The use of the diaphragmatico-hepatic (DH) views of the abdominal and thoracic focused assessment with sonography for triage (AFAST/TFAST) examinations for the detection of pericardial effusion in 24 dogs (2011–2012)

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Abstract

Objective – To evaluate the clinical usefulness of the diaphragmatico-hepatic (DH) view of the abdominal and thoracic focused assessment with sonography for triage (AFAST/TFAST) in detecting pericardial effusion (PE) in dogs.
Design – Retrospective case series from 2011 to 2012.
Setting – Private practice emergency and critical care hospital.
Animals – Twenty-four dogs with PE diagnosed by FAST.
Interventions – None.
Measurement and Main Results – Fifty-two medical records from October 1, 2011 through September 30, 2012 had the terms “PE” within the medical record. Twenty-four dogs were diagnosed with PE by FAST with entries for the DH view. Of the 24 dogs, 7 had abdominal FAST, 6 had thoracic FAST (TFAST), and 11 had both exams performed. PE was noted on the DH view in 20 of 24 (83%) cases. Subjective PE volume assessment ranged from trivial (<5 mm) to severe. Of the 4 cases in which PE was absent via the DH view, PE was seen during the same exam at the TFAST pericardial views (n = 2) or detected on serial exam at the DH view (n = 2). The PE volume that was missed via the DH view was characterized as trivial (<5 mm; n = 1), mild (n = 1), and moderate (n = 2).
Conclusions – The DH view of FAST was found to be clinically helpful for the detection of PE. Veterinarians should make it routine practice and part of FAST training to look into the thorax via the DH view during both abdominal FAST and TFAST exams.

Keywords: AFAST, cardiac tamponade, diagnostic imaging, FAST, TFAST

Introduction

Diagnostically, ultrasound is considered the gold standard for the diagnosis of cardiac tamponade and arguably (vs. computerized tomography) for the detection of pericardial effusion (PE).1–3 In the human emergency department, PE and cardiac tamponade may be diagnosed by a single view using the subxiphoid focused assessment with sonography for trauma (FAST) site.1,4,5 In contrast, thoracic radiography is unreliable having poor sensitivity and specificity for both the diagnosis...
of PE and cardiac tamponade in dogs and people.\textsuperscript{1,3,5–7} Thus, the diagnosis of this potentially life-threatening condition is often delayed or missed when ultrasound is unavailable,\textsuperscript{3,5,8–11} or not used because of lack of training.

The subxiphoid view is the preferred first-line screening test for the detection of PE and cardiac tamponade during FAST exams in people\textsuperscript{1,3,4} because anatomically the human heart normally lies in direct apposition with the diaphragm avoiding air interference from lung.\textsuperscript{1,8} Previously, the FAST diaphragmatico-hepatic (DH)/subxiphoid view has been shown to be useful for the detection both plural and PE in traumatized dogs\textsuperscript{12}, although true sensitivity and specificity has not been evaluated. More recently, the potential of the FAST DH view for the rapid detection of PE and diagnosis of cardiac tamponade in nontrauma subsets of dogs has been suggested.\textsuperscript{8,9,13,14}

The DH view is part of both the abdominal FAST (AFAST) and the more recently modified 5-point thoracic FAST (TFAST) ultrasound examinations.\textsuperscript{8,9,13–15} The DH view, analogous to the subxiphoid view in human FAST exams, is advantageous over transthoracic views because the liver and gallbladder serve as acoustic windows into the thorax avoiding air interference from the lungs,\textsuperscript{8,9,13–15} which can be problematic for both novice and expert sonographers.\textsuperscript{9,16} Moreover, transthoracic air interference via the TFAST pericardial sites (similar to echocardiographic parasternal sites) is often further exaggerated when small animals are evaluated in sternal or standing position, commonly used during TFAST and by veterinary cardiologists because it is safer than lateral recumbency in respiratory distressed or compromised animals.\textsuperscript{8–11,13,16–18}

Interestingly, although the subxiphoid view is the preferred acoustic window for the detection of PE and is helpful in diagnosing life-threatening cardiac tamponade in people,\textsuperscript{1–5} it has been overlooked in veterinary medicine including the most recently published reviews and textbooks on the subject.\textsuperscript{10,11,19} Despite the ultrasonographic advantages of using the subxiphoid/subcostal views for the diagnosis of PE in people, veterinarians have historically ignored and even discouraged usage of this view.\textsuperscript{10,11,20–23} Because most veterinarians easily master the AFAST exam\textsuperscript{12,24} compared to the more technically challenging TFAST exam,\textsuperscript{17} veterinarians using ultrasound should be aware of the diagnostic potential, if one exists, of the DH view when performing either FAST exam.

The purpose of the study was to determine the clinical usefulness of the DH view for the detection of PE in dogs. It was suspected that in most cases of PE, the diagnosis could be made via the FAST DH view.

\textbf{Materials and Methods}

Fifty-two electronic medical records were retrospectively retrieved over a 1-year period between October 1, 2011 and September 30, 2012 by searching the keywords “PE.” Inclusion criteria consisted of dogs diagnosed with PE on their initial AFAST or TFAST exams with findings recorded within the standardized templates that are part of the electronic medical records system,\textsuperscript{4} used by the practice of which the DH view was a mandatory entry item. Mandated entries items for the AFAST and TFAST DH views were limited to “present,” “absent,” or “indeterminate”; however, the DH view entry had to be listed as “present” or “absent” for inclusion. “Indeterminate” entries for the DH view in dogs with PE were excluded. Images were not subsequently reviewed by a veterinary radiologist. However, 11 cases were referred for complete echocardiography by a board-certified veterinary radiologist or performed by a board-certified internist with advanced ultrasound training. When present, PE was subjectively characterized as “trivial (< 5 mm),” “mild,” “moderate,” or “severe” often without performing any actual measurements. When 2 descriptors were used, for example, mild to moderate, the larger was used to tabulate results. Patient positioning was only mandated for AFAST exams with right or left lateral recumbency being preferred.\textsuperscript{8,9,14,24} In contrast, the TFAST template did not have a patient positioning entry; however, lateral and sternal recumbency, and standing positions were used (Figure 1). When both AFAST and TFAST were performed the exam was referred to as combination FAST (CFAST).\textsuperscript{25} Following

\begin{figure}[h]
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\includegraphics[width=\textwidth]{image}
\caption{Shown is the application of the diaphragmatico-hepatic (DH) view part of both abdominal FAST (AFAST) and thoracic FAST (TFAST) exams as the view with the circle around the probe head in a standing dog. The other probe positions show standard views of TFAST with its bilaterally applied chest tube site and pericardial site views. With permission, Lisciandro GR, Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley Blackwell; 2014.}
\end{figure}
application of inclusion and exclusion criteria, 24 dogs were included in this retrospective review.

Recorded patient data included presenting complaint, signalment, body weight, sex, vital signs, and pericardial-related findings. Three different ultrasound machines were used during the study period.3–6

Statistical Methods

Quantitative data were summarized using medians and ranges while categorical data were summarized using frequencies and proportions.

Results

Fifty-two records were identified within the electronic medical records using the key words “PE.” Of these 52, 28 cases were excluded and comprised of 4 cats (3 with PE, 1 without) and 24 dogs. Of the excluded dogs, 2 arrived with a diagnosis of PE by the referring veterinarian; 5 were diagnosed with PE by FAST without use of the standardized template; 2 with PE via the DH view listed as “indeterminate”; 13 suspected of having PE either through clinical suspicion or radiographically with a subsequent negative FAST exam (n = 12) or a negative complete echocardiogram (n = 1); and 1 deceased on arrival having PE on the rule out list for sudden death (not necropsied); and 1 deceased on arrival with PE that was confirmed via postmortem examination. Over 1,200 FAST exams (caseload 11,000 cases/y) were performed during the study period.

Standardized templates with AFAST and TFAST findings were reviewed in 24 dogs meeting the inclusion criteria. Of these 24 dogs, 7 had AFAST, 6 TFAST, and the remaining 11 dogs had both AFAST and TFAST (referred to as combination FAST [CFAST]) exams performed. Subjective PE volume assessment included trivial (<5 mm; n = 1), mild (n = 5), moderate (n = 7), and severe (n = 11). The DH view was recorded as positive for PE in 20/24 or 83% of cases. Of the 4 cases in which PE was not recorded at the DH view, PE was seen during the same exam at the TFAST pericardial views (n = 2) or detected on serial exam at the DH view (n = 2). PE volume that was missed via the DH view was subjectively characterized as trivial (<5 mm; n = 1), mild (n = 1), and moderate (n = 2). Patient positioning (at the discretion of the attending veterinarian) included the following: right lateral recumbency (n = 11; AFAST 3, CFAST 8), left lateral recumbency (n = 6; AFAST 4, CFAST 2), and standing (n = 1; CFAST 1). TFAST positioning was not listed as a standardized entry in the TFAST template and likely involved combinations of lateral and standing/sternal recumbency depending on patient status. Of the veterinarians performing FAST, 8 were staff veterinarians, 1 was a board-certified practitioner, and 2 were board-certified criticalists diagnosing PE on 14, 4, and 6 cases, respectively.

The most common presenting complaint was labored breathing (n = 10), followed by weakness (n = 7). Thirteen different breeds were represented with the most common being mixed breed (n = 4), and Golden Retriever (n = 4). Only 1 dog, a Boston Terrier, returned and is included in the group of 24 dogs because the dog was seen by a different attending veterinarian several weeks later. Sex included intact males (n = 2), neutered males (n = 10), intact females (n = 1), and spayed females (n = 11). Median values and ranges were as follows: age (10; 4–15 y), weight (27; 2.75–43.8 kg), temperature (101°F; 98–103.8°F), heart rate (130/min; 72–180/min), respiratory rate (58/min; 20–160/min), and 9-point body condition score (6; 4–8). Of the 24 dogs, 11 were subsequently referred for complete echocardiography performed by a board-certified veterinary radiologist (n = 9) or a board-certified internist with advanced ultrasound training (n = 2). Of these 11, 10 had PE confirmed by complete echocardiography (1 without PE had dilated cardiomyopathy).

Other patient information of interest included whether pericardiocentesis was performed (n = 13 dogs; 12 of which were successful [negative tap had no PE on complete echocardiography]), the presence of tamponade (n = 9), and those with additional effusions (n = 13, PE and ascites; n = 5, PE and pleural effusion; n = 2, PE, pleural effusion and ascites). Four dogs had only PE with no other effusion.

Discussion

FAST has been a frontline screening test in blunt and penetrating human trauma patients since the 1990s.8 More recently, FAST applications in human and veterinary emergency and critical care have extended beyond trauma to nontrauma subsets of patients including those with respiratory distress, unexplained dyspnea, uncharacterized hypotension (eg, collapse, weakness, shock) and postinterventionally.1–4,8,9,15,26 As a result, the author has proposed that veterinarians adopt the acronym FAST3 (eg, AFAST3 and TFAST3) with a “T3” indicating its use for trauma, triage, and tracking (monitoring)8,9,13–15 With the change in mindset (FAST uses beyond trauma), PE has been more frequently detected in the human and veterinary emergency departments.1–5,8,9,26

Similar to human FAST ultrasound studies,3,4 the DH view was clinically helpful in detecting the presence of PE in 83% of FAST-diagnosed PE cases. The use of the FAST DH view advantageously provided an acoustic window into the thorax by avoiding air interference.
from the lungs, problematic at the transthoracic TFAST pericardial sites\textsuperscript{9,13,14} when dogs were in lateral or sternal recumbency or the standing position (considered less stressful and safer in critical, distressed cases).\textsuperscript{11,13,16,18,27} Moreover, the muscular apex of the heart is viewed via the FAST DH view helping discriminate pleural from PE and either from heart chambers. Thus, the DH view may improve accuracy for the detection of PE as previously suggested.\textsuperscript{8,9,13,14} Additional diagnostic views for PE are best performed at the right pericardial view of TFAST. Such diagnostic views mandate a global appreciation of the heart by recognizing the pericardium (the brightest white (hyperechoic) line on the far side of the heart). Once the heart is appreciated globally, PE may be diagnosed by the 4-chamber long-axis view, in which all 4 heart chambers may be identified. In short-axis views, PE should only be diagnosed by directing the probe toward the muscular apex of the heart.\textsuperscript{13,15} PE should never be diagnosed in short-axis views at the level of the left and right ventricle or toward the heart base because cardiac chambers may easily be mistaken for PE; thus, potentially leading to performing centesis on a heart chamber.\textsuperscript{9,11,13,14,18} Of the 11 dogs referred for complete echocardiography, 10 had confirmation of PE and the other negative dog diagnosed by complete echocardiography with dilated cardiomyopathy, likely and unknowingly incurred centesis of its heart due to mistaking the right ventricle for PE at the TFAST right pericardial short-axis view. The dog fortunately survived.

The first line use of the subxiphoid view, analogous to the veterinary FAST DH view, for rapid diagnosis of PE by nonradiologist physicians is well established; however, to the author’s knowledge no prospective studies with documented sensitivity and specificity have been performed in human medicine. In the present study, although standardized templates were used by the practice similar to those previously published,\textsuperscript{8,9,b} the order of views and the patient positioning were discretionary and likely varied by attending veterinarian depending on patient status and clinical judgment. Measuring the greatest width of PE may have been helpful for both initial and serial evaluations to better characterize the limitations of the DH view over the subjective assessments recorded as trivial, mild, moderate, and severe. A measurement-based grading system has been developed for people as mild (<5 mm), moderate (5–10 mm), and severe (>10 mm),\textsuperscript{1,2,19} and measurement should be similarly validated for dogs. Future prospective studies are needed to establish the true sensitivity and specificity of the FAST DH view for the diagnosis of PE in dogs.

Since ultrasound images at the respective FAST views were not saved, it is presumed that PE was diagnosed by the DH view (part of both AFAST and TFAST protocols), or by 1 or more positive pericardial sites on TFAST, in no standardized order, for example, the DH view was either performed before or after the pericardial view(s) as previously described.\textsuperscript{8,9,24} The DH view should be obtained by placing the ultrasound probe longitudinally (probe marker directed toward the patient’s head) immediately caudal to the xiphoid with the acquisition of the

Figure 2: (a and b) The FAST diaphragmatico-hepatic (DH) view shown externally on a dog with a correlating ultrasound image. (a) The probe is placed in longitudinal fashion with the probe marker directed toward the head of the dog (to the left). The black elliptical represents the xiphoid process and the bold black lines the costal arch. (b) The corresponding expected ultrasound image labeled as Heart; DIA, diaphragm; GB, gallbladder; and CVC, caudal vena cava. There is no pericardial effusion in the image. With permission, Lisciandro GR, Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley Blackwell; 2014.
shown is the classic ultrasound image of pericardial effusion via the FAST diaphragmatico-hepatic (DH) view. In real time, the beating heart clearly helps identify its apex within a rounded track of anechoic (black) fluid located between the epicardium and pericardial sac. In smaller dogs or with ultrasound machines with large depth limits, it is possible to view the entire heart and its chambers thus evaluating for the presence of cardiac tamponade. LIV, liver; PCE, pericardial effusion; Heart. With permission, Lisciandro GR, Focused Ultrasound Techniques for the Small Animal Practitioner; Wiley Blackwell 2014.

Figure 3: Shown is the classic ultrasound image of pericardial effusion via the FAST diaphragmatico-hepatic (DH) view. In real time, the beating heart clearly helps identify its apex within a rounded track of anechoic (black) fluid located between the epicardium and pericardial sac. In smaller dogs or with ultrasound machines with large depth limits, it is possible to view the entire heart and its chambers thus evaluating for the presence of cardiac tamponade. LIV, liver; PCE, pericardial effusion; Heart. With permission, Lisciandro GR, Focused Ultrasound Techniques for the Small Animal Practitioner; Wiley Blackwell 2014.

gallbladder immediately adjacent to the diaphragm, and the depth adjusted so that the distal 25–33% of the ultrasound field of view extended into the thorax (Figure 2).8,9,13,14 PE is identified at the DH site by the observation of fluid contained within the pericardial sac (between the hyperechoic [bright white] pericardium and epicardium) and it rounding the apex of the beating heart (Figure 3).9,13,14 Pleural effusion is identified by a more angular, uncontained, irregular, sharper-angled image present in more than 1 view (combining TFAST pericardial views with the DH view findings).9,13,14 The diagnosis of PE at the parasternal views (analogous to the TFAST pericardial sites) has been well described.10,11,18–20

In people, the use of the subxiphoid view for the detection of PE is less likely to be confused with pleural effusion since the human heart lies in direct contact with the diaphragm; and thus PE is conspicuous, and easily viewed, by its rounded, fluid contained appearance between the epicardium and pericardium.1,3 Thus, even small volume PE (<5 mm) in people may be readily detected via the subxiphoid view when compared to transthoracic views.1–3 In contrast, the canine heart variably lies against the diaphragm28 likely dependent on patient conformation and positioning. Thus, when there is separation between the heart and the diaphragm by lung (air) in normalcy, air interference would likely confound ultrasonographic imaging of the canine heart. However, in standing or sternal positioning, or when clinically relevant PE is present, the canine heart may come into proximity (direct apposition) to the diaphragm and thus the heart would displace lung (air) providing an acoustic window via the DH view. Moreover, as similarly shown in people, because the muscular apex of the heart is viewed here, the potential mistaking of cardiac chambers for PE may be less likely.9,13,14

Anatomical considerations were not directly addressed in this retrospective study. It appears, however, that the canine heart commonly rests against the diaphragm, displacing lung when clinically relevant PE is present reflected by the high percentage of cases (83%) in which PE was observed via the DH view. Logically, the shortest distance to the heart subcostally also occurs at the subxiphoid area (the DH view; Figure 4). The effect of canine positioning (lateral recumbency vs. sternal and standing) and its relationship to the quality of the acoustic window via the DH view to the heart was not evaluated. Interestingly, pericardial fat located between the liver and the apex of the human heart, also referred to as epicardial fat, has led to false positives for PE at the subxiphoid view.29 To the author’s knowledge, although suggested in veterinary publications with human references, the same phenomenon has not been documented in dogs.19,20

Given the retrospective nature of this study, the number of dogs with PE missed during the study period, in other words the true frequency of PE for the study year, could not be estimated. In a study at a veterinary referral hospital, however, the reported overall frequency of PE was 0.43% which included 7% of all cardiac cases.21 In contrast, the frequency of PE reported here was 0.24% (24/11,000) at a 24-hour emergency and critical care facility. Interestingly, only 48 dogs had “PE” listed within their electronic medical record during our search. Explanations could include incomplete differential lists or PE abbreviations that were not captured within the search. With most cases of unexplained hypotension (eg, generalized weakness, collapse, tachycardia, mentation changes), pallor, and respiratory distress having FAST exams at triage, PE was likely ruled out before differentials were entered within the patient’s electronic medical record contributing to the lower than expected number of canine cases in the search. It is also possible that cases of PE were missed or misdiagnosed because AFAST and TFAST were used as the first-line screening tests. As a result, many cases may not have proceeded to the radiology department for complete echocardiography either because of a favorable clinical course or the patient did not survive (died or euthanized) long enough for referral or for financial reasons. Interestingly in 2005, before the...
Figure 4: (a–d) Lateral thoracic radiographs of the dog illustrating the ability to view the heart through the FAST diaphragmatico-hepatic (DH) view with a corresponding ultrasound image. (a) Separation between the heart and the diaphragm with lung (air) and thus the ultrasound beam (arrow) will reflect back to the transducer unable to image the canine heart (ultrasound does not transmit through air). (b) The heart is shown in direct apposition with the diaphragm and thus an acoustic window to the heart is present and the heart is thus visualized. (c) The outline of pericardial effusion (white lines) evident within the same acoustic window shown in b). Clinically relevant pericardial effusion displaces lung and thus is visualized via the DH view. (d) Ultrasound image showing the classic appearance of pericardial effusion via the DH view. Note this is the same image as in Figure 3. (a–c) Courtesy of Vet Imaging 2014 and (d) with permission, Lisciandro GR, Focused Ultrasound Techniques for the Small Animal Practitioner, Wiley Blackwell; 2014.

Routine implementation of FAST, only 3 cases of PE were diagnosed at the same practice leading the author to conclude that PE was either missed, mistreated (potentially leading to the demise of the patient), or delayed (if survived) until referred for complete echocardiography by a veterinary radiologist or cardiologist.

Limitations of the study include its retrospective design without a standardized order of FAST views and the lack of complete echocardiography evaluation, a gold standard, of each case by a board-certified veterinary radiologist (or other specialist with advanced ultrasound training) to confirm the diagnosis of PE. By not standardizing the FAST view order, the determination of the DH view being clearly positive for PE may have been biased by previous TFAST findings at pericardial sites thus falsely increasing the percentage of PE cases evident at the DH view. Moreover, several dogs were diagnosed by the AFAST DH view (1 view) without the addition of TFAST pericardial views. However, in human studies, nonradiologists can...
easily detect the presence of PE with minimal ultrasound training and the subxiphoid site is preferred in the emergent setting and diagnostic as a single view. In 10/11 dogs with FAST-diagnosed PE had confirmation of diagnosis on subsequent complete echocardiography examinations.

In conclusion, the DH view of AFAST and TFAST was found to be clinically useful for the detection of PE and thus FAST training should incorporate the use of the FAST DH view for the detection of PE. By recording FAST findings in a structured, standardized format, future prospective studies may be used to document the true sensitivity and specificity for the detection of PE with the FAST DH view. Veterinarians should make it routine practice to look into the thorax via the DH view during both AFAST and TFAST exams.

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Footnotes

a Animal Intelligence, Animal Intelligence Software, Inc, Port Orchard, WA.
b Aloka SSD-900V ultrasound machine, Aloka Company Limited, Wallingford, CT.
c Logiq XP Note Book ultrasound machine, General Electric, Milwaukee, WI.
d SonoSite Edge, SonoSite, Inc, Bothell, WA.

References