SMALL ANIMALS

Evaluation of a focused assessment with sonography for trauma protocol to detect free abdominal fluid in dogs involved in motor vehicle accidents

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Objective—To establish a focused assessment with sonography for trauma (FAST) protocol in dogs, determine whether FAST can be performed by veterinary clinicians without extensive ultrasonographic experience, and assess the frequency of free fluid (as determined via FAST) in the abdominal cavity of dogs following motor vehicle accidents (MVAs).

Design—Prospective study.

Animals—100 client-owned dogs evaluated within 24 hours of an MVA.

Procedure—Dogs were placed in lateral recumbency for the FAST examination. To detect fluid in the abdomen, 2 ultrasonographic views (transverse and longitudinal) were obtained at each of 4 sites (just caudal to the xiphoid process, on the midline over the urinary bladder, and at the left and right flank regions).

Results—In the 100 dogs evaluated via FAST, free abdominal fluid was detected in 45 dogs. In 40 of those 45 dogs, abdominocentesis was performed; hemoperitoneum and uroperitoneum were diagnosed in 38 and 2 dogs, respectively. Compared with dogs that had no free abdominal fluid detected via FAST, dogs that had free abdominal fluid detected via FAST had significantly higher heart rates and serum lactate concentrations and significantly lower PCVs and total solid concentrations.

Conclusions and Clinical Relevance—Results indicate that FAST is a simple and rapid technique that can be performed on dogs in an emergency setting to detect intra-abdominal free fluid and can be performed by veterinary clinicians with minimal previous ultrasonographic experience. (*J Am Vet Med Assoc* 2004;225:1198–1204)

Intra-abdominal injury may be difficult to detect and can result in considerable illness and death in animals that have sustained blunt trauma to the abdomen.[1-3] Abdominocentesis performed by use of a hypodermic needle has been used extensively for detection of intra-abdominal fluid in small animals,[4] but false-negative results are commonly obtained.[2,4-6] In 1965, **diagnostic peritoneal lavage (DPL)** was introduced as a diagnostic aid for use in humans with blunt abdominal trauma, and results of studies[2,4,5] have subsequently proven it to be a sensitive and specific technique for detection of intra-abdominal fluid in dogs and cats. Although the complication rate associated with the technique is low, DPL is considered invasive and can result in urinary bladder and intestinal perforation, as well as splenic, vessel, and pancreatic lacerations.[7-12] Diagnostic peritoneal lavage inconsistently detects retroperitoneal injury and hematoma,[7,9,10] and difficulty in retrieving a sample has been reported.[6,13] Finally, determining which patients with abdominal trauma will benefit from laparotomy on the basis of findings of DPL may be difficult and can result in unnecessary laparotomy procedures.[1,8,14-16] For these reasons, DPL is presently used less frequently as an initial diagnostic aid in humans with blunt abdominal trauma.[10,11,15,17-22]

The **focused assessment with sonography for trauma (FAST)** technique is becoming the diagnostic test of choice for the early evaluation of humans with blunt abdominal trauma.[10,16,17,23-26] A FAST examination can be performed during the initial triage within minutes of a patient's arrival at an emergency medicine facility. It is a noninvasive, rapid, and repeatable technique requiring equipment that is portable.[1,21] When performed by physicians with extensive ultrasonographic experience, as well as by surgical and emergency residents with minimal ultrasonographic training,[1,7,21,24,27-31] the FAST procedure has good sensitivity (81% to 98%) and specificity (98% to 100%) for detection of free fluid in body cavities. When used to detect the presence of free fluid in the abdomen of humans after blunt abdominal trauma, FAST has sensitivity and specificity similar to that of computed tomography and DPL.[1,10,12,29] Via FAST, fluid can be localized and samples collected with ultrasound guidance. In some instances, parenchymal or retroperitoneal injury can also be detected during a FAST examination.[8,10,11,23,28,29]

Despite its rapid acceptance by the human medical profession, to the authors' knowledge, there are no published studies regarding the use of FAST to detect free abdominal fluid in dogs. The objectives of the study of this report were to establish a FAST protocol for use in dogs, determine whether FAST can be performed by veterinary clinicians without extensive ultrasonographic experience (following short didactic and laboratory training sessions), and assess the frequency of free fluid detected via FAST in the abdominal cavity of dogs following **motor vehicle accidents (MVAs)**.

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Materials and Methods

A prospective clinical trial was performed. Dogs were included in the study if they were involved in an MVA and could be examined ultrasonographically within 24 hours of the injury. Initial emergency point-of-care testing and resuscitative measures were performed at the discretion of the admitting veterinary clinician.

The FAST protocol developed for this study was modified from FAST protocols established for use in humans and based on available veterinary medical literature that described the areas in which free abdominal fluid can be detected sonographically most frequently and the organs most commonly affected after blunt abdominal trauma in dogs.[7,8,21,23,32-36]

The ultrasonographic examination was performed in the emergency room as soon as possible after admission of the dog to the hospital, typically while the attending veterinary clinician continued to evaluate and treat the dog. The FAST examination consisted of 2 ultrasonographic views (transverse and longitudinal) at 4 sites (**Figure 1**). A 2 X 2-inch area of hair was clipped just caudal to the xiphoid process, just cranial to the pelvis, and over the right and left flanks caudal to the ribs at the most gravity-dependent location of the abdomen. Alcohol and acoustic coupling gel were used at the ultrasound probe-to-skin interface. Each dog was placed in left lateral recumbency for evaluation unless an injury (eg, flail chest, fractures, or injury to the vertebral column) precluded placement in this position, in which instance the dog was placed in right lateral recumbency. For all dogs, FAST was performed by use of the same ultrasound machine[a] with either a 5- or 7.5-MHz curvilinear probe (the former was used for dogs that weighed ≥ 18.2 kg [≥ 40 lb], and the latter was used for dogs that weighed < 18.2 kg [< 40 lb]). The ultrasound probe was placed just caudal to the xiphoid process for detection of free fluid between the liver lobes and between the liver and the diaphragm. The ultrasound probe was then placed on the midline over the bladder for detection of free fluid at its apex. The most gravity-dependent areas of the abdomen (ie, the left flank view of dogs in left lateral recumbency and the right flank view of dogs in right lateral recumbency) were examined for fluid accumulation between the spleen and the body wall, between the spleen and liver, and between the spleen and left kidney in the left flank view and between adjacent loops of intestine, between the intestinal tract and the right kidney, and between the intestinal tract and the body wall in the right flank view. Finally, the probe was placed over the nondependent flank region (ie, the right flank view of dogs in left lateral recumbency and the left flank view of dogs in right lateral recumbency). At each location, the probe was placed parallel to the long axis of the dog to obtain the longitudinal view and placed at a 90° angle to the long axis of the dog to obtain the transverse view. The ultrasound probe was fanned through an angle of 45° from the long- and short-axis positions and also moved 1 inch cranial and caudal and to each side of the starting point to increase the likelihood of detecting free fluid in the abdominal cavity. For each view, an image was frozen and printed for documentation (8 printed images/dog); all printed images were evaluated for the presence or absence of fluid by a board-certified radiologist (AST). The purpose of the FAST examination was to determine the presence of free abdominal fluid, and therefore, this study was not designed to identify parenchymal or retroperitoneal injury.

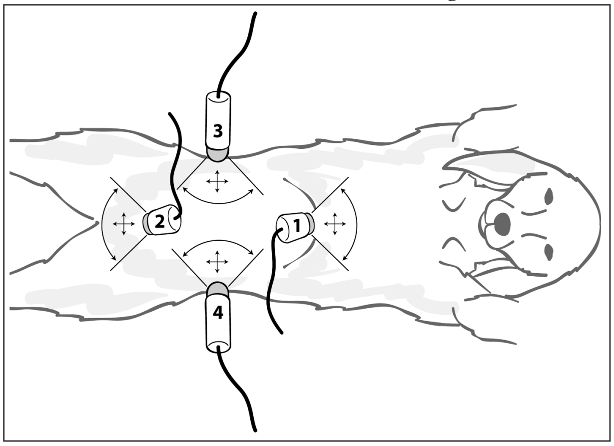

Figure 1—Illustration of the probe placements and movements used to obtain ultrasonographic views of the abdomen via focused assessment with sonography for trauma (FAST) in a dog. In this illustration, the dog is positioned in left lateral recumbency. The FAST examination involves transverse and longitudinal views at the subxiphoid region (1), the midline position over the bladder (2), and the right (3) and left (4) flank (gravity-dependent and gravity-independent locations in dogs in lateral recumbency). The ultrasound probe is fanned through an angle of 45° from the long and short axis positions (large curved arrows) and is moved 1 inch in each of 4 directions (ie, cranial, caudal, left, and right) from the starting point (small arrows). For clarification, the subxiphoid and midline bladder views are shown in the transverse plane and the right and left lateral flank views are shown in the longitudinal plane.

The time from the start to completion of the FAST examination was recorded. The time required to clip a 2 X 2-inch area for each sonographic view (an activity that was completed while the ultrasound machine was being moved into the emergency room and turned on) was not included in the time reported to perform the FAST examination.

Prior to performing FAST on dogs involved in MVAs, the veterinary clinicians participating in this study each underwent 2 hours of didactic training in the basic physics of ultrasonography and performed FAST on 5 healthy dogs. The practice FAST examinations were performed on 12 healthy dogs (ie, some of the dogs were used more than once). This training protocol was chosen on the basis of suggested guidelines for training of surgery residents performing FAST on humans.[1,31,37]

Samples of abdominal fluid were collected via unguided or ultrasound-guided needle abdominocentesis. Collection of a sample of nonclotting blood was considered indicative of hemoperitoneum. Creatinine concentration was assessed in each fluid sample that did not grossly appear to be blood and compared with the creatinine concentration in serum obtained from that dog; a sample of abdominal fluid that had creatinine concentration > 2 times the serum creatinine concentration was considered indicative of uroperitoneum. At the time of admission, needle abdominocentesis was performed at the discretion of the attending veterinary clinician. For dogs in which free abdominal fluid was detected via FAST and the initial needle abdominocentesis had failed to obtain any fluid or had not been performed, ultrasound-guided abdominocentesis was performed at the discretion of the attending veterinary clinician. Any abdominal exploratory surgeries that were performed because of intra-abdominal injury, and the results of these exploratory surgeries, were recorded.

The results of other diagnostic tests including radiography, pulse oximetry, measurement of respiratory rate, and needle abdominocentesis were recorded. Extra-abdominal injuries were noted. In addition, administration of blood products (ie, packed RBCs, whole blood, or plasma) was recorded. Final outcome for each dog was classified as either death or discharge from the hospital.

The frequency of intra-abdominal free fluid determined via FAST and the frequency of hemoperitoneum and uroperitoneum determined by unguided and ultrasound-guided needle abdominocentesis were recorded. The peripheral blood

PCV, plasma total solids concentration, serum lactate concentration, heart rate, age, and weight were also recorded for each dog; mean values of these variables were compared between the 2 groups of dogs (ie, dogs with and without abdominal fluid detected via FAST) by use of an unpaired Student *t* test for normally distributed data or a Mann-Whitney *U* test for skewed data. The data were examined graphically to determine which data were normally distributed and which were skewed. Comparison of the type of injury in the 2 groups of dogs was performed by use of a Pearson χ^2 analysis. A *P* value of ≤ 0.05 was considered significant for all comparisons.

Results

Four veterinary **emergency critical care (ECC)** clinicians underwent training and performed the FAST examinations. Three clinicians were residents in emergency and critical care training, and 1 (EAR) was a diplomate of the **American College of Veterinary Emergency and Critical Care (ACVECC)**. During the FAST training sessions, 12 healthy dogs were examined and all had no free abdominal fluid detected during the FAST training examinations.

One hundred dogs that had been involved in MVAs were prospectively evaluated. The age of the dogs (rounded to the nearest year) ranged from 1 to 15 years (median age, 3 years). Eight sexually intact females, 32 spayed females, 20 sexually intact males, and 40 castrated male dogs were included in the study; this distribution was not different (*P* = 0.17) from that of the general population of dogs evaluated at the hospital during the study period. Most dogs were primary emergency cases (n = 65), and the others (35) had been evaluated by a veterinary clinician outside the hospital prior to referral.

The time from the MVA to arrival at the hospital was 1 to 13 hours (median interval, 3 hours). The time from hospital admission to the start of the FAST examination ranged from 1 to 10 hours (median interval, 1 hour). For all dogs, FAST was performed within 24 hours of the MVA. The time required to perform the FAST examination ranged from 2 to 15 minutes (median duration, 6 minutes). The duration of the FAST examination was < 10 minutes in 94 of the 100 dogs. The number of FAST examinations performed by each ultrasonographer varied considerably. The board-certified member of the ACVECC performed 5 FAST exams. The remaining 95 FAST examinations were performed by the 3 ECC residents, who performed 86, 8, and 1 FAST examinations, respectively. The ECC resident who performed the 8 FAST examinations required > 10 minutes to complete the procedure in 6 of the 8 dogs; of the 4 ultrasonographers, only this individual required > 10 minutes to perform a FAST examination. There was no difference (*P* = 0.274) in the frequency of detection of free abdominal fluid in dogs via FAST among the 4 examiners.

Of the 100 dogs that underwent FAST, 97 had clinically detectable injury as a result of the MVA. The most common injury (45 dogs) was free abdominal fluid detected ultrasonographically. Of the 45 dogs with free abdominal fluid detected via FAST, needle abdominocentesis was performed in 40 (with ultrasound guidance in 29 dogs); assessment of the fluid samples obtained revealed that 38 dogs had hemoperitoneum and 2 dogs had uroperitoneum. Five dogs with free abdominal fluid detected via FAST did not undergo abdominocentesis because the primary veterinary clinician believed that the fluid detected via FAST was indicative of hemoperitoneum and did not consider the collection of a fluid sample to be necessary. There were 16 dogs with free abdominal fluid detected via FAST that had needle abdominocentesis performed prior to the FAST examination; fluid was obtained by use of needle abdominocentesis from 11 of these dogs, and no fluid was obtained from 5 dogs. Of the 5 dogs from which no fluid was obtained by use of needle abdominocentesis prior to the FAST examination, 4 had ultrasound-guided abdominocentesis performed subsequently, which yielded specimens of fluid (3 dogs had hemoperitoneum and 1 dog had uroperitoneum); the remaining dog did not undergo ultrasound-guided abdominocentesis at the primary veterinary clinician's discretion. For 21 of the 40 dogs that had free abdominal fluid detected via FAST and from which fluid was obtained by use of needle abdominocentesis, mean values of PCV and total solids concentration in the abdominal fluid were 45.3 ± 9.2% and 4.9 ± 1.0 g/dL, respectively. The 2 dogs that subsequently were determined to have a ruptured bladder both had free abdominal fluid detected via FAST and ultrasound-guided abdominocentesis. In 11 dogs, no fluid was obtained by use of needle abdominocentesis performed prior to the FAST examination and no free abdominal fluid was detected ultrasonographically; the remaining 44 dogs in which no free abdominal fluid was detected ultrasonographically did not undergo abdominocentesis prior to the FAST examination.

None of the dogs in this study underwent surgery as a result of hemoperitoneum. Surgical exploration was performed in the 2 dogs with uroperitoneum. Diagnostic peritoneal lavage was not performed on any of the dogs.

Concurrent injuries were diagnosed in 86 dogs. When findings of FAST examinations were excluded, the number of injuries per dog ranged from 0 to 4 (median, 1 injury/dog). A single injury was detected in 54 dogs, 20 dogs had 2 injuries, 11 dogs had 3 injuries, and 1 dog had 4 injuries. These injuries included pulmonary contusions (n = 31), pneumothorax (21), pelvic fractures (20), limb fractures (15), skin laceration requiring surgical repair (14; 4 were degloving injuries to the distal portions of limbs), head trauma (10), luxation of the hip joint (7), spinal injury (5), hemothorax (5; pleural effusion was incidentally diagnosed during the FAST examination in 2 dogs), proptosis (2), and retroperitoneal injury (1). The number of injuries and the specific type of injury were not significantly correlated with detection of free abdominal fluid via FAST.

Ninety of 100 dogs were discharged from the hospital; of the dogs that were not discharged, 7 dogs were euthanatized and 3 dogs died. Reasons for euthanasia included spinal cord injury that carried a grave prognosis in 4 dogs and the cost of treatment in 3 dogs. Hemoperitoneum was diagnosed in 5 of 7 dogs that were euthanatized and in 2 of 3 dogs that died and was considered a contributing factor to the cause of death in the latter. When euthanatized dogs were excluded, the overall mortality rate of dogs that were involved in an MVA and underwent FAST was 3% (3/93 dogs) and the mortality rate in dogs with a confirmed diagnosis of hemoperitoneum was 6.1% (2/33 dogs).

During the FAST examinations, the view in which free fluid (when present) could be observed most commonly was the gravity-dependent view (ie, the left flank view of dogs in left lateral recumbency or the right flank view of dogs in right lateral recumbency; n = 41) followed by the view of the xiphoid region (39; **Table 1**). Free abdominal fluid was detected least frequently in the non–gravity-dependent flank view (n = 20).

One board-certified radiologist (AST) retrospectively reviewed all of the FAST images. Disagreement regarding the assessment of findings of the FAST examination between the clinician performing the procedure and the radiologist was apparent in 2 instances; results of 1 of the 5 FAST examinations performed by the board-certified member of the ACVECC and results of 1 of the 86 FAST examinations performed by one of the ECC residents that had been classified as indicative of an absence of free abdominal fluid were each classified by the radiologist as indicative of the presence of free abdominal fluid.

A transfusion of packed RBCs was administered to 12 of the dogs in the study of this report. Of the dogs that received a transfusion, 10 had free abdominal fluid detected via FAST result and were confirmed via abdominocentesis to have hemoperitoneum (n = 9) or uroperitoneum (1). Of the 9 dogs with hemoperitoneum that received a transfusion, 1 died and 1 was euthanatized. Injuries in addition to hemoperitoneum or uroperitoneum were identified in 6 of the dogs that received a transfusion.

At the initial evaluation, mean heart rate among all dogs was 144 ± 33 beats/min. Dogs that had free abdominal fluid detected via FAST had significantly (*P* = 0.015) higher heart rate (154 ± 34 beats/min; n = 45) than that of the dogs that did not have free abdominal fluid detected via FAST (137 ± 32 beats/min; 55). At the initial evaluation, mean blood PCV and plasma total solids concentration among all dogs were 46.2 ± 7.7% (reference range, 37% to 55%) and 5.9 ± 1.1 g/dL (reference range, 6.0 to 7.5 g/dL), respectively. Dogs with free abdominal fluid detected via FAST (n = 45) had significantly (*P* = 0.001) lower mean blood PCV (43.4 ± 7.6%) and significantly (*P* < 0.001) lower mean plasma total solids concentration (5.4 ± 1.0 g/dL), compared with values in dogs that did not have free abdominal fluid detected via FAST (48.4 ± 7.2% and 6.2 ± 1.0 g/dL, respectively; n = 55). Serum lactate concentration was measured in 67 of 100 dogs after MVAs and ranged from 1.2 to 13.3 mmol/L (median concentration, 4 mmol/L; reference range, 0 to 2.5 mmol/L). Dogs that had free abdominal fluid detected via FAST had significantly (*P* = 0.025) higher serum lactate concentration (1.6 to 13.3 mmol/L; median concentration, 5.2 mmol/L; n = 35) than dogs that had no abdominal fluid detected via FAST (1.2 to 12.2 mmol/L; median concentration, 3.7 mmol/L; 32). Assessment of coagulation abilities was not performed prior to the FAST examination in any dog.

Respiratory rates were recorded in 65 of the 100 dogs and ranged from 15 to 100 breaths/min (median respiratory rate, 40 breaths/min). The remaining 35 dogs were reported as panting, and an exact respiratory rate was not recorded. Rectal temperature was recorded in 90 dogs and ranged from 34.4°C to 40.0°C (94° to 104°F; median temperature, 38.3°C [101°F]). Pulse oximetry was performed on 44 of the 100 dogs, and oxygen saturation ranged from 78% to 100% (median value, 95.5%). Weights were recorded in 99 of the 100 dogs; mean weight was 25.4 ± 12.5 kg (55.9 ± 27.4 lb). There was no significant difference in respiratory rate, age, weight, rectal temperature, or oxygen saturation between dogs with free abdominal fluid detected via FAST and dogs with no free abdominal fluid detected via FAST.

Table 1—Number of dogs involved in motor vehicle accidents with free abdominal fluid detected via focused assessment with sonography for trauma (FAST) at each of 4 sites evaluated during placement in left lateral or right lateral recumbency.

	Position		
Examination view Probe orientation	**Left lateral recumbency**	**Right lateral recumbency**	**No. of dogs with free abdominal fluid detected via FAST/view**
Subxiphoid region			
Transverse	27/80	12/20	39/100
Longitudinal	27/80	12/20	39/100
Bladder region			
Transverse	26/80	8/20	34/100
Longitudinal	26/80	8/20	34/100
Left flank			
Transverse	28/80	8/20	36/100
Longitudinal	28/80	8/20	36/100
Right flank			
Transverse	12/20	12/20	24/100
Longitudinal	12/20	13/20	25/100
No. of dogs with free abdominal fluid detected via FAST/position	**32/100**	**13/100**	**45/100**

Discussion

The results of this study support the use of FAST in dogs after blunt abdominal trauma secondary to an MVA. It is a rapid, noninvasive, and easily performed procedure that can be done during the initial stabilization of injured dogs to detect free abdominal fluid that may develop as a result of intra-abdominal injury. In dogs in which free abdominal fluid is detected via FAST, findings of ultrasound-guided abdominocentesis are useful in determining the type of fluid.

In humans, the FAST examination can be performed in < 10 minutes and has been proven to be accurate for the detection of free abdominal fluid[7,11,18,27] with a specificity of 86% to 100% and a sensitivity of 99% to 100%.[1,7,8,10,11,14,18,19,23,24,27-31] The length of time required to perform the FAST examination in our study (median duration, 6 minutes) was similar to that reported in humans[18,27]; in 94 of the 100 dogs involved in MVAs, FAST examinations were performed in < 10 minutes. With experience, some human trauma specialists have used FAST to identify parenchymal as well as retroperitoneal injury in addition to the presence of free fluid in the abdomen,[1,38] but this requires considerably more ultrasonographic experience and was not evaluated in our study.

The FAST protocol developed for our study was based on human protocols but differed from that used in humans in several aspects. In humans, a 4-view examination is most commonly used to detect the presence of fluid in the abdominal cavity, the pericardial space, and, in some instances, the pleural space.[7,20,38] Our study focused on the detection of free fluid in the abdominal cavity and did not involve attempts to localize fluid to the pericardial or pleural spaces; nevertheless, it should be noted that pleural fluid was incidentally detected in 2 dogs during FAST examinations. Because multiple injuries are common in dogs after involvement in an MVA and discomfort and excitement can occur during attempts to examine dogs in dorsal recumbency, we elected to perform FAST examinations with dogs placed in lateral recumbency. In creating the FAST protocol for detection of free abdominal fluid in dogs after involvement in an MVA, we attempted to incorporate the most likely places for fluid to accumulate (based on the anatomic positioning of organs in dogs in lateral recumbency, the effects of gravity, and consideration of the most common organs to be injured as a result of an MVA).[33-36]

On the basis of the results of the present study, detection of free abdominal fluid via FAST is most likely in the gravity-dependent lateral view and the subxiphoid view, whereas such detection by use of the non–gravity-dependent flank view is least likely. We speculate these former views were most useful because the spleen (left lateral view) and liver (subxiphoid view) have been reported as the organs most commonly injured in dogs after abdominal trauma[35,36] and free fluid may be more likely to accumulate in the most gravity-dependent areas of the abdomen.

In humans, results of FAST examinations performed by surgeons with minimal prior ultrasonographic experience have compared favorably to findings of ultrasonographic examinations performed by radiologists for the rapid detection of free abdominal fluid.[17,31] The results of our study indicated that veterinary clinicians with minimal prior ultrasonographic training can interpret findings of FAST performed on the abdomen of dogs after involvement in an MVA and correctly identify the presence of free abdominal fluid. One of the limitations of the study of this report was the lack of a large control population of clinically normal dogs that could have been evaluated to confirm the premise that the ultrasonographic findings of free abdominal fluid are always abnormal. However, during the training phase undertaken by the 4 clinicians involved in our study, repeated FAST examinations performed by the trainees and the training supervisor in 12 healthy normal dogs revealed no signs of free abdominal fluid. Likewise, in other studies,[39,40] fluid was not detected ultrasonographically in clinically normal dogs, which supports the clinical observation of one of the authors (AST) that a readily detectable amount of free abdominal fluid should not be evident during ultrasonographic examination in healthy adult dogs.

The frequency of abdominal injury in dogs after involvement in MVAs has been reported to range from 6% to 13%.[35,36] The frequency of hemoperitoneum, which is reported to be a common and sometimes fatal result of trauma,[36] has not previously been reported in dogs. By use of FAST, the frequency of detection of abdominal free fluid after MVAs was 45% and the frequency of hemoperitoneum (based on results of abdominocentesis) was 38% in the study of this report. The actual frequency of hemoperitoneum may be greater because not all dogs with free abdominal fluid detected via FAST had abdominocentesis performed. In addition, because dogs were evaluated by recently trained clinicians and not by a radiologist, it is possible that a more skilled ultrasonographer with use of a higher frequency transducer would detect smaller amounts of fluid and therefore identify a higher percentage of dogs involved in MVAs with hemoperitoneum. In the present study, if all dogs that were considered by a board-certified radiologist to have free abdominal fluid on the basis of findings of the FAST examinations are included and it is assumed that dogs with free abdominal fluid detected via FAST in which the fluid type was not confirmed had intra-abdominal hemorrhage, then the frequency of hemoperitoneum among the study dogs may have been as high as 45%. Although we believe that abdominocentesis is usually a benign procedure, it is possible that some of the dogs with free abdominal fluid detected via FAST may have developed that fluid accumulation as a result of an unguided abdominocentesis procedure performed before the FAST examination, rather than as a result of the MVA. Further studies to evaluate the development of free fluid in the abdominal cavity of healthy dogs subsequent to unguided abdominocentesis would have to be performed to determine whether this might have had a notable effect on the frequency of detection of free abdominal fluid via FAST in dogs after involvement in MVAs. The frequency of detection of free abdominal fluid in dogs after vehicular injury in our study was much higher than that previously reported[35,36] and may reflect the technique that was used to determine the presence of free fluid in the abdomen in the different studies. Traditionally, findings of physical examination, radiography, needle abdominocentesis, and DPL have been used to assess dogs for abdominal injury.[2,4,5,35,36] Results of physical examination alone are insensitive and unreliable in the detection of intra-abdominal injury in humans.[1,8,15,17,23] Radiographically, intra-abdominal hemorrhage may take several hours to become apparent,[3] and fluid volumes of as much as 8.8 mL/kg (4 mL/lb) of body weight are required before a consistent diagnosis can be made in dogs.[39] Results of needle abdominocentesis have previously been reported as only 49% accurate for detection of intra-abdominal injury in dogs and cats after blunt abdominal trauma,[2] and a volume of as much as 5.2 to 6.6 mL/kg (2.4 to 3.0 mL/lb) of body weight is required for accurate detection of abdominal fluid in 78% of dogs.[36] Although DPL is sensitive and accurate in detecting intra-abdominal fluid in dogs and cats after blunt abdominal trauma and can detect fluid volumes as low as 0.2 to 1 mL/kg (0.09 to 0.45 mL/lb) of body weight, it has not been used to report the incidence of intra-abdominal injury following trauma in those species to our knowledge.[2,36,41] Ultrasonography, which is more sensitive than radiography and physical examination for the detection of free abdominal fluid in dogs[39] and as sensitive as DPL or computed tomography for the detection of free abdominal fluid in humans,[9,10,42,43] was used to identify all dogs with intra-abdominal fluid in our study. The use of ultrasonography to detect free abdominal fluid most likely explains the apparent increase in frequency of intra-abdominal injury in our study, compared with findings of other studies.

It is interesting to note that among the 45 dogs with free abdominal fluid detected via FAST, only the 2 dogs with uroperitoneum underwent abdominal surgery. None of the 38 dogs with hemoperitoneum in our study underwent surgery, although hemoperitoneum was considered a contributing factor to death in 2 dogs. This is likely reflective of the fact that most of the dogs in our study received IV administration of crystalloid or colloid solutions (or both) in an attempt at medical stabilization before proceeding with any possible surgery.

The use of FAST in dogs after blunt abdominal trauma enables the attending veterinarian to localize injury to the abdominal cavity in a rapid, noninvasive fashion while the patient is being stabilized. In conjunction with the dog's overall status and entire spectrum of clinical findings, detection of free abdominal fluid via FAST should prompt the veterinary clinician to monitor the patient more closely for adverse effects of intra-abdominal injury. In several studies[9,18,44] in humans, scoring systems have been developed in an attempt to quantitate the amount of free fluid in the abdomen after blunt abdominal trauma and thereby identify those patients that would benefit from surgery. If further evaluation of these scoring systems reveals that they are sensitive and specific for predicting which human patients with blunt abdominal trauma require surgery, development of a similar scoring system for use in dogs may assist clinicians in determining which dogs would benefit from surgery.

In dogs that have free abdominal fluid detected via FAST, needle abdominocentesis to determine the type of fluid present is recommended by the authors; if analysis of samples obtained via needle abdominocentesis confirms the presence of free urine, bile, or intestinal contents, surgery is warranted. The usefulness of the FAST examination for detection of biliary damage or gastrointestinal tract perforation after trauma in dogs was not evaluated in our study, although results of studies[1,17,26,38,45] have indicated that the FAST examination is not reliable for the detection of intestinal injury in humans. One limitation of the study of this report was the failure to perform abdominocentesis in all dogs after completion of the FAST examination. In some dogs, abdominocentesis was performed before the FAST examination, and in other instances, the attending veterinarian declined abdominocentesis because of a perceived lack of clinical indication for the procedure.

In an investigation of dogs involved in trauma in an urban setting, a mortality rate of 12.5% was calculated for dogs involved in MVAs.[46] In our study, the overall mortality rate was 3% for dogs involved in MVAs. The aforementioned urban study included euthanatized dogs in its calculation of mortality rate, which would account for some of the difference in rates between that and our study. If euthanatized animals are also considered, the overall mortality rate in our study becomes 10%, which is similar to that previously reported for dogs involved in MVAs.[46]

Dogs that had free abdominal fluid detected via FAST had significantly lower PCV and total solids concentration and significantly higher serum lactate concentration and heart rate, compared with values in dogs with no free abdominal fluid detected via FAST. These findings are likely associated with blood loss into the abdomen that results in hemorrhagic shock with poor tissue perfusion.

In humans, patients with chest injury (eg, pulmonary contusions, rib fractures, hemothorax, and pneumothorax), gross hematuria, pelvic fractures, and fractures of the thoracolumbar vertebrae have an increased likelihood of concurrent intra-abdominal injury.[45] In our study, there was no significant correlation between the number or type of extra-abdominal injuries sustained and the detection of free abdominal fluid via FAST in dogs.

Our data have suggested that FAST is a useful diagnostic procedure to help identify free fluid in the abdominal cavity of dogs after involvement in MVAs. When free abdominal fluid is identified, analysis of samples obtained via ultrasound-guided abdominocentesis may allow hemoperitoneum or uroperitoneum to be confirmed. The usefulness of FAST for detection of biliary or intestinal injury associated with abdominal trauma in dogs remains to be determined. In human trauma patients for whom the findings of a FAST examination are equivocal yet the clinician has a strong suspicion of intra-abdominal injury, serial FAST examinations performed after fluid resuscitation may identify free abdominal fluid that was not detected during the initial examination[1,21]; such a protocol may be of benefit in some injured dogs with shock that are unresponsive to treatment and in dogs with equivocal findings on an initial FAST examination. In dogs with free abdominal fluid (detected via FAST) that fail to respond to IV administration of blood products or other crystalloid and colloid solutions, exploratory surgery should be considered.

[a]Ausonics Impact VFI, Universal Medical Systems, Bedford Hills, NY.

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