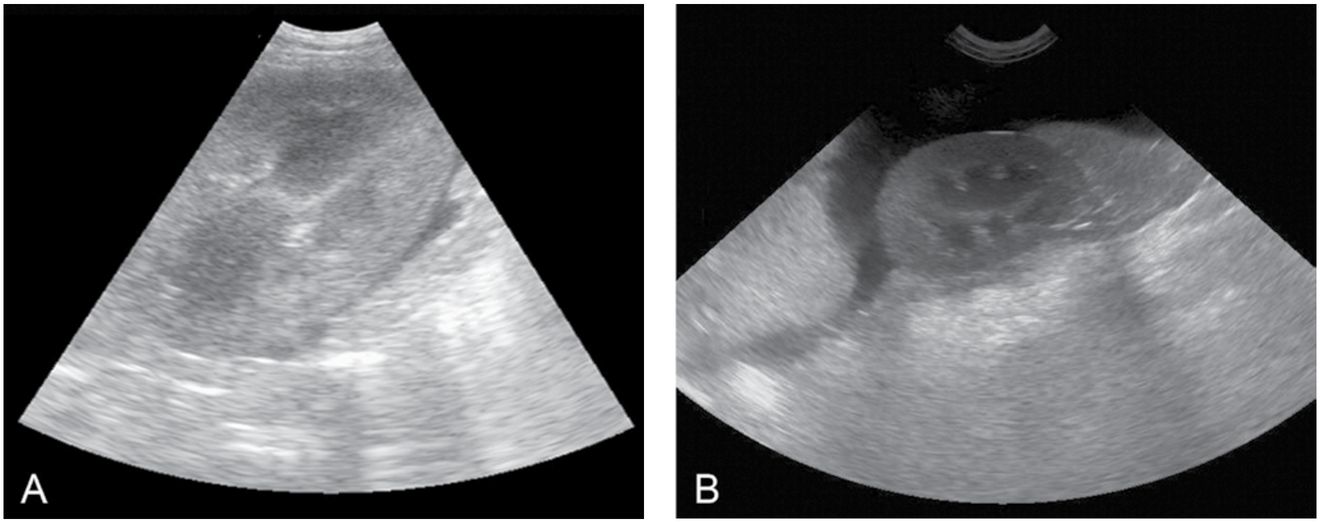


Figure 2.9. Retroperitoneal vs. peritoneal fluid at the SR view. (A) The image shows a small rim of retroperitoneal effusion that is easily discriminated from peritoneal fluid by zooming away (increasing depth). The thin rim of fluid shown is classic for acute kidney injury and is from a dog with heat stroke. The fluid resolved 24 hours later (serial exam) as its kidney failure resolved. Note that such a small rim of fluid is not safely amenable to sampling by aspiration. (B) The image shows a large peritoneal effusion that is easily discriminated from retroperitoneal fluid by zooming away (increasing depth) as well as placing the kidney of interest on the non-gravity dependent side (left kidney imaged in right lateral recumbency; right kidney imaged in left lateral recumbency) because confounding structures fall away. Retroperitoneal fluid is not scored as part of the abdominal fluid scoring system. © Gregory Lisciandro

False Negatives

Serial AFAST^3 exams increase sensitivity. Don't sweat questionable small pockets of free fluid. Serially repeat the AFAST^3 exam at least a second time four hours later.

Repeat AFAST^3 serially in four hours post-admission (sooner as clinical course dictates), or after resuscitation and rehydration. The four-hour post-admission rule of thumb is supported by the American College of Emergency Physicians (ACEP) guidelines (www.acep.org) as standard of care.

The AFAST^3 Cysto-Colic View: The Little Fib

The classic cysto-colic (CC) view includes imaging the urinary bladder (when present) "kissing" the abdominal wall by longitudinally placing the probe on top of the site and directing the probe into the gravity dependent pocket formed between the bladder and the ventral body wall (Greg's pouch) (Figure 2.10A and B). The CC view is slightly a misnomer, or a "little fib," because of its target organs; only the bladder is imaged, whereas the colon is not. It is important to remember, though, that an air-filled colon will obscure imaging (ultrasound does not transmit through air), and because of its air-filled proximity may create some odd-appearing bladder images.

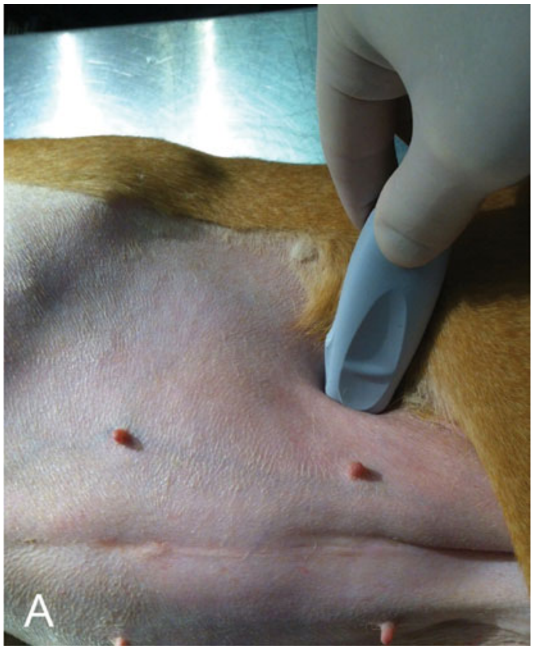
Classic Positives

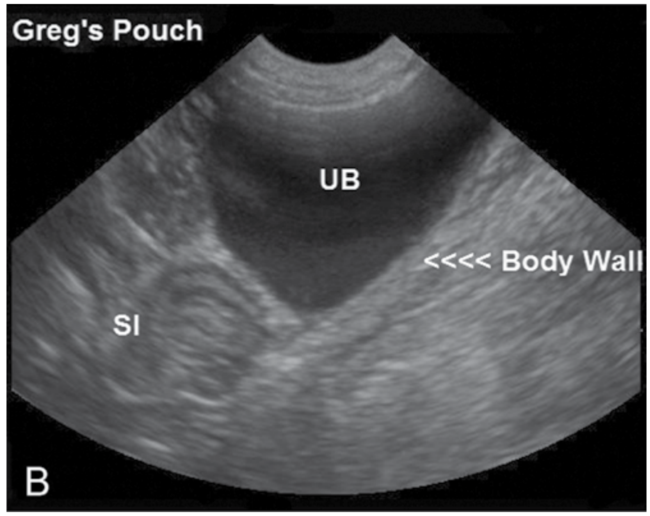
The classic CC positive in a small volume effusion is a small anechoic (black) triangle at the base of Greg's pouch between the urinary bladder apex and the body wall (Figure 2.10C). Large-volume positives are usually easy to see in real-time with the wafting movement of small intestines and omentum (Figure 2.10D and E).

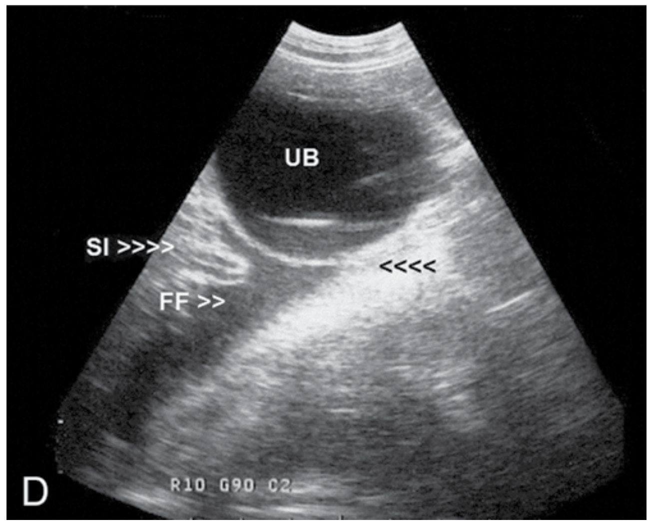
Artifacts

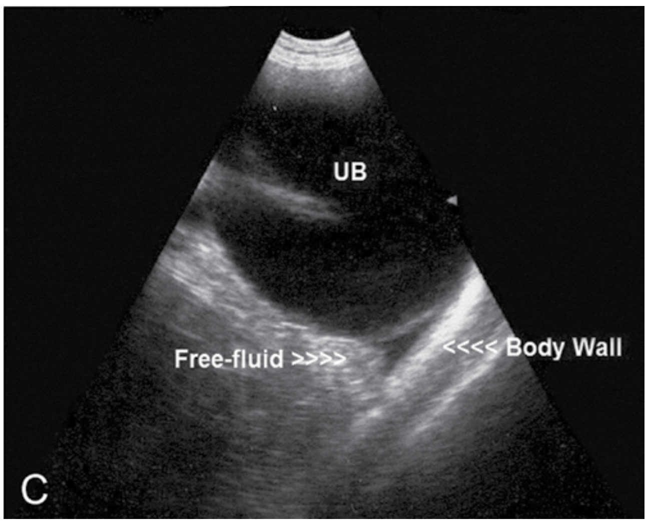
Acoustic enhancement artifact: The fluid-filled urinary bladder makes the soft tissue distal through it brighter (hyperechoic). By the recommended probe positioning above, the body wall will be bright in the far field in the Greg's pouch because of this artifact (see Figures 1.6 and 6.9). The artifact is readily seen along the ventral abdominal wall in Figure 2.10C and D.

Reverberation and shadowing artifact: An overlying air-filled colon can obscure the far field, making









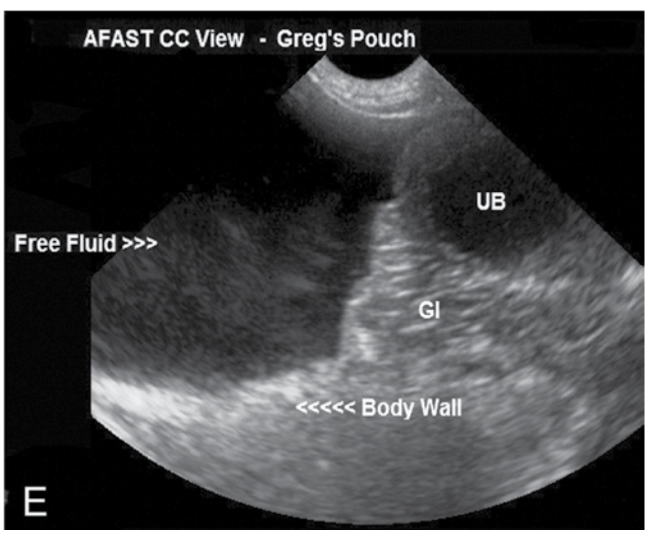


Figure 2.10. The classic cysto-colic view and its positives. (A) The probe is placed over the urinary bladder region and directed into the gravity dependent pouch (Greg's pouch) in that area. (B) The classic CC view is acquired by directing the probe downward toward the table top and thus imaging the urinary bladder (UB) against or "kissing" the ventral abdominal wall. By doing so the sonographer has a view of the most gravity dependent area where free fluid accumulates (small intestine, SI). (C) The small anechoic triangle (free fluid) between the apex of the urinary bladder and the ventral body wall (Greg's pouch) is classic for small volume effusions. (D) Zooming away and observing Greg's pouch with acoustic enhancement artifact, making the body wall brighter (dark arrows) and seeing clearly the free fluid (FF) and small intestine (SI) appearing like "hamburgers" in transverse view adjacent to a full urinary bladder (UB). (E) A final image illustrating the difference when the urinary bladder (UB) is smaller (or absent) with small bowel (GI) floating (obvious in real-time imaging) in the free fluid typically seen in larger volume positives. © Gregory Lisciandro

the bladder appear in odd shapes (see Figures 1.4, 1.5, 6.3, and 6.10).

Change the position of the probe and alter the pressure of the probe on the patient (both a little more and a little less) to coax the colon out of your way.

False Positives

False positives are generally not a problem at the CC site when directing the probe into the pocket between the urinary bladder and the body wall (called Greg's pouch).

It should be noted that puppies and kittens may have a small amount of (anechoic) ascites, which is considered normal (see Chapter 13).

If you fan dorsally into the sublumbar area (generally unnecessary), the great vessels and lymph nodes may become confounders.

Keep your probe in Greg's pouch. Figure 2.10B through D clearly shows how the urinary bladder abuts the ventral body wall, forming Greg's pouch.

False Negatives

Serial AFAST[3] exams increase sensitivity. Don't sweat questionable small pockets of free fluid. Serially repeat the AFAST[3] exam at least a second time four hours later.

Repeat AFAST[3] serially in four hours post-admission (sooner as clinical course dictates), or after resuscitation and rehydration. The four-hour post-admission rule of thumb is supported by the American College of Emergency Physicians (ACEP) guidelines (www.acep.org) as standard of care.

The AFAST[3] Hepato-Renal View: The Big Lie

Finally, the classic hepato-renal (HR) view is obtained by placing the probe just ventral to the umbilicus. Typically the HR view includes loops of small bowel and occasionally the spleen (Figure 2.11B; also see Figures 7.3 and 13.7). The probe should be directed downward toward the table top into the most gravity dependent pouch of all the AFAST[3] sites by starting closer to the umbilicus and directing downward toward the table top. Alternately, you may move the probe below the umbilicus and fan upward again, keeping in mind that the area of interest is this most gravity dependent pouch. If you are too low toward the table top you may be imaging through planes of body wall. The probe is not routinely run under the patient unless imaging of the right kidney is necessary (Lisciandro 2009, 2011).

The HR view is performed just below the umbilicus to image the most gravity dependent area of the laterally recumbent veterinary patient (and the probe not moved underneath).

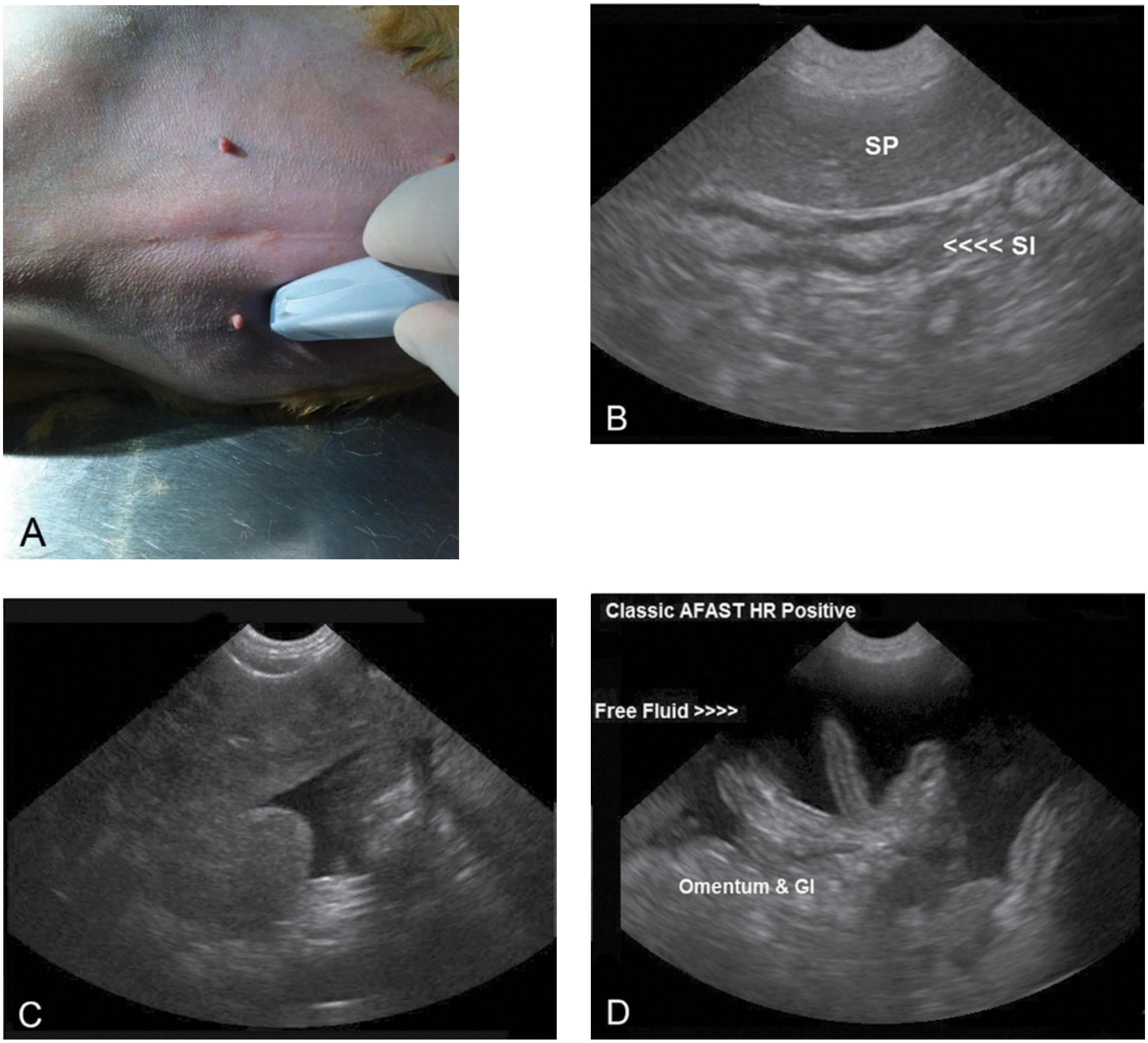
"The big lie" is two-fold: first, the liver (unless it is enlarged it is not seen) and the right kidney are not aggressively searched out; thus, neither HR target organ is directly scanned. Second, transverse imaging (in addition to longitudinal) is advised because it is less confusing at this site in discriminating intestinal contents from free fluid (Lisciandro 2009).

The probe is longitudinally placed just under the umbilicus and fanned downward to the table top into the most gravity dependent pouch (Figure 2.11A). Here, turning left for transverse imaging is not as confusing for beginners as the other sites (i.e., DH, SR, and CC) which helps differentiate small intestinal loops from free fluid (see Figures 7.3, 7.4, and 13.7, as well as Chapter 7). Small intestines generally look like hamburgers when viewed in cross section (Figure 2.8B; see also Figures 7.3 and 7.4).

Stay longitudinal at all sites (DH, SR, CC) except at the HR view where it is helpful to do both longitudinal and transverse imaging to discriminate free fluid (anechoic black triangles) from small bowel (referred to as appearing like "hamburgers" on cross-section) (Figure 2.7A and B) (also see Figures 7.3, 7.4, 13.7, and Chapter 7).

In the event that the right kidney should be imaged (if there is concern about retroperitoneal injury on the right side or that hematuria may be a kidney-related injury or non-trauma-related pathology), smaller-sized dogs and cats may be moved more dorso-laterally while in right lateral recumbency and the probe slipped underneath them (works well in most cases). Otherwise, as with larger patients, it may be necessary to move the dog to left lateral recumbency.

The right kidney is generally more difficult than the left kidney to image because of its more cranial location under the rib cage within the renal fossa of the caudate liver lobe (Figure 2.12; also see Figures 3.1 and 5.1). However, lateral recumbency is advantageous when looking at kidneys at the non-gravity AFAST[3] site because bowel falls away from the respective kidney.



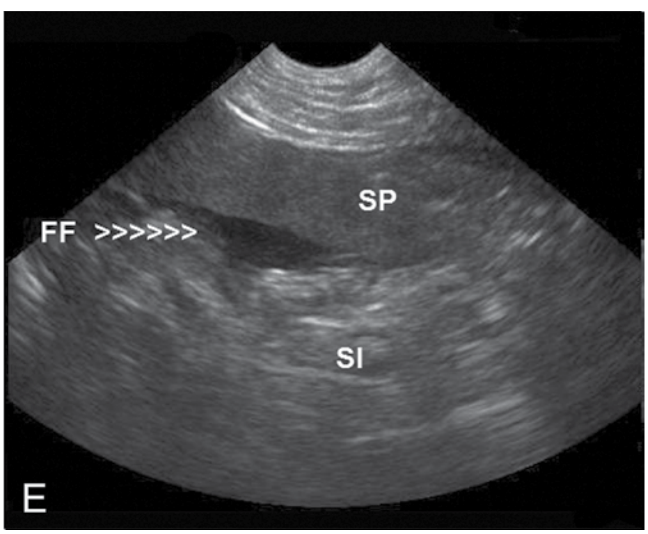


Figure 2.11. The classic AFAST[3] hepato-renal (HR) view and positives. (A) The probe is not moved under the patient, but rather placed just ventral to the umbilicus mid to just cranial mid-abdomen to image the most gravity dependent pocket in a laterally recumbent patient. The target organs are generally not seen but rather loops of small intestine and occasionally the spleen are more commonly present here. (B) Typical image for the HR view with spleen (SP) and small intestine (SI). There is no free fluid in the image. Recall that the HR view is the "big lie" because neither target organ (liver and right kidney) is searched out. (C) Small-volume HR positive with an obvious anechoic (black) triangle. D) Large-volume HR effusion with the "rabbit sign" or small intestine and omentum wafting in the free fluid, creating such an image. (E) Small-volume free fluid (FF) located between the spleen (SP) and the small intestine (SI). © Gregory Lisciandro

Classic Positives

Because the HR view is the most gravity dependent site in right lateral recumbency, the positives are usually remarkable (Figure 2.11C through E) and easily recognized. The "rabbit ear" sign is typical in large-volume effusions created by small intestine and omentum wafting in the free fluid (Figure 2.11D). The most common AFAST[3] -positive sites in low-scoring AFS-1 and 2-dogs are not the HR view, but rather the non-gravity dependent CC and DH views (Lisciandro 2009). Thus, the site is nicknamed the "home run" site because it completes the AFAST[3] exam and if positives were seen at other views, the sonographer is likely to be performing abdominocentesis here.

Figure 2.12. Image of the right kidney (RK) at the HR view. In right lateral recumbency the right kidney is not typically searched for and imaged (unless injury is suspected or pathology based on other findings). The right kidney is more difficult to reliably image than the left because it is tucked up into the liver (LIV). In left lateral recumbency, the right kidney should be routinely imaged at the HR view (in contrast to right lateral recumbency when it is often skipped over) so that a window into the retroperitoneal space during AFAST[3] is appreciated. © Gregory Lisciandro

Fluid should be characterized if safely retrievable by abdominocentesis because ultrasound cannot characterize the type of fluid based on its echogenicity.

False Positives

- The GI tract. Bowel may be fluid-filled or have its wall infiltrated (abnormal) in diseased states and may appear mistakenly as free fluid (see Chapter 7).

Moving your probe from longitudinal to transverse typically discriminates between free fluid (anechoic black triangles) and normal and abnormal GI tract (small bowel, referred to as "hamburgers" in cross-section; see Figures 7.3, 7.4, 8.4, and 13.7).

- Mid-abdominal masses. Large centrally located necrotic fluid-filled splenic, hepatic, mesenteric or renal masses may be mistaken for free fluid (Figure 2.13A).

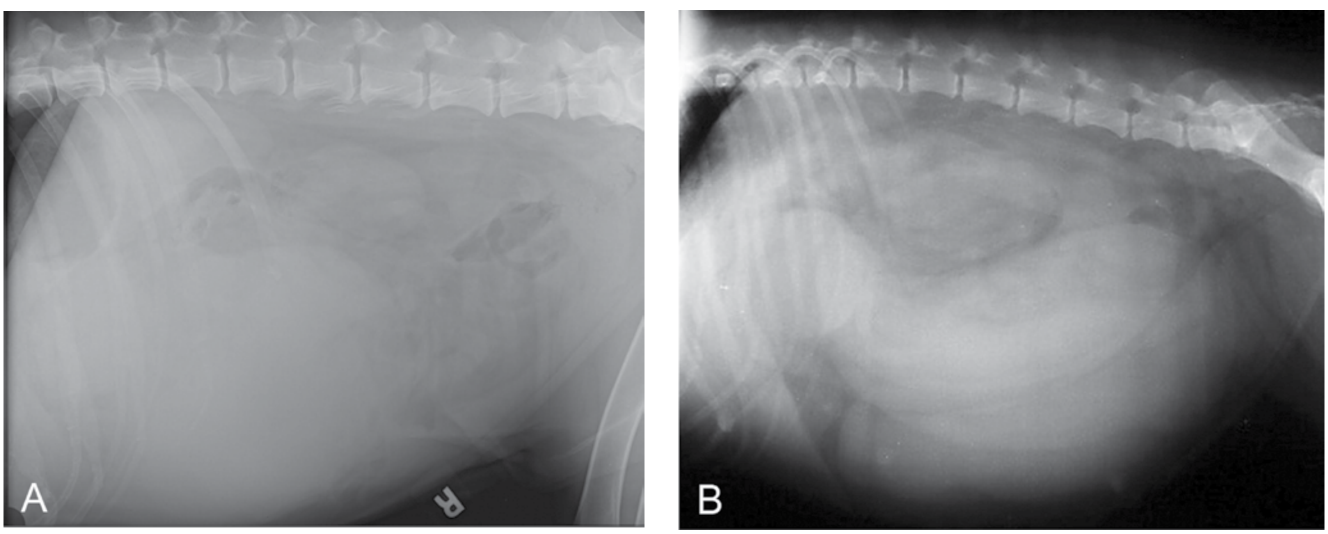


Figure 2.13. False positives at the HR view. It is possible to mistake fluid-filled structures for free abdominal fluid including large midabdominal masses (splenic mass with necrotic center, large cystic masses), pyometra, a distended fluid-filled stomach, and others. Although these possibilities are uncommon, they exist as possible mistakes. (A) A large midabdominal splenic mass with a necrotic center that falsely appeared to the sonographer as wafting free fluid. (B) A large pyometra that falsely appeared as free fluid. Pyometra is often compartmentalized into triangles and thus differentiated from free fluid (see Chapter 8). © Gregory Lisciandro

Zoom out and increase depth so margins of a centrally located mid-abdominal mass may be better recognized and not mistaken for free fluid (see Figure 4.12).

- Fluid-filled uterus. A large fluid-filled uterus in an intact female may be mistaken for free fluid (Figure 2.13B, also see Figure 8.6). The female reproductive tract is addressed in Chapter 8.

Consider your patient's signalment and don't mistake an enlarged uterus for free fluid.

False Negatives

- Serial AFAST³ exams increase sensitivity. Don't sweat questionable small pockets of free fluid. Serially repeat the AFAST³ exam at least a second time four hours later.

Repeat AFAST³ serially in four hours post-admission (sooner as clinical course dictates), or after resuscitation and rehydration. The four-hour post-admission rule of thumb is supported by the American College of Emergency Physicians (ACEP) guidelines (www.acep.org) as standard of care.

The AFAST³-applied Abdominal Fluid Scoring System

The abdominal fluid scoring system was purposely named such and not the "hemorrhage" scoring system to avoid the system being type-casted for only hemorrhage. The name, however, seems to have prevented its routine use in trauma despite its documented ability to semi-quantitate volume of hemorrhage. By predicting the anticipated degree of anemia (AFS 1 or 2, "small bleeders"; AFS 3 or 4, "big bleeders"), the scoring system may be used to anticipate the need for blood transfusions (Lisciandro 2009) and rarely exploratory laparotomy in bluntly traumatized dogs with traumatic hemoabdomen (Boysen 2004, Lisciandro 2009, Simpson 2009).

A decision-making algorithm correlating the abdominal fluid score to the anticipated degree of anemia in bluntly traumatized and post-interventional (surgery, percutaneous biopsy, laparoscopy) dogs (not reliable in cats) is shown (Figure 2.14).

The Clinical Significance of the Abdominal Fluid Score (AFS) in Dogs

The abdominal fluid score (AFS) is as follows: 0 if negative at all 4 AFAST³ views, to a maximum AFS of 4 if positive at all four views. Each of the four views receives a score of 1 that is then totaled (Figure 2.15).

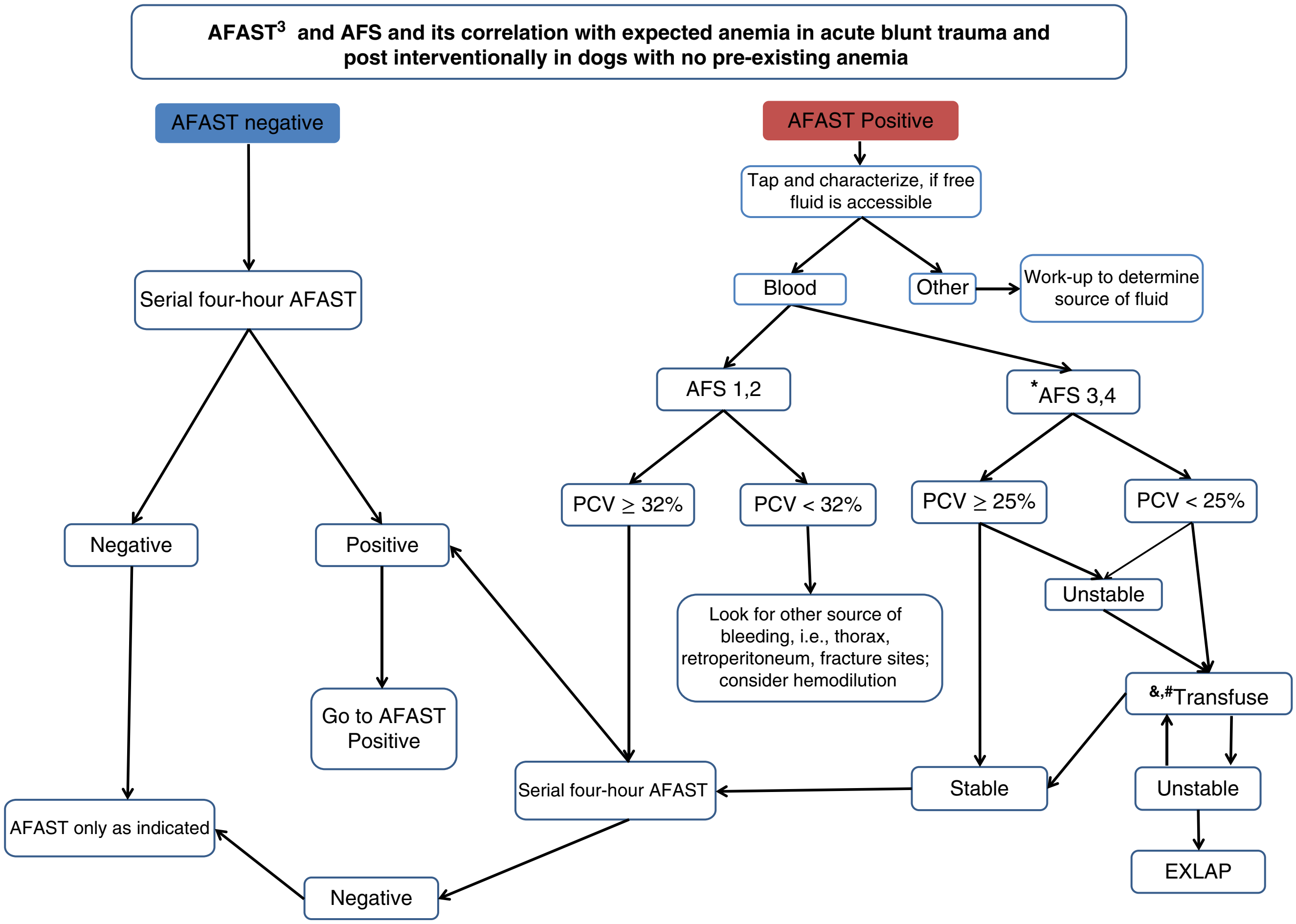
From the assigned AFS, dogs may be categorized into "small bleeders" (AFS 1 and 2) and "big bleeders" (AFS 3 and 4). AFS 1 and 2 dogs, or small bleeders, will reliably not become significantly anemic if they had no pre-existing anemia and remain AFS 1, 2 on serial examinations unless they are bleeding at another site(s) or experiencing hemodilution due to large fluid volumes.

In the event an AFS 1, 2 dog without pre-existing anemia becomes anemic (packed cell volume (PCV) less than 30%), the attending clinician should explore other sites (retroperitoneal, pericardial, pleural, lungs, fracture sites) readily accessible by AFAST³, TFAST³, and the Vet BLUE lung scan and focused musculoskeletal exams at fracture sites for hemorrhage (Chapter 15).

AFS 3 and 4 dogs, or big bleeders, will reliably become anemic, predictably 20%–25% below their admission baseline PCV if they had no pre-existing anemia. Approximately 20%–25% of these AFS 3, 4 dogs will become severely anemic (PCV less than 25%) on serial AFAST³ examinations, potentially needing a blood transfusion(s) (Lisciandro 2009) and rarely emergent exploratory laparotomy (Boysen 2004, Lisciandro 2009, Simpson 2009).

By knowing within minutes of presentation on the triage table that your dog is a bleeder (hemoabdomen), fluid therapy with more conservative endpoints may be initiated, and the anticipation for the need of blood products may be made ahead of time (directing resources) according to the small bleeder vs. big bleeder concept used on initial and serial AFAST³ examinations. A decision-making algorithm correlating the abdominal fluid score to the anticipated degree of anemia in bluntly traumatized and post-interventional (surgery, percutaneous biopsy, laparoscopy) dogs (not reliable in cats) is shown (Figure 2.14).

Humans may lose 75% and 50% of their blood volume in pelvic and femoral fracture sites, respectively, whereas dogs and cats uncommonly become anemic from these fractures. However, significant blood loss (if TFAST³ and Vet BLUE scans are unremarkable for other sources of blood loss) should be considered from fracture sites; as has been



The flow chart provides general guidelines regarding the decision-making process for acutely bleeding dogs when applying the abdominal fluid score (AFS) during AFAST. *Post-interventional cases that are bleeding, non-coagulopathic, with an AFS 3,4 are often compensating for their intra-abdominal bleed and generally should be explored rather than waiting. However, these post-interventional cases would be those with an AFS 0 post-procedure (abdominal cavity suctioned dry post-operatively [AFS 0] or AFS 0 prior to a percutaneous procedure). &In contrast, bleeding dogs with an AFS 3,4 from blunt trauma often require transfusion products but uncommonly require exploratory laparotomy to control their intra-abdominal hemorrhage. #In some dogs with graduated fluid therapy and hypotensive resuscitation strategies, blood transfusion may not be necessary despite marked anemia (< 25%).

Figure 2.14. Decision-making algorithm for dogs correlating the abdominal fluid score to the anticipated degree of anemia in bluntly traumatized and post-interventional (surgery, percutaneous biopsy, laparoscopy) canine cases. The AFS has not been proven to be a reliable predictor of anemia in cats; however, it is still a useful monitoring tool for serially assessing whether effusions are developing (negative to positive score), worsening (higher score), or resolving (lower score). © Gregory Lisciandro

sporadically reported in both species, more commonly from pelvic fractures.

Waiting on a compensated post-interventional big bleeder (AFS 3, 4) instead of surgically addressing the cause of bleeding often leads to increased morbidity and cost (e.g., transfusion products) because big bleeders predictably become markedly anemic and overtly clinical (decompensate) in time.

If it's a bleeding 3 or 4, (AFS 3, 4), then you should explore (surgically). The exception is hit-by-car dogs that often are successfully treated medically with transfusion products.

The Clinical Significance of the Abdominal Fluid Score in Cats

The same AFS system was studied prospectively in 49 traumatized cats and importantly found to not correlate with anemia as in dogs (Lisciandro 2012). However, the number of cats with traumatic hemoabdomen was small, concluding that cats more often do not survive automobile-induced traumatic hemoabdomen as dogs, similar to a previous report (Mandell 1995).

Cats with automobile-induced traumatic hemoabdomen often declare themselves non-survivors before making it to veterinarians. Free fluid in cats is more likely to be urine (or less commonly other non-hemorrhagic effusions) in these surviving cats.

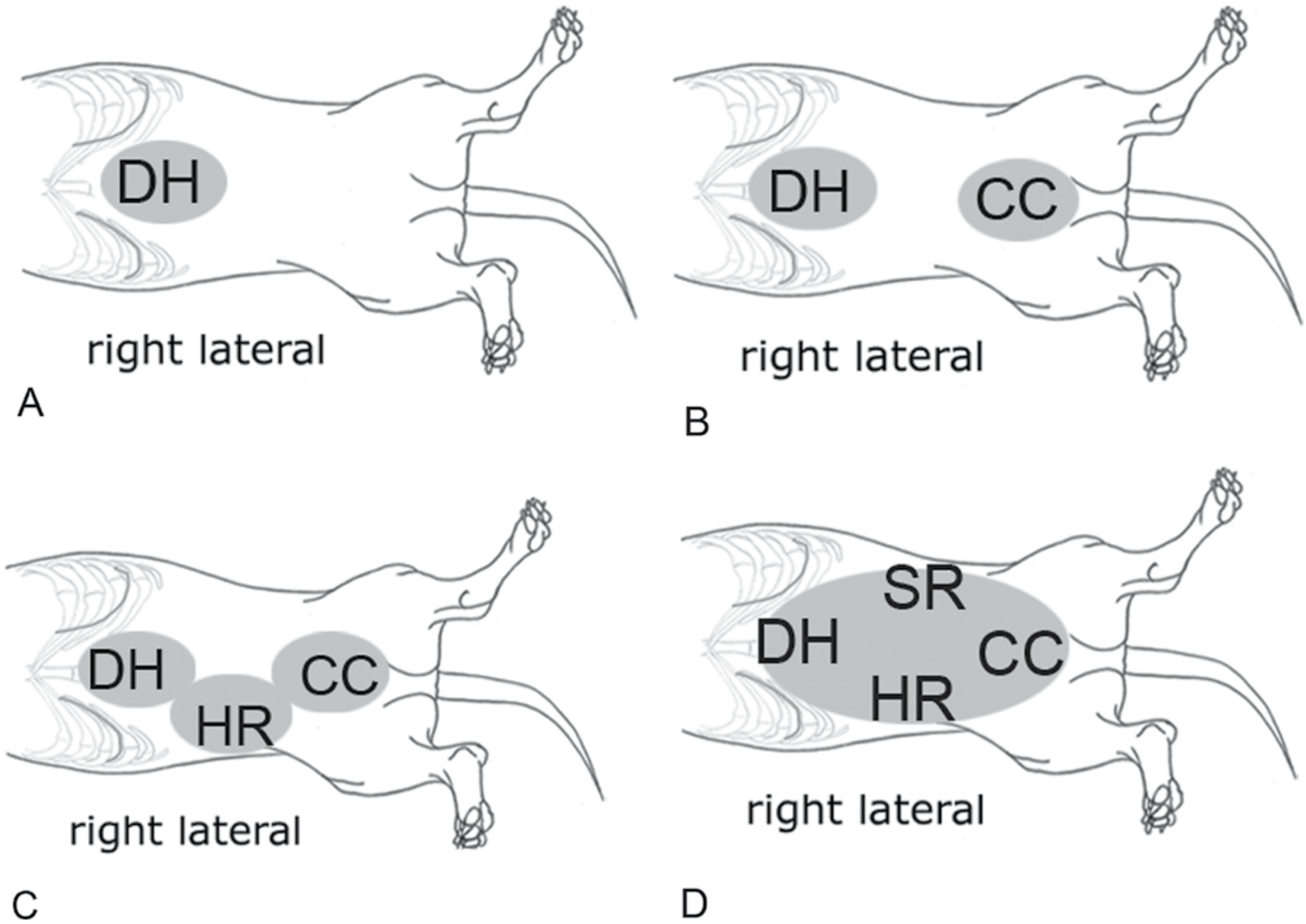


Figure 2.15. Illustration showing the relationship between abdominal fluid score (AFS) and the location(s) of the respective AFAST^3-positive site(s) in right lateral recumbency. The AFS is defined as follows: (A) AFS 1, positive at any one site; pictured is the most common AFS 1 site, the DH view. (B) AFS 2, positive at any two sites; pictured are the two most common AFS 2 sites, the non-gravity dependent DH and CC views. (C) AFS 3, positive at any three sites; pictured are the most common AFS 3 sites which now generally become gravity dependent (D) AFS 4, positive at all four sites. Lateral recumbency inherently provides a depth gauge for the volume of fluid as shown in the progression from AFS 1 to AFS 4. Note that lower-scoring AFS-1 and AFS-2 hemoabdomen dogs are most commonly positive at non-gravity dependent DH and CC AFAST^3 sites. (DH, diaphragmatico-hepatic; SR, spleno-renal; CC, cysto-colic; HR, hepato-renal) (Lisciandro 2011). © Gregory Lisciandro

Most Common AFAST^3 Positive Sites in Low-Scoring Patients

The most common positive sites in low-scoring small bleeder dogs are those in the non-gravity dependent DH and CC views. Clinicians performing AFAST^3 should become especially familiar with the proper imaging and the pitfalls of these two views as noted above (Figure 2.15A and B).

> The most common low-scoring sites in AFAST^3-positive dogs are in the non-gravity dependent DH and CC views (Figure 2.15A and B).

Use of AFAST^3 and Abdominal Fluid Score in Non-Traumatic Bleeding Subsets of Patients

The same AFS concept may be applied to dogs with non-traumatic abdominal bleeding (ruptured mass), those that are coagulopathic (actively bleeding), or in post-interventional patients that are at risk for bleeding (surgery [spay, liver lobectomy, splenectomy, adrenalectomy, etc.] and percutaneous or laparoscopic aspirate or biopsy [liver or splenic, aspirate or biopsy, etc.]). AFAST^3 is superior in detecting hemorrhage to laboratory values (packed cell volume), physical examination findings, and radiography (Lisciandro 2009; Rozycki 1998, 2001).

For example, AFAST^3 and the AFS should be used as a more effective screening test than traditional means by performing an AFAST^3 four hours (or sooner as clinical course dictates) post-percutaneous interventional and post-surgical procedures. Furthermore, AFAST^3 should be the preferred screening test for coagulopathic dogs and cats because AFAST^3 screens the peritoneal and retroperitoneal spaces and when combined with TFAST^3 and Vet BLUE also screens for occult bleeding in the pleural and pericardial spaces and within the lungs.

It is noteworthy that in contrast to dogs, cats with spontaneous non-traumatic hemoabdomen generally have a poor prognosis (Culp 2010), and the reliability of the AFS is unknown in this subset of hemoabdomen cats.

AFAST^3 should become routinely administered as a post-interventional monitoring tool in all subsets of at-risk veterinary patients. AFAST^3 can be used as an initial evaluation technique as an extension of the physical examination for the early detection of bleeding and other complications in both dogs and cats, in preference to less sensitive traditional means of clinical evaluation. The value of the technique for post-interventional monitoring has clearly been shown in people (see below) (Rozycki 1998, 2001). Initial and serial AFAST^3 with the application of the AFS will help survey for ongoing bleeders. In addition, the technique aids in the detection of big bleeders and may allow the clinician to have a high index of suspicion in advance of the possibility of overt clinical decompensation than would be possible by waiting on less sensitive traditional indicators such as packed cell volume and vital signs. In humans, it is well known that patients can compensate and fool physicians with unremarkable vital signs, mucus membrane color, heart rate, and pulse quality with up to a loss of 30% of their blood volume (Muir 2006). Dogs may very well be able to compensate even more due to blood reservoirs provided by splenic contraction.

In post-interventional dogs, AFS may be used to anticipate the need for emergent exploratory using the small bleeder vs. big bleeder concept. Remember, "If it's a 3 or 4 you should generally explore" and more expediently address [ligate] the source of bleeding in this subset of veterinary patients.

The Use of AFAST^3 and Abdominal Fluid Score in Non-Bleeding Subsets of Patients

The use of the abdominal fluid scoring system may help with tracking (monitoring) any effusive condition of the abdomen, and additionally proves helpful in tracking post-operative patients at risk for all forms of peritonitis. These subsets of veterinary patients often do not produce ultrasonographically visible free fluid until they are resuscitated and rehydrated. In human with possible bowel injury, serial ultrasound examinations are recommended out to 12–24 hours post admission (Mohammadi 2012).

Serial AFAST^3 exams increase the sensitivity in peritonitis suspects and should be performed four hours post-admission and again after resuscitation and rehydration. If the patient has not declared itself overtly surgical but remains a candidate, AFAST^3 should be used serially out to as long as 12–24 hours.

Use of AFAST^3 and Abdominal Fluid Score in Penetrating Trauma

The use of AFAST^3 in penetrating trauma such as bite wounds, especially in cases of big dog-little dog or big dog-cat, was hypothesized as being helpful in detecting intra-abdominal injury (and intrathoracic injury, see TFAST^3, Chapter 9). However, it was found that AFAST^3 performed in many of the 145 dogs in the TFAST^3 study often missed serious operative intra-abdominal injury.

Although abdominal radiography (AXR) is typically a low yield diagnostic test in bluntly traumatized dogs, it should always be part of the standard work-up in penetrating trauma.

The difference probably lies in the nature of each type of trauma, blunt vs. penetrating, because blood is rapidly defibrinated in blunt trauma and generally appears anechoically (black) and conspicuously as free fluid. In contrast, penetrating trauma, especially bite wounds, causes a different initiation of the coagulation cascade because the tissue is crushed and torn, resulting in clotted blood. Clotted blood has echogenic characteristics similar to soft tissue (shades of gray) and hence, is not readily detectable by ultrasonography. However, in time, clotted blood may defibrinate, and viscous organs may leak their contents into accessible spaces as free fluid; thus serial AFAST³ exams are helpful in the decision-making process of medical vs. surgical care.

AFAST³ misses clotted blood because its echogenicity is similar to soft tissue.

Even though no studies have specifically looked at AFAST³ in penetrating trauma, its ability to detect injury probably has low sensitivity but high specificity in such cases, in the author's experience. In other words, a negative AFAST³ warrants serial examinations (or other higher yielding tests), and although AFAST³ is a first-line test in blunt trauma, it is probably better suited as an ancillary test in penetrating trauma for more seriously injured animals when deciding whether they are best managed medically vs. surgically. A positive AFAST³, however, warrants serious consideration for emergent laparotomy because of the likelihood of significant intra-abdominal injury as shown in people, and serial examinations increase the sensitivity of FAST (Udobi 2001, Kirkpatrick 2004, Matsushima 2011). In human with possible bowel injury, serial ultrasound examinations are recommended out to 12–24 hours post admission (Mohammadi 2012).

Serial AFAST³ exams increase the sensitivity in penetrating trauma suspects with possible intra-abdominal injury, and should be performed four hours post-admission and at least once post-resuscitation and rehydration and out to 24 hours or more in questionable cases.

The Use of AFAST³ for Anaphylaxis in Dogs

In 2009, the clinical use of ultrasound in dogs for the diagnosis of anaphylaxis was documented and shown to be helpful. Because the shock organs in dogs are the liver and gastrointestinal tract, hepatic venous congestion occurs rapidly (experimentally within seconds) with massive histamine release within the portal circulation (Quantz 2009). As a result, the gallbladder wall thickens and appears striated with alternating echogenicity followed by sonolucency and then again echogenicity (Figure 2.16A and B).

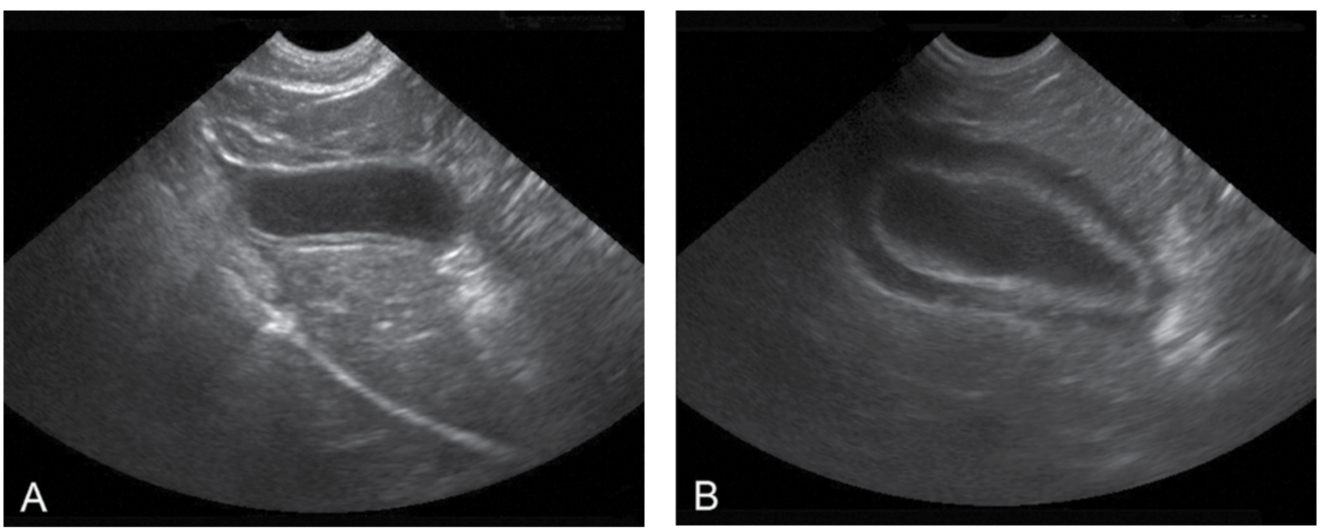


Figure 2.16. The gallbladder halo sign of anaphylaxis. (A) Anaphylaxis and the gallbladder double rim or halo sign in a dog with multiple bee stings without angioedema or urticaria. The gallbladder wall is classically thickened (greater than 3 mm) with inner and outer hyperechoic (bright white) walls sandwiching a middle layer of sonolucency (dark) causing a double rim sign, also referred to as the gallbladder halo sign. (B) Another example of an impressive gallbladder halo sign in an anaphylactic dog presenting with acute collapse and again without obvious angioedema or urticaria. It is very important to perform a complete AFAST³ exam and rule out other causes of collapse, some of which (especially pericardial effusion/cardiac tamponade) may cause a false positive gallbladder halo sign (Figure 2.17). Furthermore, canine anaphylaxis cases can develop various degrees of coagulopathic non-surgical hemoabdomen as a complication (see section on the use of AFAST³ for anaphylaxis in dogs). © Gregory Lisciandro

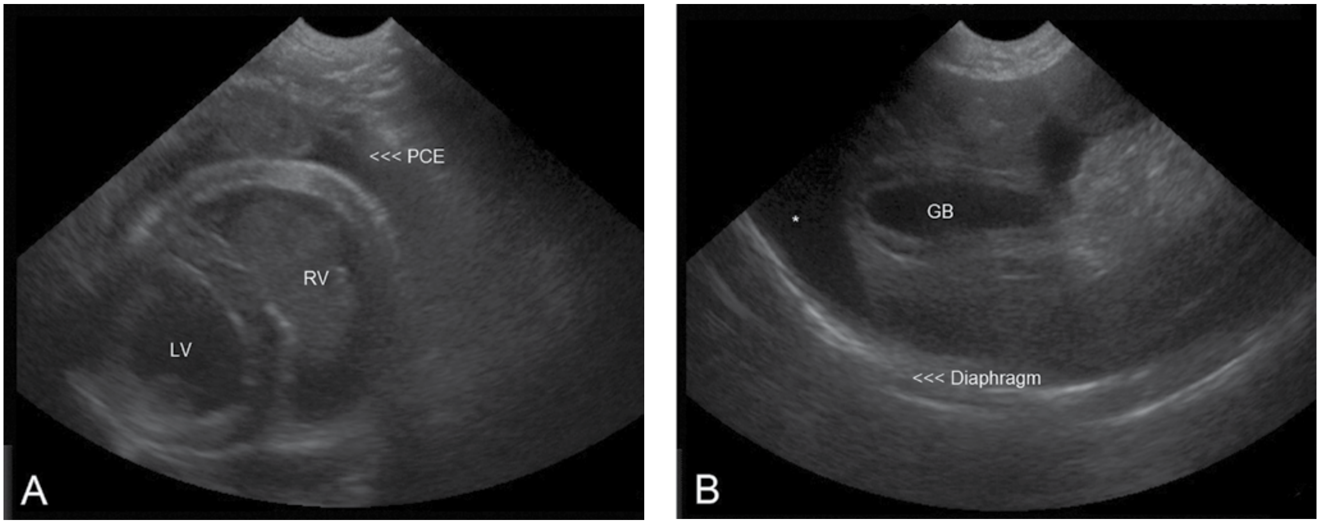


Figure 2.17. Acute tamponade and a false positive halo sign. (A) This middle-aged medium-sized dog presented in acute collapse and was rapidly assessed using combination FAST^3 (AFAST^3 and TFAST^3). Cardiac tamponade was diagnosed and an emergent pericardiocentesis was performed (pericardial effusion, PCE; right ventricle, RV; left ventricle, LV). Note the race track sign with the rim of fluid around the heart with heart chambers clearly identified. (B) Shown here at the diaphragmatico-hepatic (DH) view is abdominal effusion and a gallbladder halo sign secondary to venous congestion from the cardiac tamponade (free intra-abdominal fluid [*]; liver, LIV; gallbladder, GB). Looking into the thorax on all AFAST^3 exams will help avoid this potentially catastrophic misinterpretation of the gallbladder halo sign for anaphylaxis because a large intravenous bolus of fluids may be detrimental to this patient. © Gregory Lisciandro

These gallbladder changes are much more rapid (less than two to four minutes) than traditional markers such as the alanine transaminase (ALT) level (peak two to four hours) used in veterinary medicine. This change in the gallbladder has been termed the "halo sign" (Quantz 2009). It is critical to note that there are other causes of gallbladder wall thickening (normal thickness in dogs is less than 2–3 mm) and a double rim or halo sign, including conditions that cause obstruction to venous and lymphatic return such as cardiac tamponade and congestive heart failure; conditions that affect the regional anatomy such as pancreatitis, cholangiohepatitis, and primary gallbladder diseases (cholecystitis); and conditions that lead to third spacing such as severe hypoalbuminemia, volume overload including over-resuscitation, and others (Nelson 2010).

With that being said, regarding acute collapse, the three major rule-outs in San Antonio, Texas, are acute hemoabdomen, acute cardiac tamponade, and anaphylaxis. Importantly, acute cardiac tamponade may cause a false positive gallbladder halo sign (unpublished) (Figure 2.7). As a result, the author's practice has goal-driven templates for AFAST^3 findings that include remarks about the pleural and pericardial spaces (see Appendix II) so the gallbladder halo sign is not misinterpreted.

There are other causes of unexplained collapse in dogs so it is very important to always perform a complete AFAST^3 exam so as to not miss hemorrhage in the peritoneal or retroperitoneal spaces or cardiac tamponade, the latter of which may cause a false positive gallbladder halo sign. The resuscitative treatment for anaphylaxis includes the rapid bolus of intravenous fluids and epinephrine, in contrast to cardiac tamponade, in which such an intervention could be catastrophic to the dog.

> There are other causes of unexplained collapse in dogs so it is very important to always perform a complete AFAST^3 exam, and even better, a TFAST^3 and Vet BLUE.

It is not uncommon for anaphylactic dogs to develop a coagulopathic hemoabdomen that is typically low-scoring at the DH view (and sometimes AFS 2 at the DH and CC views). However, it is possible to have marked hemoabdomen (AFS 3, 4) in some dogs with severe anaphylaxis on presentation (unpublished). The clinical key to avoid mistakenly (and potentially catastrophically) taking the case to surgery is the finding of markedly elevated clotting times, a markedly elevated ALT, and significant hemoconcentration.

Anaphylactic dogs may have a coagulopathic hemoabdomen on admission or develop one post-resuscitation that is medically (not surgically) treated.

The Use of AFAST³ and its DH View for Pericardial Effusions

Veterinarians incorporating the FAST³ protocols into their practice should review the causes and treatment of pericardial effusion, including left atrial tears (mitral valve disease in dogs). Comparing 2005 (pre-FAST³) to 2011 (post-AFAST³ and TFAST³) at the author's practice, the incidence in detecting pericardial effusion was dramatic (two cases vs. 24, annual caseload approximately 11,000). Moreover, of the 24 cases, 21 of 24 (88%) were recognized by the diaphragmatico-hepatic (DH) view, either during TFAST³ or AFAST³. Approximately 50% had pericardiocentesis performed and cardiac tamponade could be diagnosed by the DH view (Lisciandro 2012, unpublished data) (Figure 2.3A, B). Generally, in real-time ultrasound imaging, this life-threatening condition may be easily recognized by the non-radiologist veterinarian using TFAST³ (see Figures 9.17, 9.18, 9.19, and 9.20 and Chapter 11).

Most cases of clinically significant pericardial effusion may be detected using the DH view during AFAST³ (and further confirmed as needed by the pericardial TFAST³ views, adhering to the sage axiom that "One view is no view"). Always attempt to look into the thorax via the DH view and include the data in your goal-directed templates.

Table 2.1.
Indications for AFAST³.

Uses of AFAST³ Initial and Serial Exams	Objectives
Trauma	
Blunt trauma	Hemoabdomen, uroabdomen and other effusive peritoneal and retroperitoneal conditions; and pericardial and pleural space conditions Note: Standard of care as first-line screening test as in human trauma
Penetrating trauma	Hemoabdomen, uroabdomen, bilioabdomen, septic abdomen, and other effusive peritoneal and retroperitoneal conditions; and pericardial and pleural space conditions Note: First-line screening test or secondary test, depending on suspected type of injury. Serial exams are key because clotted blood will defibrinate and viscous organs will leak contents that then can be detected as free fluid Note: May be able to detect pneumoabdomen and pneumoretroperitoneum in some cases
Non-trauma	
Uncharacterized hypotension (collapsed, weakness, even if apparently recovered)	Pericardial effusion/tamponade, pleural effusion, anaphylaxis, hemoabdomen, retroperitoneal bleed, and other effusive peritoneal and retroperitoneal conditions
Coagulopathy	Quad-cavity evaluation as screens four spaces for bleeding including peritoneal, retroperitoneal, pleural, and pericardial spaces Note: Add on Vet BLUE, and lung hemorrhage may also be screened
Anemia	Quad-cavity evaluation as screens four spaces for bleeding including peritoneal, retroperitoneal, pleural, and pericardial spaces Note: Add on Vet BLUE, and lung hemorrhage may also be screened
All peritonitis suspects	Detect septic abdomen earlier than traditional means without ultrasound
Post-interventional	
Percutaneous aspirates	Bleeding, forms of peritonitis, and pleural and pericardial space problems
Percutaneous biopsies	Bleeding, forms of peritonitis, and pleural and pericardial space problems
Post-laparoscopic	Bleeding, forms of peritonitis, and pleural and pericardial space problems
Post-surgical	Bleeding, forms of peritonitis, and pleural and pericardial space problems
CPR	See Chapter 16 Rapidly assess for potentially treatable causes of cardiopulmonary arrest. Use to survey for complications and for guiding fluid resuscitation.

Incidental Findings During AFAST^3

Incidental findings, including non-trauma related conditions in target-organs, are not uncommon during AFAST^3 exams. The phenomenon has likewise been recognized in human medicine (Sgourakis 2012). Through the repetition in performing initial and serial exams, ultrasonographic "normals" of target organs and deviations from these normals will become easily recognized by the non-radiologist sonographer, often triggering additional imaging, including a complete abdominal ultrasound or complete echocardiography by a veterinary radiologist or internist with advanced ultrasound training. Shown here are trauma-related findings of an intraparenchymal hematoma in a spleen and a large blood clot filling the entire lumen of the urinary bladder (Figure 2.18A and B).

Documenting AFAST^3 Findings in Medical Records

The use of standardized templates is imperative, not only for communication of AFAST^3 findings between veterinarians but also for evaluating serial findings. The use of standardized templates that are goal-driven also accelerates the learning curve and disciplines the sonographer by making him or her look at certain aspects of the target organs (looking into the thorax for pleural and pericardial effusion [DH view]; looking at the hepatic veins for venous congestion [DH view]). The "Comments" section allows for any findings outside of the goal-driven standard format to be listed (e.g., a urinary bladder stone or mass, a splenic mass, etc.). Finally, the AFAST^3 protocol and its strengths and weaknesses may be evaluated and improved upon with recorded data. Suggested templates for medical records are in Appendix II.

Pearls and Pitfalls, the Final Say

AFAST^3 is an advantageous ultrasonographic format for non-radiologist veterinarians to use for the timely detection of free fluid representing bleeding or forms of peritonitis because ultrasound is superior in sensitivity to physical examination and abdominal radiography. Of note:

- AFAST^3 should be a routine add-on to all intra-abdominal focused or COAST^3 exams.
- AFAST^3 should be standard of care for all bluntly traumatized dogs and cats, as it is in people.
- AFAST^3 should be used in penetrating trauma cases with the understanding that AFAST^3 is generally thought to be very specific for detecting intra-abdominal injury (by finding free fluid), but lacks high sensitivity.

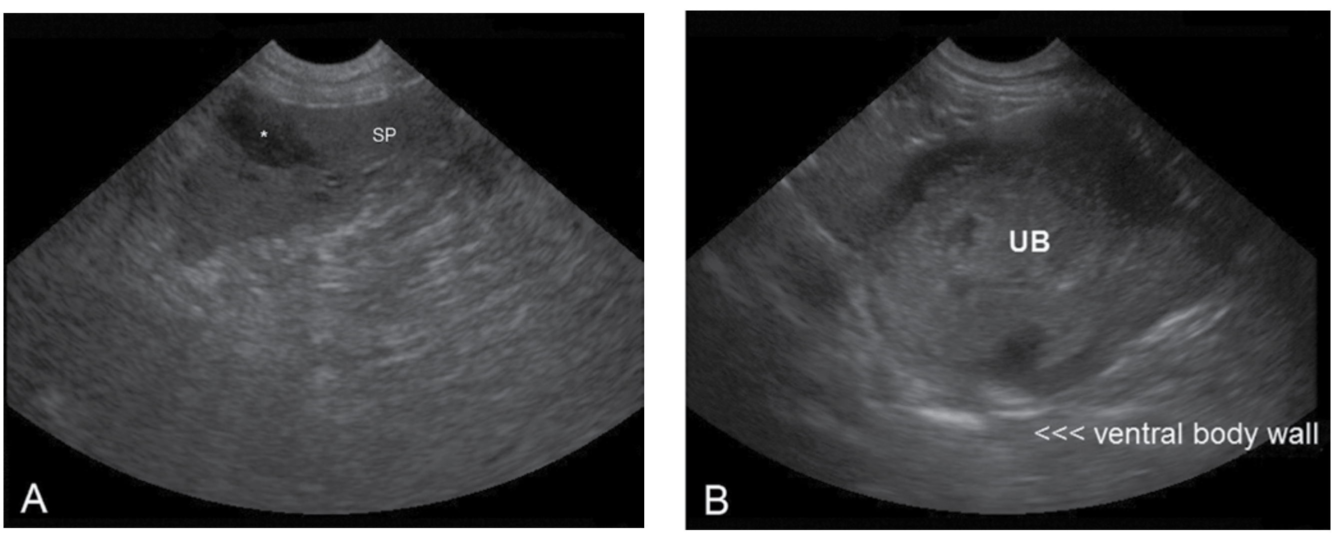


Figure 2.18. Organ injury detected during AFAST^3. (A) Splenic (SP) intraparenchymal hematoma apparent by the anechoic region (*) near the head of the spleen found during the initial AFAST^3 in a dog with automobile-induced trauma (also see Figure 13.8B). (B) A large blood clot nearly filling the lumen of the urinary bladder (UB) found during the initial AFAST^3 in a dog with automobile-induced trauma. © Gregory Lisciandro

- Serial exams should always be performed in bluntly traumatized animals four hours post-admission; and after rehydration and resuscitation in penetrating trauma and non-trauma at-risk cases, including suspect peritonitis cases.
- The use of the AFS system may be effectively applied in bleeding traumatized and non-traumatized dogs to predict the degree of anticipated anemia in dogs (not reliable in cats). It also may be used for peritonitis or other effusive conditions as a monitoring tool.
- The diagnosis of anaphylaxis in dogs may be supported with the finding of a gallbladder halo sign; however, a complete AFAST^3 including ruling out cardiac tamponade and placing the finding within the complete clinical picture is important to avoid mistakes (false positive).

References

Boysen SR, Rozanski EA, Tidwell AS, et al. 2004. Evaluation of a focused assessment with sonography for trauma protocol to detect free abdominal fluid in dogs involved in motor vehicle accidents. *J Am Vet Med Assoc* 225(8):1198–1204.

Culp WT, Weisse C, Kellogg ME, et al. 2010. Spontaneous hemoperitoneum in cats: 65 cases (1994–2006). *J Am Vet Med Assoc* 236(9):978–82.

Kirkpatrick AW, Sirois M, Ball CG, et al. 2004. The hand-held ultrasound for penetrating abdominal trauma. *Am J of Surg* 187:660–665.

Kolata RJ, Dudley EJ. 1975. Motor vehicle accidents in urban dogs: a study of 600 cases. *J Am Vet Med Assoc* 167:938–941.

Lisciandro GR. 2011. Abdominal and thoracic focused assessment with sonography for trauma, triage, and monitoring in small animals. *J Vet Emerg Crit Care* 21(2):104–122.

Lisciandro GR, Lagutchik MS, Mann KA, et al. 2009. Evaluation of an abdominal fluid scoring system determined using abdominal focused assessment with sonography for trauma in 101 dogs with motor vehicle trauma. *J Vet Emerg Crit Care* 19(5):426–437.

Lisciandro GR, Lagutchik MS, Mann KA, et al. 2008. Evaluation of a thoracic focused assessment with sonography for trauma (TFAST) protocol to detect pneumothorax and concurrent thoracic injury in 145 traumatized dogs. *J Vet Emerg Crit Care* 18(3): 258–269.

Lisciandro GR. 2012. Evaluation of initial and serial combination focused assessment with sonography for trauma (CFAST) examinations of the thorax (TFAST) and abdomen (AFAST) with the application of an abdominal fluid scoring system in 49 traumatized cats. Abstract. *J Vet Emerg Crit Care* 22(S2):11.

Lisciandro GR. 2012. The clinical utility of the AFAST diaphragmatico-hepatic view for the detection of pericardial effusion. Unpublished data.

Mandell DC, Drobatz K. 1995. Feline hemoperitoneum: 16 Cases (1986–1993). *J Vet Emerg Crit Care* 5(2):93–97.

Matsushima K, Frankel HL. 2011. Beyond focused assessment with sonography for trauma: ultrasound creep in the trauma resuscitation area and beyond. *Curr Opin Crit Care* 17(6):606–12.

Mongil CM, Drobatz KJ, Hendricks JC. 1995. Traumatic hemoperitoneum in 28 cases: a retrospective review. *J Am Anim Hosp Assoc* 31:217–222.

Mohammadi A, Ghasemi-Rad M. 2012. Evaluation of gastrointestinal injury in blunt abdominal trauma FAST is not reliable: the role of repeated ultrasonography. *World J Emerg Surg* 20;7(1):2.

Muir W. 2006. Trauma: physiology, pathophysiology, and clinical implications. *J Vet Emerg Crit Care* 16(4):253–263.

Nelson NC, Drost WT, Lerche P, et al. 2011. Noninvasive estimation of central venous pressure in anesthetized dogs by measurement of hepatic venous blood flow velocity and abdomen al venous diameter. *Vet Rad and Ultrasound* 51(3):313–323.

Quantz JE, Miles MS, Reed AL, et al. 2009. Elevation of alanine transaminase and gallbladder wall abnormalities as biomarkers of anaphylaxis in canine hypersensitivity patients. *J Vet Emerg Crit Care* 19(6):536–544.

Rozycki GS. 1998. Surgeon performed US: its use in clinical practice. *Ann Surg* 228:16–28.

Rozycki GS, Pennington SD, Feliciano DV. 2001. Surgeon-performed ultrasound in the critical care setting: its use as an extension of the physical examination to detect pleural effusion. *J Trauma* 50(4):636–42.

Sgourakis G, Lanitis S, Zacharioudakis C, et al. 2012. Incidental findings in trauma patients during focused assessment with sonography for trauma. *Am Surg* 78(3):366–72.

Sigrist NE, Adamik KN, Doherr MG, et al. 2011. Evaluation of respiratory parameters at presentation as clinical indicators of the respiratory localization in dogs and cats with respiratory distress. *J Vet Emerg Crit Care* 21(1):13–23.

Simpson SA, Syring R, Otto CM. 2009. Severe blunt trauma in dogs: 235 cases (1997–2003). *J Vet Emerg Crit Care* 19(6):588–602.

Udobi KF, Rodriguez A, Chiu WC, et al. 2001. Role of ultrasonography in penetrating abdominal trauma: a prospective study. *J Trauma* 50:475–479.