Point-of-Care Ultrasound Techniques for the Small Animal Practitioner
Point-of-Care Ultrasound Techniques for the Small Animal Practitioner

SECOND EDITION

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Dedication

To my late grandparents, Sam and Bernice Long, John and Mary Lisciandro, my parents Richard and Judy, and my lovely wife Stephanie, and our four beautiful children Noah, Hannah, Sarah, and Joshua for their patience and inspiration, to all those who have believed in Global FAST, and to the good Lord for making the textbook and all its many variables fall in place to its completion.
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Over the past three decades, the technological miniaturization of ultrasound machines has made compact, portable ultrasound devices, ranging from pocket-sized devices to laptop-style machines, available to healthcare providers at the bedside. Healthcare providers are using ultrasound to look inside the body during their bedside evaluation of patients, which has given rise to a new field of clinical medicine called point-of-care ultrasound. Point-of-care ultrasound is defined as a goal-directed, bedside ultrasound examination performed by a healthcare provider to answer a specific diagnostic question or guide performance of an invasive procedure at the bedside. Providers from nearly all healthcare professions have begun to learn how to use point-of-care ultrasound, and veterinary medicine is ideally suited for integration of point-of-care ultrasound given the diverse complaints and wide range of animals that are cared for by veterinarians on a daily basis.

The first edition of this book, called Focused Ultrasound Techniques for the Small Animal Practitioner, was published in 2014 and described the most common focused ultrasound examinations in veterinary medicine. The first edition established a standardized approach to perform a multisystem veterinary ultrasound examination, particularly of the heart, lungs, and abdomen, and has served as a guide for veterinarians to incorporate ultrasound into their clinical practices around the world. The book has been translated into Spanish, Chinese, Greek, Japanese, and Polish, and over 2000 copies have been sold worldwide.

In this second edition, the reader experience has been enhanced in several ways. The core chapters describing the fundamental veterinary ultrasound examinations have been expanded to discuss a broader range of species, including exotic species, and a more in-depth discussion of feline species. Several new chapters have been added, including chapters on the use of ultrasound to evaluate marine mammals and zoo animals. Chapters on the nervous system describe evaluation of the brain and peripheral nerves, as well as performance of ultrasound-guided nerve blocks. The online video library has been expanded to include over 100 videos of normal and abnormal findings to supplement the book chapters.

For veterinary clinicians seeking to improve their knowledge and skills in point-of-care ultrasound, this book has evolved to become a standard reference for its high-yield chapters, online video content, and practical teaching points written by experts in the field.

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POCUS is point-of-care ultrasound. Veterinary POCUS (V-POCUS), which includes FAST ultrasound examinations, is defined as a goal-directed ultrasound examination(s) performed by a veterinary healthcare provider at the point of care (cageside) to answer a specific diagnostic question(s) or guide performance of an invasive procedure(s).

The translational study from the human to the veterinary patient regarding the focused assessment with sonography for trauma (FAST) exam by Dr Søren Boysen and colleagues in 2004 was a landmark study opening the eyes of the veterinary world to the nonradiologist, noncardiologist use of ultrasound, and that the principle of FAST ultrasound, that the nonradiologist sonographer is able to recognize anechoic triangulations representing free cavitory fluid, was not only achievable but also had the potential to improve patient care and save lives.

The following year, 14 years after graduating from veterinary school, I began my residency training in emergency and critical care in San Antonio, Texas, a city supportive of military training with several bases, and thus a mecca for FAST ultrasound. At the time, my program mentor encouraged me to take on FAST ultrasound as my clinical research requirement. I balked at the idea, having failed a complete abdominal ultrasound course in 1999, six years earlier, and thus concluding that ultrasound was a skill I would never master. However, I finally agreed to read the Boysen et al. study, after which I thought: “This (FAST ultrasound) will improve patient care. And I only have to be able to recognize black (anechoic) triangles. I like anatomy and surgery. I can memorize four views. It’s only four views.”

Thus, I decided that I would give ultrasound one more try. The FAST study intrigued me in the numbers of dogs with occult injury missed with traditional screening tests of physical exam, baseline blood and urine testing and radiography, but captured using FAST ultrasound. The study raised many fascinating questions, including looking past the diaphragm, adding a fluid scoring system to better categorize a positive FAST examination, and exploring the thorax with its own FAST format. Thus, my unimaginable journey began with developing AFAST, its target organ approach and its fluid scoring system; developing TFAST for pneumothorax, pleural and pericardial effusion, and its echo views for cardiac abnormalities; and most recently Vet BLUE (Veterinary Brief Lung Ultrasound Exam). Initially (2005), we combined AFAST and TFAST and referred to the study as “Combo (Combination) FAST” because we quickly realized how important it was to screen both cavities. Combining these three formats circa 2010, the study is now referred to as Global FAST and serves as an extension of the physical exam.

Now, 15 years later, the ultrasound probe is not only used by emergency veterinarians but also other nonradiologist, noncardiologist specialists as well as general practitioners. The use of ultrasound as a first-line, daily imaging modality has become commonplace globally throughout veterinary medicine, improving patient care and saving lives often by capturing disease otherwise missed with traditional work-ups without
answering clinically relevant questions is also key for
organized, well-defined imaging protocol for
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standardization with clear objectives is imperative not only
human and veterinary medicine on a daily basis, stan-
dard in New York City in 1991–1992, our Intern Director, the
late Dr Michael Garvey, always emphasized that we
should “never send a patient out the door with
something you could have easily detected by
performing a good physical exam and your quick
assessment tests.” The day has come when the Global
FAST approach should be part of your quick assessment
tests. In other words, Global FAST is “an extension of the physical exam” for most if not
every patient. The new mantra should be “Physical
examination and Global FAST!” as the starting point for
every patient, providing an unbiased set of data
imaging points in both cavities, the abdomen and
thorax, for every veterinarian seeing clinical cases.

In my internship year at the Animal Medical Center
in New York City from 1991 to 1992, our Intern Director, the
late Dr Michael Garvey, always emphasized that we
should “never send a patient out the door with
something you could have easily detected by
performed a physical exam and your quick
assessment tests.” The day has come when the Global
FAST approach should be part of your quick assessment
tests. In other words, Global FAST is “an extension of your physical exam,” a term coined by Rozycki and
colleagues over 20 years ago. Importantly, POCUS
then follows the Global FAST approach for more tar-
getted evaluations as subsequently explained.

With POCUS examinations now being used in
human and veterinary medicine on a daily basis, stan-
dardization with clear objectives is imperative not only
establishing for validity and a healthy respect among
our colleagues but for perfecting your skills. Recording
data on goal-directed templates that demonstrate
an organized, well-defined imaging protocol for
answering clinically relevant questions is also key for
veterinary medicine as a whole to embrace this
movement. These questions must be realistically
achievable, often binary, for the nonradiologist, non-
cardiologist sonographer. In this second edition, we
have tried to make POCUS and FAST ultrasound
examinations as clear as possible.

However, even with this approach, we think that
cautions should be exercised in how individual POCUS
examinations are applied to patients. For example, a
POCUS gallbladder examination may prove un-
remarkable, but if the Global FAST approach is applied
to every patient as part of the initial evaluation process,
the pericardial effusion, poor systolic function (dilated
cardiomyopathy), low-grade peritonitis or small-
volume hemoabdomen would not have been missed or
delayed in its detection. In other words, the Global
FAST approach should be considered your baseline
imaging test with POCUS examinations considered as
adjuncts. This imaging strategy prevents “satisfaction
of search error” to which POCUS examinations by
themselves are prone. Global FAST prevents the pick-
ning and choosing of whichever POCUS examination
helps fulfill your preconceived clinical bias by
by providing a mandated, standardized set of imaging
data points of the abdomen and thorax.

In another example, the POCUS heart provides an
overview for cardiac information but is too focused,
missing lung abnormalities and comorbidities within
the patient’s abdominal cavity. Through a Global FAST
approach plus the add-on of a POCUS heart, the
enlarged caudal vena cava suggesting right-sided
heart congestive failure is detected, or the splenic mass
or small-volume ascites is not missed, that was not
ever considered by the clinician but found as an unex-
pected comorbidity. Lastly, an unremarkable POCUS
heart exam on a coughing dog, without an integrated
approach with Global FAST, misses the widespread
small lung nodules or the aspiration pneumonia that are inapparent on thoracic radiography. The “POCUS
only” analogy would be similar to a selective physical
examination, in which only the abdomen is palpated in
a vomiting cat, or only the heart and lung ausculted in
a coughing dog, or only the limb evaluated in a limping
older dog. Most of us are aware of missing major prob-
lems when doing incomplete physical exams.

You may have or soon will have the epiphany of
how powerful a tool first-line ultrasound is. The same
epiphany has occurred in human medicine with sim-
ilar stories of how first-line medical personnel are cap-
turing aortic dissections in patients who have recovered
and compensated, ectopic pregnancies with internal
intermittent bleeding, and pulmonary thromboembo-
ilism as life-saving examples that historically would
have been delayed or completely missed (possibly resulting in death). Capturing these traditionally problematic life-threatening conditions is now possible on initial evaluation within minutes of presentation by “seeing” the problem.

In this second edition, we provide additional knowledge on what we have learned since the first edition, with more chapters and additional topics. These include additional chapters on eye and musculoskeletal exams as well as ultrasound-guided procedures, including the thoracic procedures and nerve blocks. Moreover, we devote an entire chapter to cats. We continue to push the envelope with the addition of more species including exotic companion mammals, marine mammals, birds, and reptiles. Personally, after performing thousands more exams, publishing numerous clinical studies, and through training over 1000 veterinarians in these techniques, we also share what we have learned using the Global FAST approach. We also welcome not only our previous chapter authors, who have also learned much since the first edition, but also a new set of thought-leading authors sharing their expertise in their respective chapters.

And, finally, as I prepared this second edition, reading through lists and lists of references, it became even more apparent that this paradigm change would not be possible without the many sonographers, veterinarians, residents, radiologists, and cardiologists who have painstakingly worked through untold hours of scientific research and clinical studies that have laid the foundation, for where veterinary diagnostic ultrasound is today. We extend a big thank you!

So let’s get on with it. We welcome feedback by email at FASTSavesLives@gmail.com and via our Facebook page, www.facebook.com/FASTVet, or our website www.FASTVet.com. Your stories and experiences as general practitioners, emergency and critical care veterinarians, and clinical specialists are awaited. Your stories and experiences help keep the POCUS and FAST train moving forward, helping with advancements in training, perfecting imaging techniques, and their clinical applications.
The following are acknowledged for their illustrative contributions: Suji Park, Englewood Cliffs, New Jersey (www.sujsuji.com); Dr Judy Brown, DVM, Dipl. ACVECC, Toronto, Canada; Hannah M. Cole, Adkins, Texas; Nancy Place, MS, Association of Medical Illustrators, San Antonio, Texas; Alice MacGregor Harvey, Medical Illustrator, North Carolina State University; and Randi Taggart, Richmond, Virginia.

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The chapter authors from the United States and internationally, who not only believe in the potential for point-of-care and FAST ultrasound to make a positive impact in veterinary medicine but also generously gave their time and expertise in making this second edition possible.

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ABOUT THE COMPANION WEBSITE

Don’t forget to visit the companion website for this book: www.wiley.com/go/lisciandro/ultrasound2

There you will find valuable material designed to enhance your learning, including:

• Video clips

Scan this QR code to visit the companion website.
SECTION I

BASICS OF ULTRASOUND AND IMAGING
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 Trauma, Triage, and Tracking (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
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).

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.

- 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

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.
• 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).
The terms may be used relatively between structures like “X relative to Y” and “Y relative to Z.” For example, the spleen is hyperechoic (brighter than) to the left kidney. The liver is hypechoic (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).

*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.