CHAPTER ONE

POCUS: Introduction

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Veterinary POCUS (V-POCUS) Defined

- *POCUS is point-of-care ultrasound*.
- *FAST is focused assessment with sonography for trauma, triage, and tracking (Lisciandro 2011)*.
- *Veterinary POCUS (V-POCUS), which includes FAST examinations, is defined as a goal-directed ultrasound examination(s) performed by a healthcare provider at point of care (cageside) to answer a specific diagnostic question(s) or guide performance of an invasive procedure(s)*.

We will use the acronyms POCUS and FAST throughout the textbook. It is important to read the Preface *prior to* Chapter One.

Terminology Updates

Briefly, we will mention some of the more important changes and developments since our first edition. A more complete list of terminology and abbreviations is found in the Appendices. For a grasp of some of the basic concepts within this textbook, let's define a few things.

The "T³" of Trauma, Triage, and Tracking

We have mostly dropped the "T³" designation that previously emphasized the "3-T approach" of applying FAST for *T*rauma, *T*riage, and *T*racking (T³), primarily because since the first edition, the T³ approach has become routine throughout North America, South America, Europe, and the Middle East in the author's experience.

COAST³ is Out, POCUS is In

COAST³ or "cageside organ assessment with sonography for trauma (triage and tracking)" is out (similar to BOAST in human medicine) and POCUS is now the preferred mainstream term similar to what has occurred in human medicine (Rozycki et al. 2005; Lisciandro et al. 2014).

We have replaced COAST with POCUS in this second edition and advocate for POCUS (or Focused) X, or POCUS (Focused) Y, or POCUS (Focused) Z as giving better clarity to the examination and have proposed approaches to the various systems throughout this edition. The use of FoCUSED for "Focused Cardiac Ultrasound" and other confusing acronyms we hope to avoid in veterinary medicine. FoCUSED in human medicine would have been better named POCUS (or Focused Heart) Heart or POCUS (or Focused Echo) Echo. The term "Focused" as in our first edition similarly provides clarity to the examination and may be used interchangeably with specific POCUS examinations.

FAST Survives and Continues

FAST stands for Focused Assessment with Sonography for Trauma and has been applied to the abdomen (FAST) and extended thorax (EFAST) in people (Rozycki 1998; Rozycki et al. 2001; Kirkpatrick et al. 2004). Its applications have expanded to

Point-of-Care Ultrasound Techniques for the Small Animal Practitioner, Second Edition. Edited by Gregory R. Lisciandro.

Companion website: www.wiley.com/go/lisciandro/ultrasound2

nontrauma and tracking (Lisciandro 2011, 2016; McMurray et al. 2016). Problems arise in the human literature with terminology and they are not always right. For example, what exactly is EFAST? Is it a FAST *and* the thorax or *only* the thorax? What if we just do the thorax, then what FAST do we call it? Abdominal FAST (AFAST) and thoracic FAST (TFAST) give exact clarity and have been standardized and validated in published studies (Lisciandro et al. 2008, 2009; Lisciandro 2016; McMurray et al. 2016). Their acoustic windows have *exact clarity*, as does the "FAST" lung examination called Vet BLUE (Lisciandro et al. 2014, 2017).

The Flash Exam is Not a FAST Exam

The "Flash Exam" term is applied for a general whole-cavity acoustic window approach to rapidly answer a simple binary question: is free fluid present or not in the abdominal and thoracic cavity? And now, with lung ultrasound becoming accepted among colleagues, are B-lines present or not? There is so much more to gain by using standardized acoustic windows of AFAST and TFAST (and Vet BLUE) that take about the same amount of time as the "Flash" approach. The "Flash" usually is followed by "looking around," often leading to a "satisfaction of search error" approach. Again, in the *same* amount of time, you could have done AFAST, TFAST, and Vet BLUE (Global FAST) with *standardized* acoustic windows following a protocol and gained so much more unbiased baseline patient information, while avoiding "satisfaction of search error." AFAST, TFAST, and Vet BLUE are not "Flash" exams and the terms should not be used interchangeably. We should stop teaching the "Flash" approach, just as we would not teach limited physical examinations – such as only quickly palpating the abdomen of a vomiting cat to draw clinical conclusions without looking further (Figure 1.1).

Radiologist and Cardiologist Studies

We will refer to these studies as complete detailed abdominal ultrasound" and "complete detailed echocardiography." "Diagnostic" is a term that can be more universally applied as both a POCUS (or Focused) and FAST examination are potentially diagnostic, for example for ascites, pleural and pericardial effusion, calcaneus tendon rupture, skull fracture, a splenic mass, gallbladder mucocele, to name a few.

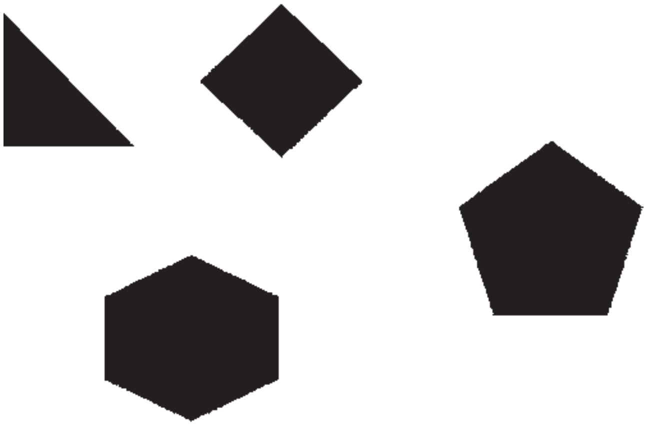

Figure 1.1. The premise of FAST ultrasound – anechoic triangulations are abnormal and represent free cavitary fluid. The nonradiologist can be readily trained to recognize anechoic (black) triangulations within cavities and spaces, which are abnormal in adult patients. The "Flash" exam answers a simple binary question of whether fluid is present or absent, whereas the AFAST provides more information through fluid scoring and its target organ approach, TFAST through echo views and volume status, and Vet BLUE through a regional, pattern-based approach. Courtesy of Dr Gregory Lisciandro, Hill Country Veterinary Specialists and FASTVet.com, Spicewood, TX.

Other Terms

We have done our best to make this second edition uniform in terminology and up to date with the current consensus in both human and veterinary medicine. Some examples in which multiple terms relating to similar things are used are listed here.

The preferred term is listed first but each may be considered synonymously.

- POCUS exam and Focused exam
- sonographer and ultrasonographer
- ultrasonographically and sonographically
- color Doppler and color flow Doppler
- beam and scanning plane
- acoustic window and view
- fanning and tilting
- longitudinal and sagittal (and long axis)
- transverse (and short axis)
- orientation and plane
- probe and transducer
- curvilinear probe and microconvex probe
- B-lines and ultrasound lung rockets
- lung sliding and glide sign
- gallbladder halo sign, gallbladder halo effect, and gallbladder double rim effect

- FAST diaphragmatico-hepatic view and subxiphoid view
- acoustic coupling and probe–skin contact

We have provided a comprehensive list of abbreviations, terms, and definitions in the Appendices.

Recording Your Findings on Goal-directed Templates

Recording data on goal-directed templates with clear objectives for answering defined clinical questions is imperative to gain the respect of our colleagues, to stay disciplined during the respective POCUS or FAST examination, to allow *post hoc* evaluation of studies, and to detect training strengths and deficiencies. Without recording your data, you cannot measure. If you cannot measure, you cannot critically study with the potential to improve. We have made great strides in Global FAST training by reevaluating our results recorded on goal-directed templates and saved video clips. A prime example is the establishment of clear tenets for the accurate TFAST diagnosis of pericardial effusion (Lisciandro 2016).

We have presented POCUS and FAST goal-directed templates and methods to efficiently save video clips for you to adapt and modify for your practice according to the types of cases you see, your practice type, and your skill level in the Appendices and Chapter 45.

Echogenicity – Whites, Grays, and Blacks

The jargon of ultrasound can be intimidating to the novice sonographer. Clarity may be accomplished through acknowledging that *ultrasound is generally the opposite of how free fluid, air, and soft tissue appear on radiographic studies* (our brain needs to reformat itself). For example and very simplistically, air is white on ultrasound and black on radiographs. Fluid is black on ultrasound and white on radiographs. However, bone is black (shadows) on ultrasound? And white on radiographs? Or white along its proximal surface with acoustic shadowing through the far field. Now if we are losing you, hang in there. The figures help (Figures 1.2, 1.3, 1.4, 1.5). *Study them now.*

The ultrasound terms describing whites, grays, and blacks are anechoic (black), degrees of echogenicity (hypoechoic, shades of gray), and hyperechoic (white).

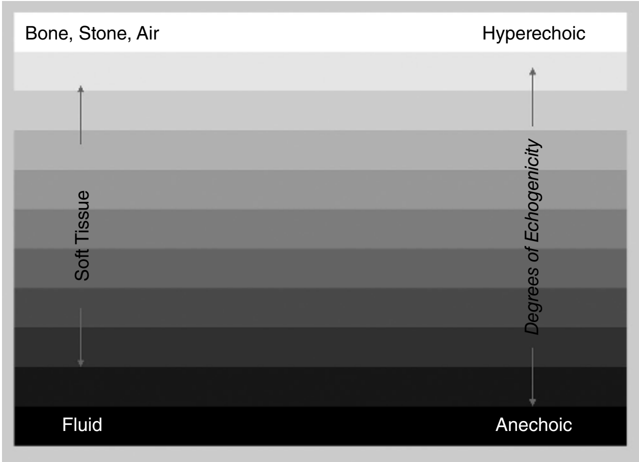

Figure 1.2. The figure shows the ultrasound differences in B-mode gray scale of various tissues, with bone, stone and air being most reflective of the ultrasound beam and thus portrayed as white along its surface, to soft tissues being shades of gray, to fluid which is black. Ultrasound terminology corresponds to these gray-scale colors as hyperechoic, degrees of echogenicity (hypoechoic), and anechoic. Study this chart to get the visual of what these gray-scale terms mean. Courtesy of Dr Gregory Lisciandro, Hill Country Veterinary Specialists and FASTVet.com, Spicewood, TX.

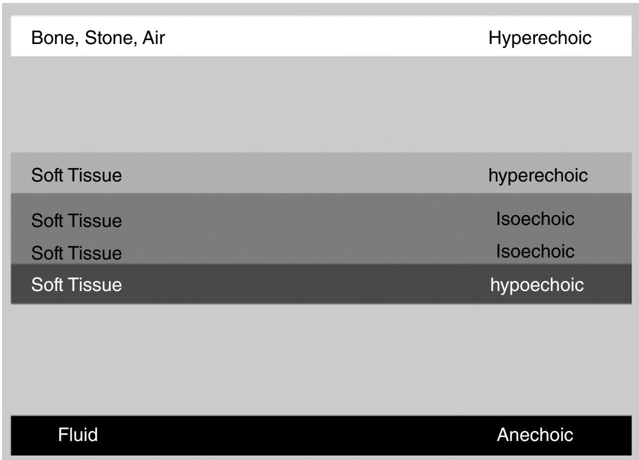

Figure 1.3. This figure is similar to Figure 1.2 but with some of the gray scale removed to illustrate how descriptive ultrasound terminology is used for different tissues. The soft tissue is isoechoic (same as), hyperechoic (brighter than), and hypoechoic (darker than) relative to one another. Correlate with Table 1.1 Courtesy of Dr Gregory Lisciandro, Hill Country Veterinary Specialists and FASTVet.com, Spicewood, TX.

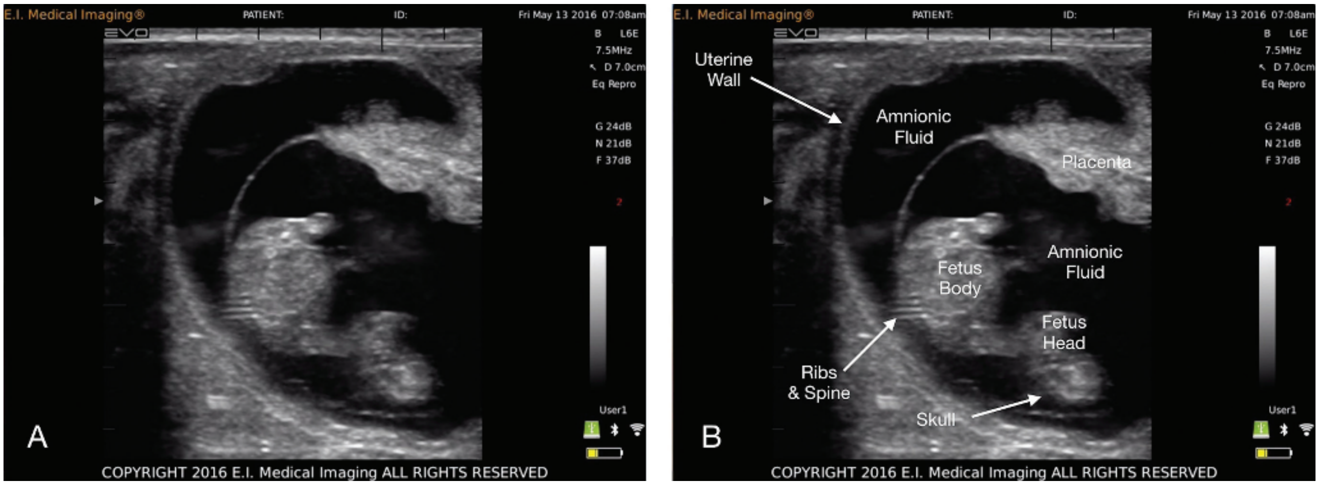

Figure 1.4. This figure is unlabeled and labeled for contrast of what tissue looks like in a gravid female, illustrating the different tissues and structures that correlate with concepts in Figures 1.1 and 1.2. Image used with permission from E.I. Medical, Loveland, CO, USA. www.eimedical.com

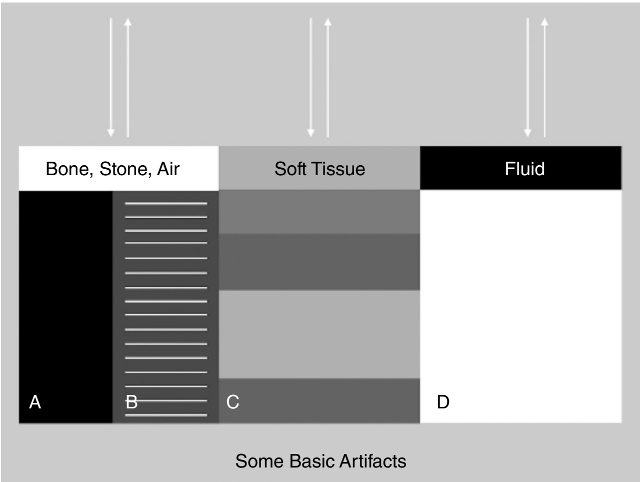

Figure 1.5. Ultrasound and different tissues and elements. Schematic that ties into the previous images showing various elements and the general behavior of ultrasound and its associated artifacts. The arrows represent the ultrasound beam being transmitted and returned to the transducer (probe). In (A) and (B), bone, stone, and air *reflect* because ultrasound (its echoes) does not transmit through them. As a result, they create shadowing of the beam, resulting in (A) "clean shadowing" (anechoic or black past the surface of the structure or element) or (B) "dirty shadowing," including air reverberation called A-lines (hyperechoic horizontal bars past the air). Soft tissues will absorb the ultrasound in different degrees depending on the soft tissue, thus (C) shows different degrees of echogenicity. Lastly, fluid will not absorb much of the ultrasound (echoes pass through the fluid), resulting in (D) acoustic enhancement through the far-field beyond the distal boundary of fluid, making tissues more hyperechoic (brighter) than their adjacent counterparts outside the fluid-related beam. Courtesy of Dr Gregory Lisciandro, Hill Country Veterinary Specialists and FASTVet.com, Spicewood, TX.

The terms may be used relatively between structures like "X relative to Y" and "Y relative to Z." For example, the spleen is *hyper*echoic (brighter than) to the left kidney. The liver is *hypo*echoic (darker than) to the falciform fat. The feline cortex of the kidney is isoechoic (same as) to the spleen (see Figure 1.3).

- **Anechoic (homogeneous black)**: occurs when *no ultrasound waves* are reflected back to the receiver. Thus, normal urine, normal bile, transudates, and blood all are purely anechoic (black).
- **Hypoechoic (shades of gray)**: occurs when *variable degrees of ultrasound waves* are reflected back to the transducer. Thus, the more echoes reflected back, the brighter gray the structure, and the fewer echoes, the darker the gray. Thus, all soft tissues that are not fully aerated are described relative to other distinct tissues, such that the liver is hypoechoic (darker than) relative to the spleen. Viscus organs (i.e., stomach) cannot be described this way, only their walls (i.e., stomach wall).
- **Hyperechoic (whites, bright whites)**: occurs *when all or nearly 100% of ultrasound waves* are reflected back to the transducer. Thus, bone, stone (metals), and air are strong reflectors resulting in hyperechoic (bright white) interfaces with shadowing, comet tail artifact, ring-down artifact, ultrasound lung rockets, or reverberation artifact projected *distal* to the reflective surface.
- **Isoechoic (same echogenicity)**: occurs when tissues are the same shades of gray. For example, if the liver is isoechoic to the spleen then they are the same echogenicity (same shades of gray).

How Ultrasound Behaves Relative to Tissues and Elements

The knowledge of how ultrasound behaves relative to the structures and elements it encounters is very important. From normal tissues within the body to its various constituents (elements) of fluid, air, and mineralization, ultrasound behaves differently, causing a number of artifacts, which can be learned with diligent study, training, and practice. Foreign materials, such as plastic, metal, bone, stone, glass, and vegetative materials, also cause predictable artifacts. These artifacts will be covered in the next few chapters and throughout the textbook. It is a good idea to consider them every time you look at an image to accelerate your learning process.

Degrees of echogenicity of commonly encountered structures from hypoechoic to hyperechoic structures are listed in Table 1.1.

Ultrasound Screen Orientation

The screen orientation should always be "head to the left and tail to the right," similar to the orientation for radiography (Figure 1.6). Thinking in this manner will help you learn the anatomy you are seeing and help you with the direction you need to go to get to the POCUS and FAST ultrasound structures of interest. The exception to this rule is that most cardiologists *reverse* the screen orientation of the heart, which is very problematic for learning image acquisition when doing a Global FAST approach. Many human institutions have rejected this approach for the noncardiologists performing POCUS and FAST examinations for the aforementioned reason.

Table 1.1.
Degrees of echogenicity of commonly encountered structures.

	Structure
Anechoic – hypoechoic (black)	**Bile, urine**
	Muscle
Darker	Renal medulla
	Renal cortex
	Liver
Shades of gray	Fat
	Spleen
	Prostate
Brighter	Renal sinus
	Vessel walls
Hyperechoic (white)	**Bone, air, gas**

Directional Terms for Orientation

Longitudinal and Sagittal

The term *longitudinal* refers to orientation parallel to the spine *or long axis* of the patient's body (see Figures 4.1, 4.2, 4.3). The term *sagittal* refers to the longitudinal axis of the respective deeper structure being evaluated. For example, the superficial jugular vein is imaged in longitudinal whereas the more deeply located and oblique right kidney (not parallel to the body's long axis) is imaged in sagittal planes (parallel to the right kidney's long axis). The terms are often used interchangeably (or, arguably, misused); however, by appreciating that both terms are in their own right long-axis views, directional communication between veterinarians seems to be clear by use of either term. Thus in longitudinal planes, the probe marker is directed towards the patient's head to maintain the same orientation as radiography, head to the left and tail to the right of ultrasound (and radiographic) image.

Transverse

The term *transverse* refers to orientation 90° to the long axis of the structure being evaluated or the *short axis* of the patient (see Figures 4.1, 4.2, 4.3). The probe marker is turned to the left (or counterclockwise) to the patient's right side. Thus, in transverse planes, the probe marker is directed to the patient's right side to maintain the same orientation as radiography, right side on left side of ultrasound (and radiographic) image.

With that said, let's get on with Dr Fulton's chapters that will cover in more detail the physics of ultrasound, its artifacts, and various pointers on the ultrasound machine features and settings and image acquisition.

It's worth your effort and time investment to learn this core skill – POCUS and FAST improve care and save lives!

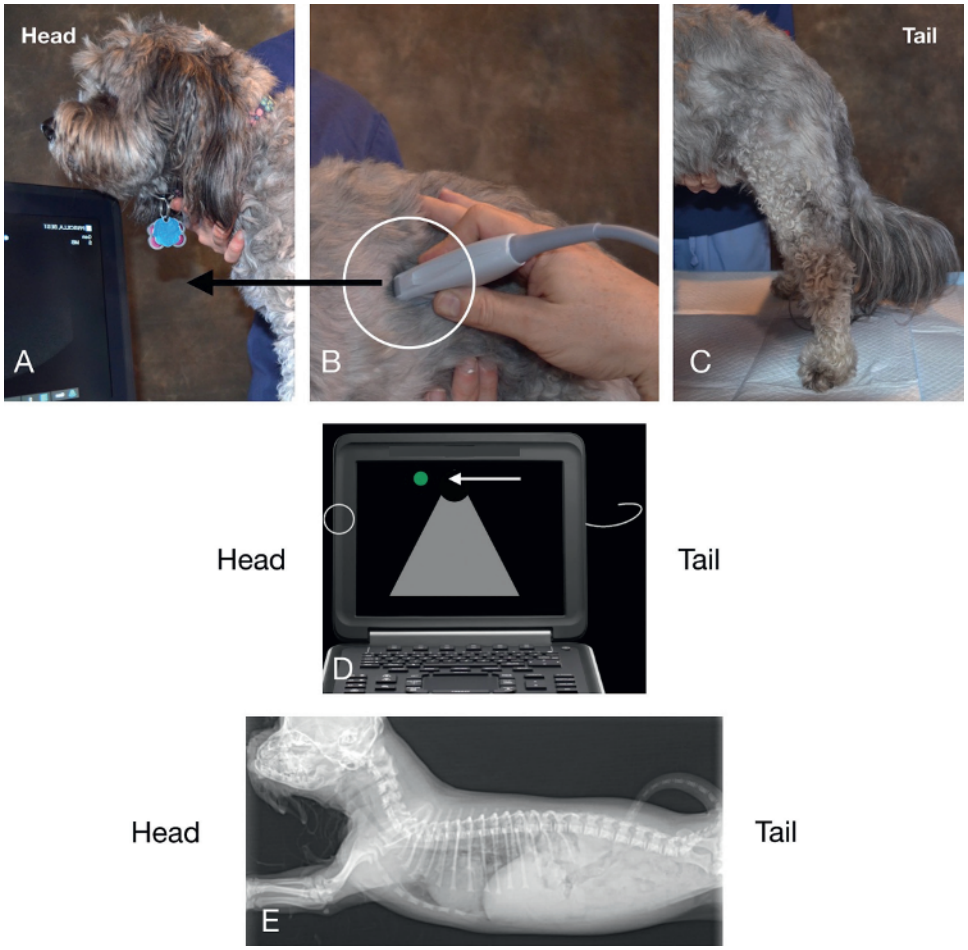

Figure 1.6. Longitudinal (sagittal) planes and orientation. Make the screen marker and the probe marker both consistent with "head to the left and tail to the right," which is the *same* orientation as radiography. (A) shows the head of the dog and (C) its tail. In (B), the probe is placed on the truncal area of the same dog. The white circle highlights the probe marker (can be a notch, a raised line or button, or an LED light). Every probe has its marker. In (D) is a pictorial of the ultrasound screen, and the green dot indicates the screen marker (arrow ←). Make sure that this is to the left of the screen and the probe marker is toward the head of your patient. In (E) is a radiograph showing the *same* orientation used for ultrasound, "head to the left, tail to the right." Courtesy of Dr Gregory Lisciandro, Hill Country Veterinary Specialists and FASTVet.com, Spicewood, TX.

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Further Reading

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