Veterinary point of care ultrasound probe orientation and position for detection of pleural effusion in dog cadavers by novice sonographers: a pilot study

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Introduction
- In humans the extended focused assessment with sonography for trauma (E-FAST) exam and lung ultrasound (VPOCUS) protocol have been described to detect pleural effusion, although interobserver variability has been reported.1
- In contrast to humans, veterinary studies have shown questionable sensitivity and specificity for VPOCUS and Vet BLUE to detect pleural fluid and lung pathology.2
- For pleural effusion specifically, to the authors’ knowledge there is only a single study that has compared the accuracy of FAST to the gold standard of CT for the detection of pleural effusion; this study reported an accuracy of 50% for experienced ER doctors (k = 0.52).3

Objectives
1. To compare the performance of novice sonographers (intensities) using a current thoracic VPOCUS protocol to a newly developed pleura and lung ultrasound (PLUS) protocol that considers pleural space and lung borders, location of the probe on the thorax, and orientation of the probe, for identification of pleural effusion in positive pressure ventilated (PPV) canine cadavers.

Hypotheses
- We hypothesize there will be a difference between protocols, when performed by novice sonographers, for identification of pleural effusion in an experimental positive pressure ventilated canine model.

Material and Methods

Cadaver preparation
- 4 frozen and thawed male castrated, mix breed cadavers, weighing between 25 and 30 kg were used.
- Cadavers were imaged, manually received PPV using an adult size Ambu bag, and placed in sternal recumbency.
- Point of care lung ultrasound performed by two experienced point of care sonographers (AR, SRR), while positive pressure ventilation was continued.
- Pneumothorax was ruled out by detecting a bilateral glide sign at the most caudal dorsal border of the thorax.
- The ventral areas of the thorax were assessed for pleural effusion.
- All cadavers had pleural effusion noted bilaterally, subjectively and independently assessed by the two experienced sonographers; one cadaver had moderate, one mild, and two scant pleural effusion bilaterally. One cadaver with scant pleural effusion had 20 ml/kg of fluid added to the pleural space via ultrasound guidance to create a large bilateral pleural effusion. Cadavers were then arranged in order of large, scant, moderate, and mild pleural effusion.

Results
- Each participant scanned 8 hemi-thoraces. All scans for each dog were completed in < 5 minutes. Overall there was no significant difference between protocols for detection of pleural effusion (P1 n=14/16, P2 n=13/16).
- There was no statistical difference for moderate/large volume pleural effusion (P1 n=14/16, P2 n=14/16) but there was for scant/small volume pleural effusion (P1 n=3/16, P2 n=13/16, respectively, p=0.048).

Discussion
- The current study suggests probe orientation and position play an important role in the detection of pleural effusion, particularly when the quantity of fluid is minimal, and when sonographic exams are performed by novices. As all patients were positioned in sternal recumbency, the impact of patient position was not assessed. In patients presenting with dyspnea, the detection of pleural effusion is likely high, regardless of probe orientation, as long as the probe is placed in the ventral third of the thorax. The ability of the novice to create a fluid layer is likely significant enough to fill the ventral third of the pleural space. However, when small quantities of pleural fluid are present, which may contribute to dyspnea when other lung or pleural space pathology is present, or may be diagnostic following thoracentesis and fluid analysis, then turning the probe parallel to the ribs and scanning the regions below the costochondral junction appears to be more accurate than scanning at the costochondral junction with the probe oriented perpendicular to the ribs. Limitations of this study include the use of cadavers, a PPV model, use of novice sonographers, a small sample size, lack of a gold standard, and absence of a cadaver without pleural effusion present. Further research is required to determine if these findings are applicable in the clinical setting and to determine if probe orientation of probe position, patient position (sternal vs. lateral) or a combination of these factors is more accurate at identifying pleural effusion in patients scanned in sternal recumbency. Research to determine if probe orientation and position also impact other pleural space and lung pathology findings is also recommended.

Conclusion
- The accuracy of VPOCUS protocols for detection of pleural effusion by novices in PPV cadavers varies, particularly when fluid quantity is scant/small. This is likely explained by protocol differences in probe orientation and location. Further research is required to validate the accuracy of VPOCUS probe orientation and location for detection of pleural effusion in spontaneously breathing companion animals.

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References

Figure 1: Identification of pleural effusion based on the pleura and lung ultrasound (PLUS) protocol which involves locating the pericardio-diaphragmatic window, turning the probe parallel to the ribs, identifying the ventral pleural border, and scanning the ventral pleural border from the diaphragm to the thoracic inlet.

Material and Methods
- Animal and human ethics approval was obtained through the University of Calgary (AC17-0092, REB18-1405). Consent forms were obtained from all participants in this study.
- Scanning protocol: PPV cadavers were scanned bilaterally by intensities, randomly starting with one of two protocols, alternating protocols for each subsequent cadaver.
- Protocol 1 (P1): probe perpendicular to the ribs, starting at the costochondral junction, sliding cranially and caudally similar to Vet-BLUE described by Walters et al (ventral and dorsal movement allowed).
- Protocol 2 (P2): locating the pericardiophrenic-diaphragmatic window (or costochondral junction), rotating the probe parallel to the ribs to the ventral pleural space borders, sweeping cranially from the diaphragm to the thoracic inlet as per PLUS (ventral and dorsal movement allowed, figure 1).
- Intens were timed and recorded pleural fluid as present/absent.

Figure 2: Ultrasound still image and schematic depicting the bat sign when the probe is perpendicular to the ribs, showing rib shadows, the pleural line, A lines. The bat sign is used to help locate the pleural line.

Figure 3: The ‘ski slope’ sign seen with dry lungs when the probe is oriented parallel to the ribs at the ventral pleural border.

Figure 4: The location of the pericardiophrenic-diaphragmatic (PD) window: a) image of probe location on a dog, b) schematic image of sonographic findings that define the PD window, c) ultrasound still image of the PD window: ME: mediastinal triangle; LV: left ventricle; RL: right ventricle.

Figure 5: Ultrasound still image depicting pleural effusion with the probe perpendicular to the ribs.

Figure 6: The ‘sail sign’ which appears at a triangular reflection of pleural effusion when the probe is parallel to the ribs.