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RETROSPECTIVE STUDY

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Assessment of prehospital care in canine trauma patients presented to Veterinary Trauma Centers: A VetCOT registry study

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Abstract

Objective: To analyze the epidemiology of veterinary care in canine trauma patients prior to presentation to a Veterinary Trauma Center (VTC).

Design: Retrospective observational cross-sectional study.

Methods: Retrospective descriptive analysis from 22,998 canine case records from the Veterinary Trauma Registry from September 2013 through April 2018. Analysis was focused on the type of injury, care provider, and care provided prior presentation to a VTC (pre-VTC care). A log-likelihood ratio test was used to test for association of outcome and pre-VTC care. Mann–Whitney *U* tests were used to compare modified Glasgow Coma Scale and Animal Trauma Triage (ATT) scores between pre-VTC and non-pre-VTC care groups.

Measurements and Main Results: Pre-VTC care was provided in 5636 out of 22,998 dogs (24.5%) by veterinarians (81%), owners (19.6%), and first responders (0.03%). The most common nonveterinary interventions included wound care and bandaging in 42% and 39% of the patients, respectively. Mortality was higher in the pre-VTC care group (8.7% vs 7.5%); dogs receiving pre-VTC care were 1.5 times (95% confidence interval [CI], 1.15–1.88) more likely to die and 1.2 times (95% CI, 1.07–1.37) more likely to be euthanized. The ATT scores were significantly higher in dogs receiving pre-VTC care (mean = 2.53 vs 1.78; $p < 0.0001$).

Conclusion: Our data demonstrate that the majority of more severely injured dogs receiving pre-VTC care obtained care by a veterinarian. Dogs receiving pre-VTC care possessed a greater mortality rate but also a greater ATT score; therefore, mortality rate is more likely related to severity of trauma rather than reception of pre-VTC care. We propose that these data should prompt further research and education about prehospital care in veterinary medicine.

ABBREVIATIONS: ATT, Animal Trauma Triage; EMS, emergency medical services; GSW, gunshot wound; LOD, line of duty; MGCS, modified Glasgow Coma Scale; MWD, military working dogs; OpK9, operational canine; OTC, over the counter; POI, point of injury; VetCOT, Veterinary Committee on Trauma; VTC, Veterinary Trauma Center

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KEYWORDS
Animal Trauma Triage, body condition score, canine, trauma

1 | INTRODUCTION

In the United States, unintentional injuries account for the leading cause of trauma-induced deaths in people up to the age of 45 years and are the fourth most common cause of death in all age groups.[1,2] Approximately 40%–70% of these traumatic fatalities occur during the prehospital period before the casualty ever reaches a medical treatment facility.[3–8] Nearly a quarter of these trauma-induced fatalities are due to what is termed preventable deaths, or deaths that could be prevented simply by initiating immediate basic first aid techniques.[7,9–13] The most common preventable deaths reported in people include massive extremity hemorrhage followed by tension pneumothorax and upper airway obstruction.[14]

In contrast to human medicine, there is a void in published scientific analysis regarding veterinary prehospital trauma care and associated outcomes in injured dogs. A paucity of data related to more common line of duty (LOD) injuries is available for select subsets of dog populations such as military working dogs (MWD) and civilian operational canines (eg, operational canine [OpK9], law enforcement, search-and-rescue, other security-related dogs). In 2014, a retrospective analysis identified gunshot wounds (GSWs), vehicular trauma, and heat-related illnesses as the top 3 causes of LOD deaths for civilian law enforcement dogs.[15] Published in 2018, a retrospective analysis evaluating the causes of death in 92 MWD supporting Operation Iraqi Freedom and Operation Enduring Freedom from 2001 to 2013 identified GSWs, explosions/blast injuries, and heat-related illnesses as the leading causes of death for this population of dogs.[16] In 2019, Reeves et al reported that GSWs were the most common combat-related injury sustained by a group of MWD assigned to the 160th Special Operations Aviation Regiment (SOAR).[17] Lessons learned and retrospective analysis of natural disasters (eg, Hurricane Katrina; mudslides in Oso, WA; Haiti) and mass casualty events (eg, 9/11/World Trade Center terrorist attack; Oklahoma City bombing) identified paw pad injuries and other soft tissue injuries (minor lacerations and abrasions) as the primary trauma-induced injuries suffered by urban search-and-rescue dogs deployed to these events.[18–21] Of note, all injuries suffered by these dogs were considered minor, with nearly all of them amenable to basic first aid and minimal veterinary medical attention. Despite the similar mechanisms of trauma (eg, struck by car, GSW) in people and dogs, the anatomic and conformational differences raise the question of whether we can expect a different prevalence in the severity of traumatic injuries and its mortality in dogs.

Since 2013, Veterinary Trauma Centers (VTCs) have collected data from trauma patients presenting to their facility and entered data into the Veterinary Committee on Trauma (VetCOT) trauma registry, a portion of which is dedicated to information regarding "prehospital care." Prehospital care from a VTC's perspective includes any care provided prior to the animal's admission to a VTC; this includes care provided by non-veterinarians (eg. owner, OpK9 handler, emergency medical services [EMS]/Fire, law enforcement officer) as well as referring veterinarians. The aim of this study is to describe the epidemiology of veterinary pre-VTC care in dogs through describing the following:

1. The proportion of dogs presenting to a VTC that received pre-VTC care;
2. Injury types of dogs receiving pre-VTC care. Injury types are further characterized according to mechanism of action (blunt vs penetrating) and severity (modified Glasgow Coma Scale [MGCS] and Animal Trauma Triage [ATT] score);
3. Description of the pre-VTC care providers based upon veterinary versus nonveterinary (eg, owner, handler, EMS/Fire);
4. Description of pre-VTC medical care provided (eg, oxygen, wound care, bandaging, pharmaceuticals);
5. Differences in outcome (survived to discharge, death [euthanasia vs natural]) between patients that received pre-VTC care and those that did not.

We hypothesized that the delay in transport or treatment at a VTC might have a negative effect in outcome in trauma patients; hence, patients receiving pre-VTC will have higher mortality than patients that did not.

2 | METHODS

The VetCOT[22] REDCap[23] database collected by the VTCs from September 2013 until April 2018 was analyzed. All cases in the database were collected, both pre-VTC and those who did not receive prehospital care. There are two databases: pre-April 2017 and post-April 2017. The post-April 2017 file had two additional categories of non-veterinarian care added, namely, oral "over-the-counter" (OTC) medications inclusive of nonantibiotics and antibiotics. To be accurate, the pre_hosp_care "other" variable in both the pre- and post- April1 2017 dataset was examined, and some responses from the "other" group were changed to either OTC nonantibiotics or oral antibiotics as appropriate. In addition, any response from the "other" group that fell into any of the categories described was also changed as appropriate in the pre-April 2017 dataset (eg, wound care).

All dogs presenting to a VTC with a history of trauma and receiving some form of pre-VTC care were included (Table 1). Type of trauma (blunt, penetrating, both), type of care provider, and type of care given were analyzed; in the "type of providers," primary veterinarians referring patients were included as prehospital care providers. MGCS, ATT score, and outcome (euthanized, died, survived to discharge) were compared between groups that had received pre-VTC care and the ones that had not.

TABLE 1 VetCOT trauma registry pertinent questions about prehospital care

Presentation to other DVM prior to admission?

- Yes
- No

Is this an Operational Canine (OpK9)?

- Yes
- No
- (Police canines, Military Working Dogs, Force Protection K9s, and Search and Rescue (SAR) canines)

Type of work OpK9 Performs:

- Describe: _____

Did the injury occur during active duty or training exercises

- Yes
- No

Was any pre-hospital care provided by a non-DVM?

- Yes
- No

Describe care administered (Multiple selections permitted)

- Bandage
- Oxygen administration
- Wound care (topical medication, apply pressure, flush, etc.)
- Chest compressions
- Oral OTC (over-the counter) - non-antibiotic
- Oral antibiotic
- Other
- Describe "other": _____

By Whom?

- Owner
- EMT
- MD
- Police
- Military personnel
- Firefighter
- Other
- Describe "Other": _____

2.1 | Statistical analysis

Descriptive analyses were performed using commercially available software.[a,b,c] A significance threshold of 0.05 was used. A log-likelihood ratio test was used to test for association of outcome and prehospital care. A multinomial logistic regression was used to calculated odds ratios and 95% confidence intervals (CIs). Histograms and probability plots were made for residuals from the prehospital care group means for MGCS and ATT scores. Multiple normality tests including Shapiro–Wilk were run. Both distributions were skewed and were non normally

TABLE 2 Proportion and percentages of dogs with blunt[a] injuries receiving pre-VTC care by blunt injury type

Injury type: Blunt	Number and proportion
Struck by vehicle	1553/3473 (44.7%)
Other	864/3473 (24.8%)
Fall from height	740/3473 (21.3%)
Unknown	75/3473 (2.1%)
Injured by falling object	70/3473 (2.0%)
Nonpenetrating bite wound	60/3473 (1.7%)
Ejected from vehicle	50/3473 (1.4%)
Injured inside vehicle	30/3473 (0.8%)
Struck by weapon	21/3473 (0.6%)
Choking/pulling injury	10/3473 (0.2%)

[a]Includes blunt and both blunt and penetrating. VTC, Veterinary Trauma Center

TABLE 3 Proportion and percentages of dogs with penetrating[a] injuries receiving pre-VTC care by penetrating injury type

Injury type: Penetrating	Proportion of dogs
Bite	1541/2427 (63.5%)
Other	441/2427 (18.1%)
Laceration from metal	137/2427 (5.6%)
Unknown	93/2427 (3.8%)
Impalement	90/2427 (3.7%)
Ballistic	55/2427 (2.2%)
Laceration from glass	52/2427 (2.1%)
Quilling	13/2427 (0.5%)
Laceration from knife	5/2427 (0.2%)

[a]Includes penetrating and both blunt and penetrating. VTC, Veterinary Trauma Center

distributed, therefore Mann–Whitney *U* tests were used to compare MGCS and ATT scores between prehospital care "yes" and "no" groups.

3 | RESULTS

Five thousand six hundred thirty-six out of 22,998 total dogs, or 24.5% (95% CI, 24.0%–25.1%), were included in the analysis as they received veterinary care before presenting to a VTC. Of these dogs, 56.9% (3207/5636) suffered "blunt trauma," 38.3% (2163/5636) suffered "penetrating trauma," and 4.7% (266/5636) suffered "both." For the mechanisms of injury categories of "blunt" and "both blunt and penetrating," the most common injury types included "struck by a vehicle" 44.7% (1553/3473) followed by "fall from height" 21.3% (740/3473) (Table 2). "Bite wounds" represented 63.5% (1541/2427), whereas "lacerations resulting from glass, metal, or knife" represented up to 7.9% (194/2427) of total "penetrating injuries" (Table 3). In addition, 24.8% (864/3473) and 18.1% (441/2427) of the "blunt and penetrating injuries," respectively, were not categorized and therefore were listed as "other." Some of the "penetrating injuries" classified as "other" may have included lacerations not listed as previously described (eg,, "laceration from wood"). The category "other" differs from "unknown," which includes 2.1% (75/3473) and 3.8% (93/2427) of "blunt and penetrating injuries," respectively.

TABLE 4 Proportion and percentages of dogs who received pre-VTC care by care provider[a]

Care provider	Proportion of dogs
DVM/VMD	4569/5636 (81.0%)
Owner	1108/5636 (19.6%)
Other	76/5636 (1.3%)
Emergency medical technician	7/5636 (0.1%)
Medical doctor	7/5636 (0.1%)
Police	8/5636 (0.1%)
Firefighter	3/5636 (0.05%)
Military personnel	0/5636 (0%)

[a]Dogs received care from more than one care provider, so counts do not add up to the total. VTC, Veterinary Trauma Center

Pre-VTC care was provided by a veterinarian in 81.0% (4569/5636), by an owner in 19.6% (1108/5636), and by a nonveterinary healthcare provider or other first responder (EMS, medical doctor, police, military personnel, firefighters) in 0.4% (25/5636) of the total dogs receiving pre-VTC care. "Other" providers included bystanders, pet sitters, dog daycare and boarding facilities, and groomers in 1.3% (76/5636) of the cases (Table 4).

In April 2017, the question "Is this an OpK9?" was added as a question in the REDCap trauma registry. Prior to this, only three patients were noted to be Opk9. In total, 23 OpK9s out of 22,998 patients were admitted to VTC during our study period and were identified as 12 police dogs: four "Explosive sniffing dogs"; one MWD; one State Park security dog; and five "Other." Five out of 23 OpK9s received pre-VTC care: two received care from a veterinarian and the other three received care by "Police." For the latter, it remains unknown whether the care provided by "Police" was provided by the OpK9 handler or other law enforcement officers. The care rendered in three of the five OpK9s was recorded as "wound care and bandaging" ($n = 2$) and "administration of fentanyl and fluid therapy" ($n = 1$); the route and dose of fentanyl administration were not recorded. Three of the OpK9s that received non-veterinarian pre-VTC care were injured during training or while on duty. Five OpK9s that did not receive any pre-VTC care were also injured in the LOD. One OpK9 from the group that did not receive pre-VTC care did not survive to discharge and was euthanized after presenting to a VTC.

The most common interventions provided by nonveterinary personnel included bandaging and wound care in 39.3% (475/1209) and 41.9% (507/1209), respectively (Table 5). In 31.4% (380/1209) of dogs, the care provided included "removing foreign bodies" (fish hooks, bones in the mouth/throat), "bathing, administering prescribed medication (tramadol or opioids), placing Elizabethan collars, cauterizing wounds, adding creams or topical medications, among others."

TABLE 5 Proportion and percentages of dogs who received pre-VTC care by type of care[a]

Type of non-veterinarian care	Proportion of dogs
Wound care	507/1209 (41.9%)
Bandage	475/1209 (39.2%)
Other	380/1209 (31.4%)
Oral over-the-counter nonantibiotic	63/1209 (5.2%)
Oral antibiotic	19/1209 (1.5%)
Chest compressions	8/1209 (0.6%)
Oxygen administration	6/1209 (0.5%)

[a]Dogs received more than one type of care, so individual proportions do not add up to the total. VTC, Veterinary Trauma Center

The overall mortality was 7.5% between September 2013 and April 2018, with 92.5% (21,090 /22,795) of dogs that presented to a VTC surviving to discharge, 24.0% (5072/21,090) of which had received pre-VTC care; 7.5% (1705/22,795) of dogs did not survive to discharge, of which 17.7% (302/1705) died and 82.3% (1403/1705) were euthanized.

The mortality in the pre-VTC care group was 8.7% (485/5557), which was significantly higher than the mortality in the group that did not receive pre-VTC care (7.1% [1220/17,238; $p < 0.0001$). It is worth noting that the statistical analysis does not compare the pre-VTC group to the overall mean (which would also include the pre-VTC cases) but to the non-pre-VTC cases. From the groups of dogs that died and were euthanized, 31.7% (96/302) and 27.7% (389/1403), respectively, had received pre-VTC care. Note that the proportion of dogs that received pre-VTC care was not equal between outcome categories. However, the MGCS score was significantly lower (mean = 17.3 vs 17.4, $p < 0.0001$; range: 3–18) and the ATT score was significantly higher (mean = 2.5 vs 1.8, $p < 0.0001$; range: 0–18) in dogs receiving pre-VTC care. There were 203 dogs lost to outcome in the registry, 80 of which had received pre-VTC care, the causes of which are unknown.

Dogs were 1.5 times (95% CI, 1.15–1.88) more likely to die than survive to discharge if they received pre-VTC care. Furthermore, dogs were 1.2 times (95% CI, 1.07–1.37) more likely to be euthanized than survive to discharge if they received pre-VTC care.

4 | DISCUSSION

In our study, 24.5% of the dogs presenting with trauma to a VTC received some type of prehospital care. Of those, 81.0% had care provided by a primary veterinarian. The remaining 19.6% had some type of care provided by the owner, and only 0.4% had care provided by first responders (eg, EMS, police, or firefighters). In our analysis, it was difficult to identify the number of OpK9 handlers providing prehospital care to their own dogs. The number of OpK9s recorded in the registry increased significantly post-April 2017; this is most likely attributed to the addition of the question "Is this an OpK9?" to the trauma registry questionnaire. At present, there is not a question specifically asking whether "Was the OpK9 handler providing the care to the injured OpK9?" This could be considered for a more accurate analysis in future studies.

Although our analysis revealed that a veterinarian rendered care in the majority of dogs receiving pre-VTC care, it is also unknown whether care was provided at the point of injury (POI) or at a veterinary facility. To date, we do not have an EMS system in veterinary medicine (VEMS) that is comparable to those used in people. Typically, when a domestic pet is injured, it is the owner's responsibility to bring their injured animal to a veterinary facility. As a result, it is our assumption that the care provided by a veterinarian was likely given at a veterinary treatment facility rather than at the POI.

In this study, dogs receiving pre-VTC care had significantly worse outcomes compared to those dogs that did not; however, these dogs also possessed higher ATT and lower MGCS scores. We believe that the association between dogs receiving pre-VTC care and possessing a higher mortality rate is not because pre-VTC care increased an animal's chance of dying. Instead, it is more likely that dogs with more severe injuries (higher ATT, lower MGCS scores) are more likely to be referred to a VTC to seek specialist care and, subsequently, have higher mortality risks because of their injuries. This is supported in the human literature in several studies in which patients with increased Injury Severity Score (ISS) had higher mortality rates.[24,25]

We have not assessed the difference in survival outcome by the types of provider; however, this is an important factor to evaluate in future analysis. Moreover, in our study we observed that care provided by the owner includes care given "prior" or "post" primary veterinary care. From our data, it was difficult to assess the degree of interaction between the owners and the primary care veterinarian; some cases in the registry had recorded "treatment recommended or prescribed by vet" in the box describing the "type of Non-DVM care." It remains unclear when these recommendations were provided to the owners, whether the patient was directly assessed by a veterinarian prior to giving medications, or if annotated treatments were made on the owners' own initiative. Case in point, "Owner care" is marked in the registry with a comment in the explanatory box stating, "Meloxicam prescribed by primary veterinarian"; it remains unclear what exact care the owner provided and at what point and to what extent during the pre-VTC period the veterinarian became involved.

Although most of the care provided by non-veterinarians seems appropriate (bandaging, wound pressure, even CPR), there are numerous patients where interventions were questionable. For example, giving nonsteroidal anti-inflammatory drugs designed for people at unknown doses (as stated in the registry), applying salt to wounds, giving cannabinoids for several days prior to presentation to a veterinarian, and others. Unfortunately, we could not analyze the effect of these interventions individually in this study. Further characterization of the non-veterinary pre-VTC care provided is needed to assess if there is a negative impact on outcome for these patients.

In human medicine, evidence supports that basic first aid provided by nonmedical personnel or bystanders can prevent fatalities.[26] For example, a study by Bur et al demonstrated that basic life support, given by bystanders to people suffering out-of-hospital cardiopulmonary

arrest, was significantly associated with good neurological outcome and fewer expenses spent on in-hospital efforts.[27] Moreover, Hussain and Redmond's study hypothesizes that up to 39% of prehospital deaths might have been preventable with the provision of basic first aid.[28] Extrapolating to veterinary medicine, training owners and handlers on veterinary first aid may help mitigate potential life-threatening consequences and improve outcome in the veterinary trauma patients. Further research is warranted to determine the benefit that prehospital care provided by owners and handlers has on the overall survival in dogs suffering major trauma.

Currently, the guidelines of prehospital care published by Hanel et al are intended to be used by qualified veterinary personnel, EMS professionals, law enforcement officers, and OpK9 handlers that have already received additional training. Even in these patients, to prevent further harm, it is imperative that responders only perform skills on which they are trained and with which they are proficient.[29] It would be very interesting and important for future research to evaluate the differences in outcome, where pre-VTC care is provided by medical personnel and first responders (eg, EMS, medical doctor, firefighters, police, military), and identify what type of interventions are provided at the POI. The number of interventions by first responders observed in this study was lower than expected by the authors, with only 0.44% of the patients receiving pre-VTC care by a first responder; however, this may reflect the fact that only cases presented to a VTC are recorded into the trauma registry and, to date, only a small number of certified VTCs (approximately 30 as of August 1, 2019) presently exist in the United States. As such, the authors believe that the proportion of prehospital care provided by nonveterinary first responders is most likely significantly greater than observed in our analysis. We did not characterize the specific care provided by first responders in this study.

There are several limitations of this study. We did not have access to the full records of the patients included in the study; in some cases, these data were not complete (description of "Other" fields) or were confusing. With regard to care provided by owner, it is unclear whether the owner provided care based on their own accord or whether they had first consulted with and received direction from a veterinarian. Furthermore, some of the data rely on the information provided by the owner, which could, potentially, be inaccurate. Additionally, the results obtained reflect the patients presenting to VTCs, which might differ from the reality of primary veterinary emergency practices or hospitals (non-VTC).

We offered a very broad analysis of prehospital care provided in veterinary medicine for patients admitted to VTCs, and there is large variability within the analyzed patients, the type of trauma, or the pre-VTC provider. At the moment, the interventions provided by a primary veterinarian prior to presentation to VTC are not recorded in the Veterinary Trauma Registry. The question of whether the case received any care provided by a veterinarian is answered with "Yes/No" only. For this reason, we could not analyze the type of interventions provided by the primary veterinarian prior to referral to a VTC. Adding this information could facilitate further analysis regarding the provision of prehospital care by primary veterinarians and the effect on mortality. Furthermore, we have analyzed all thetrauma patients presented despite the mechanism of injury. Future studies are needed to evaluate similar categories with more detail (eg, blunt vs penetrating trauma, or with higher severity scores).

In conclusion, this study provides the first preliminary data of prehospital care in veterinary trauma. Further investigation about the current practices in prehospital trauma care will help identify where training is lacking and where to focus our efforts in further teaching and training of nonveterinary personnel, OpK9 handlers, and first responders. Lastly, we hope that sharing this information will help promote the knowledge about the work of VetCOT and the efforts to improve trauma care within the veterinary community. We hope this study will prompt veterinary professionals to research, learn, and improve prehospital care in trauma veterinary medicine.

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DISCLAIMER

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Center For Research Resources or the NIH. Study data were collected and managed using REDCap electronic data capture tools hosted at the University of Minnesota.[e]

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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ENDNOTES

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[b] *DescTools: tools for descriptive statistics*. R package version 0.99.24. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

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