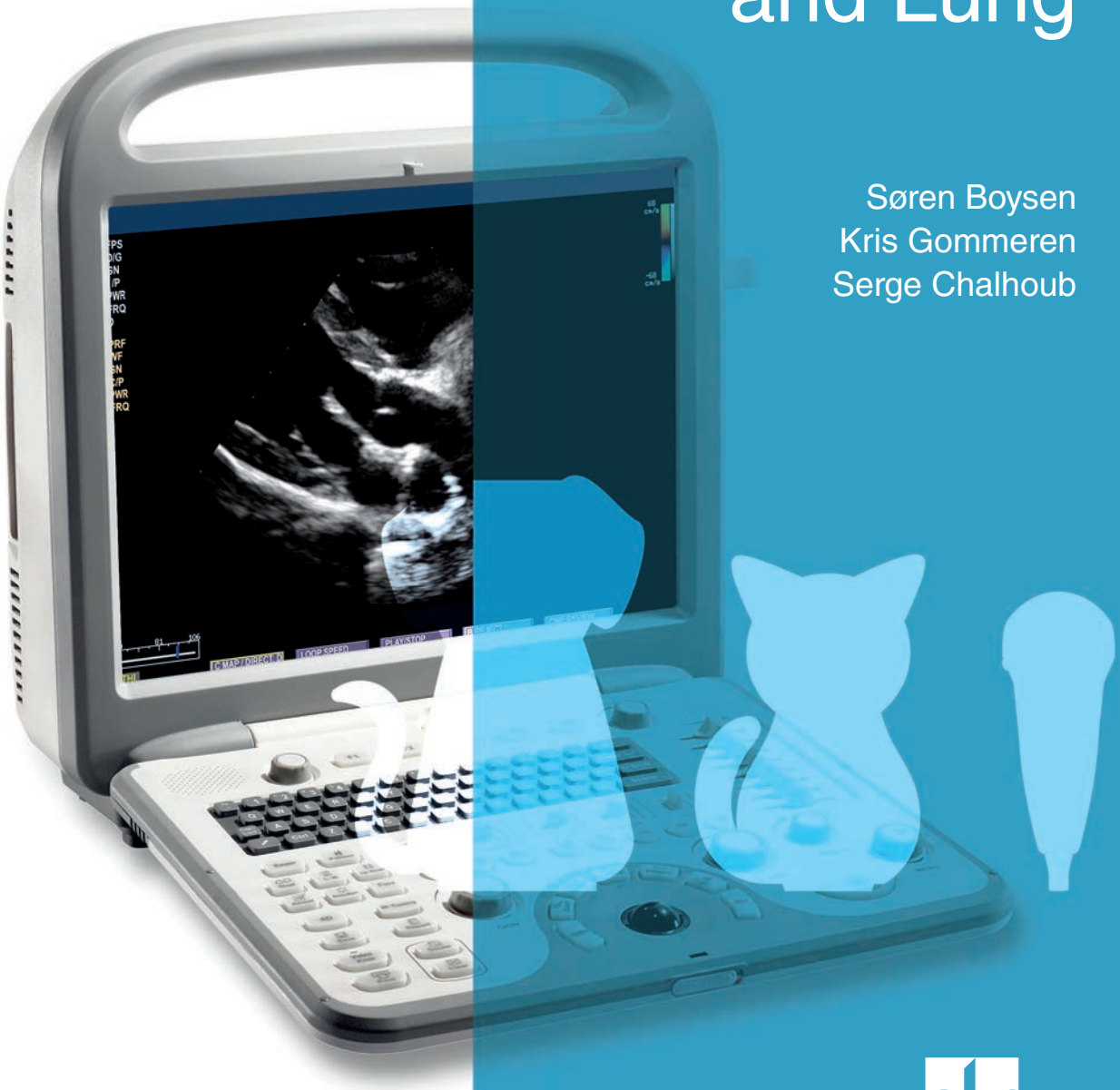
VIDEOS INCLUDED

THE ESSENTIALS OF VETERINARY POINT OF CARE ULTRASOUND

Pleural Space and Lung



Søren Boysen
Kris Gommeren
Serge Chalhoub

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THE ESSENTIALS OF VETERINARY POINT OF CARE ULTRASOUND

Pleural Space and Lung

Plaza Antonio Beltrán Martínez n.º 1, planta 8 - letra I
(Centro empresarial El Trovador)
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Warning:

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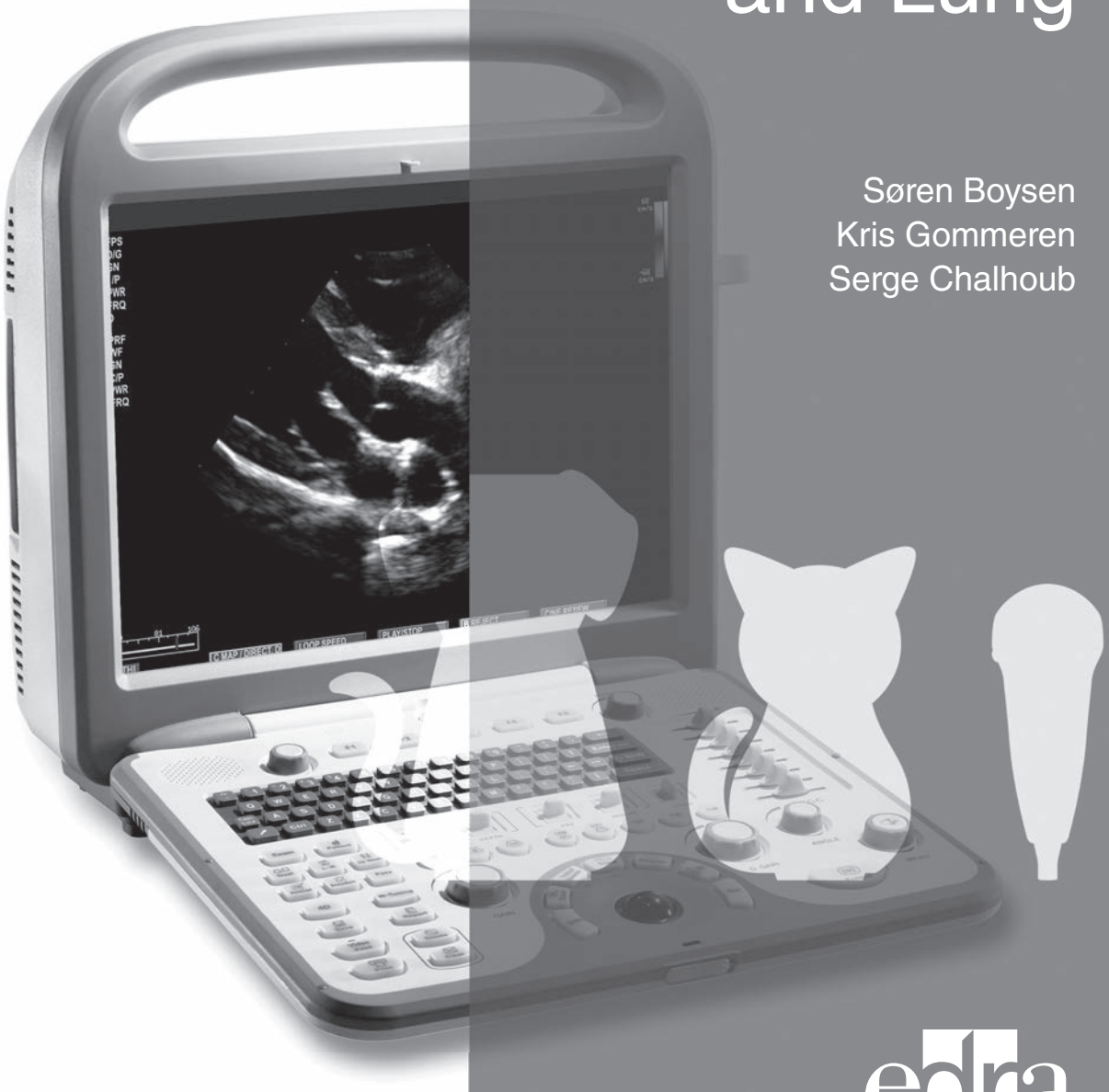

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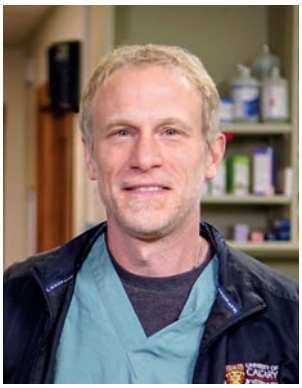
THE AUTHORS

Søren Boysen



Dr. Søren Boysen obtained his DVM from the University of Saskatchewan (Canada), completed a small animal internship at the Atlantic Veterinary College (Canada), and a residency at Tufts University (United States), becoming a diplomate of the American College of Veterinary Emergency and Critical Care in 2003. He is the former Chief of Small Animal Emergency and Critical Care at the University of Montreal, and currently a full professor of veterinary emergency and critical care at the University of Calgary. Extensively published, and a recipient of numerous teaching and research excellence awards, he has become an internationally recognized speaker. Although he loves all things emergency and critical care, he is considered a pioneer of veterinary point-of-care ultrasound (POCUS), having published the first small animal Focused Assessment of Sonography for Trauma (FAST) exam in collaboration with colleagues from Tufts. With many great colleagues from around the world he continues to actively research and develop ultrasound training techniques, education programs, and workshops for nonspecialist practitioners. Along with point-of-care ultrasound, his research interests include hemorrhage, coagulation, and perfusion.

Kris Gommeren

Kris Gommeren graduated in 2002 from Ghent University, where he subsequently performed an internship and a residency in internal medicine, becoming a Diplomate of the European College of Veterinary Internal Medicine in 2009. After his residency he briefly worked in a private referral practice, but soon moved to the University of Liège, where he has been in charge of the Emergency and Critical Care Service since 2008. He completed a PhD on the effects of systemic inflammation on the cardiovascular system. In 2017 he became a Diplomate of the European College of Veterinary Emergency and Critical Care. Kris has been actively involved in the European Veterinary Emergency and Critical Care Society (EVECCS) for over ten years. His main fields of interest are point-of-care ultrasound, the cardiovascular system, fluid therapy including the assessment of volume status, as well as transfusion medicine.

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INTRODUCTION

EVOLUTION OF PLEURA AND LUNG ULTRASOUND (PLUS)

Thoracic veterinary point-of-care ultrasound (POCUS) has evolved greatly over the last several years as its application into clinical veterinary medicine has grown. In 2008, Lisciandro et al. published a veterinary thoracic focused assessment with sonography for trauma (TFAST) protocol to evaluate thoracic injury in dogs predominantly placed in right lateral recumbency using two bilateral sonographic windows: the chest tube site and the pericardial site[1]. The initial objective was to identify trauma-induced thoracic injury, particularly pneumothorax via assessment of lung sliding (glide sign) at the chest tube site, and pleural and pericardial effusion, at the pericardial site. Following the 4-point exam, a 5-point TFAST protocol, which included the subxiphoid site, demonstrated that thoracic POCUS is not limited to the trauma setting and may be beneficial in the triage assessment of all unstable animals[2]. However, given TFAST was not originally designed to assess more than a single sonographic window of lung surface on either hemithorax (e.g. it only assessed a single intercostal space at the chest tube site), numerous veterinary lung ultrasound protocols were quickly developed to assess multiple lung regions for the presence of lung pathology[3-7]. Most recently, newer thoracic veterinary POCUS approaches that incorporate pleura, pleural space and lung under the same umbrella have been developed[6,7].

Unfortunately, the accuracy of thoracic POCUS to identify pleural space pathology in dogs and cats has been met with conflicting results[8,9]. The original TFAST study demonstrated there is a steep learning curve to diagnose pneumothorax in dogs with an overall sensitivity of 45 % for less experienced sonographers, which increases up to 95 % when performed by experts, although the true sensitivity is unknown as TFAST was not compared to the reference standard computed tomography (CT)[1]. The accuracy of TFAST to identify other pleural space pathology, lung pathology, and pericardial effusion was not reported in the original study, likely due to the low incidence of these pathologies being identified and lack of a reference standard for comparison[1]. Computed tomography is the reference standard for detecting lung and pleural space lesions such as small quantities of pleural effusion or air, which may not be related to clinical signs and may not be detectable with TFAST[8,9]. Subsequent veterinary studies in dogs and cats showed only poor to fair accuracy of TFAST and veterinary bedside lung ultrasound evaluation (Vet BLUE) compared to CT for the diagnosis of pneumothorax and pleural effusion, respectively, although results should be interpreted with caution as the methodology used varied slightly between studies and only small case numbers were included[8,9].

The conflicting results between early thoracic POCUS protocols and CT for detection of pleural space pathology are probably multifactorial, and likely depends on the experience of the sonographer, underlying pathologies, patient positioning, scanning protocol, and criteria used to diagnose these pathologies[6,8,9]. Some authors also suggest TFAST and Vet BLUE sites are not the most sensitive locations to detect smaller volume pneumothoraces and pleural effusions[8,9]. Two recent studies support

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GENERAL APPROACH

THE CALGARY PLEURA AND LUNG ULTRASOUND (PLUS) APPROACH

The Calgary Pleura and Lung Ultrasound (PLUS) approach is unique because it considers how the location of pleural space and lung pathology is affected by species and breed anatomic differences, the mechanics of breathing (lung and thoracic wall recoil), the effects of gravity, and different patient positioning, and modifies the sonographic windows evaluated accordingly. There are multiple lung ultrasound protocols currently used in veterinary medicine, all of which tend to start in the caudodorsal thoracic region at specific intercostal spaces, and all of which scan multiple lung fields. Unfortunately, consistently identifying the correct starting caudodorsal region of the thorax can be a challenge, given that the location of lung borders varies by breed, species, respiratory effort, and patient positioning. In the authors' experience, starting too low or too far cranial on the chest is the most common reason for sonographers failing to identify smaller volume pneumothorax.

An advantage of the Calgary PLUS approach is that it uses sonographically identifiable landmarks (and not set intercostal spaces) to standardize transducer location and orientate the sonographer to where they are during the scanning process. This helps to avoid the pitfalls of mistaking normal structures for pathology (e.g. gas in the stomach for B lines) and ensures the most likely areas to find pathology of the pleural space are assessed (e.g. the most caudodorsal sites for pneumothorax and the most ventral sites for fluid when the patient is in sternal recumbency or standing, and the widest parts of the thorax for patients in lateral recumbency).

Another important advantage of the Calgary PLUS approach includes evaluation of the abdominal curtain sign (vertical soft tissue-to-air interface, sonographically defined caudal lung/pleura border; see Chapter 3), which aids in the diagnosis of pleural space and lung pathology, and evaluation of the pericardiodiaphragmatic window, which helps identify and differentiate pleural and pericardial effusion. Failure to assess the ventral regions of the pleural space below the costochondral junction and not turning the transducer parallel to the ribs in the ventral thoracic regions are reasons that small-volume pleural effusion is often missed. The subxiphoid site is also included in the evaluation of the lungs and pleural space.

Depending on patient history and/or physical examination findings, not all portions of the PLUS examination need to be performed at one time. The order may vary depending upon whether life-threatening pathology is suspected and the binary question the clinician is trying to answer; the entire scan can be completed following stabilization of any life-threatening conditions.

CONTRAINDICATIONS AND COMPLICATIONS

No significant contraindications or complications are associated with PLUS examinations. PLUS is a noninvasive, rapid, repeatable, point-of-care diagnostic tool that can be performed at the time of initial patient evaluation and treatment (physical examination, blood pressure, intravenous IV catheter, IV fluids,

Indications

Dyspneic patients:

- Patients with suspected pneumothorax (e.g. dyspnea with decreased breath sounds dorsally, trauma patients).
- Patients with suspected pleural effusion (e.g. dyspnea with decreased breath sounds ventrally, cats in congestive heart failure, trauma patients).
- Patients with suspected lung pathology (e.g. crackles, cough, heart murmur, trauma, etc).

Trauma patients:

- Thoracic or generalized blunt or penetrating trauma.

Unstable patients:

- Any collapsed and/or unstable patient (e.g. elevated shock index, hyperlactatemia, unexplained hypotension, tachycardia, or decreased mentation), particularly if the underlying cause is uncertain.
- Postsurgical patients not recovering as expected.
- Any hospitalized patient that is, or becomes, unstable.

Treatment:

- To assist with ultrasound-guided procedures (i.e. thoracocentesis).

Tracking:

- To monitor progression or resolution of identified pathology.

Total:

- Following transfer to a service.
- As part of ICU patient daily management.
- Pre- and postanesthesia.

Note: All patients of the ICU service at the authors' clinic have daily systemic POCUS scans performed as part of the routine patient evaluation.

sedation, analgesia, pulse oximetry (SPO_2), minimum emergency database, etc), or as part of continued daily patient monitoring.

Stabilization efforts take priority and are not interrupted for the sake of obtaining medical imaging; therefore, the machine is brought to the patient and stabilization continued during POCUS.

SERIAL EXAMINATIONS

Serial examinations are warranted to track the development of pathology over time, to document whether it is worsening or improving, and to determine if therapy is meeting its intended goals. They are also indicated to reassess patients that did not have visible pathology at presentation, particularly those that are unstable, and/or have received significant quantities of intravascular fluid. The timing of serial examinations should be based on the overall clinical assessment of the patient, as well as consideration of the suspected disease process (e.g. a patient involved in vehicular trauma will be serially scanned for the development of pleural effusion, pneumothorax, and pulmonary contusions).

If a patient's condition fails to stabilize after therapeutic efforts, or destabilizes at any point, serial PLUS examinations should be performed.

For example, a dog that presents for vomiting, has unremarkable POCUS findings at presentation, and becomes acutely dyspneic while hospitalized on intravenous fluids, should have serial PLUS examinations performed. These are indicated to search for the underlying cause of dyspnea, particularly aspiration pneumonia, fluid overload, and/or pulmonary embolism, and to monitor the progression and/or resolution of any identifiable PLUS pathology over time.

MACHINE FUNCTIONS

Most PLUS clinical questions can be answered with confidence in the absence of obtaining the "perfect image", in a short amount of time and without using expensive or advanced ultrasound equipment. A portable, hand held, or refurbished ultrasound machine is sufficient for most PLUS applications. Things to consider in purchasing a machine include cost, mobility, resolution, start-up time, durability, and transducer selection. A mobile machine that can be brought to the patient, and a microconvex 5–8 MHz transducer, is sufficient for most POCUS applications, including PLUS. Although ultrasound units have multiple machine functions, there are only three main functions that are essential to understand in performing PLUS: gain, depth, and frequency (Fig. 1).

Figure 1. Typical ultrasound machine keyboard. The 3 main ultrasound machine functions used during POCUS examinations: gain, depth and frequency. The gain is used to make an image sharper and to highlight different structures and fluid. Depth is used to change how deep the ultrasound beams go and what is visible on the screen. The frequency setting of the transducer will affect image quality and depth perception.