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Retrospective Study

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Retrospective evaluation of coyote attacks in dogs: 154 cases (1997–2012)

Virginia M. Frauenthal, DVM, DACVECC; Philip Bergman, DVM, MS, PhD, DACVIM and Robert J. Murtaugh, DVM, MS, DACVECC, DACVIM

Abstract

Objective – To describe the clinical presentation and outcome of known attacks in client-owned dogs caused by the common coyote, *Canis latrans*.
Design – Retrospective observational study.
Setting – Private referral hospital.
Animals – One hundred fifty-four client-owned dogs known to be attacked by coyotes.
Interventions – None.
Measurements and Main Results – Records from a private referral hospital from May 1997 through December 2012 were reviewed. Time of day and month/season of year, signalment, body temperature, heart rate, respiratory rate, body weight, location and severity of wounds inflicted, common injuries, length of hospitalization, necessity of surgical wound repair under anesthesia, antimicrobial use and mortality were recorded. Eighty-six percent of dogs presenting following coyote attack weighed <10 kg. Overall mortality rate was 15.6%. Dogs with bite wounds to the thorax had the highest mortality at 21.3%. Criteria for systemic inflammatory response syndrome (SIRS) based on admission vital signs were met in 58.8% of dogs and the presence of SIRS was significantly associated with mortality ($P < 0.001$). Common coyote-induced injuries included rib fracture (38/154; 24.6%), pulmonary contusion (30/154; 19.4%), tracheal tear (18/154; 11.6%), pneumothorax (16/154; 10.3%), abdominal wall hernia (9/154; 5.8%), and abdominal penetrating wounds (8/146; 5.5%). Dogs <10 kg were significantly more likely to incur wounds to multiple body parts or sustain abdominal penetrating wounds. The presence of rib fracture was significantly associated with mortality. Frequency of coyote attacks over the time of this study increased by 330%.
Conclusions – Coyote attacks on dogs are a problem in Southern California and are associated with substantial morbidity and mortality, especially in dogs with wounds to the thorax. Aggressive management involving surgical wound repair was associated with survival to discharge.

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Keywords: bite wounds, morbidity, SIRS, trauma

Introduction

The common coyote, *Canis latrans*, is a species of feral canids that is found throughout North and Central America. Unlike the wolf, the coyote's range has expanded in the wake of human civilization, with coyotes readily reproducing in urban areas.[1,2] Coyotes are drawn into suburban environments that can support an abundance of wildlife including rodents and rabbits. Furthermore, coyotes adapt to utilize alternate water sources such as outdoor fountains or water bowls and are virtually unopposed as predators. The cohabitation of coyotes

Abbreviations

LOH	length of hospitalization
MODS	multiple organ dysfunction syndrome
SIRS	systemic inflammatory response syndrome

From the Department of Emergency and Critical Care, VCA Care Speciality and Emergency Animal Hospital, 301 E. Haley Street, Santa Barbara, CA 93101 (Frauenthal); VCA All Care Animal Referral Center, 18440 Amistad Street, Suite E, Fountain Valley, CA 92708 (Murtaugh); and VCA Clinical Studies and Katonah-Bedford Veterinary Center, 546 N Bedford Road, Bedford Hills, NY 10507 (Bergman).

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Address correspondences and reprint requests to
Dr. Virginia M. Frauenthal, VCA Care Specialty and Emergency Animal Hospital 301 E. Haley Street Santa Barbara, CA 93101. Email: Virginia.frauenthal@vca.com
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in proximity to people has led to an increased frequency of attacks on people and companion animals.[2]

A review of the current medical literature reveals 3 studies that characterize coyote attacks on people.[3–5] One case series documented apparent predatory attacks on 4 children <4 years of age in Western North American national parks.[3] A second case report described a coyote attack on a German tourist in Yellowstone National Park.[4] The man was bitten on his right foot while sleeping and suffered minor injuries; the coyote implicated was subsequently captured and destroyed. Postmortem examination on the coyote did not identify rabies or canine distemper, which could have explained unprovoked aggression. The third study detailed 48 coyote attacks on children and adults in Southern California.[5] The study noted the majority of adults attacked in this study (62%) were protecting either a child or family pet from coyote attack. Increasing frequency of attacks was noted over the years of the study (1978–2003), with 79% of total attacks occurring from 1993 to 2003. This case series concluded that coyote attacks on companion animals precede attacks on people. A review of the current veterinary medical literature reveals no descriptions of bite wound trauma inflicted by coyotes.

Further studies have proposed the coyote as the reservoir host for *Bartonella vinsonii* spp. *berkhofii*, a documented zoonotic cause of infectious endocarditis in dogs and people as well as myocarditis, polyarthritis, chorioretinitis, meningoencephalitis, anemia, and thrombocytopenia in the dog.[6–10] Incidence of antibodies to *B. vinsonii* spp. *berkhofii* in California coyotes ranged from 7% to 76% among these studies, whereas 29% of coyotes from the California Central Coast were determined to be bacteremic with *B. vinsonii* spp. *berkhoffii*.[8] The results of these studies demonstrate the common coyote as a potential source of an important zoonotic pathogen in both dogs and people.

It is estimated that dog bites comprise 10%–27% of trauma-related emergencies in dogs and are the second most common cause of trauma in dogs behind motor vehicle accidents.[11,12] A study was performed investigating the nature of dog bites in 185 dogs and 11 cats.[13] Small dogs (weighing <10 kg) were attacked in the majority of cases (61%), with multiple injured sites being more common among this group (58%). Sites of injury in this study included the thorax and extremities (35%), head and back (31%), neck (28%), abdomen (24%), pelvic limbs (19%), thoracic limbs (12%), perineum (8%), and tail (3%). Small dogs were most likely to have thoracic and back wounds while medium dogs (10–20 kg) were more likely to suffer wounds to the neck, back, and extremities. Dogs weighing >20 kg in this study were more likely to suffer bite wounds to the head and extremities when compared with their smaller canine counterparts.

Severe dog bite wounds are a reported cause of both systemic inflammatory response syndrome (SIRS) and multiple organ dysfunction syndrome (MODS) in people and dogs.[14–16] A recent study evaluated the prevalence of SIRS and MODS in dogs with severe bite wound trauma.[14] In this study, 54.3% of dogs with severe bite wounds met the diagnostic criteria for SIRS, whereas MODS occurred in 27.7% of the study population. Presence of SIRS and MODS was associated with mortality in this study, with a mortality rate of 24% in dogs with SIRS and 67% in dogs with dysfunction of 4 or more organs.

This retrospective clinical study of dogs sustaining coyote bites was conducted with two main objectives. The first was to characterize data on bite wounds inflicted on dogs attacked by one or more coyotes. The second objective was to identify risk factors that correlate with outcome including length of hospitalization (LOH) and survival to discharge. We hypothesized smaller dogs, dogs with wounds to more than one body part, dogs with body cavity penetration, and dogs with SIRS would have increased LOH and mortality.

Materials and Methods

The medical cases of 183 client-owned dogs bitten by coyotes were reviewed retrospectively. Twenty-nine records were excluded from the study because of incomplete medical records. All dogs were patients evaluated at a private referral hospital from July 1, 1997 to December 31, 2012. Dogs included for evaluation in the study were directly witnessed being attacked by one or more coyotes. The incidence of coyote attacks over the years of the study was also evaluated. Information was collected regarding each animal's signalment, body weight, time of day and time of year of presentation, location and severity of bite wounds, presenting physical examination parameters, clinical signs manifested, LOH, necessity of surgical wound repair under general anesthesia, antimicrobial use, and mortality.

The diagnosis of SIRS was made in dogs that met at least 2/3 previously described SIRS criteria based on admission vital signs alone.[17] LOH was reported as time from initial presentation to the hospital to time of discharge or transfer to another veterinary facility, cardiopulmonary arrest, or humane euthanasia. Survival was reported as survival to discharge or transfer to another veterinary facility.

Statistical analyses

For all statistical analyses, a value of $P < 0.05$ was considered significant. Descriptive statistics were calculated for all clinical variables described. Univariate Cox proportional hazards analysis was used to evaluate all variables

Table 1: Common dog breeds attacked by coyotes in this study

Breed	Number of dogs	Percentage of total population (%)
Chihuahua	31	20.1
Dachschund	15	9.7
Shih Tzu	11	7.1
Jack Russell Terrier	8	5.2
Miniature Poodle	8	5.2
Maltese	7	4.5
Bichon Frise	5	3.2
Mixed breed	5	3.2

and impact on survival. A multivariate stepwise Cox proportional hazards analysis was then performed on all univariate variables with $P \leq 0.2$. Categoric variables (location of wounds, complications, need for surgery, antimicrobial(s) used) were evaluated using chi-square analysis and the Fisher exact test. Continuous variables were analyzed using simple regression analysis. A Bonferroni correction was used whenever possible to correct for multiple comparisons. All analyses were performed by use of a computer software program.[a]

Results

The study inclusion criteria were met in 154 cases. Sixty-one neutered females and 21 intact females are represented in this study. Fifty-five neutered males and 17 intact males were included in this study. Eleven of the 17 intact males were <1 year of age. Fifteen of the 21 intact female dogs were <1 year of age. Median age was 4.5 years with a range of 2 months to 14 years. The average weight of dogs in this study was 6.0 kg with a range of 0.7– 40.4 kg. The majority of dogs (125/154; 81.1%) weighed <10 kg. A total of 42 dog breeds were represented, with the most common breeds shown in Table 1. Multiple other breeds were represented, including 4 each of Labrador Retriever, Chihuahua/terrier mix, terrier mix, Papillon, Yorkshire Terrier and Beagle (3.2%), 3 Cocker Spaniels (1.9%), 2 each of Australian Shepherd, Miniature schnauzer, Pomeranian, Pug and Shetland sheepdog (1.3%) and 1 each of American eskimo, bichon frise/Cavalier spaniel mix, Boston terrier, French bulldog, Cavalier King Charles spaniel, Japanese chow, coton de Tulear, English bulldog, golden retriever, Labrador mix, Lhasa apso, Pekingese, pharoah hound, pit bull terrier, miniature poodle, rat terrier, schipperke, shiba inu, Siberian husky, silky terrier, and West Highland white terrier (0.6% of study population).

Time of day the patient was attacked was available in 128 cases. The majority of attacks occurred from 7 PM to 7 AM (90/128; 70.3%), with the most common time frame of attack being from 9 PM to 11 PM (27/128; 21.1%). Geographic location of attack was available in 38/154 cases, with the majority of dogs 29/38 (76.3%) being attacked in backyards while off leash. Multiple coyotes were implicated in the attack of 7 dogs included in this study. Seasonality and month of attack was also analyzed. Month of attack data is available in Figure 1, with July being the most common. Incidence of coyote attacks was noted to increase during the time of this study. Whereas only 13 canine patients were seen for coyote attack from 1997 to 2000, 35 patients were seen during the 4-year time period from 2001 to 2004. This trend continued with 70 canine patients treated from 2009 to 2012 (Table 2).

Admission vital signs including temperature, pulse, and respiratory rate were available for 114 dogs. White blood cell count was not available for the dogs included in this study. Criteria for SIRS based on admission vital signs alone were met in 67/114 (58.8%) dogs, whereas 47/114 (41.2%) of the dogs included in this study did not meet the criteria for SIRS. Mortality rate among dogs with SIRS was 26.8%. All 47 dogs that did not meet the criteria for SIRS survived. Presence of SIRS criteria was significantly associated with mortality ($P < 0.001$).

A summary of wounds is provided in Table 3 for all dogs in this study. The most commonly reported wound locations included the thorax and cervical region. Injuries sustained involving >1 body area occurred in 71/154 (46.1%) dogs and just 1 body area in 83/154 (53.8%) dogs. Patients weighing <10 kg were significantly more likely to sustain wounds to the thorax and cervical region ($P < 0.0001$) and sustain wounds to >1 area compared to dogs weighing >10 kg ($P = 0.024$). Penetrating abdominal wounds were only noted in dogs weighing <20 kg compared to those weighing >20 kg ($P = 0.0064$). Common injuries and their association with mortality were also reported in Table 4. Presence of pulmonary contusions was associated with both pneumothorax and rib fractures ($P < 0.0001$). Likewise, presence of rib fractures was associated with pneumothorax and pleural effusion ($P < 0.0001$ and 0.0149, respectively).

Hospitalization was provided in 50.9% of patients in the current study with an average LOH of 1 day and range of 0 to 26 days. The LOH was not associated with increased mortality in this study ($P = 0.175$). Overall mortality rate was 15.6% (24/154) and mortality rate in dogs <10 kg was 17.6% (22/125). Body weight of < 10 kg was not significantly associated with mortality ($P = 0.253$). Twenty-four (15.6%) dogs were euthanized (12/24; 7.8% of total) or died (12/24; 7.8% of total) as a sequela to their injuries. Two of the dogs included in this study were pronounced dead on arrival. Three dogs died within 1 hour of arrival to the hospital. Of the remaining nonsurvivors, 6 died within 24 hours of initial presentation to the hospital and 1 died 36 hours post-presentation. Two of the dogs (1.2%) included in the

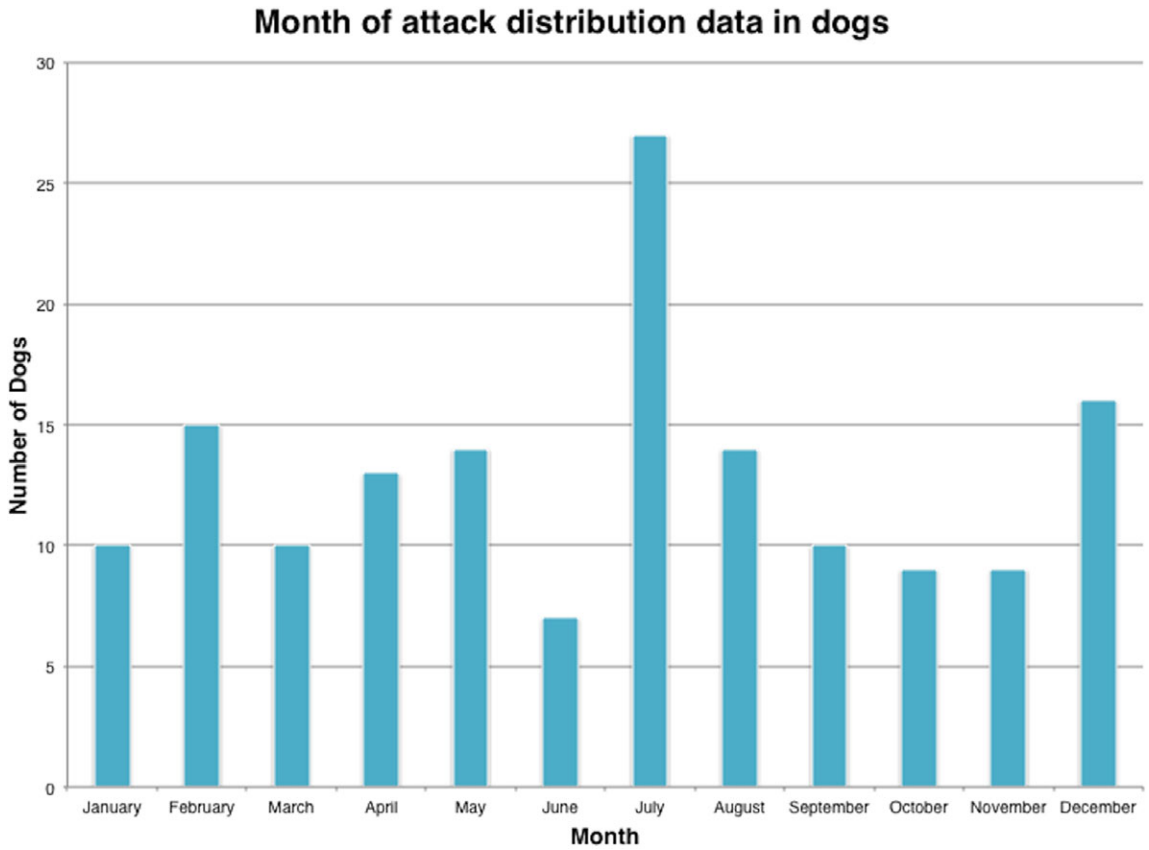

Figure 1: Month distribution data in dogs attacked by coyote.

euthanasia group had suffered cardiopulmonary arrest, achieved successful return of spontaneous circulation, and were subsequently humanely euthanized within 4 hours of initial presentation to the hospital. Of the other 10 dogs that were humanely euthanized, 8 were euthanized due to grave prognosis and 2 were euthanized due to owner financial constraints. All but 1 of these 10 dogs were euthanized within 1 hour of initial presentation to the hospital; the other dog was euthanized after 72 hours of hospitalization. Data regarding wound location and association with mortality are listed in Table 3.

Nineteen of the 24 dogs (79.1%) that did not survive sustained penetrating thoracic wounds. Only 1 dog with abdominal wounds alone did not survive; this dog was euthanized due to evisceration with multiple intestinal perforations. The remaining 4 nonsurvivors had cervical wounds alone. All 4 of these dogs were diagnosed with severe tracheal tear/avulsion, with decapitation noted in 1 dog. Twenty-one of the 24 deaths (87.5%) were in dogs weighing <10 kg. Dogs with wounds inflicted to the thorax (either alone or as part of multiple wound sites) had 21.4% mortality and dogs with wounds to the abdomen had 20% mortality. Dogs with wounds to the cervical region only had 12% mortality and all 12 dogs with head or extremity wounds alone (7.8%) survived.

Table 2: Incidence of coyote attacks over the study period (1997–2012)

Years	1997–2000	2001–2004	2005–2008	2009–2012
Dogs affected	13	35	36	70

Table 3: Incidence of wound sites in dogs incurring bite wounds to only one body part

Wound location	Number of dogs affected	Mortality
Thorax	34	19/24 (79.1%)
Cervical region	27	4/24 (16.6%)
Abdomen, left pelvic limb	4	0/24
Cranium, lumbar region	3	0/24
Right pelvic limb, left thoracic limb	2	0/24
Flank, rectum, right thoracic limb	1	0/24

Surgical wound debridement and repair under general anesthesia was performed in nearly half of the dogs in this study (69/154; 44.8%), with 68/69 (98.6%) of

Table 4: Mortality risk associated with injuries in dogs attacked by coyote

Variable	Number of dogs	*P* value	Hazard ratio (95% CI)
Rib fractures	38 (24.6%)	0.0468	2.27 (1.01–5.10)
Pneumothorax	16 (10.3%)	0.0532	2.49 (0.98–6.28)
Pulmonary contusions	30 (19.4%)	0.4269	0.699 (0.288–1.692)
Tracheal tear	18 (11.6%)	0.1045	0.464 (0.184–1.173)
Abdominal wall hernia	9 (5.8%)	0.2808	0.513 (0.153–1.726)
Abdominal penetration	8 (5.5%)	0.6073	0.684 (0.161–2.913)
Degloving injury	5 (3.2%)	0.7659	0.738 (0.099–5.475)
Esophageal penetration	2 (1.3%)	0.3532	0.387 (0.052–2.874)

Table 5: Type of surgical repair required in dogs attacked by coyote and association with mortality

Type of surgery	Number of dogs	% Hospitalized	Number of survivors
Wound debridement and repair	60/69 (84.1%)	25/69 (36.2%)	68/69 (98.5%)
Exploratory laparotomy	7/69 (10.1%)	100%	6/7 (85.7%)
Thoracotomy	2/69 (2.9%)	100%	2/2 (100%)
Mandibular fracture stabilization	6/69 (8.7%)*	100%	6/6 (100%)

*All dogs that underwent mandibular fracture stabilization also received wound debridement and repair.

these dogs surviving to discharge. Sixty-two of the dogs that received surgery for their wounds weighed <10 kg (62/69; 89.8%). Dogs weighing <10 kg were significantly more likely to receive surgery for their wounds than dogs weighing >10 kg ($P = 0.0137$). All initial surgical procedures were performed within 24 hours of presentation to the hospital. Data regarding type of surgery performed and mortality are available in Table 5. The majority of dogs underwent surgery for wound debridement and subcutaneous drain placement. Six dogs that had wound repair also required stabilization of mandibular fractures. Three dogs that had wound repair also had thoracic splint placement for flail chest. Three dogs undergoing wound repair also required surgical repair of cervical tracheal tears. Two dogs in this study received thoracotomy and thoracostomy tube placement. Both of these patients survived to discharge.

Only 1 dog that had aggressive wound repair died. The dog that died received severe wounds to the cervical region with avulsion of 60% of the circumference of the trachea at the level of the second tracheal ring. Penetrating wounds to the esophagus was also noted during surgery. This dog suffered cardiopulmonary arrest 8 hours after surgery.

Seven dogs had exploratory laparotomy. Six of these dogs (85.7%) survived. Two dogs that had exploratory laparotomy were noted to have splenic lacerations, and 2 dogs had avulsion of a kidney into the subcutaneous tissues. One dog undergoing exploratory laparotomy was noted to have an abdominal wall hernia and 1 was diagnosed with a retroperitoneal puncture wound with no abdominal parenchymal damage noted. A seventh dog that underwent exploratory laparotomy was diagnosed with punctured diaphragm, pancreatic puncture and 7 abdominal wall rents; this patient died during recovery from anesthesia.

All but 2 dogs that received surgical repair of their wounds survived. Surgical wound repair was associated with presence of mandibular fracture ($P = 0.0058$), abdominal wall hernia ($P = 0.0423$), and penetrating abdominal wound ($P = 0.0133$), with all patients diagnosed with these injuries undergoing surgical exploration and repair of their wounds. Surgical wound repair was significantly associated with survival on multivariate analysis, with those patients having a 15-fold increased chance of survival ($P<0.001$, 95% confidence interval 15.372 [3.53–66.88]). Surgical wound repair was also significantly associated with survival in dogs weighing < 10 kg ($P < 0.001$).

Culture and antimicrobial susceptibility data were available from 5 dogs in this study. All were taken from wounds after 3–5 days of treatment with intravenous antimicrobial therapy. Four of 5 wounds cultured were located on the thorax and one wound was in the cervical region. Two wounds cultured from the thorax yielded no growth. The cervical wound culture and one thoracic wound culture both grew a multidrug-resistant *Pseudomonas aeruginosa* that was only susceptible to amikacin, gentamicin, and marbofloxacin. The dog with cervical wounds also yielded a multidrug-resistant *Enterococcus* species only susceptible to chloramphenicol. The other dog with culture data available grew coagulase-positive *Staphylococcus* spp. that was resistant to all antimicrobials in the β-lactam and fluoroquinolone families.

Oral antimicrobial therapy was dispensed in 91/154 patients (58.7%) at discharge with amoxicillin/clavulanic acid being the most commonly prescribed antimicrobial (57/91; 62.6%). Other antimicrobials prescribed included orbifloxacin (3/91; 3.3%), clindamycin

(6/91; 6.6%), enrofloxacin (1/91; 1%), cefovecin (2/91; 2.2%), and combination therapy (22/91; 24.1 %). Patients that were not discharged with oral antimicrobial therapy in this study either had oral antimicrobials filled at an outside pharmacy (28/63 remaining; 44.4%), were transferred immediately to another veterinary facility (9/63; 14.2%), received parenteral antimicrobials for the duration of their therapy in hospital (2/63; 3.2%), or died (24/63; 38%). Information regarding the antimicrobial type for the 28 dogs who had prescriptions filled at an outside pharmacy was not available due to the retrospective nature of this study. Median duration of antimicrobial therapy was 7 days with a range of 5–14 days. Duration of antimicrobial therapy increased with patient age and LOH ($P = 0.0143$ and $P = 0.0231$, respectively).

Discussion

Our study describes coyote attacks on dogs to determine whether certain presenting clinical data (eg, meeting SIRS criteria), injuries, surgical interventions, and therapies were associated with survival. In this current study, 52.6% of dogs weighing <10 kg received wounds to multiple body parts, whereas only 4.7% of dogs weighing >10 kg received wounds to multiple body parts. These findings are similar to a report of dog attacks, which found dogs weighing <10 kg were attacked in the majority of cases (61%), and that 58% of dogs weighing < 10 kg had multiple sites injured.[13] The small stature and cervical or thoracic wound location(s) in the majority of dogs in our study likely reflects the size of the average coyote (11–16 kg) and the need for the coyote to overpower its victim to kill. Greater risk of multiple body parts injured seen in small breed dogs is likely due to ability of the coyote to grasp multiple wound sites in one bite due to relative proximity. Increased risk of penetrating body cavity injuries found in small dog breeds is likely due to coyote canine tooth length exceeding the thickness of the thoracic or abdominal wall in small dogs. Thus, a small dog presenting with wounds to the cervical region, thorax, or abdomen from a coyote attack should prompt rapid intervention and aggressive management for optimal chance of survival.

The patients that died or were euthanized in this study (15.6%) received wounds to the neck, abdomen, thorax, or a combination of these injuries. These findings are consistent with the study by Shamir et al, which determined that mortality from dog bite occurred in 11% of cases, and all animals that died received thoracic or abdominal injuries.[13] Penetrating wounds were noted in 79% of dogs with abdominal wounds and 31% of dogs with thoracic wounds in that same study. The study by Ateca et al found a similar 15% overall mortality rate with 68% of dogs bitten weighing <10 kg.[14] Another smaller retrospective study of dog bite wounds reported a mortality rate of 13.3% in dogs.[18] A recent prospective multicenter study on dogs with trauma found an overall mortality rate of 9.5%.[11] This study also reported that dogs with penetrating injury, most commonly dog bite, were more likely to survive than dogs with trauma from blunt injury such as motor vehicle accident.

The majority of patients (58.8%) in this study met the diagnostic criteria for SIRS based on admission vital signs. The clinical condition of SIRS is associated with disease states that can progress to MODS, shock, and death. This association was observed in this study as the significantly increased mortality rate of 26.8% seen in patients diagnosed with SIRS in this study. A similar association between SIRS and mortality was described in a previous study on dogs with severe bite wound trauma, with a mortality rate of 24% in the subset of patients with SIRS.[14] These data suggest dogs presenting for bite wound trauma that fulfill SIRS criteria at the time of ICU admission are more likely to die from their wounds. It should be noted, however, that SIRS criteria for sepsis in dogs are highly sensitive, but nonspecific, with sensitivity and specificity of 97% and 64%, respectively.[17] Furthermore, previous studies documented presence of SIRS criteria at ICU admission rather than admission to hospital due to the concern that patients presenting in pain alone without hemodynamic compromise can also satisfy the criteria for SIRS. Previous studies on SIRS are therefore not directly applicable to this study. In addition, the study performed by Hauptman et al found that the WBC/band count was the strongest predictor for the presence of sepsis. Lack of data regarding white blood cell count and band neutrophil percentage in this study population may have under diagnosed the number of dogs that met the SIRS criteria for sepsis.

Twenty-four dogs did not survive in this current study, with nearly 80% of these patients suffering thoracic wounds. Significant underlying tissue damage to the pulmonary parenchyma by coyote bites was seen as pulmonary contusions in 30 dogs in this study. Rib fractures in dogs sustaining thoracic wounds from coyote bites were significantly predictive of death or euthanasia. The association of rib fractures with mortality likely reflects the severity of thoracic trauma in these dogs.

The mortality seen in 4 patients with cervical wounds alone in this study was associated with severe tracheal tear or avulsion. In previous studies on dog bite wounds, all dogs with cervical wounds survived.[12,13,19] The mortality associated with cervical wounds in this study likely reflects the increased severity of wounds inflicted by coyote when compared to their canine counterparts.

Euthanasia remains a confounding factor, as it is unknown whether the 12 patients that were euthanized

in this study would have survived with appropriate medical and surgical care. Grave prognosis was the cause of euthanasia for 80% of dogs in this study. This is in contrast to a recent study on canine trauma including 84 dog bite wound victims, which noted that of dogs euthanized, 36% were due to grave prognosis, and 64% were due to financial reasons.[11] This is likely because coyotes cause greater injury to their victims than dogs, due to coyotes' presumptive intent to kill the dogs attacked.

External appearance of bite wounds are thought to represent the "tip of the iceberg" in that the majority of the tissue damage is not initially visible. During initial evaluation, the clinician may not be able to gauge the full extent of wounds incurred due to multiple factors including patient fur, pain and anxiety levels, handler experience, direction of wound pocketing in relation to position of evaluation and clinician experience with wound evaluation.[13,19,20]

Disinfecting and irrigating the clipped skin around the wound is warranted regardless of location or species receiving or causing the wound. This can be safely achieved by flushing the wound with sterile lactated Ringer's solution to a pressure of 7 to 8 psi with use of a 1 L LRS bag within a pressure infusion bag pressurized to 300 mm Hg.[21] Bandages are often provided for patients with superficial wounds to prevent contamination and devitalized tissue after disinfection, decrease dead space, and absorb drainage until definitive surgical treatment can occur.[22]

Surgical wound exploration is standard of care for bite wound injury as it allows for debridement of remaining contamination, tissue apposition, and establishment of adequate drainage to prevent cellulitis or abscess formation.[13,19] In this study, surgical wound repair was the only variable that was significantly associated with survival in multivariate analysis. This finding is similar to a recent prospective multicenter study that found dogs presenting for trauma who underwent surgery were more likely to survive to discharge (OR 7.1; $P = 0.006$).[11] The association of surgical intervention with survival and ideal surgical timing remain controversial issues in human and veterinary medical fields.[11,23] Intensive perioperative monitoring as well as intravenous analgesic and antimicrobial therapy were used in all patients that had surgery in this study and may have impacted the positive outcome associated with surgery. Hemodynamic compromise or death within hours of arrival to hospital and owner desire to humanely euthanize due to severity of wounds and/or financial constraints were the reasons that dogs did not undergo surgical stabilization of their wounds in this study. As the majority of dogs that did not survive died or were euthanized before surgical intervention could occur, survivor bias is another potential cause of the association of survival with surgical wound repair in this study. These possibilities should also be considered when interpreting the study results.

No appendicular fractures were noted in dogs attacked on the extremities in this study. This may be due to the fact that only large breed dogs (Labrador, Siberian Husky) suffered wounds to a limb in this current study, suggesting the large breed dogs were able to escape with minimal wounds incurred.

Infections of animal bite wounds are common and the infecting organism usually corresponds to the normal oral microbiota of the species implicated. In dog attacks, polymicrobial bites are most common, with a median of 5 isolates per wound (typically 3 aerobes and 2 anaerobes).[24,25] Common gram-negative aerobe isolates from dogs include *Pasteurella* spp., and *Enterobacter cloaceae*, whereas common gram-positive organisms include *Streptococcus* and *Staphylococcus* spp., *Corynebacterium* spp. and *Enterococcus faecalis.* Common anaerobic isolates include *Porphyromonas* spp., *Propionobacterium* spp., *Bacteriodes* spp., *Eubacterium* spp., *Fusobacterium* spp., and *Peptostreptococcus* spp.[26,27]

Unfortunately, only 3 dogs included in this study had antimicrobial susceptibility data available from their wounds with organisms cultured. Two of these 3 cultures grew a multidrug-resistant *P. aeruginosa* susceptible only to amikacin, gentamicin, and marbofloxacin. This may reflect selection of antimicrobial resistance as both of these patients received broad spectrum intravenous antimicrobial therapy for at least 48 hours before the culture was obtained. It is well known that ICU hospitalization alone is a risk factor for the development of resistance in dogs and humans whether or not the patient has received antimicrobials.[28–34] Future prospective studies are necessary to identify the infectious organisms most commonly associated with coyote bites on dogs.

Many combinations and different lengths of antimicrobial therapy were utilized in this study, making interpretation regarding antimicrobial use and patient outcomes difficult. In those patients where information about the oral antimicrobial used was available, amoxicillin/clavulanic acid[b] was the most common. Amoxicillin/clavulanic acid is the initial drug of choice in empirical antimicrobial therapy in dog bite wounds due to its broad-spectrum activity, low toxicity, and proven efficacy against organisms in the oral cavity cultured from dog bite wounds.[35–37] The oral microbiota of the common coyote is currently unknown, however use of an antimicrobial known to be effective in dog bite wound injuries is a logical starting point until additional data become available. The association of dogs requiring increased LOH with receipt of longer antimicrobial course is likely due to the increased severity of wounds and development of antimicrobial resistance.

Association between older dogs and longer duration of antimicrobial therapy may be due to decreased rate of healing or age-related immune system compromise.

The majority of dogs represented in this study with location data available were attacked while off leash in the backyard after the coyote successfully scaled a 6–10 foot fence. This information suggests that small dogs should not be let outside off leash at night without direct supervision. As the majority of small dogs were attacked during the dusk and nighttime hours, this study would also suggest owners should not walk small dogs in the evening or early morning hours in locations where coyotes are known to live, especially parks, golf courses, wildlife reserves, or other areas on the edge of suburban areas.

As a retrospective observational study, medical interventions were left to attending clinician preference, with lack of a standardized protocol. In a future study, we suggest coyote attack victims could be compared to dogs that have sustained bite wounds from other dogs, and blunt trauma. Specifically, hemodynamic and biochemical parameters, wound bacterial cultures and impact of medical and surgical interventions among groups should be investigated. This relatively small study took place at a single private referral hospital and may not be representative of coyote attacks on dogs in different geographic locations and treated at different hospitals. Furthermore, the increase in cases of coyote attack seen over the study period was attributed to urbanization of coyote land; however, this increase may also be due in part to variations in our hospital dynamics over the study period, including increasing caseload and marketing to referring veterinarians.

Additional limitations include that patients in this study were not stratified using a scoring system to evaluate injury severity, such as the Animal Trauma Triage score (ATT) or acute-patient physiologic and laboratory evaluation (APPLE) fast score, which have recently shown promise in prognostication for canine patients presenting for traumatic injury.[38,39] Considerations for future studies would include a multicenter, prospective, randomized, blinded study with use of ATT or APPLE-fast scoring system in conjunction with hemodynamic markers such as serial lactate or central venous oxygen saturation levels to investigate the ability of these parameters to predict survival in coyote victims. Occurrence of SIRS, MODS, and sepsis as well as additional standardized therapies including antimicrobials, analgesics, stress erosion prophylaxis, and antiemetics in the therapeutic regimen and the effect of these interventions on patient outcomes could be investigated. Further information characterizing coyote attacks on cats and other common domestic species should also be performed.

Finally, our study results should be interpreted with caution given that only 24 patients in this current study died or were humanely euthanized. Therefore, some of the prediction analyses may be underpowered. The results also do not confirm that location of wounds or decision to pursue surgical repair is superior to the attending clinician's assessment and available hemodynamic and biochemical parameters regarding prediction of outcome. Larger, multicenter prospective studies are recommended to confirm our study results before extrapolation of included data to all dogs attacked by coyote should occur.

In this group of dogs, severity of injuries was the main risk factor for mortality after coyote attack as all patients that died in this study where data were available met the criteria for SIRS based on admission vital signs alone. Likewise, presence of rib fracture was strongly predictive of mortality. Smaller dogs were common in this study and more likely to receive wounds to the thorax, abdominal cavity, or both and die from their wounds. Finally, coyote attacks in dogs are an increasing problem due to urbanization and are associated with substantial morbidity and mortality.

Footnotes

[a] StatView by SAS Institutes, Inc, Cary, NC.
[b] Zoetis, Florham Park, NJ.

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