Multicenter prospective evaluation of dogs with trauma

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Objective—To determine hospital admission variables for dogs with trauma including values determined with scoring systems (animal trauma triage [ATT], modified Glasgow coma scale [MGCS], and acute patient physiologic and laboratory evaluation [APPLE] scores) and the usefulness of such variables for the prediction of outcome (death vs survival to hospital discharge).

Design—Prospective, multicenter, cohort study.

Animals—315 client-owned dogs.

Procedures—By use of a Web-based data capture system, trained personnel prospectively recorded admission ATT, MGCS, and APPLE scores; clinical and laboratory data; and outcome (death vs survival to discharge) for dogs with trauma at 4 veterinary teaching hospitals during an 8-week period.

Results—Cause of injury was most commonly blunt trauma (173/315 [54.9%]) followed by penetrating trauma (107/315 [34.0%]), or was unknown (35/315 [11.1%]). Of the 315 dogs, 285 (90.5%) survived to hospital discharge. When 16 dogs euthanized because of cost were excluded, dogs with blunt trauma were more likely to survive, compared with dogs with penetrating trauma (OR, 8.5). The ATT (OR, 2.0) and MGCS (OR, 0.47) scores and blood lactate concentration (OR, 1.5) at the time of hospital admission were predictive of outcome. Surgical procedures were performed for 157 (49.8%) dogs; surgery was associated with survival to discharge (OR, 7.1).

Conclusions and Clinical Relevance—Results indicated ATT and MGCS scores were useful for prediction of outcome for dogs evaluated because of trauma. Penetrating trauma, low blood lactate concentration, and performance of surgical procedures were predictive of survival to hospital discharge. The methods enabled collection of data for a large number of dogs in a short time. (*J Am Vet Med Assoc* 2014;244:300–308)

Trauma, defined as tissue injury caused by violence or accident that occurs suddenly and includes physical damage to the body,[1] is a common cause of morbidity and death in dogs. Results of large-scale epidemiological studies[2,3] indicate that trauma accounts for approximately 11% to 13% of all animals evaluated at urban veterinary teaching hospitals. In a recent study[4] in which causes of death in > 74,000 dogs were evaluated, trauma was the second most common cause of death in juvenile dogs (following infectious disease) and adult dogs (following neoplasia). Results of multiple large retrospective studies[2,5–8] indicate the injury characteristics and clinical and laboratory variables for dogs with trauma, including patient demographics, mechanisms of trauma, frequency of polytrauma, development of multiple organ failure, and prognostic indicators. Predictors of death or euthanasia (ie, nonsurvival) in dogs with trauma determined retrospectively include cardiac arrhythmias, body wall hernias, severe soft tissue injuries, head trauma, vertebral fractures, and recumbency at the time of hospital admission.[5,6]

Scoring systems, useful for both clinical and research applications, have been investigated for evaluation of dogs following trauma. In clinical practice, scoring systems can be incorporated in protocols developed to improve triage, guide treatments and diagnostic testing, or benchmark patient progress.[9] In clinical research, scoring systems can be used to measure effectiveness of randomization and facilitate patient stratification to de-

Abbreviations

APPLE	Acute patient physiologic and laboratory evaluation
ATT	Animal trauma triage
AUC	Area under the curve
BCS	Body condition score
CI	Confidence interval
MGCS	Modified Glasgow coma scale
Spo_2	Oxygen saturation as measured by pulse oximetry

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crease bias and confounding variables.[9] The ATT score was validated by use of a small population of dogs and cats, and its association with outcome (survival to hospital discharge vs nonsurvival) has been subsequently determined in multiple retrospective studies.[5,6,10,11] In a retrospective study[12] of dogs with head trauma, MGCS scores were predictive for nonsurvival within 48 hours after injury. Most recently, the APPLE scoring system was validated as a user-friendly scoring system for evaluation of dogs admitted to an intensive care unit.[3]

In other veterinary studies, numerous variables and scoring systems have been investigated for evaluation of dogs hospitalized after trauma; however, such studies have had a retrospective design or included dogs evaluated at a single site. The objective of the study reported here was to prospectively evaluate variables at the time of hospital admission for dogs with trauma, with particular emphasis on scoring systems (ATT, MGCS, and APPLE scores) and the usefulness of such variables for prediction of outcomes. Another objective was to determine the potential usefulness of these methods for evaluation of dogs with trauma in future multicenter prospective clinical trials.

Materials and Methods

Animals—The study was conducted with a multicenter consortium and by use of an online database. Trained personnel at 4 veterinary teaching hospitals (University of Minnesota Veterinary Medical Center, Tufts University Foster Hospital for Small Animals, Ontario Veterinary College Health Sciences Center, University of Pennsylvania Matthew J. Ryan Veterinary Hospital) prospectively recorded information for all dogs evaluated after a witnessed or suspected traumatic incident between June 27 and August 22, 2011. Trauma was defined as any tissue injury that occurred suddenly as a result of an external force, including blunt force injury (eg, motor vehicle accident or fall from a high height), penetrating injury (eg, gunshot, laceration, impalement, injury sustained during an altercation with another animal, or imbedded porcupine quills), or crushing injury. Dogs were excluded if they had acute lameness suspected or determined to be attributable to a cruciate ligament rupture, nontraumatic acute paresis (eg, intervertebral disk disease or fibrocartilaginous embolism), or minor superficial bite wounds limited to 1 limb. Owner consent regarding use of data from medical records was obtained for all dogs at the time of hospital admission.

Data collection—Study data were collected and managed with electronic data capture tools hosted at the University of Minnesota.[a] The online database[a] was a secure, Web-based application designed to support data capture for research studies and provided an intuitive interface for validated data entry, audit trails for tracking data manipulation and export procedures, automated export procedures for data downloads to commonly used statistical software packages, and procedures for importing data from external sources.[13]

Data were transcribed to a paper worksheet and then entered into the online database[a] and retrospectively verified by means of comparison with the completed medical record. Where possible, the online database used dropdown menus (categorical values) or was programmed to only accept certain numbers to minimize transcription errors (eg, dropdown menu for BCS included only numeric values 1 to 9; text box for body weight only allowed entry of numeric values to 1 decimal point). Additionally, 2 authors (KEH and MKH) independently reviewed the data and contacted investigators at each site for clarification or correction of questionable data prior to data analysis.

The following variables were recorded for each dog: ATT score (**Appendix 1**), MGCS score (**Appendix 2**), age, sex, BCS, body weight, time and cause of injury, veterinary care prior to arrival at the hospital, whether the trauma was witnessed, preexisting medical conditions, blood product administration, performance of CPR, total cost, and the number and type (soft tissue, orthopedic, or CNS) of surgeries (defined as a surgical episode which may have included ≥ 1 surgical procedures) and surgical procedures (defined as surgical repair of tissues in 1 region) performed (eg, femoral fracture repair and shoulder laceration repair during 1 anesthetic episode would be considered 1 surgery and 2 surgical procedures) and where such procedures were performed (emergency room or operating room). Time from injury to hospital admission was calculated, and cause of injury was further categorized into 1 of 3 groups: blunt trauma (motor vehicle accident, fall, or other), penetrating trauma (bite wounds or penetrating nonbite wounds), or unknown. Age was also categorized as young, middle, or old with correction for body weight performed on the basis of methods used in another study.[14] Animals were categorized by body weight (giant, > 45 kg [99 lb]; large, > 20 kg [44 kg] and < 45 kg; medium, > 10 kg [22 lb] and < 20 kg; small, > 5 kg [11 lb] and < 10 kg; and toy, < 5 kg), then subsequently divided by age in years into young (toy or small, < 7 years; medium, < 6 years; large, < 5 years; and giant, < 3 years), middle-aged (toy or small, 7 to 12 years; medium, 6 to 10 years; large, 5 to 9 years; and giant, 3 to 7 years) and old (toy or small, > 12 years; medium, > 10 years; large, > 9 years; and giant, > 7 years). For dogs that were discharged from the hospital after an initial evaluation and were returned for trauma-associated wound management, the total cost was only recorded for the initial evaluation; however, surgical procedures performed during subsequent evaluations were included in the total number of surgeries if they were performed for problems that were the result of the initial traumatic injury.

Additional data, obtained at the discretion of the attending clinician, were recorded for each dog, including values for calculation of the APPLE score (ie, serum creatinine, albumin, and total bilirubin concentrations; blood lactate concentration; WBC count; Sp_{O_2}; mentation score; respiratory rate; and body cavity fluid score [0 = no abdominal, thoracic, or pericardial free fluid identified; 1 = abdominal or thoracic or pericardial free fluid identified; 2 = ≥ 2 of abdominal, thoracic, and pericardial free fluid identified])[3] and ultrasonographically assessed abdominal fluid score.[15] The ultrasonographically assessed abdominal fluid score indicates the number of abdominal sites in which fluid is detected during a methodical ultrasonographic examination of the abdomen. The score indicates the number of sites (of 4 specific anatomic regions) in which fluid is detected. Outcome for each dog was classified as survival to discharge from the hospital, euthanasia, or death. Time of death was recorded and categorized as < 2, 2 to < 6, 6 to < 12, 12 to < 24, 24 to 72, or > 72 hours after the initial evaluation at the hospital. For dogs that were euthanized, information regarding the reason (cost or grave prognosis) was also recorded (determined after communication with the attending clinician). Dogs that were euthanized for financial reasons were excluded from outcome analyses.

Statistical analysis—Continuous variables were analyzed for normality with a Shapiro-Wilk test. Descriptive statistics were reported as mean and SD (for data with a normal distribution) or median and range (for data with a nonnormal distribution). Depending on normality of data distribution, a pooled Student *t* test or Wilcoxon Mann-Whitney test was used to assess differences in the mean or median for clinical and laboratory variables between surviving and nonsurviving dogs. Univariate exact conditional logistic regression was used to assess categorical variables including sex, age category, trauma category, previous illness, performance of surgery, blood product administration, positive results for fluid score or ultrasonographically assessed abdominal fluid score, and whether trauma was witnessed as risk factors for nonsurvival. Univariate exact conditional logistic regression was used to assess the variables age, BCS, body weight, time from injury to hospital admission, MGCS score, ATT score, serum albumin concentration, serum total bilirubin concentration, serum creatinine concentration, blood lactate concentration, Spo_2, WBC count, and total cost of care as risk factors for nonsurvival. Receiver operating characteristic curve analysis was performed to determine the AUC and select the optimum cutoff value that maximized the Youden *J* statistic (sensitivity + specificity – 1) for sensitivity and specificity reporting. Data analysis was performed by use of computer software.[b] Values of $P < 0.05$ were considered significant for all comparisons.

Results

Animals—Data were initially recorded for 327 dogs. Data for 12 dogs were excluded from analysis on the basis of exclusion criteria; these dogs were excluded because of a small puncture wound to an extremity (n = 6), chronic orthopedic disease or cranial cruciate ligament rupture (4), chemical burn (1), and hemivertebrae causing spinal cord injury (1). Therefore, 315 dogs were included in the study; these dogs were enrolled at Tufts University (107/315 [34.0%]), University of Pennsylvania (101/315 [32.1%]), University of Minnesota (73/315 [23.2%]), and University of Guelph (34/315 [10.8%]). Of the 315 dogs included in the study, 137 (43.5%) were female and 178 (56.5%) were male. Most (95/137 [69.3%]) female dogs were spayed, and most (109/178 [61.2%]) male dogs were castrated. For the 312 dogs with available data, 208 (66.7%), 81 (26.0%), and 23 (7.4%) were classified as young, middle-aged, and old, respectively. Fifty-two of the 315 (16.5%) dogs included in the study were undergoing management of previously diagnosed illness (eg, diabetes, chronic kidney disease, or atopy) at the time of their injury.

Trauma—For the 315 cases of trauma, causes included motor vehicle accidents (94 [29.8%]), bite wounds (84 [26.7%]), falls (57 [18.1%]), unknown (35 [11.1%]), other (24 [7.6%]), penetrating non–bite wounds (12 [3.8%]), and porcupine quills (9 [2.9%]). Blunt trauma (173 [54.9%]) occurred most commonly, followed by penetrating trauma (107 [34.0%]) and trauma of other causes (35 [11.1%]). Trauma was witnessed for 220 (69.8%) dogs. Two hundred seventeen (68.9%) dogs were evaluated at the study center the same day of the injury, 50 (15.9%) the day after injury, 11 (3.5%) 2 days after injury, and 29 (9.2%) 3 days after injury; for 8 (2.5%) dogs, the time from injury to evaluation was unknown.

Treatments and procedures—Of the 315 dogs included in the study, 101 (32.1%) were evaluated by another veterinarian prior to hospital admission. Previously administered treatments included crystalloid fluids (35 [34.7%]), colloid fluids (2 [2.0%]), hypertonic saline (7.5% NaCl) solution (4 [4.0%]), glucocorticosteroids (10 [9.9%]), NSAIDs (30 [29.7%]), or both glucocorticosteroids and NSAIDs (2 [2.0%]). Sedatives or analgesics were administered prior to hospital admission for 60 of 286 (21.0%) dogs for which such information was recorded. Surgery was performed for 157 of 315 (49.8%) dogs (164 surgeries). Most (151/157 [96.2%]) dogs underwent 1 surgery; 6 (3.8%) dogs had ≥ 2 surgeries. Eighty-four of the 164 (51.2%) surgeries were performed in an emergency room, and 80 (48.8%) were performed in an operating room. A total of 174 surgical procedures (repairs) were performed, including 114 (65.5%) soft tissue procedures, 55 (31.6%) orthopedic procedures, and 5 (2.9%) CNS procedures. Soft tissue procedures (eg, wound management) were the most commonly performed procedures in emergency rooms; all orthopedic and CNS procedures were performed in an operating room. Ultrasonography was performed for determination of abdominal fluid scores for 37 of 315 (11.7%) dogs; the ultrasonographically assessed abdominal fluid score for most (32/37 [86.5%]) of these dogs was 0. A body cavity fluid score was determined for 54 of 315 (17.1%) dogs; the score for most (42/54 [77.8%]) of these dogs was 0. Only 7 of 315 (2.2%) dogs received blood products (3 dogs received plasma, 1 received packed RBCs, and 3 received both plasma and packed RBCs).

Outcome—A total of 285 of 315 (90.5%) dogs survived to hospital discharge. Of the 30 dogs that did not survive, 5 (16.7%) died, 9 (30.0%) were euthanized because of a grave prognosis, and 16 (53.3%) were euthanized for financial reasons. Of the 30 dogs that did not survive, 3 died and 16 were euthanized within 2 hours after arrival at the hospital, 5 were euthanized 2 to 6 hours after arrival, 3 were euthanized 12 to 24 hours after arrival, and 2 died and 1 was euthanized 24 to 72 hours after arrival. Cardiopulmonary resuscitation was performed for 5 of the 315 (1.6%) dogs in the study; none of those dogs survived to discharge from the hospital (4 died and 1 was euthanized).

Table 1—Values of clinical and serum (albumin, total bilirubin, and creatinine concentrations) and blood (lactate concentration) laboratory variables for 315 dogs with trauma that did or did not survive to discharge from the hospital.

	Survivors			Nonsurvivors			
Variable	No. of dogs	Mean ± SD	Median (range)	No. of dogs	Mean ± SD	Median (range)	*P* value
Age (y)	283	4.1 ± 3.6	3.3 (0.2–16.3)	14	5.2 ± 3.6	4.8 (0.8–15.0)	0.238
BCS	214	5.3 ± 1.1	5 (3–9)	7	5.7 ± 1.0	6 (4–7)	0.420
Body weight (kg)	275	17.2 ± 13.5	12.0 (1.0–60.4)	10	19.5 ± 14.6	16.0 (3.5–42.9)	0.598
Time from injury to hospital admission (d)	278	1.4 ± 6.7	0 (0–98)	13	0.5 ± 1.4	0 (0–5)	0.655
Time from injury to initial evaluation by the referring veterinarian (d)	88	0.8 ± 4.4	0 (0–41)	7	0 ± 0	0 (0)	0.396
MGCS score	283	17.8 ± 0.7	18 (10–18)	11	15.3 ± 3.4	17 (6–18)	< 0.001
ATT score	284	2.1 ± 1.7	2 (0–9)	12	7.9 ± 3.9	8.5 (2–14)	< 0.001
Albumin (g/dL)*	54	3.1 ± 0.7	3.0 (1.7–4.5)	5	3.0 ± 0.9	2.9 (1.9–4.3)	0.772
Bilirubin (mg/dL)	50	0.2 ± 0.2	0.2 (0–0.9)	5	0.1 ± 0.1	0.1 (0.1–0.2)	0.377
Creatinine (mg/dL)	121	1.0 ± 0.7	0.9 (0.4–6.4)	8	1.1 ± 0.5	1.0 (0.6–2.0)	0.299
Lactate (mmol/L)	106	2.8 ± 1.9	2.0 (0.6–10.6)	5	6.5 ± 5.2	4.5 (2.0–14.0)	0.005
Spo_2 (%)	30	95.2 ± 6.2	97 (72–100)	2	94.5 ± 0.7	94.5 (94–95)	0.605
WBC count (× 10^3 WBCs/µL)	56	14.2 ± 5.6	13.7 (4.9–28.6)	5	10.7 ± 3.3	12.8 (6.2–13.4)	0.168
Cost ($)	285	1,491.53 ± 2,213.00	586.00 (37.10–21,865.40)	14	1,393.00 ± 1,598.14	449.00 (120.00–4,961.29)	0.869
Duration of hospitalization (d)	284	1.5 ± 2.3	1 (0–21)	14	0.7 ± 1.1	0 (0–3)	0.208

*Data are normally distributed.

Data are nonnormally distributed unless otherwise indicated. The maximum number of nonsurvivor dogs reported is 14 because data for 16 dogs euthanized for financial reasons were excluded from analyses.

Scoring systems and prognostic indicators—An APPLE score was calculated for only 13 of the 315 (4.1%) dogs because of insufficient data in the medical record, whereas ATT (312 [99.0%]) and MGCS (310 [98.4%]) scores were calculated for almost all dogs. The ATT score (OR, 2.0; 95% CI, 1.6 to 2.7; $P < 0.001$), MGCS score (OR, 0.47; 95% CI, 0.30 to 0.69; $P < 0.001$), and blood lactate concentration (OR, 1.5; 95% CI, 1.1 to 2.0; $P = 0.005$) were predictive of nonsurvival of dogs (**Table 1**). Blunt trauma was significantly ($P = 0.021$) more likely for dogs that did not survive (13/14; OR, 8.5; 95% CI, 1.2 to 333.3) versus dogs that survived to discharge from the hospital (151/285 [53.0%]; **Table 2**). Surgical intervention was predictive of survival to hospital discharge (OR, 7.1; 95% CI, 1.5 to 66.7; $P = 0.006$); 155 of 285 (54.4%) dogs that survived underwent surgery, whereas only 2 of 14 dogs that did not survive (excluding dogs euthanized for financial reasons) underwent surgery. Other laboratory and clinical variables, including sex, BCS, age, age category, previous illness, blood product administration, evaluation by another veterinarian before admission to the hospital, time from injury to admission to the hospital, whether trauma was witnessed, and total cost of care, were not predictive of outcome (survival to hospital discharge vs nonsurvival).

Receiver operating characteristic curve analysis—The usefulness of blood lactate concentration, MGCS score, and ATT score for prediction of nonsurvival of dogs with trauma were evaluated on the basis of receiver operating characteristic curve analysis. A blood lactate concentration ≥ 4.0 mmol/L was predictive for nonsurvival with 80% sensitivity (95% CI, 73% to 87%) and 56% specificity (95% CI, 47% to 65%; AUC, 0.785). An MGCS score ≤ 17 was predictive for nonsurvival with 82% sensitivity (95% CI, 78% to 86%) and 87% specificity (95% CI, 83% to 91%; AUC, 0.866). The ATT score was the best predictor of outcome: an ATT score ≥ 5 had 83% sensitivity (95% CI, 79% to 87%) and 91% specificity (95% CI, 88% to 94%; AUC, 0.913) for prediction of nonsurvival of dogs with trauma in this study.

Table 2—Categorical variables for 315 dogs with trauma that did or did not survive to discharge from the hospital.

Variable	Survivors (n = 285)	Nonsurvivors (n = 14)	*P* value
Witnessed trauma	100 (35.1)	10 (71.4)	1.000
Previous illness	51 (17.9)	1 (7.1)	0.530
Surgery performed	155 (54.4)	2 (14.3)	0.006
Blood product administered	6 (2.1)	1 (7.1)	0.575
Evaluated by referring veterinarian prior to arrival	72 (25.3)	7 (50.0)	0.255
Blunt trauma	151 (53.0)	13 (92.9)	0.021

Data are No. (%) of dogs.

Data for 16 dogs euthanized for financial reasons were excluded from analyses.

Discussion

In the population of dogs with trauma in the present study, most animals were young and male, and blunt trauma was the most common cause of injury. The survival rate was high, and many of the dogs that did not survive were euthanized for financial reasons. High ATT scores, high blood lactate concentrations, and low MGCS scores were predictive of nonsurvival. Dogs with penetrating trauma (rather than blunt trauma) and dogs that underwent surgery were more likely to survive to discharge from the hospital versus other dogs.

Blunt trauma (caused by a motor vehicle accident, fall, or crush injury) occurred for approximately 55% of dogs in the study, which was slightly lower than the value determined (62%) for a large population of dogs and cats in a retrospective study.[2] Similar to results of other studies,[2,5] motor vehicle accidents were the most common causes of blunt trauma for dogs in the present study. Penetrating injuries (34% of dogs) were more common for dogs in this study than they were for dogs and cats in another study[2] (23%). Approximately 27% of dogs in the present study had bite wounds, which comprised most of the penetrating wounds; conversely, bite wounds comprised only 10% of injuries in dogs and cats with trauma in the other study.[2] Differences among results of the present study and those of other studies regarding the distribution of types of injuries may have been attributable to differences in geography, time of data collection, species evaluated, and definition of trauma. The retrospective study[2] included 1,000 dogs and cats evaluated at a single site and included animals with burn injuries, whereas another retrospective study[5] included dogs with blunt trauma evaluated at a single teaching hospital.

Scoring systems were a user-friendly and reliable method to predict outcomes for dogs in the present study. Similar to results of retrospective and single-center studies,[6,10,11] ATT score was associated with outcome and strongly predictive of nonsurvival for dogs in the present study. The ATT score includes evaluations of 6 categories (perfusion; cardiac; respiratory; eye, muscle, and integument; skeletal; and neurologic assessments) that are each assigned a score on a scale of 0 to 3 (0 = little or no injury; 3 = severe injury), with total possible scores ranging from 3 to 18; that scoring system is easy to use and does not require collection of a large amount of data other than physical examination findings and results of radiographic examination for detection of fractures.[10] An ATT score ≥ 5 had 83% sensitivity and 91% specificity for prediction of nonsurvival of dogs in the present study, which suggested this scoring system was useful for evaluation of dogs with trauma.

Similarly, the MGCS score was associated with outcome for dogs in this study; a score ≤ 17 was predictive for nonsurvival of dogs with 82% sensitivity and 87% specificity. This finding was consistent with findings of other studies[5,12]; results of those other studies indicate head trauma is a negative prognostic indicator for survival. The MGCS score includes evaluation of 3 categories (motor activity, brainstem reflexes, and level of consciousness assessments) that are each assigned a score on a scale of 1 to 6 (6 = few or no abnormalities; 1 = severe abnormalities), with total possible scores from 3 to 18. That score is easy to calculate on the basis of physical examination findings. Unfortunately, the MGCS score has limitations for evaluation of dogs with spinal cord injuries, as indicated by results of the present study. Because such dogs had altered motor activity but often no evidence of traumatic brain injury, they were assigned a lower MGCS score than other dogs with non–head injuries. Other dogs that may have been assigned a low MGCS score were those that received sedatives prior to hospital admission and assessment. This might have accounted for the lower sensitivity and specificity of this score, compared with the ATT score, which seemed to be better for differentiation of dogs with spinal or orthopedic injuries from those with traumatic brain injury.

Unfortunately, only 13 (approx 4%) dogs in the present study had enough data available for calculation of an APPLE score. To calculate the APPLE score, 9 data points are required for each dog, including serum creatinine concentration, albumin concentration, and total bilirubin concentration; blood lactate concentration; WBC count; Spo_2; mentation score; respiratory rate; and body cavity fluid score.[3] Although that scoring system was created by use of a population of hospitalized dogs with values obtained within the first 24 hours after admission, APPLE scores were calculated in the present study with variables that were available at the time of initial evaluation for dogs with trauma. However, the present study was unfunded and tests required for calculation of the APPLE score were performed at the discretion of the primary clinician. Perhaps a more appropriate application of the APPLE score would be for severely injured patients requiring hospitalization, which would be similar to the circumstances for dogs that were used during the development of the scoring system. Future prospective, funded studies would be needed to confirm the prognostic usefulness of the APPLE scoring system for dogs that are hospitalized following trauma.

Because scoring systems are developed by use of data for various populations of dogs, caution must be used when the score for an individual dog is used to assist with owner decisions regarding whether to pursue treatment. More appropriate use of scores for individual dogs might include decision making during triage or determination of resources required for patient care. For example, an ATT score ≥ 5 might suggest that use of a trauma team is indicated, or an MGCS score ≤ 17 might suggest involvement of a neurologist is indicated. Similarly, a dog with a high ATT score might require longer hospitalization, have a greater need for surgical intervention, and subsequently have a higher estimated cost of care versus a dog with a low score, which is important for client communication at the time of the initial evaluation. For clinical research, scoring systems can be useful for patient screening and study enrollment and reduction of bias in multiarm clinical trials. The ease with which ATT and MGCS scores can be calculated at the time of hospital admission and the accuracy of such scores for prediction of outcome suggest that such data should be recorded as part of a minimum database for all animals with trauma.

In this study of dogs with trauma, approximately 91% of patients survived to discharge from the hospital. Use of a cutoff ATT score of 5 had a positive predictive value of 0.28; for this population, approximately 28% of patients with an ATT score higher than the cutoff value died. Use of a cutoff ATT score of 5 had a negative predictive value of 0.99; 99% of patients with an ATT score lower than the cutoff value survived. In other words, patients with an ATT score < 5 are likely to survive their injuries. Because patients with an ATT score ≥ 5 are more likely to be nonsurvivors (OR, 2.0), further evaluation (eg, ultrasonography, thoracic radiography, coagulation testing, and blood gas analysis) may be warranted for such patients to determine the extent of their injuries and guide selection of treatments. In other patient populations (eg, urban vs rural setting) with different types of trauma or when hospital resources are limited, the proportion of dogs that die because of trauma may be > 10%. In such populations, the positive predictive value of the ATT score might be higher (perhaps substantially), suggesting this scoring system may be useful for prediction of survival, as was found in the present study.

Blood lactate concentration, although it is an objective measurement, was less predictive of nonsurvival of dogs in the present study than trauma scores. A blood lactate concentration ≥ 4.0 mmol/L at the time of admission had 80% sensitivity and 56% specificity for prediction of nonsurvival. High blood lactate concentrations are detected in dogs with various disorders, including shock, low cardiac output, acute liver failure, severe sepsis, neoplasia, seizures, and poisoning, and in dogs undergoing treatment with certain drugs.[16] Most analyzers that measure blood lactate concentration require a very small volume of blood and are typically available as a point-of-care diagnostic test, making such assays easily accessible for guidance of patient care.[17,18] Even though blood lactate concentration determined for a single time was useful for determination of a prognosis for dogs in this study, lactate clearance is likely a better method for prediction of outcome and guidance of treatment for hyperlactemic patients.[16]

Results of the present study indicated blunt injury was more likely to result in nonsurvival, compared with penetrating injury. Few studies have been conducted regarding penetrating injury patterns in small animals, and no studies have been conducted to determine survival patterns for a large population of dogs with penetrating trauma, to the authors' knowledge. Dogs in another study[2] had injuries attributable to animal altercations (10%), sharp objects (11%), or weapons (2%), but data for dogs with penetrating injuries were not reported. In another study,[19] of 84 cats and dogs with gunshot wounds, 81% survived to hospital discharge. Another retrospective study[20] included 15 dogs and 1 cat with penetrating injuries; 13 of the dogs in that study survived to discharge from the hospital. Results of studies[2,5,6] of dogs with blunt trauma indicate an 85% to 88% survival rate. Because the present study is the first in which dogs with penetrating trauma had a better survival rate than dogs with blunt trauma, further studies with large numbers of dogs are warranted to further investigate this finding; such studies should include evaluation of possible confounding variables such as differences between groups regarding trauma severity scores, time from injury to initiation of care, cost of care, and need for surgical intervention.

Approximately half of the dogs in the present study underwent surgery; this finding was similar to the proportion of dogs with severe blunt trauma that underwent surgery in another study.[5] Interestingly, the distribution of soft tissue (approx 66% of dogs) and orthopedic (approx 32%) injuries in the present study was different than the distribution of soft tissue (37%) and orthopedic (63%) injuries of dogs in another study.[5] In the present study, surgical intervention was associated with survival. A reason for this finding was not determined; owner willingness to treat dogs (including surgical treatments) rather than euthanizing animals because of the cost of surgery might have affected that finding. Alternatively, use of monitoring and analgesia during surgery and postoperative care may have contributed to the high survival rate for such dogs.

An objective of this study was to obtain data for a population of dogs that would be useful in the planning of future clinical studies of dogs with trauma. In this study of dogs, the overall rate of survival to discharge from the hospital (approx 91%) was slightly higher than the value reported in other studies[2,5,6,8] of large numbers of dogs (85% to 88%). This finding may have been attributable to the prospective design of the present study, which likely led to inclusion of dogs with a low severity of trauma that may not have been included in a study with a retrospective design. In addition, dogs with various types of trauma (ie, penetrating, blunt, and other) were included in the present study. Given the high rate of survival to hospital discharge in dogs in this study, future interventional studies intended to improve outcomes should include evaluation of alternate primary outcomes such as frequency of comorbidities (eg, development of multiple organ failure and coagulopathies), duration of hospitalization, and cost of care.

A common challenge in veterinary clinical research is the influence of euthanasia on survival analysis. During the present study, efforts were made to determine the estimated cost of treatment and prognosis communicated to owners by the attending clinician at the time of euthanasia. These data were obtained to increase the accuracy of exclusion from analysis of animals that were euthanized because of cost, versus retrospective interpretation of the reasons for euthanasia on the basis of information in medical records. Recording of data regarding prognoses for dogs with spinal injuries was challenging; even though the prognosis for survival to discharge recorded for such dogs was typically good, the prognosis for return to function was not recorded and might have influenced owner's decisions. In future prospective studies of animals with trauma, the prognosis regarding return to function for dogs with brain or spinal injury should be recorded, in addition to the prognosis for survival to hospital discharge. Unfortunately, euthanasia of dogs may also have confounded evaluation of the time to death after initial evaluation. Most dogs that were nonsurvivors died or were euthanized within 2 hours after the initial evaluation at the hospital; such dogs were typically euthanized. Of the dogs that died without euthanasia, 3 died within 2 hours after the initial evaluation and 2 died 24 to 72 hours after that time. Although the number of such animals was too small to determine definitive conclusions, this pattern of time to death was similar to the pattern for humans with trauma; humans with trauma who do not survive typically die within a few hours after trauma or a few days after that time.[21]

Results of this multicenter, prospective study of dogs with trauma indicated ATT and MGCS scores, blood lactate concentration, type of injury, and surgical intervention were associated with outcome. The overall rate of survival to hospital discharge was high. In the present study, a multicenter collaborative group successfully used a secure Web-based data-capture system[13,a] for collection of data from a large number of dogs during a short period. Although people working at multiple sites voluntarily spent a large amount of time obtaining data during an 8-week period in this study, the ability to obtain data for > 300 dogs in such a short time suggests similar collaborations and data capture systems may be useful in future, large-scale clinical trials for the investigation of veterinary patients with trauma.

a. REDCap [database online], Clinical and Translational Science Institute, University of Minnesota, Saint Paul, Minn.
b. SAS OnlineDoc, version 9.1.3, SAS Institute Inc, Cary, NC.

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Appendix 1

The ATT scoring system used to assess dogs with trauma.

Grade	Perfusion	Cardiac	Respiratory	Eye, muscle, and integument	Skeletal	Neurologic
0	Mucous membranes pink and moist	Heart rate 60–140 beats/min	Regular respiratory rate with no stridor	No or partial thickness abrasion or laceration	Weight bearing in 3 or 4 limbs	CNS: conscious and alert to slightly dull with interest in surroundings
	Capillary refill time 0–2 s	Normal sinus rhythm	No abdominal component to respiration	No fluorescein uptake in eye	No palpable fracture or joint laxity	Peripheral nervous system: normal spinal reflexes; purposeful movement with nociception in all limbs
	Rectal temperature ≥ 37.8°C					
	Femoral pulses strong or bounding					
1	Mucous membranes hyperemic or pale pink and tacky	Heart rate 140–180 beats/min	Mildly increased respiratory rate and effort with or without abdominal component	Full-thickness abrasion or laceration with no deep tissue involvement	Closed appendicular or rib fracture or any type of mandibular fracture	CNS: conscious but dull, depressed, or withdrawn
	Capillary refill time 0–2 s	Normal sinus rhythm or < 20 ventricular premature complexes/min	Mildly increased upper airway sounds	Corneal laceration or ulcer of eye without perforation	Single joint laxity or luxation including the sacroiliac joint	Peripheral nervous system: abnormal spinal reflexes with purposeful movement and nociception intact in all 4 limbs
	Rectal temperature ≥ 37.8°C				Pelvic fracture with unilateral intact sacroiliac joint, ilium, and acetabulum	
	Fair femoral pulses				Single limb open or closed fracture at or distal to carpus or tarsus	
2	Mucous membranes very pale pink and very tacky	Heart rate > 180 beats/min	Moderately increased respiratory effort with abdominal component and elbow abduction	Full-thickness abrasion or laceration with deep tissue involvement, but arteries, nerves, and muscles intact	Multiple closed appendicular or rib fractures; multiple mandibular fractures; multiple joints with laxity or luxation; multiple pelvic fractures; multiple limb fractures at or distal to carpus or tarsus	CNS: unconscious but responds to noxious stimuli
	Capillary refill time 2–3 s	Consistent arrhythmia	Moderately increased upper airway sounds	Corneal perforation with punctured globe or proptosis	Single long bone, open fracture proximal to carpus or tarsus with cortical bone preserved	Peripheral nervous system: absent purposeful movement with intact nociception in ≥ 2 limbs or nociception absent only in 1 limb
	Rectal temperature < 37.8°C				Nonmandibular skull fracture	Decreased anal or tail tone
	Detectable but poor femoral pulses					
3	Mucous membranes gray, blue, or white	Heart rate ≤ 60 beats/min	Markedly increased respiratory effort or gasping or agonal respiration or irregularly timed effort	Penetration of thoracic or abdominal cavity	Vertebral body fracture or luxation (except coccygeal)	CNS: nonresponsive to all stimuli and refractory seizures
	Capillary refill time > 3 s	Erratic arrhythmia	Little or no detectable air passage	Full-thickness abrasion or laceration with deep tissue involvement and artery, nerve, or muscle compromise	Multiple long bone, open fractures proximal to tarsus or carpus	Peripheral nervous system: absent nociception in ≥ 2 limbs; absent tail or perianal nociception
	Rectal temperature < 37.8°C				Single long bone, open fracture proximal to tarsus or carpus with loss of cortical bone	
	Femoral pulse not detected					

(Adapted from Rockar RA, Drobatz KS, Shofer FS. Development of a scoring system for the veterinary trauma patient. *J Vet Emerg Crit Care* 1994;4:77–84. Reprinted with permission.)

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Appendix 2

The MGCS used to assess dogs with trauma.

Criteria	Score
Motor activity	
Normal gait and normal spinal reflexes	6
Hemiparesis, tetraparesis, or decerebrate activity	5
Recumbent, with intermittent extensor rigidity	4
Recumbent, with constant extensor rigidity	3
Recumbent, with constant extensor rigidity with opisthotonus	2
Recumbent, with hypotonia of muscles and depressed or absent spinal reflexes	1
Brainstem reflexes	
Normal pupillary light reflexes and oculocephalic reflexes	6
Slow pupillary light reflexes and normal to reduced oculocephalic reflexes	5
Bilateral unresponsive miosis with normal to reduced oculocephalic reflexes	4
Pinpoint pupils with reduced to absent oculocephalic reflexes	3
Unilateral, unresponsive mydriasis with reduced to absent oculocephalic reflexes	2
Bilateral, unresponsive mydriasis with reduced to absent oculocephalic reflexes	1
Level of consciousness	
Occasional periods of alertness and responsive to environment	6
Depression or delirium; capable of responding but response may be inappropriate	5
Semicomatose; responsive to visual stimuli	4
Semicomatose; responsive to auditory stimuli	3
Semicomatose; responsive only to repeated noxious stimuli	2
Comatose; unresponsive to repeated noxious stimuli	1

(Adapted from Platt SR, Radaelli ST, McDonnell JJ. The prognostic value of the modified Glasgow coma scale in head trauma in dogs. *J Vet Intern Med* 2001;15:581–584. Reprinted with permission.)

From this month's *AJVR*

Characteristics of respiratory tract disease in horses inoculated with equine rhinitis A virus

Andrés Diaz-Méndez et al

Objective—To develop a method for experimental induction of equine rhinitis A virus (ERAV) infection in equids and to determine the clinical characteristics of such infection.

Animals—8 ponies (age, 8 to 12 months) seronegative for antibodies against ERAV.

Procedures—Nebulization was used to administer ERAV (strain ERAV/ON/05; n = 4 ponies) or cell culture medium (control ponies; 4) into airways of ponies; 4 previously ERAV-inoculated ponies were reinoculated 1 year later. Physical examinations and pulmonary function testing were performed at various times for 21 days after ERAV or mock inoculation. Various types of samples were obtained for virus isolation, blood samples were obtained for serologic testing, and clinical scores were determined for various variables.

Results—ERAV-inoculated ponies developed respiratory tract disease characterized by pyrexia, nasal discharge, adventitious lung sounds, and enlarged mandibular lymph nodes. Additionally, these animals had purulent mucus in lower airways up to the last evaluation time 21 days after inoculation (detected endoscopically). The virus was isolated from various samples obtained from lower and upper airways of ERAV-inoculated ponies up to 7 days after exposure; this time corresponded with an increase in serum titers of neutralizing antibodies against ERAV. None of the ponies developed clinical signs of disease after reinoculation 1 year later.

Conclusions and Clinical Relevance—Results of this study indicated ERAV induced respiratory tract disease in seronegative ponies. However, ponies with neutralizing antibodies against ERAV did not develop clinical signs of disease when reinoculated with the virus. Therefore, immunization of ponies against ERAV could prevent respiratory tract disease attributable to that virus in such animals. (*Am J Vet Res* 2014;75:169–178)

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