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A RETROSPECTIVE STUDY ON 103 DOGS AND 172 CATS REFERRED FOR TRAUMA (2018 – 2022)

STUDIO RETROSPETTIVO SU 103 CANI E 172 GATTI RIFERITI PER TRAUMA (2018 – 2022)

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ABSTRACT

This retrospective study describes a population of dogs and cats referred to Ospedale Veterinario Universitario Didattico (OVUD) of University of Parma, with a suspicion or certainty diagnosis of of trauma. The purpose of this study is to analyze the short-term outcome of traumatized patients and its correlation with the type of injury, the type of trauma, and other clinical and clinical-pathologic variables. The final aim is to verify the presence of possible prognostic factors for the short-term outcome of the patients among these variables.

On a total of 878 animals referred to OVUD in a period between January 1st 2018 and March 31st 2022, only 103 dogs and 172 cats met the inclusion criteria. In both study populations, patients were primarily adults, with a median age of 6,4 years for dogs and 4,1 years for cats. There was no significant difference between females and males. In both populations, the main type of trauma was motor vehicle accident, counting 60% of dogs and 65% of cats. The survival rate was excellent, with 87,5% of survivor dogs and 89% of survivor cats. The main type of injury was skeletal trauma, counting 51% of dogs and 61% of cats: in this body region, hindlimb luxation/fractures for dogs and pelvic-sacral fractures/luxations were the most frequent injuries. However, this type of injury was not negatively correlated with the outcome. The principal cause of death was abdominal trauma and, in particular, the most frequent injuries were hepatic contusion, abdominal hernia and hemoabdomen. Among the clinical-pathological variables, the presence of hyperlactatemia resulted a negative prognostic factor in dogs. However, no prognostic factor has been identified in cats.

ABSTRACT

Questo studio retrospettivo descrive una popolazione di cani e gatti afferiti all'Ospedale Veterinario Universitario Didattico (OVUD) dell'Università di Parma, con una diagnosi di certezza o di sospetto di trauma.

L'obiettivo dello studio è stato quello di analizzare la sopravvivenza a breve termine dei pazienti traumatizzati e la sua correlazione con il tipo di lesione, il tipo di trauma e altre variabili cliniche e clinico-patologiche. Lo scopo finale è stato quello di verificare tra queste variabili la presenza di possibili fattori prognostici per determinare l'exitus a breve termine del paziente.

Su un totale di 878 animali afferiti all'OVUD nel periodo compreso tra 1 Gennaio 2018 e 31 Marzo 2022, solo 103 cani e 172 gatti rispettavano i criteri di inclusione. In entrambe le popolazioni oggetto di studio, i soggetti erano primariamente giovani adulti con età media di 6,5 anni per i cani e 4,1 anni per i gatti. Non si è notata una differenza statisticamente significativa tra maschi e femmine. Il 36,8% dei cani e il 18% dei gatti presentavano lesioni ad almeno due regioni corporee. In entrambe le popolazioni, il trauma più frequente è risultato essere il trauma automobilistico, colpendo il 60% dei cani e il 65% dei gatti. La sopravvivenza è stata buona, con 87,5% dei cani e 89% dei gatti sopravvissuti. La regione corporea più frequentemente traumatizzata è risultata essere l'apparato scheletrico, interessando il 51% dei cani e il 61% dei gatti: il tipo di lesione più frequente in questa sede è risultato essere fratture/lussazioni dell'arto posteriore per il cane e fratture/lussazioni pelviche-sacrali per il gatto. Tuttavia, questo tipo di trauma non è stato correlato negativamente alla sopravvivenza. La causa più frequente di morte è stata il trauma addominale e in particolare, le lesioni più frequenti sono risultate essere: contusione epatica, ernia addominale ed emoaddome. Tra le variabili clinico-patologiche, la presenza di iperlattatemia è risultata essere fattore prognostico negativo nei cani, mentre nel gatto non si sono identificati fattori prognostici.

BACKGROUND OF THE STUDY

1 POLYTRAUMA PATIENT

Trauma is defined as a tissue injury that occurs more or less suddenly and includes any physical damage (e.g., fracture, laceration) to the body caused by violence or accident (Muir, 2006).

Injury to tissues may be classified by the type of forces applied to the body, such as blunt and penetrating, and can occur secondary to motor vehicle accidents, animal abuse, falls, gunshot wounds, and animal-animal interactions. Traumatic injuries may be minor, such as lacerations or single bite wounds that are easily addressed and fixed. However, trauma can be severe and life threatening with injuries to multiple body systems (Dobratz et al., 2019).

Trauma is therefore in all respects an emergency and as such requires a particular methodological approach to protect the patient’s life.

In veterinary medicine, evidence-based protocols for the approach to trauma are lacking. Most of the commonly employed practices are extrapolated from human literature on trauma, despite the recognition that key differences exist in the types of trauma, the availability of pre-hospital care, and in the medical and surgical approaches to certain types of injuries (Hall & Delaforcade, 2013).

2 EPIDEMIOLOGY AND MORTALITY

2.1 Epidemiology

Traumatic injury is a common occurrence in veterinary medicine.

According to some epidemiologic studies, trauma patients make up 10%-30% of cases admitted to the Intensive Care Unit in Veterinary Hospitals. In particular, in a population of over 800 dogs admitted at the Emergency Unit of the Veterinary Teaching Hospital of the University of Guelph in Canada, trauma represents the second primary reason for admission with 10,7% of the total, following gastrointestinal diseases and pancreatitis (Hayes et al., 2010).

A similar assessment, conducted on 2,4 million canine emergency access at Banfield Pet Hospital during 2014, the 22,8% were dogs with motor vehicle accidents, making this type of trauma the most common cause of an emergency visit (Saito & Rhoads, 2015).

Unfortunately, in the veterinary literature, the same epidemiological assessment is not available for cats, because of the paucity of data.

In this regard, in 2013 The American College of Veterinary Emergency and Critical Care Veterinary Committee on Trauma (ACVECC-VetCOT) was set up with the aim to inform improvement of trauma patient care and aid in the design of clinical and preclinical trials that could inform go/no go decisions for interventional strategies and tools (Hall, 2019).

In the period of time between 2013 and 2017, the Registry Report by ACVECC-VetCOT collected data from twenty-nine Veterinary Trauma centers in North America, Europe and Australia, for a total of 17.335 dogs and 3.425 trauma cats. Admission data revealed that the median age of dogs was 4,1 years and for cats 3,4 years, suggesting that trauma is more common in young animals. Moreover, the majority of these animals was male, with greater prevalence of neutered dogs and whole cats. Blunt trauma was more frequent in cats, while penetrating trauma was more frequent in dogs. Regarding blunt traumas, the motor vehicle accident was the most common, followed by the fall from a height, in both species. Bite injuries were the most common penetrating trauma in both species (Hall et al., 2018).

Previous studies found similar data, with a higher prevalence of trauma between males with blunt trauma, followed by penetrating trauma, as the most common cause (Hall et al., 2014; Kolata, 1980).

2.2 Mortality

The prognosis following trauma is excellent in dogs, with survival to hospital discharge reported to be around 90% (Hall et al., 2014).

This data is confirmed by several studies mentioned above in which the survival rate ranged between 87% and 92% (Hall, 2019; Hall et al., 2018; Kolata, 1980).

Despite the good prognosis, in a large epidemiological study on 75.000 dogs from North America, over a 20-year time period, trauma was the second leading cause of death in both juvenile and adult dogs (Fleming et al., 2011).

However, this result might be influenced by the fact that this study collected data since the nineties, and the veterinary critical care evolved significantly in the last decade. Moreover, it is important to stress that, in the context of polytrauma, the mortality and morbidity percentages increase compared to those obtained from the sum of the individual injuries, due to the sharing of functional insufficiencies that derive from it (Butcher et al., 2009).

Indeed, in a retrospective study on feline trauma patients admitted to a referral center, it has been evidenced that cats with polytraumatic injuries were at greater risk of mortality than those with single injuries (Hernon et al., 2018).

In human medicine, it has been recognized that mortality in traumatized patients follow a trimodal distribution (American College of Surgeons, 1997):

- The first peak occurs within seconds to minutes of injury. During this early period, deaths generally result from apnea due to severe brain or high spinal cord injuries or rupture of the heart, aorta, or other large blood vessels. Very few of these patients can be saved because of the severity of their injuries.
- The second peak occurs within minutes to several hours following injury. Deaths that occur during this period are usually due to subdural and epidural hematomas, hemo/pneumothorax, ruptured spleen, lacerations of the liver, pelvic fractures, and/or multiple other injuries associated with significant blood loss. The Golden Hour of care after injury is characterized by the need for rapid assessment and resuscitation, which are the fundamental principles of Advanced Trauma Life Support.
- The third peak, which occurs several days to weeks after the initial injury, is most often due to sepsis and multiple organ system dysfunctions. Care provided during each of the preceding periods affects outcomes during this stage.

Although this trend is widely recognized in human medicine, it is not easy to place mortality in these three peaks in veterinary medicine. This is the reason why it is important to recognize "the Golden Hour" in veterinary patients, so that a correct approach to the treatment of the traumatized patient could influence positively the outcome of the patient (American College of Surgeons, 1997).

3 GLOBAL APPROACH TO POLYTRAUMATIZED PATIENT

Trauma is defined as a “wound or injury” caused by an “accident.” Severity of injury secondary to any trauma can range from undetectable to fatal. Therefore, a global and thorough approach is required to improve survival and decrease morbidity in traumatized dogs and cats (Ettinger et al., 2017).

3.1 Triage and clinical visit

Early diagnosis of injuries, first aid, restoration and support of vital functions are key moments to ensure the patient’s survival and functional recovery (Novello, 2001).

The term triage derives from the French verb *trier*, which means “to choose” and it is currently used in medicine to guarantee a high level of assistance to patients in the emergency room by assigning them a code of severity. In veterinary medicine, triage aims to systematically approach the patient, in order to focus on primary, or most serious, lesions and therefore improve the quality of care and reduce the morbidity (Dobratz et al., 2019).

Therefore, the success of managing small animals in the emergency room or critically ill patients relies in large part on the veterinary health care team's ability to quickly identify and immediately manage life-threatening problems. For this reason, carrying out a triage correctly does not only mean giving priority to one patient over another, but it also involves identifying life-threating problems and the need for immediate intervention.

According to the Advanced Trauma Life Support (ATLS) guidelines, the standard approach involves a first assessment aimed at ensuring the restoration of vital functions, followed by a detailed secondary assessment and finally the start of the definitive treatment (American College of Surgeons, 1997).

A. Immediate global assessment

The immediate global assessment consists of an evaluation of vital functions almost as if it was a glance. It must be a quick but complete evaluation aimed at gathering important information such as concomitant or previous pathologies, ongoing drug treatments or any allergic reactions to drugs. Information regarding the type of trauma, the exact dynamics if known, the patient's conditions up to that moment may be useful (Novello, 2001).

B. Primary survey

The ABCDEF's method is a reasonable systematic approach to this primary survey. This approach includes the priorities to be analyzed and derives from an extension of Basic Life Support (BLS) and Advanced Cardiovascular Life Support (ACLS) maneuvers adapted to the peculiarities of a trauma patient (ATLS). The primary survey includes evaluation of the same physical parameters as performed during the technician triage, but it is much more detailed and may involve both subjective and objective evaluations (Dobratz et al., 2019).

1. **AIRWAY AND SPINE STABILIZATION**: the goal is to evaluate the airway patency. If they are obstructed, prompt action must be taken to remove the obstruction and allow spontaneous ventilation to resume, or more often to initiate artificial ventilation (Dobratz et al., 2019).

   In fact, a respiratory arrest always leads in a short time to a cardiocirculatory arrest and for this reason it represents the first step in the evaluation of the traumatized patient.

   Any signs of airway obstruction, such as foreign bodies, facial or mandibular fractures, injuries to the trachea and larynx can compromise the air flow. At this level, it is important to consider the protection of the spinal column in its cervical tract to limit and avoid the aggravation of any spinal cord injury (American College of Surgeons, 1997).

2. **BREATHING**: it consists in evaluating breathing and ventilation. The patency of the airways alone does not ensure, by itself, proper ventilation, so the lungs, chest wall and diaphragm activity is required. The first goal with a critically injured trauma patient is to optimize oxygen delivery to the tissues (Ettinger et al., 2017).

   At presentation, supplemental oxygen should be provided to the severely affected trauma patient until assessment of an arterial blood gas or measurement of hemoglobin saturation confirms that oxygen supplementation is not required. Clinical signs of respiratory impairment include increased respiratory rate or effort, flail chest, pale or cyanotic mucous membranes, increased heart rate, increased upper airway sounds, or altered lower airway sounds (increased or decreased). If these signs are present, oxygen supplementation is essential (Drobatz et al., 2011).

3. **CIRCULATION**: the goal is to evaluate the circulatory status and hemorrhages. Initial assessment of adequate cardiac output and circulating volume includes mucous membrane color, capillary refill time, pulse rate and pulse quality (Drobatz et al., 2011).

   Pale mucous membranes, prolonged capillary refill time (>2 sec), tachycardia (or bradycardia in cats), weak peripheral pulses, and hypotension indicate inadequate tissue perfusion (Dobratz et al., 2019).

4. **DISABILITIES**: to evaluate disabilities caused by trauma. It is important to assess brain function at presentation to obtain a baseline for potential dynamic changes that may occur. Conclusions regarding brain and neurologic function (brain and spinal cord) should be withheld until perfusion is adequate and function is reassessed. Profound neurologic changes may be found with poor tissue perfusion and corrected once tissue perfusion is improved (Dobratz et al., 2019).

5. **EXPOSURE**: which means to control the exposure to the environment. This phase includes the removal of any bandages, dressings and other protective devices that prevent the complete evaluation of the patient. It is essential to prevent the patient from hypothermia (Dobratz et al., 2019).

6. **FRACTURES**: every trauma patient has head, spinal and orthopedic trauma until proven otherwise. To rule out the presence of a neurological or orthopedic lesion is essential, in the global prognostic evaluation, the management and the communication with the owner (Corlazzoli, 2018).

   Damage to the appendicular skeletal system has a lower priority than vascular and nerve damage. For this reason, only multiple rib fractures or maxillofacial injuries need to be stabilized immediately, as they can cause acute respiratory failure. However, pelvic or long bone fractures should also not be underestimated as they can cause hemorrhagic shock (Raimondi, 2018).

C. Secondary survey

Whereas the primary evaluation allows to obtain an initial clinical balance of the patient to safeguard his vital functions by implementing life-saving procedures, the secondary evaluation allows to provide more information both in the diagnostic and therapeutic fields. Animals with significant trauma often have injuries to multiple body systems and a thorough physical examination should be performed (Ettinger et al., 2017).

This examination includes an evaluation of several parameters that led to examine the animal from the tip of the nose to the tip of the tail (Dobratz et al., 2019).

- Mucous membrane color
- Capillary refill time
- Heart rate and cardiac auscultation
- Peripheral pulse quality
- Respiratory rate and effort
- Rectal and extremity temperature
- Level of consciousness
- Abdominal palpation
- Observation of the all the limbs function and the ambulation. Palpation of appendicular and axial skeleton including rectal examination, palpation of skull and manipulation of jaw
- Full evaluation of peripheral nerves

The objectives of the triage must therefore be to carry out a rapid evaluation of the vital systems, focus on the problem and set up standard procedures such as oxygen therapy, intravenous catheter and laboratory investigations for the minimum database.

3.2 Minimum database

Immediately after the triage assessment, venous access should be ensured and, if possible, a sample of blood should be obtained for packed cell volume (PCV), total protein (TP), lactate, blood gas analysis, blood electrolytes, and creatinine.

The initial assessment of the PCV and TP may aid in the diagnosis of active hemorrhage. As a result of splenic contraction in dogs with active hemorrhage, initial evaluation of the PCV and TP typically reveals a relative hypoproteinemia (TP < 6 g/dL) and a PCV within the reference range.

Following initial fluid resuscitation, the PCV typically decreases to less than 30% and the TP decreases to less than 3,5 g/dL (Dobratz et al., 2019).

According to Lynch et al., in a recent study investigating transfusion practices in dogs after trauma, a PCV of 39% and TP of 4,5 g/dL were specific (92% and 89%), but insensitive (43% and 55%) predictors for the need for blood transfusion (Lynch et al., 2015).

Blood gas analysis is an important bloodwork in a traumatized patient. It is recognized that metabolic acidosis is common in dog and cat that have suffered a trauma and it is most often characterized by acidemia in association with a decrease in bicarbonate concentration with hyperlactatemia. Lactate is produced from hypoxic tissue, in concert with hydrogen ion, and it is a global indicator of adequacy of oxygen delivery to the tissues or oxygen utilization by the tissues. An elevated lactate in traumatized patient indicates inadequate oxygen delivery to the tissues (Drobatz et al., 2011).

According to Rosenstein et al., lactate values of 3-5 mmol/L indicate mild hypoperfusion, which becomes moderate with values of 5-7 mmol/L and severe when greater than 7 mmol/L. However, in the same study, it has been shown that the measurement of lactates, performed in a serial manner, is a more reliable prognostic index than the single measurement because it also evaluates its clearance (Rosenstein et al., 2018).

The same consideration could be made on the base excess. In fact, in a patient with blood loss and normal clinical signs, occult hypoperfusion can be observed, characterized by an imbalance between oxygen delivery and oxygen demand. When oxygen delivery is inadequate, anaerobic metabolism occurs and consequently metabolic acidosis takes place with a decrease in the base excess. In a study by Stillion and Fletcher on 52 dogs with blunt trauma, a base excess of -6,6 at admission was 88% sensitive and 73% specific to predict the need for a blood transfusion (Stillion & Fletcher, 2012).

In patients with head trauma, it is also important to monitor the glycemic trend. In human medicine, it has been shown that in patients with head trauma, hyperglycemia is associated with increased mortality, increased hospitalization time and worse neurological outcome, as it accelerates secondary brain damage (Jeremitsky et al., 2005). In veterinary medicine, a study correlated hyperglycemia with an indication of traumatic brain injury (TBI) severity but not necessarily with a worse prognosis (Sigrist et al., 2004).

Traumatized animals are physiologically dynamic and should be continuously monitored until physiologic parameters are stable. Close monitoring of cardiovascular and respiratory trends allows early detection of problems, before they become life threatening (Ettinger et al., 2017).

3.3 Diagnostic imaging

3.3.1 Focus Assessment with Sonography for Trauma

Today, Focus Assessment with Sonography for Trauma (FAST) represents a fundamental component of the diagnostic protocol in the patient victim of a trauma, as it can rapidly provide useful and accurate information regarding the possible presence of free fluid in the traumatized patient's abdomen, with results comparable even to computed tomography (CT). This guarantees to provide an excellent level of assistance to the traumatized patient even in the absence of expensive and always usable technologies (Lisciandro, 2011).

The FAST exam is a relatively inexpensive, radiation sparing, point-of-care, noninvasive, imaging modality requiring minimal patient restraint that can be performed simultaneously with other interventions like placement of an IV catheter, supplementation of oxygen or additional treatments (Lisciandro et al., 2008).

However, it should be emphasized that the FAST exam does not replace the accuracy of advanced diagnostic imaging tests performed by a specialist in the field.

The Abdominal FAST examination (A-FAST) is carried out by placing the patient in the right or left lateral recumbency. According to the clinical review by Lisciandro, the author prefers the right lateral recumbency as it is the standard position for echocardiographic and ECG evaluation and it has also probably the best one for performing a possible abdominocentesis, as the iatrogenic puncture of the spleen is less probable. Also, this position gives a better visualization of the gallbladder and retroperitoneal space (Lisciandro, 2011).

Scans of four defined anatomical regions are performed. These regions are represented by an area close to the xiphoid process of the sternum (diaphragmatic-hepatic view, DH), an area close to the cranial margin of the pubis (cysto-colic view, CC) and by the regions of the right flank (hepato-renal view, HR) and left flank (spleno-renal view, SR), just posterior to the last ribs (Figure 1).

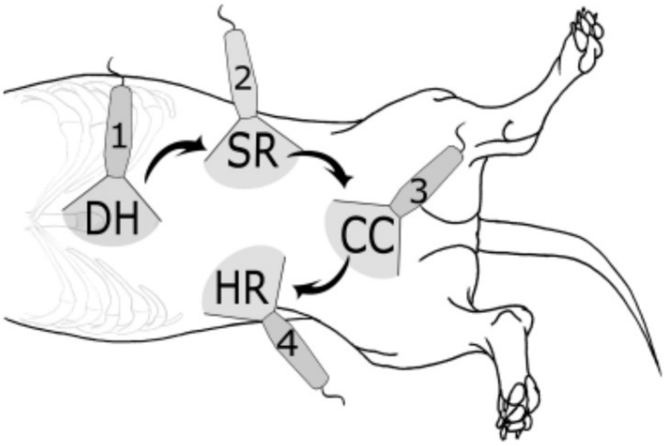


Figure 1: Depiction of the 4-point of the A-FAST (Lisciandro, 2011).

In these sites, it is possible to assess the presence of free fluid in the abdomen and the integrity of some organs such as the gallbladder and urinary bladder (Table 1).

Patient positioning	Right or left lateral recumbency (right preferred)
Gall bladder	Present or absent, contour (normal or not) and wall (normal or not)
Urinary bladder	Present or absent, contour (normal or not) and wall (normal or not)
Diaphragmatico-hepatic (DH) view	
Pleural fluid	Present or absent (mild, moderate, severe)
Pericardial fluid	Present or absent (mild, moderate, severe)
Positive or negative (0 negative, 1 positive)	
Diaphragmatico-hepatic (DH) site	0 or 1
Spleno-renal site	0 or 1
Cysto-colic site	0 or 1
Hepato-renal site	0 or 1
Abdominal fluid score: 0-4 (0 negative all quadrants to a maximum of 4 positive all quadrants)	

Table 1: A-FAST template for medical records made by Lisciandro in his article "Abdominal and thoracic focused assessment with sonography for trauma, triage, and monitoring in small animals" (Lisciandro, 2011).

To assess the presence of free fluid in the abdomen more objectively, an Abdominal Fluid Score (AFS) system was developed to predict the patient's degree of anemia and the potential need for blood transfusions. In particular, a score from 0 to 4 is assigned in relation to the positivity of the examination in the four regions investigated. A score of 0 is assigned when all scans are negative, while the presence of free liquid in each of the four sites is scored 1, with a total score of 4 if fluid is present in all quadrants (Lisciandro, 2011).

The correct use of this score allows to identify a possible bleeding in progress before the patient becomes hemodynamically unstable. In a study by Lisciandro et al. in 2009, in fact, all dogs with AFS greater or equal than 3, presented a decrease in hematocrit of at least 20%. In addition, the serial evaluation of this score can provide information on the patient's clinical progress: an increasing AFS is indicative of ongoing bleeding, a static AFS is indicative of cessation of bleeding while a decreasing AFS is indicative of resolution through autotransfusion (Lisciandro et al., 2009).

The Thoracic FAST examination (T-FAST) is an ultrasound scan aim to detect chest wall, lungs, pleural and pericardial space alterations, in order to optimize resuscitation efforts and patient care (Lisciandro, 2011).

Although computed tomography is the "gold standard" in the diagnosis of thoracic trauma injuries, the T-FAST technique represents an excellent diagnostic tool for identifying traumatic pneumothorax, pleural or pericardial effusion, with a specificity and sensitivity comparable to radiographic examination, but with the advantage of being able to be performed in the emergency room, without the need to move the patient, avoiding unnecessary or even harmful manipulations (Lisciandro et al., 2008).

The examination can be performed in both lateral and sternal recumbency, generally less stressful and safer for patients with respiratory problems. Similarly to A-FAST, both hemithorax scans are performed in some defined anatomical regions which include chest tube site view (CTS), pericardial site (PCS) and diaphragmatic-hepatic view (DH) (Figure 2).

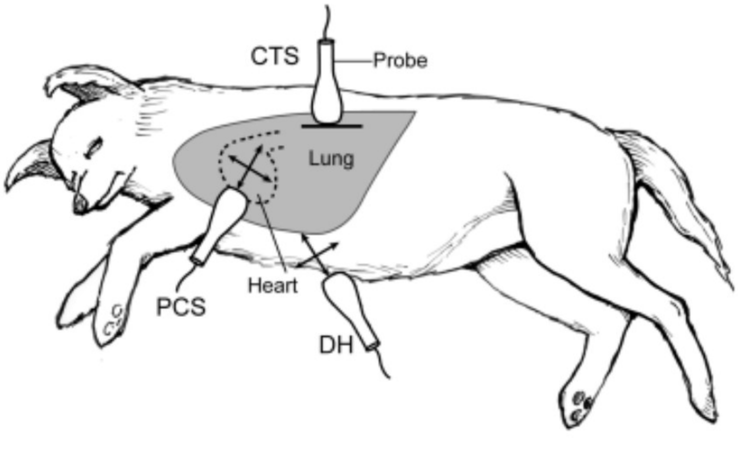


Figure 2: Depiction of the point of the T-FAST (Lisciandro, 2011).

In these views it is possible to detect alterations associated with several pathologies, as can be seen from the table below (Table 2).

CTS glide sign	Present	No pneumothorax
	Absent	Pneumothorax
CTS lung rockets	Present	Interstital lung fluid (edema, hemorrhage)
	Absent	No interstitial lung fluid (edema, hemorrhage)
CTS step sign	Present	Concurrent thoracic wall trauma (ribs fractures, hematoma, intercostal muscle tear) or pleural space disease is suspected
	Absent	No concurrent thoracic wall trauma or pleural space disease is suspected
PCS view	Absent	No pleural or pericardial fluid
	Present	Pleural or pericardial fluid or both (mild, moderate, severe)
Cardiac tamponade	Absent	
	Present	
	Indeterminate	
LV filling (short-axis)	Adequate	Normovolemia
	Inadequate	Hypovolemia
	Indeterminate	
DH view	No apparent pericardial or pleural fluid present or there is pericardial effusion or pleural effusion	

Table 2: T-FAST template for medical records (Lisciandro, 2011).

3.3.2 Radiographic examination and computed tomography

Thoracic radiographs are recommended in veterinary trauma patient to evaluate for pleural space (e.g., hemo/pneumothorax, diaphragmatic hernia), pulmonary parenchymal (e.g., contusion), and body wall (e.g., rib fractures, subcutaneous emphysema) disease. Likewise, abdominal radiographs and ultrasound may be indicated to evaluate for fluid or air, diaphragmatic or body wall hernia, urinary bladder rupture, and pancreatitis (Lisciandro, 2011).

However, in veterinary medicine, obtaining radiographs during the initial assessment and resuscitation period is limited by the fact that the animal must be transported to the radiographic area, and any movement or constriction may increase the stress and oxygen request (Sigrist et al., 2004).

The same principle can be applied to the CT. Although CT is the gold standard for intra-abdominal and intrathoracic injuries, because it detects free fluid, free air and parenchymal injury, it is also expensive, not portable and not widely available. In veterinary patients this exam requires a hemodynamically stable patient for safe transport to the radiology suite and has additional risks related to sedation or anesthesia (Lisciandro et al., 2008).

For these reasons, these examinations are part of the advanced diagnostics that can be performed once the animal is stable.

4 GRAVITY SCORE SYSTEM

Objective risk stratification models are used routinely in human critical care medicine to estimate the illness severity (Le Gall, 2005). Scoring systems for illness severity typically are based on several clinical variables that predict mortality risk and provide an objective basis for patient triage and risk stratification for scientific purposes (Hayes et al., 2010).

The drafting of a clinical score must be validated on an adequate number of patients, must be based on objective criteria and must be easy to perform, but accurate at the same time (Le Gall, 2005).

In the evaluation of a trauma patient, the most used scores in veterinary medicine are: Shock Index (SI), Animal Trauma Triage Score (ATTS), Acute Patient Physiologic and Laboratory Evaluation Score (APPLE score) and Modified Glasgow Coma Scale (MGCS) (Ettinger et al., 2017).

4.1 Shock Index

The shock index (SI) is defined as the ratio of heart rate (HR) to systolic arterial blood pressure (SBP) and it was developed as a simple mean of quantifying the severity of shock on presentation to the Emergency Room, and has also been used to monitor the response to treatment in people (Rady et al., 1994).

The SI was initially developed in a porcine model of hemorrhage, in which it was seen that it was inversely related to cardiac index, stroke volume, mean arterial pressure, and left ventricular stroke work (LVSW), as well as oxygen delivery and mixed venous oxygen saturation (Rady et al., 1992).

Its measurement represents a useful, fast and easy to perform tool that in an emergency setting allows to promptly identify a hemodynamically unstable patient in different types of shock. However, the veterinary literature lacks publications on this topic, and it is difficult to define a reliable cut-off in order to use this index as a prognostic factor.

In human medicine, SI has been defined with a normal range between 0,5 and 0,7 (Birkhahn et al., 2005). In veterinary medicine, published studies have reported many limitations in maintaining the same reference value.

The first limitation, and most relevant, is that, if the selection of patients is based exclusively on heart rate and hypotension, there is a bias associated to the selection of dogs with a high SI. For this purpose, the SI has been associated with other shock indices (i.e., hyperlactatemia); however, despite the statistical significance, when comparing SI there is a degree of overlap between normal dogs and sick dogs with shock. This means that a normal dog could have a SI as high as 1,30 and it could be confused with a sick dog. This demonstrates the need to evaluate SI in the context of the patient, as the stress might influence the SI. The second limitation is that the objective parameters used to identify shock in a clinical setting vary drastically between breeds and even individually within a single breed (Porter et al., 2013).

This was supported by another study by Kraenzlin et al., which evidenced that the high number of clinically healthy dogs with an increase in SI (> 0,9) was due to several factors including the presence of anxiety, stress, pain, or an underlying disease that was not evident on routine physical examination and blood tests. However, in the same study, the shock index was significantly higher in dogs with motor vehicular trauma than in the control group and it was significantly higher in deceased than surviving animals (Kraenzlin et al., 2020).

Serial SI monitoring can provide more insight into the true usefulness of SI in emergency veterinary or critical care settings.

Similarly, in a previous study, 38 dogs with hemorrhagic shock were compared with 78 healthy dogs and it was found that the SI is significantly higher in patients with hemorrhagic shock (median 1,37, range 0,78-4,35) compared to healthy patients of the control group (median 0,91, range 0,57-1,53). Indeed, 92% of dogs with hemorrhagic shock had an SI> 0,91 (Peterson et al., 2013).

There are no publications available to value this index in cats.

4.2 Animal Trauma Triage Score (ATTS)

The Animal Trauma Triage (ATT) scoring system was designed to provide stratification of patients with veterinary trauma. Based on this system, physical examination parameters are divided into six categories (perfusion, cardiac, respiratory, ocular/muscle/integument, skeletal, and neurological) and are rated on a scale of 0 to 3, where 0 indicates no or little injury and 3 indicates serious injury (Table 3). Animals with higher ATT scores would receive treatment priorities than animals with lower ATT scores (Dobratz et al., 2019).

The ATT score was tested in a study carried out in 1994. This study documented the prognostic value of this index, indeed it evidenced that the increase of one point in the score was associated with an increase in the probability of death by 2,6 times (Rockar et al., 1994).

The ATT score is widely used in clinical practice and an ATT score value ≥ 5, according to a survey carried out by Hall et al., has 83% sensitivity and 91% specificity in predicting the non-survival. In the same study, higher ATTS values were correlated with longer hospitalization, greater need for surgery and higher costs. This factor becomes important when communicating with the owner during the initial evaluation (Hall et al., 2014).

Furthermore, although their relationship requires further investigation, it was noted that the shock index is weakly positively associated with ATT score. This is probably because both indexes assess the patient's cardiovascular status (Kraenzlin et al., 2020).

Perfusion	
MM pink/moist, CTR 2 sec, T ≥ 100F, strong or bounding femoral pulse quality	**0**
MM hyperemic or pale pink, MM tacky, T ≥ 100F, CRT 0-2 sec, fair femoral pulses	**1**
MM very pale pink & tacky, T< 100F, detectable but poor pulses	**2**
MM gray/blue/white, CRT > 3 sec, T < 100F, non-palpable femoral pulses	**3**
Cardiac	
HR canine: 60-140 bpm; HR feline: 120-200 bpm, normal sinus rhythm	**0**
HR canine: 140-180 bpm; HR feline: 200-260 bpm; NSR or VPC < 20/min	**1**
HR canine > 180 bpm; HR feline > 260 bpm; consistent arrhythmia	**2**
HR canine: < 60 bpm; HR feline < 120 bpm, erratic arrhythmia	**3**
Respiratory	
Regular RR with no stridor, no abdominal component	**0**
Mild increasing RR and effort, ± abdominal component, mild upper airway sounds	**1**
Moderate increased RR and effort, abdominal component, elbow abduct, moderate increased upper airway	**2**
Marked respiratory effort of gasping/agonal resp, little/no air passage	**3**
Eye/Muscle/Integument	
Abrasion/laceration – none or partial thickness. Eye: no fluorescein uptake	**0**
Abrasion/laceration – full thickness. No deep tissue involved. Eye**:** corneal lac not perforation	**1**
Abrasion/laceration – full thickness, deep tissue involved but art/nerve/muscle intact. Eye: corneal perforation, punctured globe or proptosis	**2**
Penetration of abdomen/thorax. Abrasion/laceration full thickness, deep tissue involved, artery/nerve/muscle compromised	**3**
Skeletal	
WT bearing 3 or 4 limbs. No palpable fx/joint laxity	**0**
Closed limb fx/rib fx or any mandibular fx. Single joint laxity/lux (including SI). Pelvic fx with unlateral intact SI-ilium-acetabulum. Single limb open/closed fx at or below carpus/tarsus	**1**
Multiple grade 1 conditions, single long bone open fx above carpus/tarsus with cortical bone preserved. Non-mandibular skull fx	**2**
Vertebral body fx/luxation except coccygeal, multiple long bone open fx above tarsus/carpus, single long bon open fx above tarsus/carpus with loss of cortical bone	**3**
Neurologic	
Central: consciousness: alert to dull, interest in surrounding. Periph: normal spinal reflexes; purposeful movement and nociception in all limbs	**0**
Central: dull/depressed/withdrawn. Periph: abnormal spinal reflexes with purposeful movement and nociception intact in all 4 limbs.	**1**
Central: unconscious, responds to noxious stimuli. Periph: absent purposeful movement with intact nociception in 2 or more limbs, absent tail or perianal nociception.	**2**
Central: non responsive to all stimuli, refractory seizures. Periph: absent nociception in two or more limbs, absent tail or perianal nociception	**3**

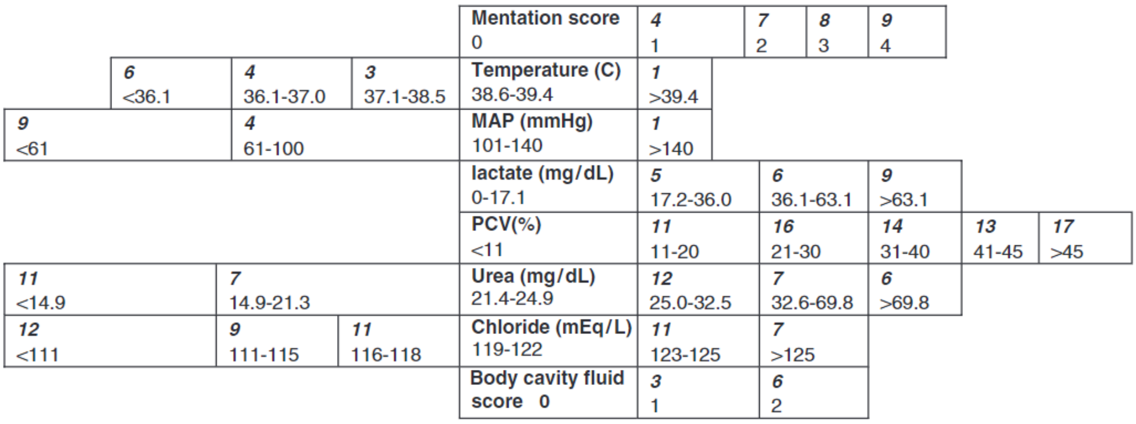
Table 3. The Animal Trauma Triage Scoring System (Ash et al., 2018).

4.3 Acute Patient Physiologic and Laboratory Evaluation (APPLE) score

In 2010 Hayes et al. develop a classification system for critically ill hospitalized patients able to predict the patient's exitus, regardless the pathology that led to hospitalization in intensive care. Although this score is not specific for trauma, a positive correlation was found in dogs between the Acute Patient Physiologic and Laboratory Evaluation (APPLE) score and the ability to predict exitus in traumatized patient (Hayes et al., 2010).

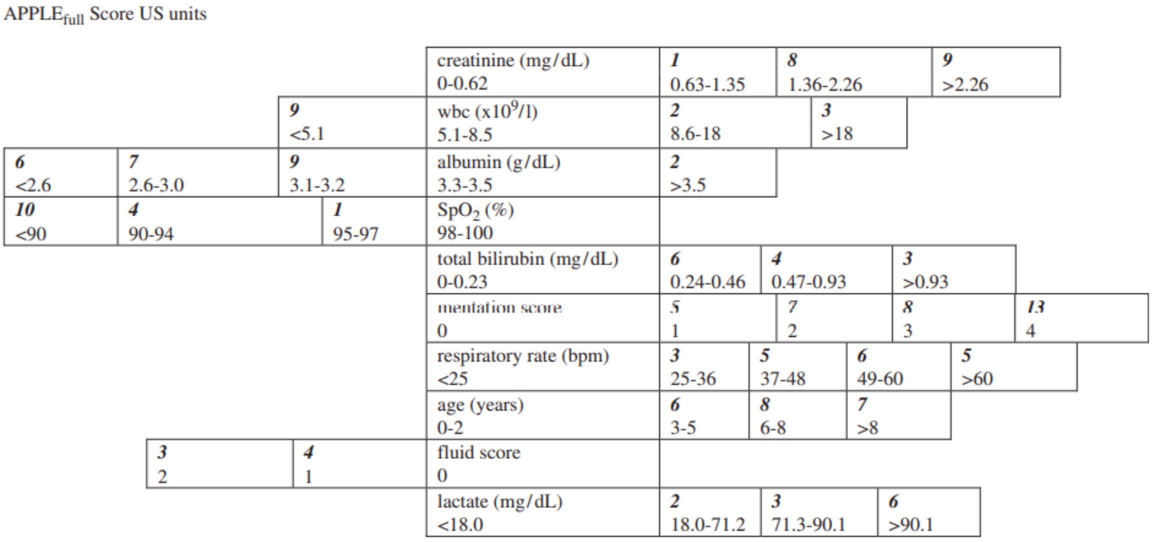
Two different versions of this score have been developed to maximize the possibility of use: the APPLE full score which includes 8 variables in the cat (Figure 3) and 10 variables in the dog (Figure 4) with a maximum predictive capacity and the APPLE fast score which includes 5 variables for both species (Figure 5-6).

For each of these variables a range of physiological and pathological values has been established, which is assigned a score. To apply the APPLE full score is not always feasible, especially in a retrospective study. However, the same study reported that the APPLE fast score higher than 25, had a specificity of 85% predict death (Hayes et al., 2010).



			Mentation score 0	*4* 1	*7* 2	*8* 3	*9* 4	
6 <36.1	*4* 36.1-37.0	*3* 37.1-38.5	**Temperature (C)** 38.6-39.4	*1* >39.4				
	9 <61	*4* 61-100	**MAP (mmHg)** 101-140	*1* >140				
			lactate (mg/dL) 0-17.1	*5* 17.2-36.0	*6* 36.1-63.1	*9* >63.1		
			PCV(%) <11	*11* 11-20	*16* 21-30	*14* 31-40	*13* 41-45	*17* >45
	11 <14.9	*7* 14.9-21.3	**Urea (mg/dL)** 21.4-24.9	*12* 25.0-32.5	*7* 32.6-69.8	*6* >69.8		
12 <111	*9* 111-115	*11* 116-118	**Chloride (mEq/L)** 119-122	*11* 123-125	*7* >125			
			Body cavity fluid score 0	*3* 1	*6* 2			

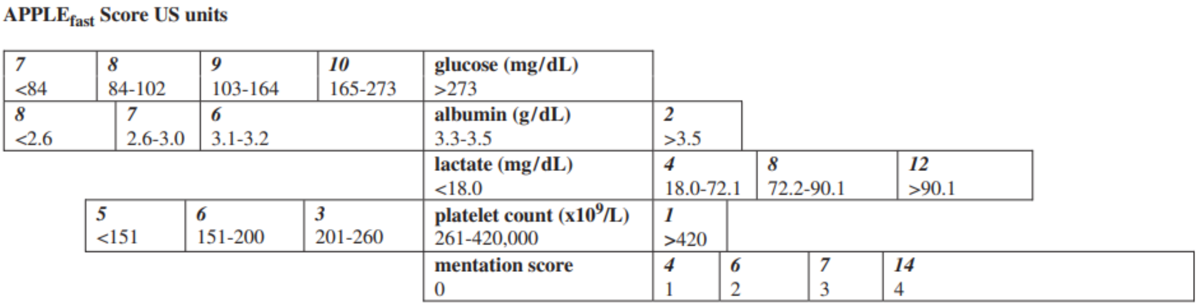
Figure 3: Feline Acute Patient Physiologic and Laboratory Evaluation (APPLE full score) (Hayes et al., 2010).



APPLE$_{full}$ Score US units

			creatinine (mg/dL) 0-0.62	*1* 0.63-1.35	*8* 1.36-2.26	*9* >2.26	
		9 <5.1	wbc (x10^9/l) 5.1-8.5	*2* 8.6-18	*3* >18		
6 <2.6	*7* 2.6-3.0	*9* 3.1-3.2	albumin (g/dL) 3.3-3.5	*2* >3.5			
10 <90	*4* 90-94	*1* 95-97	SpO$_2$ (%) 98-100				
			total bilirubin (mg/dL) 0-0.23	*6* 0.24-0.46	*4* 0.47-0.93	*3* >0.93	
			mentation score 0	*5* 1	*7* 2	*8* 3	*13* 4
			respiratory rate (bpm) <25	*3* 25-36	*5* 37-48	*6* 49-60	*5* >60
			age (years) 0-2	*6* 3-5	*8* 6-8	*7* >8	
	3 2	*4* 1	fluid score 0				
			lactate (mg/dL) <18.0	*2* 18.0-71.2	*3* 71.3-90.1	*6* >90.1	

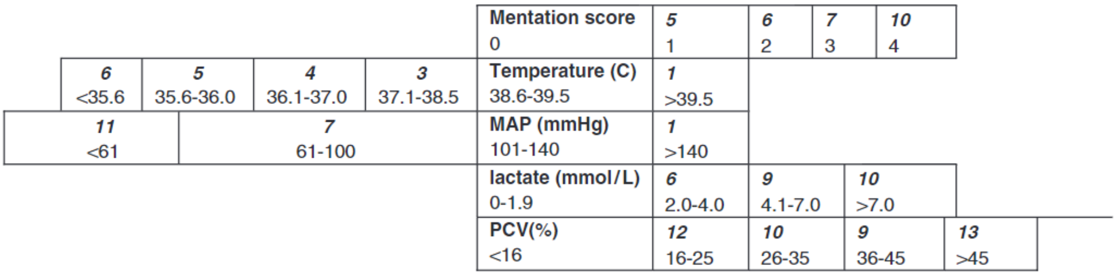
Figure 4: Canine Acute Patient Physiologic and Laboratory Evaluation (APPLE full score) (Hayes et al., 2010).



APPLE$_{fast}$ Score US units

7 <84	*8* 84-102	*9* 103-164	*10* 165-273	**glucose (mg/dL)** >273				
	8 <2.6	*7* 2.6-3.0	*6* 3.1-3.2	**albumin (g/dL)** 3.3-3.5	*2* >3.5			
				lactate (mg/dL) <18.0	*4* 18.0-72.1	*8* 72.2-90.1	*12* >90.1	
	5 <151	*6* 151-200	*3* 201-260	**platelet count (x10^9/L)** 261-420,000	*1* >420			
				mentation score 0	*4* 1	*6* 2	*7* 3	*14* 4

Figure 5: Canine Acute Patient Physiologic and Laboratory Evaluation (APPLE fast score) (Hayes et al., 2010).



				Mentation score 0	*5* 1	*6* 2	*7* 3	*10* 4
6 <35.6	*5* 35.6-36.0	*4* 36.1-37.0	*3* 37.1-38.5	**Temperature (C)** 38.6-39.5	*1* >39.5			
		11 <61	*7* 61-100	**MAP (mmHg)** 101-140	*1* >140			
				lactate (mmol/L) 0-1.9	*6* 2.0-4.0	*9* 4.1-7.0	*10* >7.0	
				PCV(%) <16	*12* 16-25	*10* 26-35	*9* 36-45	*13* >45

Figure 6: Feline Acute Patient Physiologic and Laboratory Evaluation (APPLE fast score) (Hayes et al., 2010).

4.4 Modified Glasgow Coma Scale (MGCS)

The Modified Glasgow Coma Scale (MGCS) is a scoring system that evaluates the motor activity, brainstem reflexes, and level of consciousness based on a score out of 18 (Table 4). The MGCS was originally created to evaluate dogs with neurological impairment following head trauma (Ettinger et al., 2017).

Later, in a study by Ash et al., the MGCS was applied to all dogs, and it evidenced that the score was abnormal (<18) in 380 dogs (10,6%) without apparent head injury and higher score predict better prognosis (Ash et al., 2018).

Motor activity	**Score**
Normal gait, normal spinal reflex	6
Hemiparesis, tetraparesis, or decerebrate activity	5
Recumbent, intermittent extensor rigidity	4
Recumbent, constant extensor rigidity	3
Recumbent, constant extensor rigidity and ophisthotonus	2
Recumbent, hypotonia of muscles, depressed or absent spinal reflexes	1
Brain Stem	
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

Table 4. The Modified Glasgow Coma Scale (Ash et al., 2018).

5 CLINICAL MANIFESTATIONS OF TRAUMA

5.1 Thoracic trauma

Injuries to the thorax are common in trauma patients and can affect any one or all components of the thoracic wall and thoracic cavity (Bertolini et al., 2020).

Depending on the dynamics with which the trauma occurred, it can be divided into blunt or penetrating trauma (Ettinger et al., 2017).

Blunt thoracic trauma occur secondary to a high-velocity impact to the chest wall without penetration into the thoracic cavity. The energy created by the impact is transmitted throughout intrathoracic viscera, potentially leading to life-threatening injuries. It can be the result of various events including motor vehicular accidents, falls from a height, abuse, thoracic compression during cardiopulmonary resuscitation or non-penetrating bites (Dobratz et al.,, 2019).

According to Simpson et al., the chest was the most commonly traumatized region and in the majority of the 235 dogs with blunt trauma that they analyzed were hit by car (Simpson et al., 2009). The same result can be confirmed for cats. In a study of Hernon et al., out of 185 traumatized cats 104 were hit by car, resulting in a blunt trauma (Hernon et al., 2018).

Penetrating thoracic trauma, instead, is defined as any wound that extends from the outside of the thoracic wall through the pleural lining. The most common type of penetrating injuries in veterinary medicine are bite wounds from other animals, gunshot and impalement injuries (Dobratz et al., 2019).

Even if blunt trauma is more frequent than penetrating trauma, in the multicenter prospective study by Hall et al., penetrating trauma occurs in 107 on 315 dogs (34%). Approximately 27% of dogs in the present study had bite wounds, which comprised most of the penetrating wounds (Hall et al., 2014).

Although dog bite wounds are common in veterinary medicine, in a study of 65 dogs and cats with thoracic bite wounds, only eight had an injury penetrating the thoracic cavity (Cabon et al., 2015).

The thorax is the body region most likely to experience trauma from a bite wound in dogs whereas it is second only to the back region in cat (Sharmir et al., 2002).

Penetrating trauma can cause damage to the respiratory tree, lung parenchyma, cardiovascular structures, and esophagus (Dobratz et al., 2019). The internal injuries associated with both categories of trauma can be similar; however, it is important to make the distinction because further exploration of skin, muscle, and subcutaneous space over these cavities may be necessary (Silverstein & Hopper, 2015). Common chest injuries included pneumothorax, pulmonary contusions, hemothorax, rib fractures and diaphragmatic hernia.

5.1.1 Pneumothorax

Pneumothorax is the accumulation of air in the pleural space, and it is one of the most common trauma-associated thoracic injuries (Dobratz et al., 2019).

The high incidence of pneumothorax in traumatized patients was already demonstrated in a retrospective study on dogs with blunt trauma, in which pneumothorax occurred in 30% (Sigrist et al., 2004). Similar results were found also in two prospective studies in which the canine population reported a 17,5% and 21% incidence of pneumothorax (Boysen et al., 2004; Lisciandro et al., 2008).

Depending on the integrity of the chest wall, pneumothorax can be distinguished in open or closed pneumothorax. The open pneumothorax is the result from an insult to the thoracic wall, whereas in closed pneumothorax the air originates from a lesion within the lung parenchyma, trachea, airways, esophagus, mediastinum or diaphragm. There is another particular form, called *tension pneumothorax*, in which there is a site of air leakage that creates a one-way valve during inspiration and results in a rapidly increasing pleural pressure because air is unable to be evacuated (Silverstein & Hopper, 2015).

Both blunt and penetrating trauma can cause pneumothorax. Blunt trauma generally causes a closed pneumothorax. It is thought that the energy absorbed by the thoracic wall at the time of impact is transmitted to the lungs, resulting in rapid compression of air, a transient increase in airway pressure, and rupture of alveoli (Wingfield & Raffe, 2002).

Penetrating trauma to the chest wall, such as bite wounds, cause an open pneumothorax. Air enters the chest from the outside but there may also be leakage of air internally from damaged alveoli (Dobratz et al., 2019).

The degree of respiratory compromise, following the development of pneumothorax, depends on the volume of air and the patient’s innate pulmonary reserve. When air enters the pleural space, the negative intrapleural pressure, which keeps alveoli open, is lost and the result is atelectasis. The larger the volume of air, the greater number of alveoli affected and the less the gas exchange capability. The classic clinical findings in a patient with pneumothorax are tachypnea or dyspnea with soft or absent lung sounds. This is explained because patients with pneumothorax compensate for the loss of functional pulmonary volume by breathing at a faster rate to maintain minute ventilation and prevent hypoxemia. Other clinical signs may be present if there is concurrent disease: in fact, patients who have experienced trauma are likely to have other thoracic injuries such as pulmonary contusions and rib fractures (Dobratz et al., 2019).

Beyond clinical approach, the gold standard for the diagnostic approach is radiography. In radiographs, pneumothorax is visualized as a radiolucent area adjacent to the chest wall or diaphragm where no pulmonary tissue can be seen (Figure 7) (Ettinger et al., 2017).

Figure 7: Cat, domestic short haired, male, 3 years old, referred for bite wounds. Chest radiograph, right lateral recumbency. It is visible a mild amount of pleural effusion, alveolar pattern and caudal atelectasis compatible with pneumothorax.

Thoracic ultrasound is harder to interpretate than radiography, but it has the benefit of being bedside, limiting time to diagnosis and stress for the patient. In a normal thorax, the parietal and visceral pleura can be visualized as two hyperechoic lines sliding past each other during normal respiration (called, *glide sign*); pneumothorax is diagnosed if the glide sign is absent (Lisciandro et al., 2008).

Regarding the treatment, the goal is to restore normal lung expansion by eliminating excess air. Thoracocentesis is the first-line treatment, followed by thoracostomy tubes and continuous suction if needed (Dobratz et al., 2019).

5.1.2 Pulmonary contusion

Pulmonary contusion consists of pulmonary interstitial and alveolar hemorrhage and edema associated with blunt chest trauma, usually after a compression-decompression injury of the thoracic cage (Silverstein & Hopper, 2015).

The interstitial hemorrhage is followed by the modification of capillary permeability, the development of interstitial edema and a progressive migration of inflammatory cells. The inflammatory response causes a decrease in lung compliance and alters the gas exchange, causing hypoxemia and even hypercapnia, in severe cases (Ettinger et al., 2017).

In several studies, it was shown that pulmonary contusion is the most prevalent thoracic lesion after trauma and occurs in roughly 50% of animals with thoracic injuries (Hall et al., 2018; Simpson et al., 2009). Pulmonary contusion was of the most frequent lesions associated with motor vehicular trauma in dogs and with high-rise syndrome in cats (Sigrist et al., 2004; Vnuk et al., 2004).

This lesion can occur as an isolated abnormality or in combination with other thoracic injuries. In two different studies, only 32% and 36,3% of dogs had concurrent fractures or luxation (Selcer et al., 1987; Powell et al., 1999).

From a clinical point of view, patients with pulmonary contusion have tachypnea or dyspnea, depending on the severity of the contusions and the time elapsed between injury and arrival at the veterinary hospital. On general physical examination, auscultation findings may be normal or with increased respiratory sounds and crackles. Hemoptysis appears to be an uncommon finding in small animals but is usually associated with severe lesions. In animals that survive the initial hours, the respiratory derangements associated with pulmonary contusions usually resolve in 3 to 7 days, but delayed deterioration may occur; this may be secondary to complications such as bacterial pneumonia or acute respiratory distress syndrome (ARDS) secondary to the local or systemic inflammatory response (Silverstein & Hopper, 2015).

As for the diagnosis, in addition to the history and clinical-pathological findings, diagnostic imaging can show characteristic changes. The most used method is radiography, which can show areas of patchy or diffuse interstitial or alveolar lung infiltrates that can be either localized or generalized (Figure 8-9) (Silverstein & Hopper, 2015).

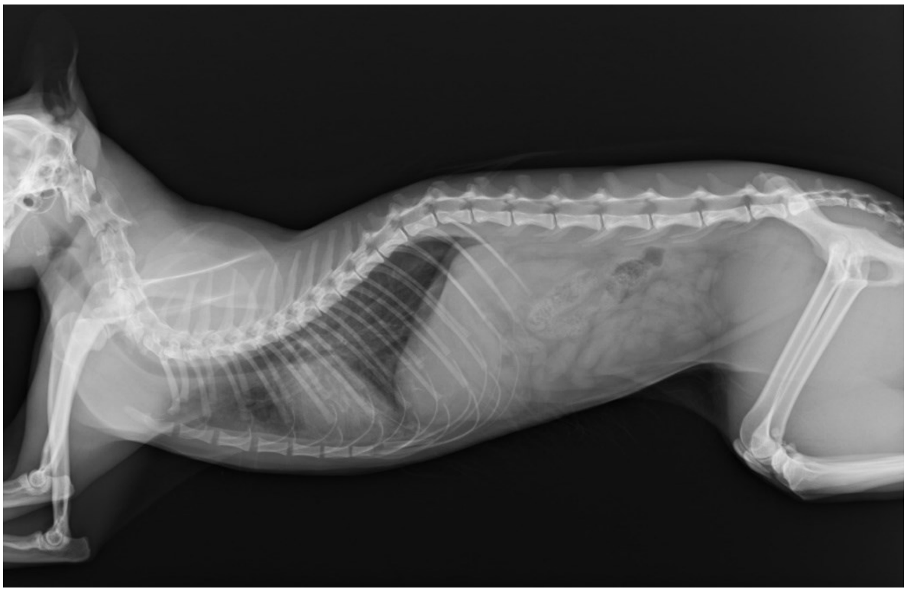


Figure 8: Cat, domestic short haired, male, 3 years old, referred for motor vehicle accident. Total body radiograph, right lateral recumbency. Focal alveolar pattern in the pars caudalis of the left cranial lung lobe and left caudal lung lobe compatible with lung contusion.

Figure 9: Cat, domestic short haired, male, 3 years old, referred for motor vehicle accident. Total body radiograph, dorsal recumbency. Focal alveolar pattern in the pars caudalis of the left cranial lung lobe and left caudal lung lobe compatible with lung contusion.

Due to influx of inflammatory cells and edema, pulmonary contusions typically will worsen radiographically over the first 12-36 hours. However, radiographs may be taken at any point after the patient is assessed as stable enough for radiographs (Ettinger et al., 2017).

Thoracic ultrasound and computed tomography (CT) scanning are becoming more widely used and may have diagnostic advantages compared with radiographs (Dicker et al., 2020; Silverstein & Hopper, 2015).

Management of pulmonary contusions is supportive. Oxygen therapy, judicious fluid therapy and adequate analgesia are essential components of patient management (Dobratz et al., 2019).

5.1.3 Hemothorax

Hemothorax is another possible sequela of thoracic trauma and it has been defined as a pleural space effusion with hematocrit greater than 10% (Lynch et al., 2012).

Pleural effusion can develop from blood loss coming from damaged pulmonary parenchyma or the soft tissue structures; even small arteries and veins may also bleed (Ettinger et al., 2017). Wounds can also involve the great thoracic vessels. In this case, however, they cause a massive hemothorax that does not allow the animal to survive long enough to be taken to the emergency room and death occurs in a short time (Silverstein & Hopper, 2015).

The impact of hemothorax is more likely from hypovolemia associated with the blood loss, than from pleural effusion (Ettinger et al., 2017).

Clinically, signs of dyspnea and tachypnea may be present. However, the volumetric capacity of the pleural space in the dog is about 50-60 ml/kg of fluid, before serious alterations in the breathing characteristics, linked to the mechanical impediment offered by the liquid, can become evident (Silverstein & Hopper, 2015).

Treatment is supportive, including rest and transfusions. Autotransfusion could be considered in blunt trauma patients, as the blood is unlikely to be contaminated. Surgical exploration is a last resort and it should be considered only in case of massive hemorrhage (Ettinger et al., 2017).

5.1.4 Rib fractures

Rib fractures are common in the patients with thoracic trauma (Silverstein & Hopper, 2015).

Recognizing these injuries in a traumatized patient is very important for a few reasons. First of all, rib fractures appear to be painful, particularly on inspiration. This causes a certain stiffness in the chest wall of the patient, resulting in impaired ventilation and expectoration. For this reason, one of the most common complications in animals with rib fractures is the development of pneumonia (Ettinger et al., 2017).

Secondly, rib fractures represent an important early marker of injury to the intrathoracic and abdominal organs. They are often associated with other thoracic injuries, including pneumothorax, hemothorax, pulmonary contusion and diaphragmatic hernia (Figure 10) (Wanek & Mayberry, 2004).

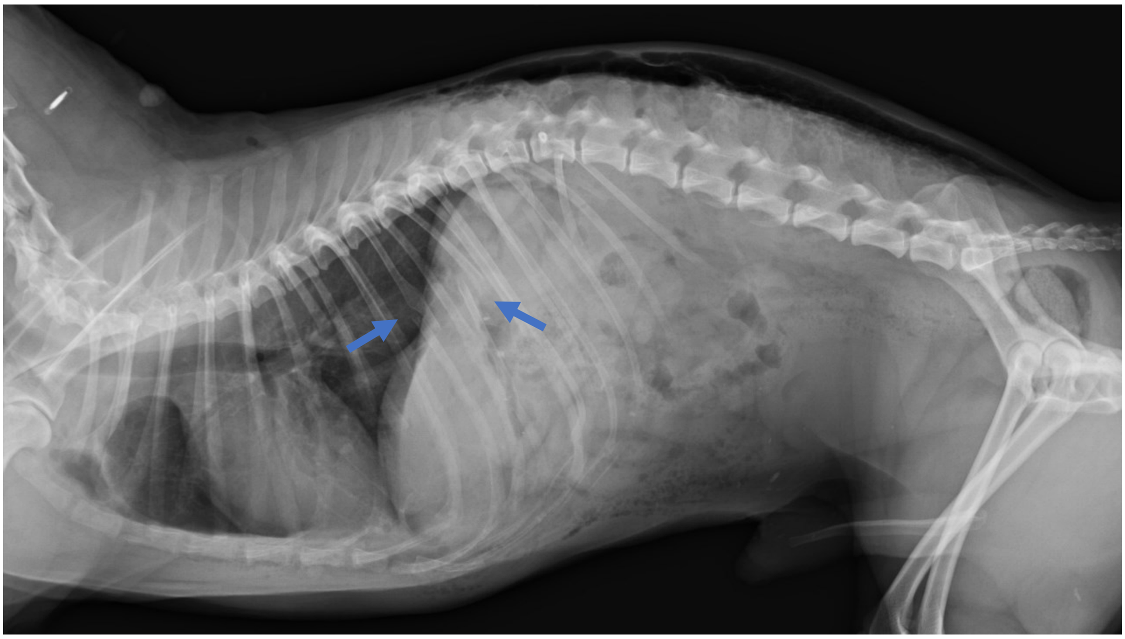


Figure 10: Dog, mixed breed, male, 7 years old, referred for motor vehicle accident. Total body radiograph, right lateral recumbency. The arrows in the picture show rib fractures.

In a study conducted on 364 dogs with blunt thoracic trauma, it was found that 11 out of 46 patients presenting with pulmonary contusion had concomitant rib fractures (Bertolini et al., 2020). A particular form of rib fractures is "*flail chest*", defined as a "fracture of several adjoining ribs resulting in a segment of thoracic wall that has lost continuity with the rest of the hemithorax". This causes a paradoxical movement of the segment during breathing: during the inspiration as the chest wall moves outward, the flail segment collapses inward because of negative intrapleural pressure, and vice versa (Wingfield & Raffe, 2002).

Therapy for rib fractures and flail chest typically is conservative and includes pain management. In case of flail chest, the chest can be wrapped to reduce the bulging of the segment during exhalation to minimize pain and secondary trauma. Time, cage rest, analgesia and, if needed, a support of ventilation, are the treatments of choice for rib fractures (Silverstein & Hopper, 2015).

5.1.5 Diaphragmatic hernia

Traumatic diaphragmatic hernia is created when an opening in the diaphragm allows any of the abdominal organs access to the thoracic cavity (Peterson et al., 2015). It is usually the result of blunt trauma associated with motor vehicular trauma, high-rise syndrome, or dog fighting or attacks by other animals (Silverstein & Hopper, 2015).

More generally, diaphragmatic hernias can also occur in animals with significant thoracic injuries, but they are less common than sometimes believed (Ettinger et al., 2017). Actually, in the study by Streeter et al., in a population of 239 dogs with blunt trauma, only 5% had diaphragmatic hernia (Streeter et al., 2009).

The mechanism by which diaphragmatic hernia is created seems to be an acute transdiaphragmatic pressure gradient. The energy from the blunt trauma causes an increase in intra-abdominal pressure, with subsequent dissipation of the energy cranially toward the diaphragm. If the animal, at the moment of trauma, presents the glottis open, air is expelled from the lungs, with loss of the counterforce, resulting in a rupture of the diaphragm (Dobratz et al., 2019).

Clinical signs of traumatic diaphragmatic hernia are most commonly associated with the respiratory and/or gastrointestinal tracts. Dyspnea varies from none to severe according to the organ herniated, resulting pleural effusion, and concomitant thoracic injuries (Silverstein & Hopper, 2015). These animals may also present with non-specific clinical signs that either developed acutely or may be more insidious, chronic, and intermittent in nature (Dobratz et al., 2019).

The organs most often involved are the liver, stomach and small intestine (Silverstein & Hopper, 2015). This is confirmed even by a study of Schmiedt et al., on a cats population with diaphragmatic hernia: they saw that the organs most commonly herniated into the thorax included the liver (82,3%), stomach (50%), small intestine (47%), omentum (44,1%) and spleen (44,1%) (Schmiedt et al., 2003).

The diagnostic process involves, as usual, an initial physical examination and the use of diagnostic imaging. During the initial physical examination, some non-specific clinical signs may be detected, such as abnormal color of mucous membranes or tachypnea. Other clinical signs that may advance the diagnosis of suspicion of hernia at the are the evidence of a new heart murmur, arrhythmias, decreased lung sounds, and/or borborygmus (Dobratz et al., 2019).

The diagnosis of certainty will instead take place with the use of diagnostic imaging. Radiography once again appears to be the first-choice for the diagnosis of diaphragmatic hernia. Thoracic radiographs may reveal gas-filled abdominal organs within the thorax, an incomplete diaphragmatic border, pleural effusion, or cranially displaced abdominal organ (Figure 11) (Silverstein & Hopper, 2015).

Figure 11: Dog, mixed-breed, female, 4 years old, referred for motor vehicle accident. Chest radiograph, right lateral recumbency. It is visible multiple small intestinal loops in the chest compatible with diaphragmatic hernia.

Ultrasonography may also be utilized for the diagnosis. One study reported an accuracy of 93% in confirming a diaphragmatic hernia by noting abnormal borders or positioning of abdominal structures. This modality can be also used to evaluate both the abdomen and thorax and can be quite useful when pleural effusion is present (Spattini et al., 2003).

Initial treatment of these patients is based on the severity of clinical signs. The goal of therapy is to stabilize the patient and determine if emergency surgery is indicated (Dobratz et al., 2019).

In most cases of diaphragmatic hernia, surgical intervention is required, but the timing of surgery is quite discussed. According to Sullivan et al., in a study regarding the management of 60 cases with diaphragmatic rupture, diaphragmatic hernia is a surgical emergency only if the evidence of gastrothorax is present, otherwise surgery should be delayed 24–48 hours to allow the stabilization (Sullivan & Reid, 1990).

5.2 Abdominal trauma

Involvement of the abdomen or abdominal organs following trauma is a very common occurrence in veterinary medicine. As for thoracic trauma, the etiology of abdominal trauma can be defined by blunt trauma or penetrating trauma, or a combination of these two. Among blunt trauma, the most common causes are motor vehicular accidents, high-rise falls and intentional physical injuries; instead, among the most common causes of penetrating trauma there are aggression by other animals, impalement and gunshot trauma (Silverstein & Hopper, 2015).

In a study with over 1000 dogs and nearly 200 traumatized cats, the most common causes of abdominal trauma in dogs were motor vehicular trauma (10%), aggression from other animals (9,6%) and falls from heights (7,4 %); in cats, on the other hand, the main cause was the aggression by other animals (16,6%) followed by falls from heights (12,5%) and motor vehicular trauma (7,27%) (Kolata, 1980).

The same results are confirmed by other studies. In particular, about motor vehicular trauma, a study was carried out on more than 600 dogs which showed an incidence of abdominal trauma in 5% of dogs, of which the liver was the most affected organ (31%) (Kolata & Johnston, 1975). As regards the fall from heights, an incidence of abdominal injuries was found in 15% and 7% of cases, respectively in dogs and cats (Gordon et al., 1993; Whitney & Mehlhaff, 1987). Abdominal injuries were uncommon in cats that fall from height because it was hypnotized that this was secondary to the forelimbs absorbing the impact of the landing (Vnuk et al., 2004).

It is sometimes difficult to discriminate injuries based on the type of trauma, as patients suffering severe blunt or penetrating trauma might be expected to have multiple injuries. In fact, in most cases, thoracic and abdominal injuries coexist. In a study carried out on 235 dogs with blunt trauma, abdominal trauma was isolated in 50,2% of cases in the absence of other concomitant injuries while it was found to coexist with thoracic injuries in 20,4% of cases (Simpson et al., 2009).

Common abdominal injuries include hemoperitoneum, abdominal hernia and urinary tract ruptures.

5.2.1 Hemoperitoneum

The hemoperitoneum is defined as the presence of a hemorrhagic effusion within the peritoneal cavity. Both blunt and penetrating trauma can cause hemoperitoneum, with motor vehicle injury recognized as the main leading cause (Silverstein & Hopper, 2015).

In a study of 40 dogs sustaining motor vehicle trauma, 38 dogs were found to have hemoperitoneum as diagnosed by ultrasound and fluid analysis (Boysen et al., 2004).

In most case of traumatic hemoperitoneum, the hemorrhage derives from the liver and the spleen, as well as from the avulsion of small or big vessels or fractures of abdominal organs (Dobratz et al., 2019). In a study of 38 dogs with traumatic hemoperitoneum, the liver and the spleen were bleeding respectively in 58% and 50% of total, whereas in 23% of cases it was found out kidney hemorrhages (Figure 12) (Mongil et al., 1995).

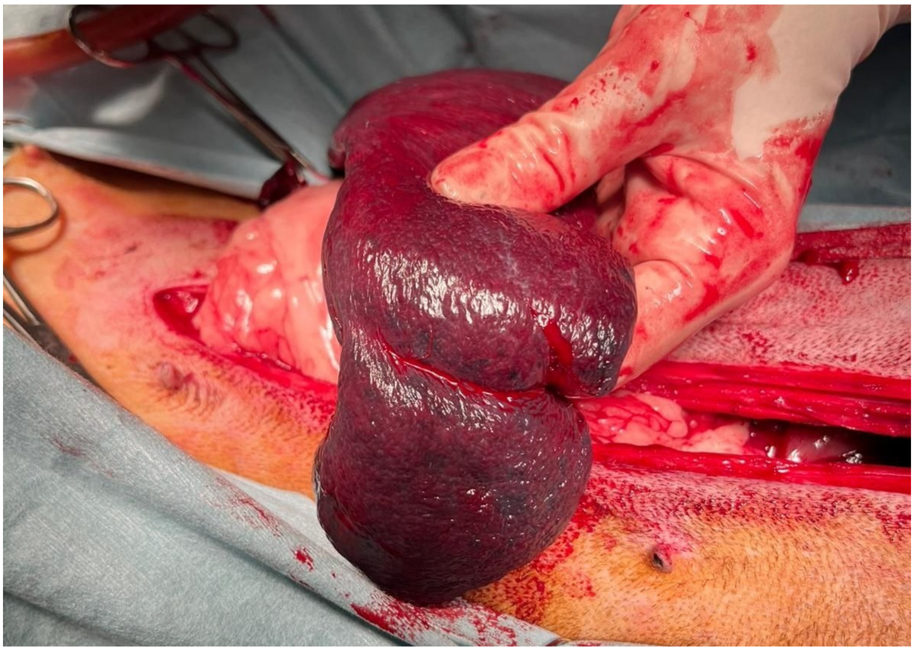


Figure 12: Splenic contusion in a dog with motor vehicle accident.

In cats, there is a paucity of available data on traumatic hemoperitoneum. A study on spontaneous hemoperitoneum in cats reveals that it is less frequent in this species than in dogs but, when present, in the cat it leads to a worse prognosis (Culp et al., 2010).

Diagnosis of hemoperitoneum begins with the detection of clinical signs and a general physical examination. Clinical signs and physical findings may vary depending on the species, the etiology, the severity and the acuteness of the hemorrhage. It should also be considered that a traumatized patient may also have concomitant injuries that can worsen the clinical picture (Dobratz et al., 2019).

On general physical examination, abdominal pain or abdominal distension may be noted. In some cases, there may also be a positive succussion test if the free fluid in the abdomen is greater than 40ml/kg. Animals may present hemorrhagic shock with white or pale mucous membranes, absent or prolonged capillary refill time, hypothermia, bradycardia or tachycardia, absent or weak peripheral pulses, generalized weakness, and an obtunded or depressed mental state (Herold et al., 2008).

Other patients, on the other hand, may have signs of compensatory shock if they have slower or less severe bleeding with hyperemic mucous membranes, rapid capillary refill time, hyperdynamic pulses, and variable tachycardia (Dobratz et al., 2019).

Cats with hemoperitoneum may have signs of lethargy, anorexia and vomiting (Culp et al., 2010).

Apparently stable patients should be closely and serially monitored as some may subsequently deteriorate if there is significant ongoing blood loss. Initial diagnostic tests can be run during patient stabilization, if necessary. The most available and cheap test, which also provides a basis for future serial monitoring, is PCV/TP performed on both blood and abdominal effusion (Dobratz, Hopper, Rozanski, & Silverstein, 2019).

In a patient with acute hemorrhage, normal PCV and low TP may occur. The descent of the PCV, on the other hand, represents a chronic process. The PCV/TP on the effusion allows to distinguish a true hemorrhage from a blood contamination of the effusion: a true hemorrhagic effusion should have a PCV that is at least 10–25% peripheral blood and not contain any other microscopic abnormalities such as bacteria or neoplastic cells (Alleman, 2003).

Subsequently, a complete blood count and a serum biochemical panel must be performed to provide information on the function of organs involved in the traumatic process. For example, elevated liver enzymes are commonly seen in cases of blunt abdominal trauma from hepatocellular injury and enzyme leakage (Simpson et al., 2009).

The next step is the diagnostic imaging: an initial A-FAST, and then repeated serially, allows to identify and monitor the amount of fluid present in the abdomen. Thoracic and abdominal radiographs and a complete abdominal ultrasound can verify the presence of concomitant injuries and possibly detect the origin of hemorrhage (Dobratz et al., 2019).

The choice of the treatment and the prognosis depend on the underlying cause and on the response to resuscitation measures. Patients with traumatic hemoperitoneum may or may not require surgical intervention and should be closely monitored during resuscitation efforts, whereas small volume or self-limiting hemoperitoneum could be treated with medical treatment. The medical treatment includes fluid therapy, abdominal compression, and/or transfusion therapy. If patients remain unstable, surgery should be considered (Herold et al., 2008; Mongil et al., 1995).

The prognosis, in cases of traumatic hemoperitoneum, will widely very depending on how severe the blood loss is and on the severity of concurrent injuries. Generally, there is a good prognosis for both treatments. In a study by Mongil et al., the survival rates for animals that had surgical intervention and animals that were treated medically were 67% and 75%, respectively (Mongil et al., 1995).

Animals with significant blood loss, concurrent injuries, or who do not stabilize after initial treatment may have a less favorable prognosis (Dobratz et al., 2019).

5.2.2 Abdominal evisceration

Abdominal evisceration is defined as herniation of the contents of the peritoneal cavity through the body wall with exposure of the abdominal viscera (Çığdem et al., 2006).

The rupture of the body wall can occur when penetrating trauma results in an opening of the abdominal cavity with herniation of abdominal contents (Silverstein & Hopper, 2015).

Most cases reported in the literature are secondary to bite wounds or motor vehicle trauma. In a study on 36 cases, 54% of dogs with abdominal evisceration received bite wounds and 38% had motor vehicle trauma (Shaw et al., 2003).

This type of injury is considered an emergency and surgery should be pursued as soon as possible. Complications are not only caused by the lesion of the abdominal wall and by any injury to the organs, but also by the contamination of the same once they receive contact with the external environment, especially if injuries are caused by bites. For this reason, a full abdominal exploration should be performed to evaluate all intra-abdominal organs for injury or compromise. Intestines have been reported to be displaced through the rupture in as many as 54% of cases and often require a resection and anastomosis because of devitalized tissue. Other organs commonly displaced include the omentum, liver, and urinary bladder (Silverstein & Hopper, 2015).

There are not many studies regarding prognosis. In a study on 12 cases with abdominal evisceration injuries, all animal survived whereas in another study on 36 dogs and cats, 73% of dogs and 80% of cats survived to discharge (Gower et al., 2009; Shaw et al., 2003).

5.2.3 Urinary tract injuries

Urinary tract injuries are common, following trauma, and these could vary from contusions to full-thickness lacerations or avulsions (Drobatz et al., 2011).

When the distal ureters, the bladder or the proximal part of the urethra are injured, the urine contained in them will pour into the peritoneal cavity causing uroperitoneum. Conversely, when kidneys or proximal ureters are injured and the peritoneum remains intact, urine leakage will result in uroretroperitoneum. Therefore, the presence of uroperitoneum or uroretroperitoneum, or both, is referred as uroabdomen (Thornhill & Cechner, 1981).

Uroabdomen in dogs and cats is most often associated with blunt trauma to the abdomen or pelvis and its reported incidence following trauma is 0,003% to 5% (Kolata & Johnston, 1975).

The bladder appears to be the most frequently ruptured organ. In a study on 26 cats with abdominal blunt trauma, 13 cats presented uroperitoneum and 11 of them had the urinary bladder ruptured (Aumann et al., 1998). The reason seems to be related to a rapid increase in intraperitoneal pressure at the time of the trauma which can cause the bladder to rupture, especially if distended at the moment of impact (Harrahill, 2004).

Another common site of injury is the urethra. The rupture of the urethra in dogs is often associated with pelvic fractures. In a study on 20 dogs and 29 cats, the 85,5% of dogs had concomitant pelvic fractures. Conversely, in cats only 37% presented pelvic injuries (Anderson et al., 2006).

Urethral rupture also seems to be much more common in males than in females. This could be explained by the fact that males have a longer, smaller diameter urethral course that is less adapted to intra-abdominal pressure changes (Osborne & Finco, 1972).

Regardless of the cause of the uroabdomen, the complications are the same. Potassium contained in the urine accumulates in the abdominal cavity and is reabsorbed systemically causing hyperkaliemia and other electrolyte imbalances (Stafford & Bartges, 2013).

At the same time, the presence of urine causes an increase in the concentration of creatinine and urea in the abdominal cavity which causes a progressive azotemia. The inability to excrete uremic acids, severe dehydration and/or hypovolemia causes metabolic acidosis with hyperlactatemia. In addition to the metabolic derangements described above, the chemical peritonitis that results from direct contact of urine with the peritoneum causes substantial pain (Dobratz et al., 2019).

Clinical signs may be non-specific with vomiting, anorexia or lethargy, or more specific with urinary signs like dysuria or anuria (Aumann et al., 1998)

On physical examination, these animals may show signs of hemodynamic compromise. In addition, they may have abdominal distention, abdominal pain, and a palpable fluid wave. The urinary bladder may or may not be palpable, but a palpable urinary bladder does not rule out a leak of rupture in the urinary tract (Fossum, 2007; Rieser, 2005).

Diagnosis of uroabdomen is based on history and physical exam findings along with laboratory evaluation and imaging studies (Stafford & Bartges, 2013).

If abdominal effusion is noted on abdominal palpation or with focused assessment with sonography for trauma (FAST) examination, a sample of the effusion should be collected by abdominocentesis with or without ultrasound guidance and analyzed for biochemical and cytologic characteristic (Boysen et al., 2004).

The sample can result in non-septic neutrophilic inflammation with a cell count > 5,000 nucleated cells per microliter, a specific gravity > 1.025 and total solids of > 3,0 g/dL (Ettinger et al., 2017). To confirm that the effusion is originating from the urinary tract, the ratios of creatinine and potassium in the abdominal effusion to peripheral blood can be compared (Table 5) (Stafford & Bartges, 2013).

Laboratory evaluation	**Clinical significance**
Creatitine of abdominal effusion is ≥ 2 times that of peripheral blood	Considered diagnostic to uroabdomen
Creatitine of the abdominal effusion > 1 but < 2 times that of peripheral blood	Suggestive for uroabdomen but additional criteria necessary to obtain diagnosis
Potassium of the abdominal effusion > peripheral blood	Suggestive for uroabdomen. The higher the ratio, the more strongly suggestive

Table 5: Guidelines for diagnosis of uroabdomen in dogs and cats (Stafford & Bartges, 2013).

Following initial stabilization and laboratory diagnostics, abdominal imaging is necessary to document the location of the disruption in the urinary tract. Imaging modalities include abdominal radiographs, abdominal ultrasound, retrograde positive contrast cystography, excretory urography and CT (Armenakas, 1999).

In veterinary medicine, radiography is the modality of choice. Loss of detail in the peritoneal cavity or retroperitoneum may be indicative of free fluid in the peritoneal cavity or retroperitoneal space. In addition, avulsion of a kidney can be noted radiographically. Visualization of a urinary bladder on radiographs does not confirm an intact bladder or urinary tract (Ettinger et al., 2017).

The location of the disruption to the urinary tract should be identified. For this purpose, retrograde positive contrast cystography remains the diagnostic of choice in most clinical settings (Figure 13) (Anderson et al., 2006).

Figure 13: Dog, Dachshund, male, 8 years old, referred for motor vehicle accident. Retrograde positive contrast urethrography, right lateral recumbency. It is visible the accumulation of free contrast medium in the abdominal cavity due to urethral rupture.

Treatment is based on patient stabilization. Once the patient is stable for anesthesia, surgical repair, if indicated, may be performed (Ettinger et al., 2017).

The prognosis of patients with uroabdomen depends on the extent of urinary and non-urinary injuries as well as the development of complications. In a study of 26 cats with uroperitoneum, the prognosis for those cats treated for uroabdomen with no concomitant injuries was uncertain with 61,5% discharged from the hospital (Aumann et al., 1998).

There is paucity of data in literature to value the prognosis for dogs.

5.3 Head trauma

Head trauma is a common cause of morbidity and mortality in small animals. In 235 dogs with severe blunt trauma, head trauma occurs in approximately 25% and is associated with increased mortality (Simpson et al., 2009).

More than 50% of head trauma in dogs and cats is caused by motor vehicle accidents or, more generally, unknown blunt trauma. Other common causes are falls from heights, bite wounds and gunshots (Kolata, 1980; Kuo et al., 2018).

In case of blunt trauma, the energy dissipates to the rest of the body so the brain injury can be evident or obscured by other injuries. Conversely, in head penetrating trauma, it is more common for the injuries to remain limited to the head because the energy is dissipated in the way (Ettinger et al., 2017).

Traumatic brain injury can be divided in two categories: primary injury and secondary injury. Primary injury occurs as an immediate result of the traumatic event and it is the result of the physical disruption of intracranial structures. Primary injury includes concussion, contusion and laceration (Silverstein & Hopper, 2015).

Concussion is characterized by a brief loss of consciousness, whereas contusion consists in parenchymal hemorrhage and edema and it clinical signs could vary from mild to severe. Laceration is the most severe primary injury and it consists in physical disruption of the brain parenchyma. Hemorrhage, hematoma formation, and subsequent compression of the brain parenchyma may also occur (Kuo et al., 2018).

Secondary injury occurs during the hours to days after trauma and is caused by a complex series of biochemical events, including release of inflammatory mediators and excitatory neurotransmitters, and changes in cellular membrane permeability (Silverstein & Hopper, 2015).

The accumulation of neurotransmitters causes an influx of sodium and calcium resulting in depolarization and release of other neurotransmitters. Excessive sodium causes cytotoxic edema, whereas calcium activates destructive proteases, lipases and endonuclease. The result is neuronal death (Kuo et al., 2018).

Some systemic conditions also get worse traumatic brain injury by compromising brain perfusion. Hypotension, hypoxia, systemic inflammation, hyperglycemia or hypoglycemia, hypercapnia or hypocapnia, hyperthermia and abnormalities in electrolytes or acid-base balance all contribute. Intracranial hypertension aggravates and accelerates the progression of secondary damage, and when the compensation systems are no longer effective, cerebral perfusion is reduced, causing cerebral ischemia (Sande & West, 2010).

An increased intracranial pressure generates a clinical condition defined as *Cushing's reflex* or ischemic cerebral response: the cerebral vasomotor center recognizes the increase in carbon dioxide (CO2) given by the reduction in cerebral blood flow and this activates the sympathetic system, which releases catecholamines, inducing vasoconstriction. The baroreceptors of the aortic and carotid arch record the increase in pressure and induce reflex bradycardia. A patient with a depressed mental state, hypertension, bradycardia and tachypnea indicates potentially fatal intracranial hypertension, for which immediate treatment is indicated (Dewey, 2000; Kuo et al., 2018).

Other clinical signs associated with intracranial hypertension are: altered pupillary reflex, decerebration posture (opisthotonos with hyperextension of the four limbs) and loss of physiological nystagmus (Siegel, 1995).

The initial neurologic examination should be interpreted considering the cardiovascular and respiratory system because shock can have a significant effect on neurologic status, reducing the patient’s level of consciousness and pupillary responses. Once this is considered, an initial neurological examination may be focused on mentation, brain stem reflexes and motor activity/posture to assign a score using the MGCS. Assessment of the cardiovascular system should focus on detecting an adequate tissue perfusion (pink mucous membranes, capillary refill time of 1 to 2 seconds, good peripheral pulse quality, and a normal heart rate). In addition, systemic blood pressure should be monitored routinely. Respiratory rate, respiratory effort and thoracic auscultation may indicate respiratory compromise (Silverstein & Hopper, 2015).

Regard to diagnostic imaging, head trauma patient may be value for concurrent injuries, that is why thorax and abdominal radiographs, a FAST exam, and even a CT scan if necessary, should be made. To investigate traumatic brain injuries, CT scanning is the modality of choice because it is helpful in identifying fractures, parenchymal damage, hemorrhage and herniation (Platt et al., 2022).

Compared to CT, radiographs of the skull in patients with head trauma are an insensitive diagnostic tool and rarely provide valuable information (Silverstein & Hopper, 2015).

The treatment of a patient with traumatic brain injury had to consider both intracranial and extracranial concerns. Extracranial priorities include ventilation, oxygenation, and maintenance of normal blood pressure, whereas intracranial priorities include treatment of intracranial hypertension and control of cerebral metabolic rate (Figure 14-15) (Ettinger et al., 2017).

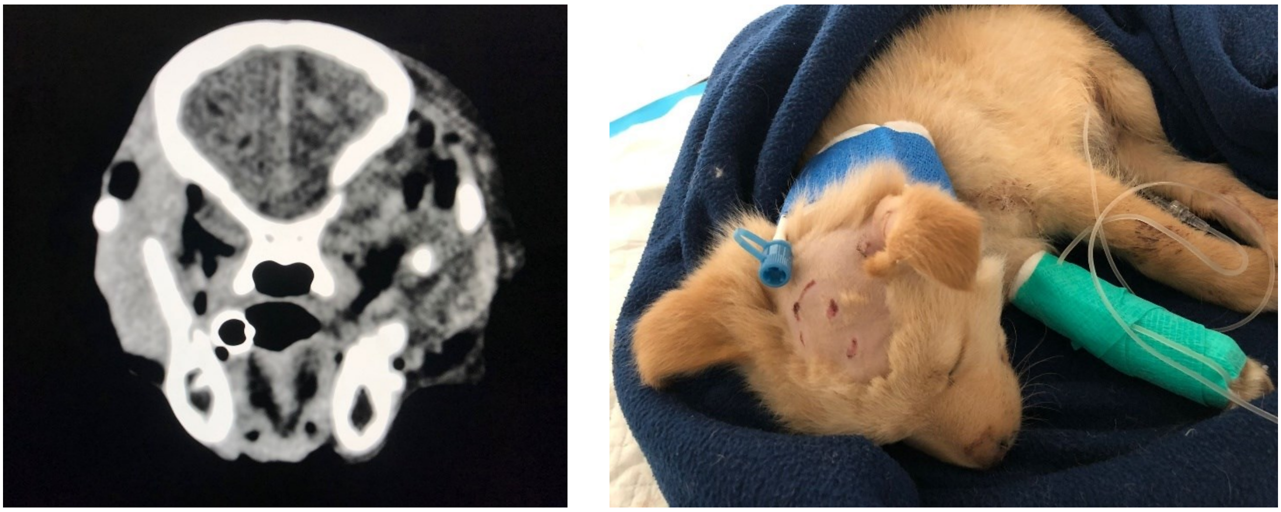


Figure 14-15: Dog, mixed-breed, male, 3 months years old, referred for bite wounds. CT shows fracture of the basisphenoid and cerebral hemorrhage compatible with head trauma.

The mortality rate for head trauma varies from 18% to 24% (Sande & West, 2010; Platt et al., 2022).

In a study on 72 dogs with head trauma, some prognostic factors were correlated to poor prognosis. Among these, decreased pulse oximetry, pH, bicarbonate concentration or base excess, increased potassium and lactate concentration were risk factors for non-survival. The MGCS score was the strongest predictor of non-survival: a score ≤ 11 was 84% sensitive and 73% specific for prediction non survival (Sharma & Holowaychuck, 2015).

5.4 Orthopedic Emergencies

Orthopedic injuries are common in polytrauma patients and occur after motor vehicle accidents, falls from heights, bite wounds and gunshot trauma (Gordon et al., 1993; Selcer et al., 1987; Simpson et al., 2009).

5.4.1 Bones fractures and joint luxation

When forces applied to a bone exceed its physiological capacity, traumatic orthopedic injury results, often in the form of a fracture. The type of fracture varies according to the type of force that is applied. For example, a compressive force causes a fracture along the lines of the highest shear stress causing an oblique fracture of a long bone, while a tensile force causes simple transverse fractures. When multiple forces are applied concurrently, combinations of fracture configurations occur (Figure 16). A fracture can be classified as open or closed fracture. This depends on the energy released and the amount of soft tissue surrounding the bone: high-energy fracture in the proximal region of the limb, where soft tissues are more plentiful, tends to be closed, while a similar injury in the distal part of the limb, where soft tissues are less robust, may results in an open fracture (Dobratz et al., 2019).

Figure 16: Dog, mixed-breed, male, 2 years old, referred for gunshot trauma. Hindlimb radiograph, right lateral recumbency. It is visible an oblique fracture of the tibial diaphysis and metallic opacities in the fracture's line compatible with bullets.

Most fractures do not need to be fixed immediately, except skull and vertebral trauma. Skull, maxillofacial and mandible fractures require prompt diagnosis and treatment due to concurrent life-threatening injury to the central nervous system and the eventual compromise of the upper airway, due to facial and oral swelling (Mulherin et al., 2014; Arzi & Verstraete, 2015).

Joint luxation occurs as a result of damage to the supporting ligaments, tendons, joint capsule, and other soft tissue structures surrounding the joint. The hip joint is the joint most commonly luxated in small animals, with the femoral head luxated in the craniodorsal direction (Figure 17) (Dobratz et al., 2019).

Figure 17: Cat, male, 2 years old, referred for motor vehicle accident. Hindlimb radiograph, dorsal recumbency. It is visible right coxo-femoral luxation and multiple fractures of the pelvis.

Detection of fractures and joint luxation is the last step in the global approach to trauma. Once the patient is stable, a gentle palpation of the limbs, along with assessment of range of motion and stability of the joints, should be done. Any suspicions will be investigated with diagnostic imaging and, in particular, with the use of radiographs.

The initial management of orthopedic emergencies therefore concerns only some types of fractures. Open fractures must be treated with the aim of limiting infection and preventing osteomyelitis, closed fractures must be immobilized to facilitate patient movement and increase comfort (Dobratz et al., 2019).

5.4.2 Spinal trauma

Vertebral trauma consists in spinal cord injury, and it occurs by two mechanisms, such as traumatic brain injury. Primary injury results from the initial traumatic compressive force exerted on the spinal cord causing contusion, hematoma and/or laceration; whereas secondary injury consists in a deleterious cascade of vascular, biochemical and inflammatory events that get worse the zone of tissue destruction (Olby, 2010).

In case of spinal cord injury, the animal must be immobilized in lateral recumbency to a rigid board. Before starting analgesic treatment, a neurological assessment should be made to allow to identify the localization of the spinal cord injury (Figure 18). Some traumatic conditions may confound neurological assessment: for example, the Schiff-Sherrington posture and the spinal shock (Dobratz et al., 2019).

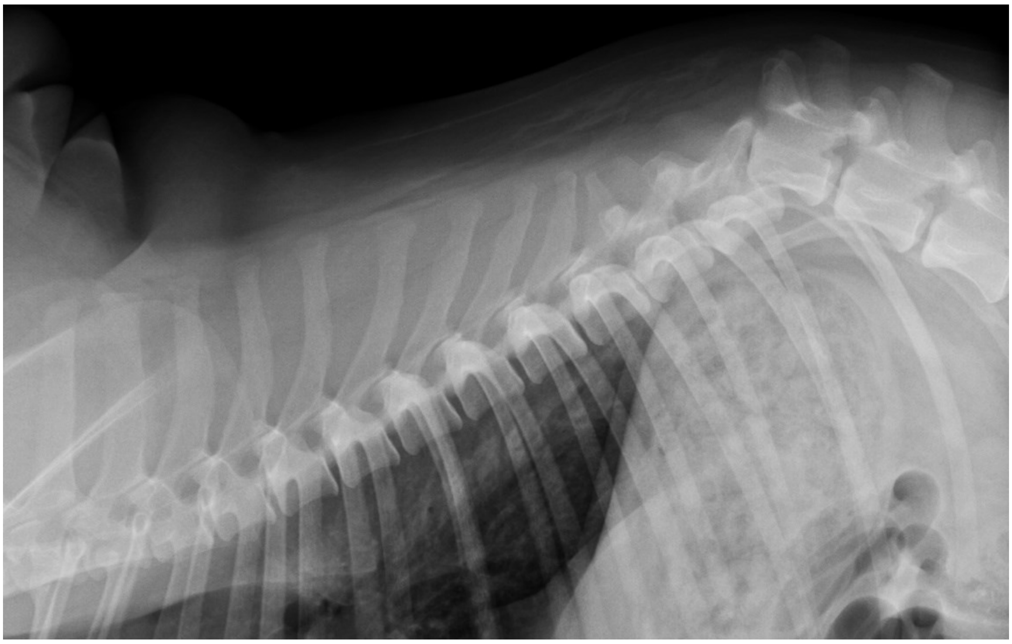


Figure 18: Dog, American Staffordshire, 5 years old, referred for motor vehicle accident. Spinal radiograph, right lateral recumbency. It is visible T13-L1 luxation.

The Schiff-Sherrington posture occurs with damage to “border cells” in the thoracolumbar spinal cord segments that normally ascend to inhibit thoracic limb extensor tone (Sprague, 1953). The result is rigid extension of the thoracic limbs. This may be misinterpreted as indicating C1–C5 lesion, but proprioception and nociception of the thoracic limbs will be intact, and movement attenuated only by the increased extensor tone (Dobratz et al., 2019).

Spinal shock, instead, is the loss of muscle tone and spinal reflexes caudal to the site of peracute spinal cord injury (Ditunno et al., 2004). This phenomenon resolves within hours in animals, but initial hyporeflexia can be confused with lower motor neuron disease (Smith & Jeffery, 2005).

Spinal cord injury should initially be directed at both preventing ongoing primary injury and minimizing the development and progression of secondary mechanisms of injury. Definitive injuries repair should be postponed until the patient is a good candidate for anesthesia and the soft tissue are sufficiently healthy for closure, grafting or continued open wound therapy (Figure 19) (Dobratz et al., 2019).

Figure 19: Vertebral fracture in a puppy with bite wounds.

RETROSPECTIVE STUDY

6 OBJECTIVE OF THE STUDY

Trauma, defined as tissue injury that occurs suddenly and includes any physical damage to the body, is a common presentation in veterinary medicine (Muir, 2006; Streeter et al., 2009).

According to some epidemiologic studies, trauma patients make up 10%-30% of cases admitted to the Intensive Care Unit in Veterinary Hospitals and prognosis has been reported to be favorable between the 87% and the 92% of patients (Hall, 2019; Kolata, 1980).

Despite this, trauma is a common cause of morbidity and death in small animal (Muir, 2006).

The prognosis is worse when associated with "*severe trauma*" or "*multiple trauma*", which are currently considered synonyms of "*polytrauma*”. Actually, polytrauma is defined “injury to at least two body regions with abbreviated injury scale ≥ 3 associated to one or more pathologic conditions like hypotension, altered state of consciousness, metabolic acidosis, hemostatic dysfunction and old age and also with the presence of SIRS on at least one day during the first 72 hours” (Butcher et al., 2009). In a study on 185 traumatized cats, polytrauma is associated with high risk of death, with a mortality between 25% and 64% (Hernon et al., 2018).

Physical injury can be caused by several type of trauma: motor vehicle accident, animal interaction, fall from heights, gunshot trauma, crushing force or unknown trauma (Kolata, 1980).

Despite the frequency and the severity of trauma patient admitted to Veterinary hospitals, literature lacks on a great deal more species-specific discussion of the subject. Indeed, comparatively few reviews, case reports, or case series published in the veterinary literature discuss or describe the physical findings, clinical course, or response to therapeutic interventions in dogs or cats suffering from naturally occurring traumatic events (Muir, 2006). Moreover, the few studies in the literature are currently dated.

This study describes a population of dogs and cats referred between January 2018 and March 2022, to the Ospedale Veterinario Universitario of Parma (OVUD), with a diagnosis of trauma. The purpose of the study was to assess the short-term outcome and its association with the type of injury, the type of trauma and other clinical, clinical-pathological and diagnostic imaging data. The second aim was to identify any prognostic factors that could predict the patient outcome.

7 MATERIALS AND METHODS

The study was conducted retrospectively on a population of dogs and cats referred to the Emergency Unit of the Ospedale Veterinario Universitario Didattico of the Department of Veterinary Sciences of the University of Parma.

The study included dogs and cats arrived at the OVUD, between January 1st 2018 and March 31st 2022, after a witnessed or suspected traumatic event.

7.1 Records research

Data collection was carried out using the database software used at OVUD. Some keywords were searched that could be linked to the cases of polytrauma patients in the last 3 years (e.g., *polytrauma, trauma, motor vehicle accident, run over, fall from heights, animal interaction, gunshot trauma, crush injury, found*).

After the initial research, patients have been included in the study based on the following inclusion criteria:

- Diagnosis of suspicion or certainty of trauma;
- Time elapsed from the traumatic event of less than 24 hours;
- No therapeutic treatment administered before admission to the hospital, in case of patients referred by other colleagues;
- Complete medical records of:
    - Blood gas analysis at the admission, or alternatively a complete blood count and a basic clinical biochemical profile;
    - Radiographic examination and/or abdominal/thoracic focused assessment with sonography for trauma (A-FAST/T-FAST) at the admission.

Dogs and cats were excluded if they did not meet the inclusion criteria or if they were discharged against medical advice.

7.2 Study methodology

For each patient included in the study, some anamnestic, clinical and clinical-pathological parameters were collected. Regarding the signalment and anamnesis, it was considered: age (in months), body weight (kg), species, sex and the event causing the trauma. In particular, the etiology of trauma was further categorized into 1 of 6 groups: vehicular trauma, fall from heights, animal interaction, crush injury, gunshot trauma and unknown.

For those animals whose blood counts, venous blood gas analysis and biochemical profile were assessed, only few parameters were recorded:

- Hematocrit (%)
- Albumin (g/dL)
- Total Protein (g/dL)
- Creatinine (mg/dL)
- Alanine-transaminase ALT (U/L)
- pH
- Glycemia (mg/dL)
- Lactate (mmol/L)

For those animals whose blood pressure and heart rate were assessed, the Shock Index (SI) was also calculated. Based on the availability of some necessary data (lactates, platelets, glycemia, albumin and mentation score; Figure 5, pag. 21), the APPLE FAST SCORE was also calculated. However, in cats the APPLE FAST SCORE was not determined because the blood pressure was measured by Doppler, therefore the mean arterial pressure, necessary for the score calculation, was not available.

For each animal, the type of injury was placed into a few categories of trauma that included: thoracic trauma, abdominal trauma, head trauma, fractures and soft tissue injuries. Thoracic trauma was subdivided in:

- Pneumothorax

- Pulmonary contusion
- Hemothorax
- Rib fractures
- Diaphragmatic hernia

Abdominal trauma was subdivided in:

- Hemoabdomen
- Abdominal hernia
- Splenic contusion
- Hepatic contusion
- Urinary bladder contusion
- Urinary tract rupture

Fractures was categorized in:

- Pelvic/sacral fractures or luxation
- Spinal fractures/luxation
- Cranial fractures
- Forelimbs fractures/luxation
- Hindlimbs fractures/luxation.

Soft tissue injuries include any tissue laceration, wound or abrasion.

7.3 Statistical method

All data were collected into electronic spreadsheets (*Microsoft Excel, Microsoft Corporation, Redmond, USA*) and then imported into a statistical software package (*MedCalc Statistical Software version 19.5.1, Ostend, Belgium*) for further analysis. To make the populations studied more homogeneous for statistical purposes, it was decided to carry out the descriptive analysis in two distinct populations between dogs and cats.

Data distribution was assessed using the Shapiro-Wilk test. Data were expressed by standard descriptive statistics and presented as mean ± standard deviation (SD) or median and range (minimum-maximum) based on normal or non-normal data distribution. To compare the variables between the different groups, the Chi-squared test for categorical variables, and the Mann-Whitney test and Student's t-test for continuous variables were performed.

For the significant variables, a risk factor analysis was also performed with logistic regression analysis using the Enter method. A P-value <0.05 was considered significant.

8 RESULTS

8.1 Dogs

In the period of time between January 1st 2018 and March 31st 2022, 878 patients were referred to the OVUD for trauma. Among them, only 275 patients met the inclusion criteria and 103/275 were dogs (37%).

8.1.1 Anamnesis, signalment and injuries

The median age of the dogs was 6,5 years (range 2 months – 15,8 years). As shown in Figure 20, 36/103 (35%) had an age between 0 and 4 years.

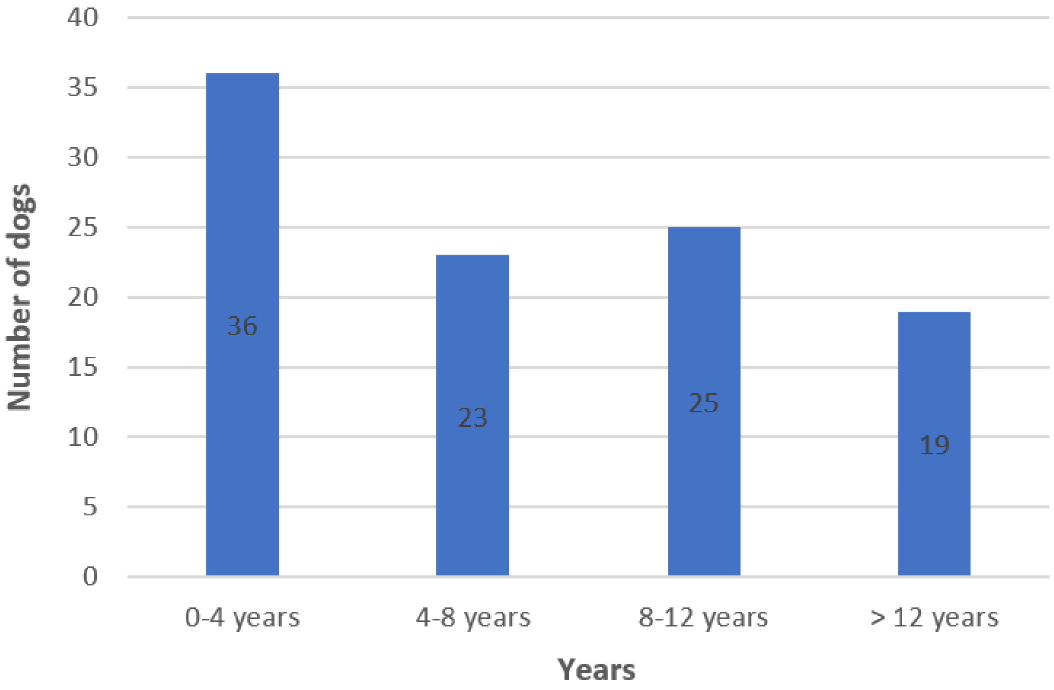


Figure 20: Distribution of age in the canine population.

In the study population, the body weight had a median value of 15 kg (range 2 – 50 kg) and, among them, 66/103 (64%) dogs weighed less than 20 kg. Female dogs represented 37% of total (39/103) whereas male dogs represented 63% of total (64/103). The most representative breed in the population was the mixed breed counting 50/103 dogs (49%), followed by Italian Segugio with 5/103 dogs (5%), German Shepherd with 4/103 dogs (4%) and many other breeds.

Considering the etiology of the trauma (Figure 21), motor vehicle accident was the main cause, affecting 62/103 dogs (60%), followed by animal interactions with 20/103 dogs (19%), unknown trauma with 9/103 dogs (9%), fall from heights with 8/103 dogs (8%), gunshot trauma with 2/103 (2%) dogs and crush injury with 2/103 dogs (2%).

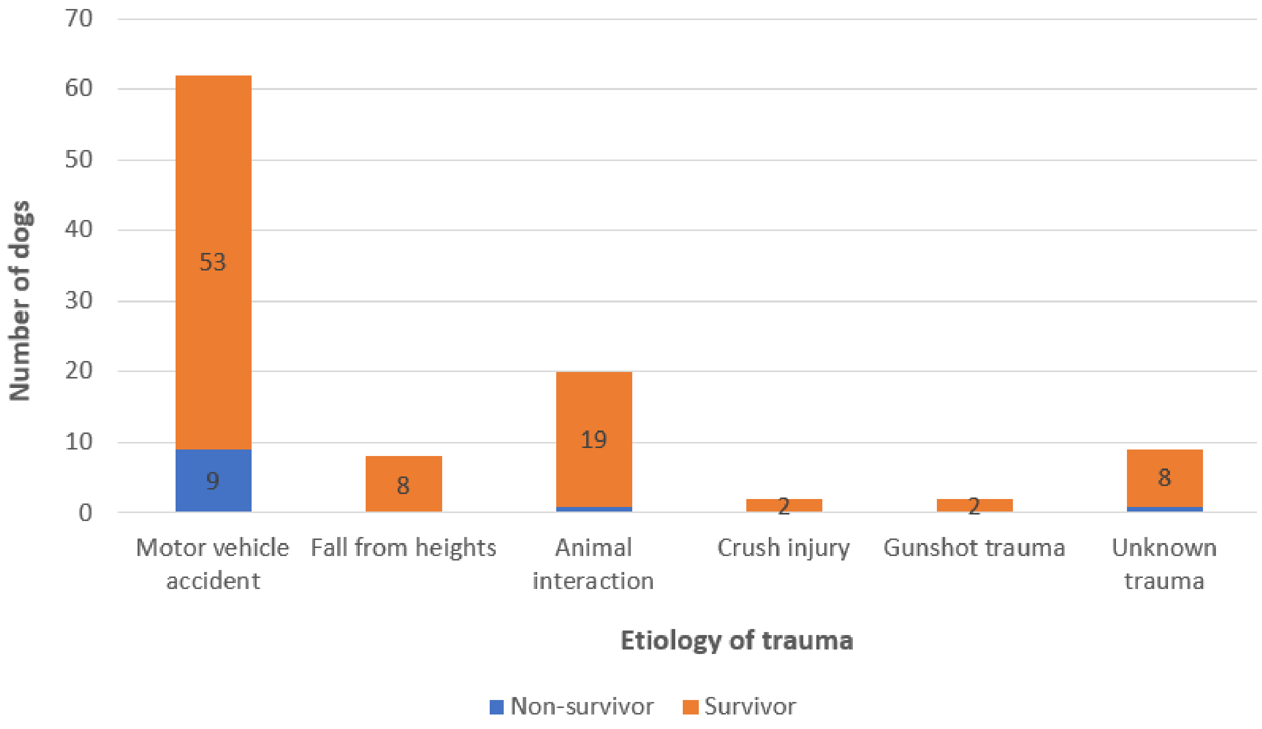


Figure 21: Distribution of the etiology of the trauma in canine population, divided in non-survivor (blue histogram) and survivor (orange histogram).

In the study population, thoracic trauma, abdominal trauma, head trauma, fractures and soft tissue injuries were observed with different distribution (Figure 22). According to the definition of polytrauma, only 38/103 (36,8%) dogs had at least two different body regions: 6/38 (15,7%) had concomitant thoracic injuries and fractures, 6/38 (15,7%) had concomitant abdominal injuries and fracture whereas 5/38 (13,1%) had concomitant thoracic and abdominal injuries. The last 21/38 (55%) polytraumatized dogs presented a mix of injuries to other body regions (Figure 23).

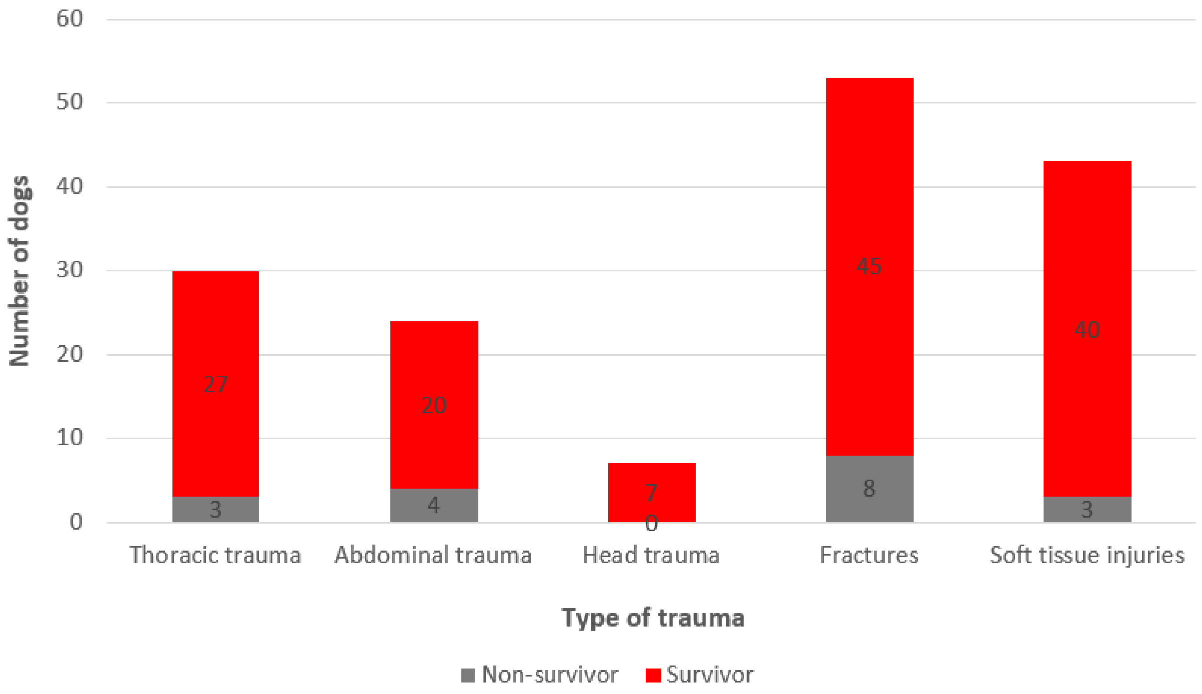


Figure 22: Distribution of traumatized body regions in the canine population, divided in survivor (red histogram) and non-survivor (grey histogram).

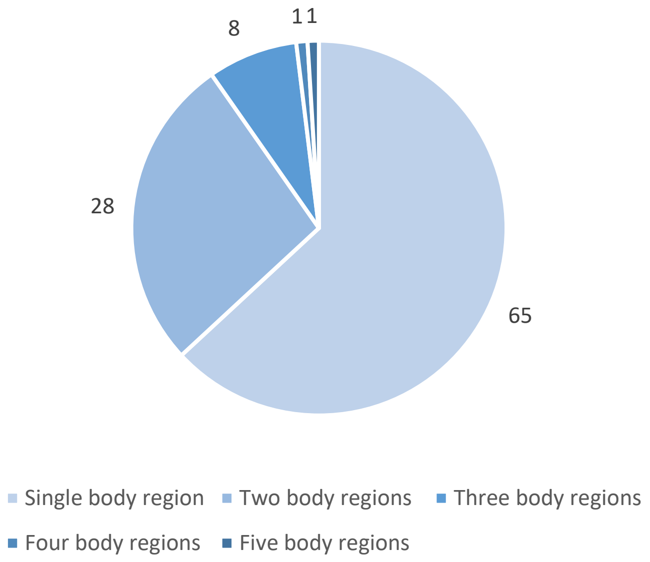


Figure 23: Representation of polytraumatized dogs in the canine population.

Thoracic trauma was observed in 30/103 dogs (30%). Thoracic injuries, as shown in Figure 24, were 15/30 (50%) pulmonary contusion, 13/30 (43%) pneumothorax, 9/30 (26%) rib fractures, 4/30 (13%) diaphragmatic hernia and 2/30 (7%) hemothorax. Also, 6/30 (20%) dogs with thoracic trauma presented concomitant abdominal trauma.

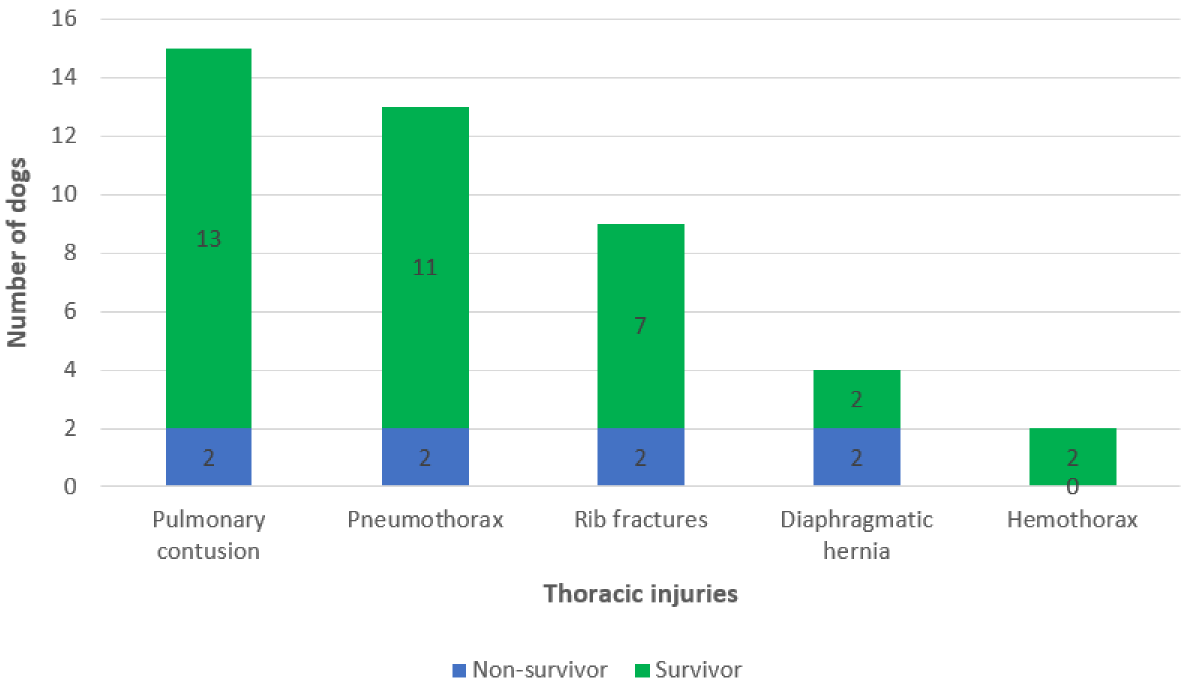


Figure 24: Distribution of thoracic injuries in the canine population, divided in non-survivor (blue histogram) and survivor (green histogram).

Abdominal trauma affected 24/103 (23%) dogs. As shown in Figure 25, the recorded abdominal injuries were 11/24 (45%) hepatic contusion, 6/24 (25%) hemoabdomen, 5/24 (20%) urinary bladder contusion, 4/24 (17%) abdominal hernia, 3/24 (12%) urinary tract rupture and 2/24 (8%) splenic contusion. Also, 3/24 (12,5%) dogs with abdominal trauma presented concomitant skeletal trauma.

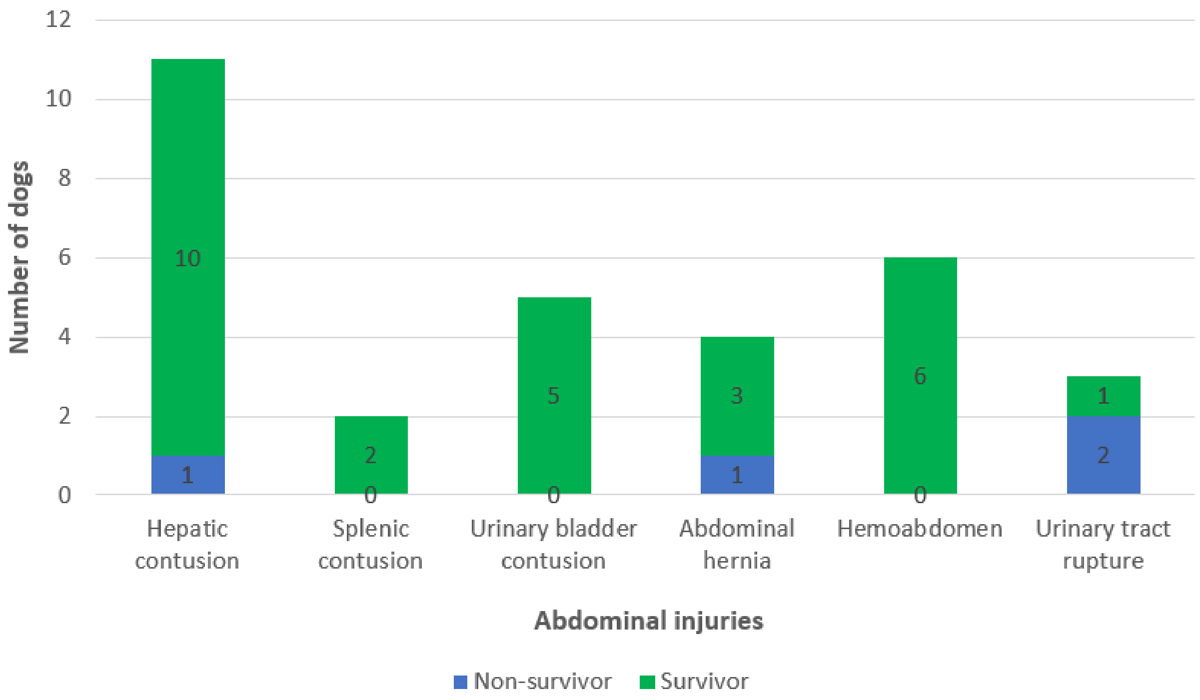


Figure 25: Distribution of abdominal injuries in the canine population, divided in non-survivor (blue histogram) and survivor (green histogram).

Skeletal trauma occurred in 53/103 (51%) dogs. In particular, 13/53 (25%) had pelvic or sacral fractures/luxation, 12/53 (22%) had spinal trauma, 8/53 (15%) had skull fractures, 7/53 (13%) had forelimb fractures/luxation and 22/53 (41%) had hindlimb fractures/luxation (Figure 26).

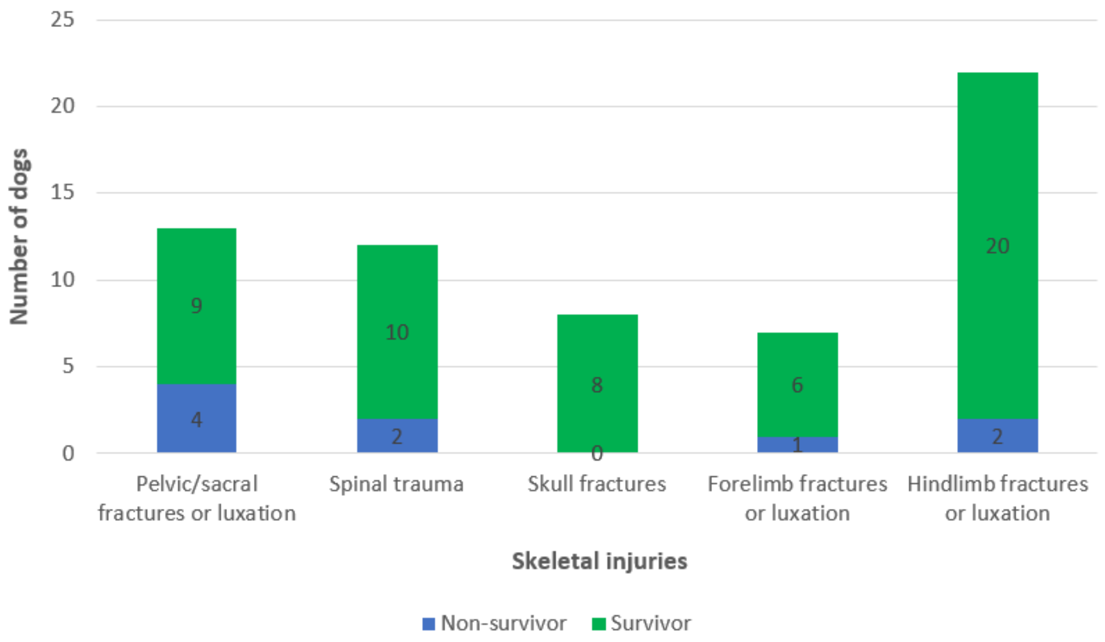


Figure 26: Distribution of skeletal injuries in canine population, divided in non-survivor (blue histogram) and survivor (green histogram).

Soft tissue injuries were recorded in 40/103 (39%) dogs. Dogs with head trauma were 7/103 (7%). Of them, only 3 (43%) presented concomitant skull fractures.

In order to analyze the etiology of trauma, only the motor vehicle accident was analyzed, due to the reduced number of patients among the other categories (Figure 27). Out of the dogs with motor vehicle accident, 24/62 (38%) presented thoracic trauma, 20/62 (32%) presented abdominal trauma, 38/62 (61%) presented fractures, 13/62 (21%) presented soft tissue injuries and only 4/62 (6%) presented head trauma. Among these, only one dog presented concomitant abdominal and thoracic injuries or abdominal injuries and fractures. 3/62 dogs presented concomitant thoracic injuries and fractures.

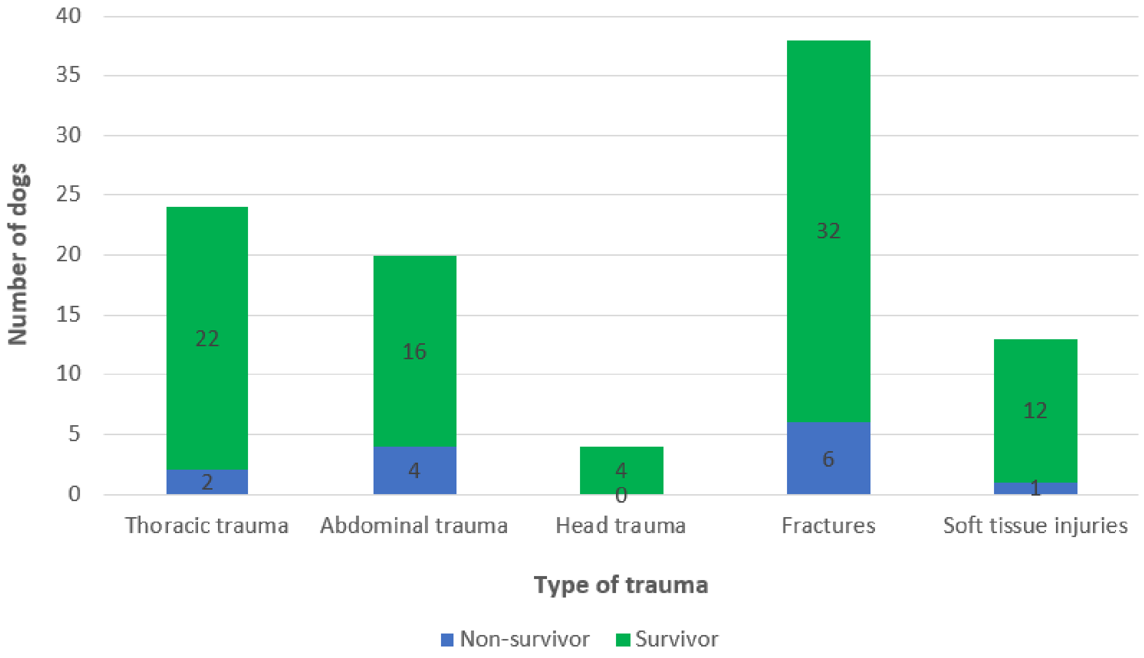


Figure 27: Distribution of injuries in canine population with motor vehicle accident, divided in non-survivor (blue histogram) and survivor (green histogram).

The survival rate was 87,4% (90/103 dogs). However, in the 13/103 dogs died, it must be considered that 8/13 (61%) has been euthanized. Also, among these 13 dogs, only 4/13 (30%) polytraumatized patients died and 2 of them presented concomitant abdominal injuries and fractures. Regarding the etiology of trauma, 9/13 (69%) patients died for motor vehicle accident, 3/13 (23%) for animal interaction and only 1 (8%) patient for unknown trauma (Figure 22).

The body region with higher mortality was abdomen, accounting 17% of mortality rate. Among these, 1/11 (9%) dogs with hepatic contusion died, 1/4 (25%) dogs with abdominal hernia died, and 2/3 (66%) dogs with urinary tract rupture died (Figure 25). Moreover, among dogs with concomitant abdominal trauma and skeletal trauma, no one died. The second type of trauma for mortality rate was skeletal trauma, amounting to 15% of dogs: among these, 4/13 (30%) died with pelvic or sacral fractures/luxation, 2/12 (16%) died with spinal trauma, 1/7 (14%) died with forelimb fractures/luxation and 2/22 (9%) died with hindlimb fractures/luxation (Figure 26).

Thoracic trauma had a mortality rate of 10%: of them, 2/15 (13%) dogs died with pulmonary contusion, 2/13 (15%) with pneumothorax, 2/9 (22%) with rib fractures and 2/4 (50%) with diaphragmatic hernia. No one of the dog with hemothorax died (Figure 24). Moreover, among dogs with thoracic trauma and concomitant abdominal trauma, only one died (3%). Soft tissue injuries had a mortality rate of 7,5% but every dog presented a concomitant injury to another body region like thoracic trauma (2/3 dogs) and fractures (1/3 dogs). Any dog with head trauma died.

In Table 6 are reported the main anamnestic and clinical variables in the canine population.

Variable	Dogs (n = 103)	Survivor (n=90)	Non-survivor (n=13)	P value
Age (months)	78 (2 – 190)	72 (2 – 184)	158 (4 – 190)	0,001
Body weight (kg)	15 (2 – 50)	15 (2 – 50)	10 (3 – 39)	0,72
Sex	39 F – 64 M	35 F – 56 M	5 F – 8 M	0,76
Etiology				
Motor vehicle accident	62	53	9	
Fall from heights	8	8	0	
Animal interaction	20	19	1	
Gunshot trauma	2	2	0	
Unknown trauma	9	8	1	
Crush injury	2	2	0	
Type of injury				
Thoracic trauma	30	27	3	
Abdominal trauma	24	20	4	
Head trauma	7	7	0	
Fractures	53	45	8	
Soft tissue injuries	43	40	3	
Polytrauma patients	38	34	4	

Table 6: Summary of the main anamnestic and clinical variables in dogs.

8.1.2 Clinical-pathological findings and gravity score system

With the clinical findings recorded at the admission, the Shock Index (SI) and the APPLE FAST score of dogs with available data were retrospectively calculated. It was possible to calculate SI for 50/103 (48,5%) dogs and the APPLE FAST score for 70/103 (68%) dogs. The Shock Index had a median value of 0,77 (range 0,34 – 2,31) whereas the APPLE FAST score had a mean of 19,58 ± 7,04.

In the study population, blood samples were collected to carry out blood gas analysis, complete blood count and biochemical profile when possible. In Table 7, the main clinical-pathological findings and gravity scores evaluated between survived dogs and non-survivor dogs are reported.

Variable	*RI*	*Dogs*	*Survivor*	*Non-survivor*	*P value*
Hematocrit (%)	39,0-54,0	47,51 ± 9,36	48,2 ± 9,25	42,6 ± 9,18	0,06
ALT (U/L)	22-78	73 (13-2076)	65,5 (13 – 3076)	134 (20 – 634)	0,37
Total protein (g/dL)	6,0-7,5	5,97 ± 0,96	5,98 ± 0,94	5,87 ± 1,18	0,76
Albumin (g/dL)	2,9-3,6	3 ± 0,5	3,024 ± 0,48	2,9 ± 0,62	0,39
Creatinine (mg/dL)	0,1-1,6	0,79 (0,34-2,2)	0,7 (0,34 – 2,2)	1 (0,5 – 1,7)	0,36
pH	7,35-7,45	7,3 ± 0,07	7,3 ± 0,06	7,27 ± 0,1	0,1
Glycemia (mg/dL)	75-125	118 (87-336)	118 (87 – 2 94)	132 (91 – 336)	0,18
Lactate (mmol/dL)	0,6-1,9	2,3 (0,2-10,2)	2,1 (0,2 – 8,6)	2,8 (2,2 – 10,2)	**0,007**
Shock Index	-	0,777 (0,34-2,31)	0,76 (0,34-2,31)	1,16 (0,85-1,5)	**0,039**
APPLE FAST score	-	19,58 ± 7,04	19,54 ± 6,68	20 ± 10,39	0,87

Table 7: Descriptive statistic of the measured variables between survivor and non-survivor in the canine population. The values of each parameter are reported as median with respective ranges or as mean with the respective standard deviation.

The variables that were statistically different between survivor and non-survivor were lactate and shock index. Thus, these two variables were included in a univariate logistic regression model, and only the lactate was significantly associated with survival (Table 8).

Variable	Odds Ratio (95% CI)	CI (95%)	P value
Lactate (mmol/L)	1,47	1,11 – 1,95	0,006
Shock Index	4,21	0,59 – 30,06	0,15

Table 8: Results of the univariate logistic regression of the variables associated with the exitus (survivor/non-survivor) of the canine population. CI, confidence interval.

8.2 Cats

Out of 275 patients that met the inclusion criteria, traumatized cats were 172/275 (63%).

8.2.1 Anamnesis, signalment and injuries

In the study population, 167/172 (97%) were domestic shorthair, the remaining 5 cats were Norwegian Forest cat (n=1), Bengala (n=1), Ragdoll (n=1), Siberian (n=1) and Siamese (n=1). The population was composed by 76/172 (44%) female cats and 96/172 (56%) male cats, and they had a median age of 2,75 years (range 2 months – 20 years). As shown in Figure 28 below, the most representative category of age was from 0 to 4 years. The median value of the weight was 3,8 kg (range 0,6 – 7,4 kg).

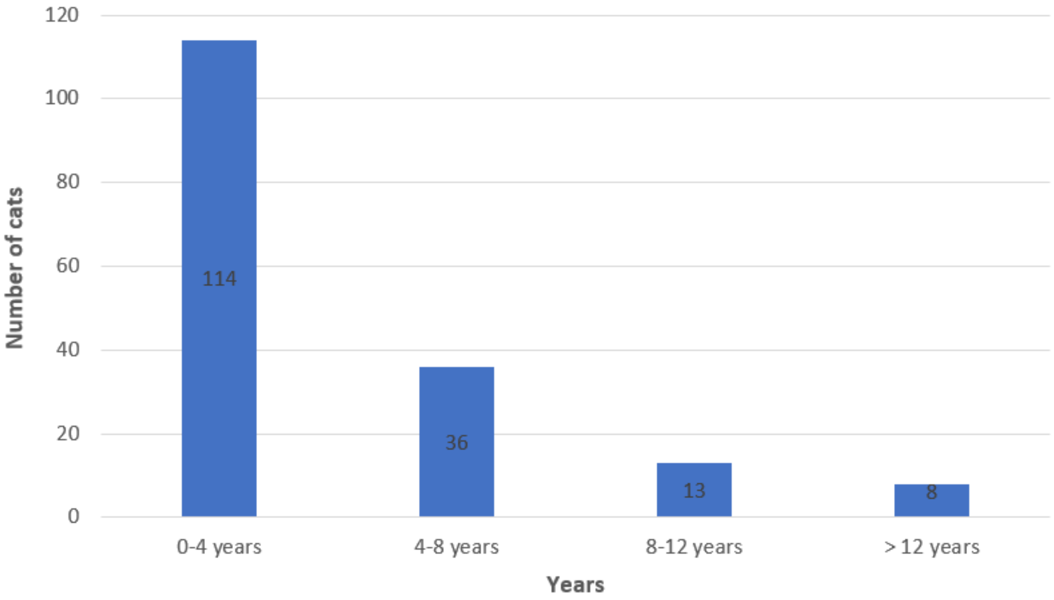


Figure 28: Distribution of the age in the feline population.

Motor vehicle accident was the main cause of trauma in cats, affecting 113/172 (65%) patient. Other minor causes were represented by fall from heights with 24/172 cats (15%), animal interaction with 12/172 cats (8%), crush injury with 2/172 cats (1%) and unknown trauma with 20/172 cats (11%) (Figure 29).

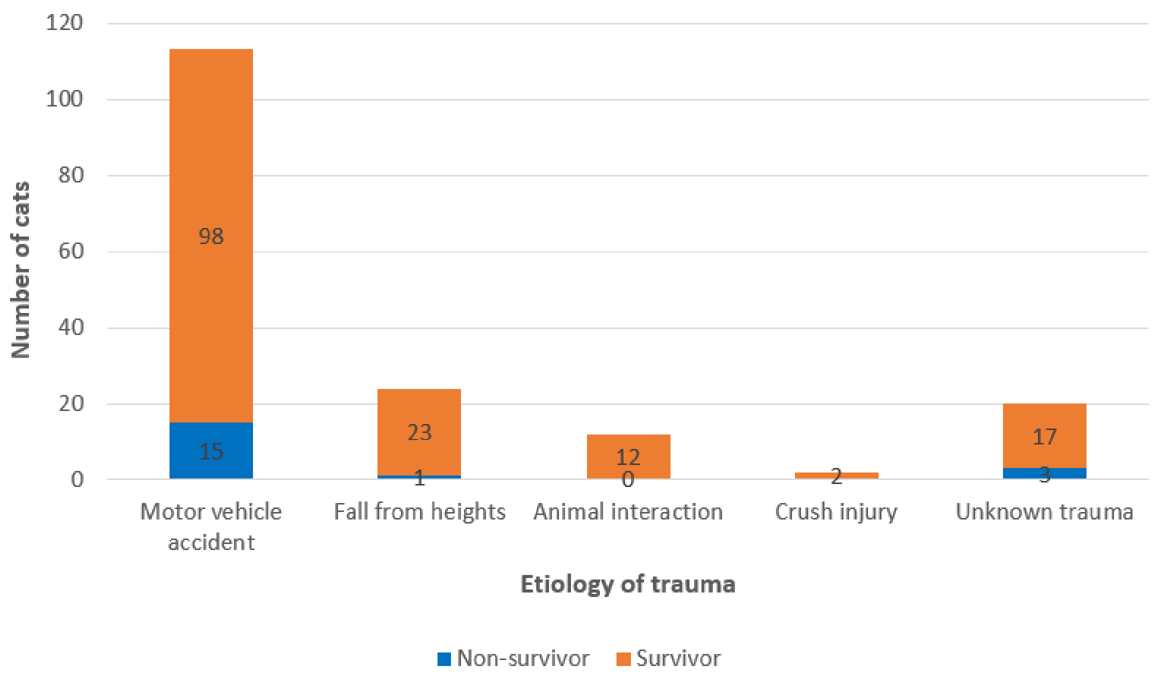


Figure 29: Distribution of the etiology of the trauma in the feline population, divided in non-survivor (orange histogram) and survivor (green histogram).

Of them, 32/172 (18%) presented injuries in at least two body regions. In the study population, it was observed 62/172 (36%) thoracic trauma, 31/172 (18%) abdominal trauma, 34/172 (20%) head trauma, 105/172 (61%) skeletal trauma and 63/172 (36%) soft tissue injuries (Figure 30-31).

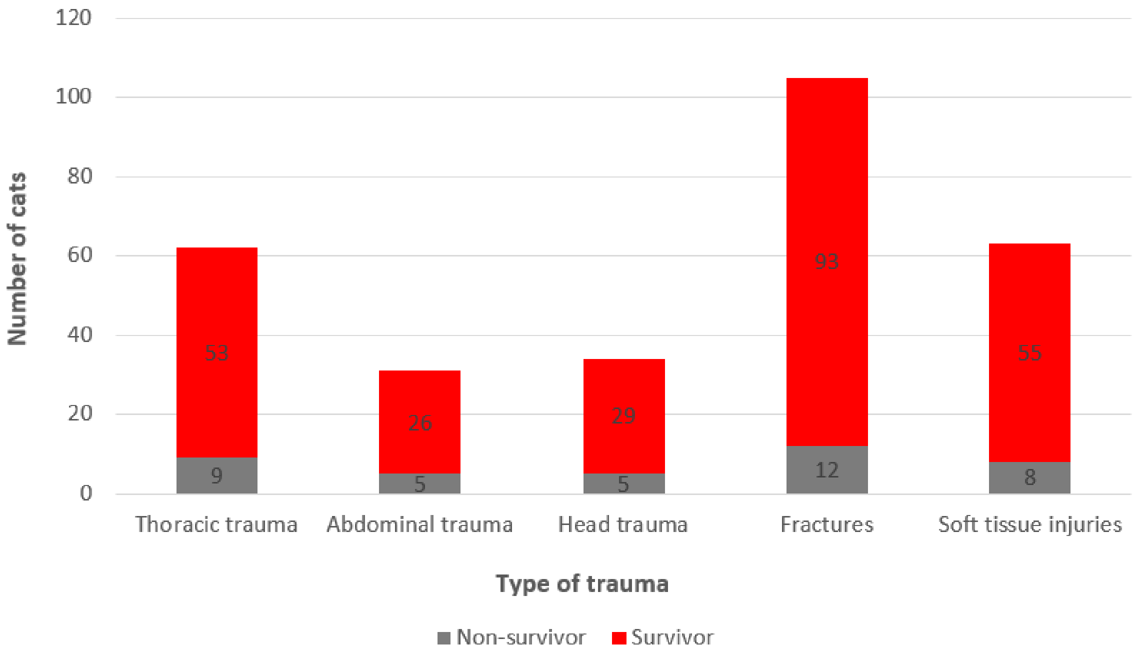


Figure 30: Distribution of traumatized body regions in the canine population, divided in survivor (red histogram) and non-survivor (grey histogram).

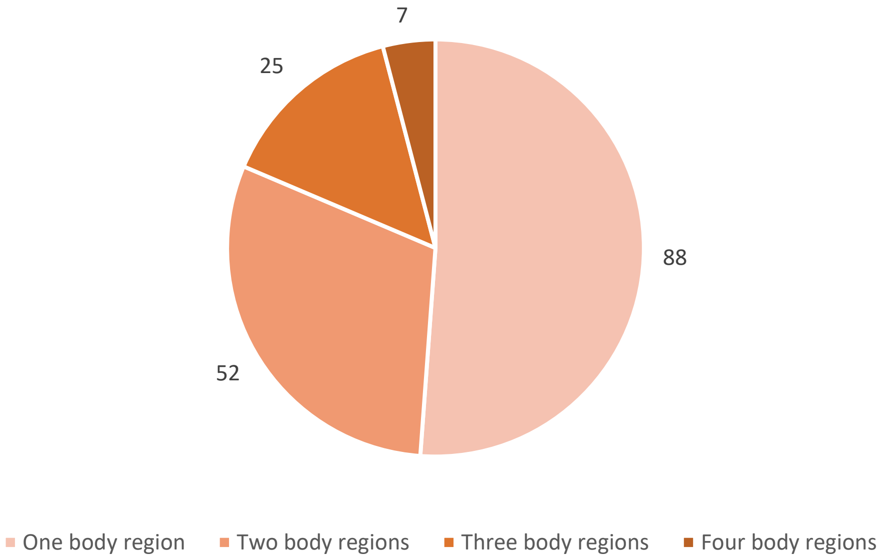


Figure 31: Representation of polytraumatized cats in the feline population.

Thoracic trauma was observed in 62/172 cats (36%) with a mortality of 9/62 (14%). Thoracic injuries, as shown in Figure 32, were 36/62 (58%) pulmonary contusion, 23/62 (37%) pneumothorax, 5/62 (8%) rib fractures, 6/62 (10%) diaphragmatic hernia and 8/62 (12%) hemothorax. Also, 5/62 (8%) cats with thoracic trauma presented concomitant abdominal trauma.

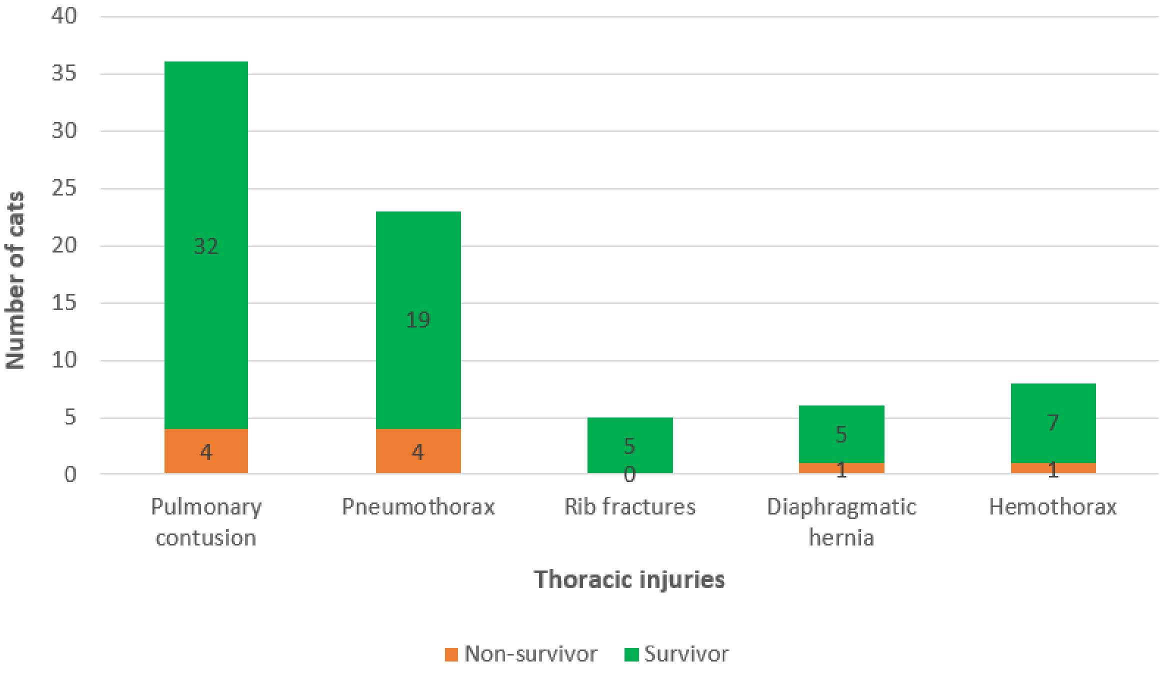


Figure 32: Distribution of thoracic injuries in the feline population, divided in non-survivor (orange histogram) and survivor (green histogram).

Abdominal trauma was observed in 30/172 (17%) cats. Of these 30 cats, 5 died (16%). The recorded abdominal injuries were 15/30 (50%) hepatic contusion, 6/30 (20%) hemoabdomen, 7/30 (23%) abdominal hernia, 2/18 (11%) urinary tract rupture, 4/30 (13%) urinary bladder contusion and 1/30 (3%) splenic contusion (Figure 33). Also, 7/30 (23%) cats with abdominal trauma presented concomitant skeletal trauma.

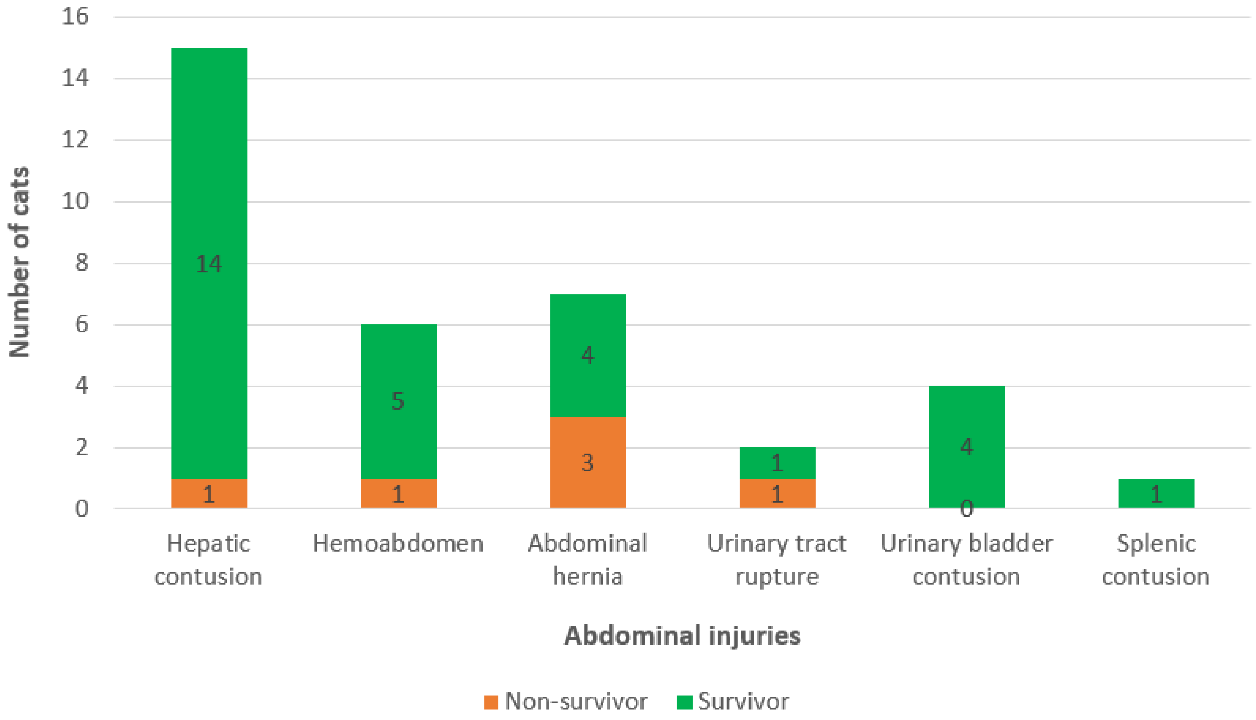


Figure 33: Distribution of abdominal injuries in the feline population, divided in non-survivor (orange histogram) and survivor (green histogram).

Skeletal trauma occurred in 105/172 (61%) cats, of which 12/105 (11%) died. In particular, 51/105 (48%) had pelvic or sacral fractures/luxation, 9/105 (8%) had spinal trauma, 21/105 (20%) had skull fractures, 8/105 (8%) had forelimb fractures/luxation and 35/105 (33%) had hindlimb fractures/luxation (Figure 34).

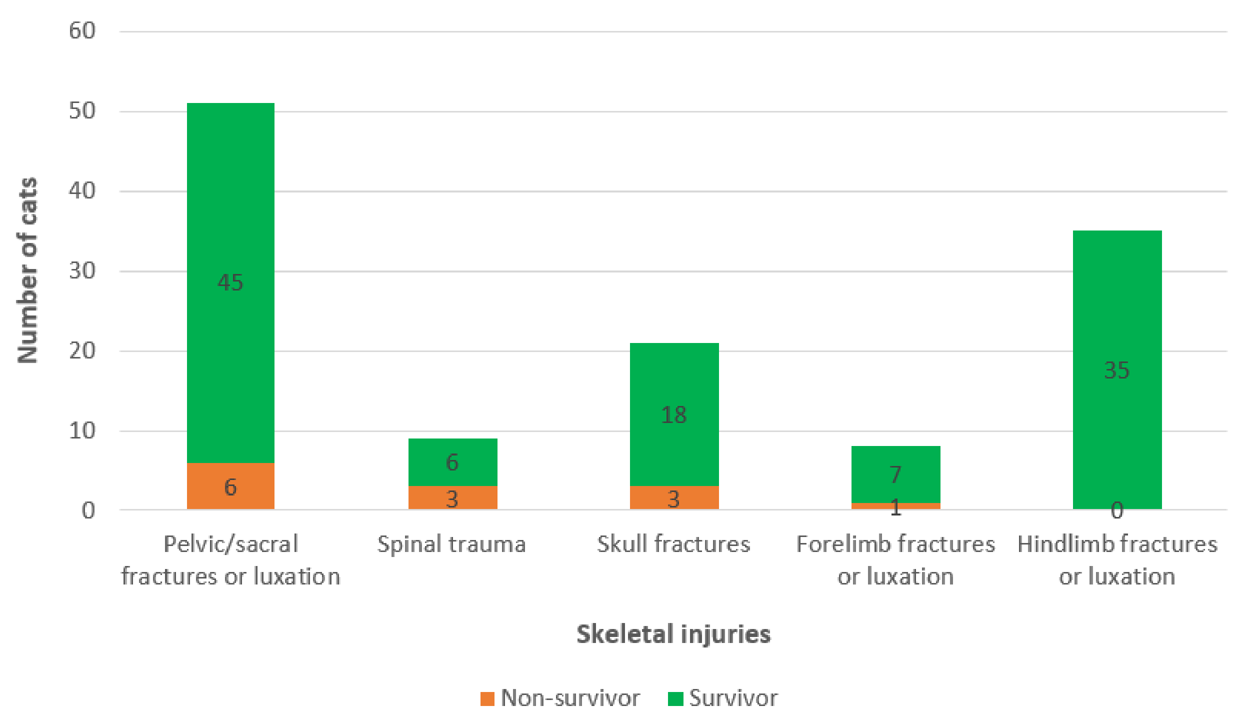


Figure 34: Distribution of skeletal injuries in feline population, divided in non-survivor (orange histogram) and survivor (green histogram).

Soft tissue injuries were recorded in 63/172 (37%) cats. Head trauma occurs in 34/172 cats. Of them, 11/34 (32%) presented concomitant skull fractures.

As for the population of dogs studied before, to make the value statistically significant, the distribution of injuries in cat populations was compared only with motor vehicle accident, that results the most representative etiology of trauma in the study population (Figure 35). Out of the cats with motor vehicle accident, 39/113 (34,5%) presented thoracic trauma, 20/113 (17,7%) presented abdominal trauma, 34/113 (30%) presented head trauma, 72/113 (63,7%) presented skeletal trauma and 33/113 (29%) soft tissue injuries. Among these, 15/113 (13%) cats presented concomitant abdominal and thoracic injuries, 7/113 (6%) presented concomitant thoracic and skeletal injuries and only one cat presented concomitant abdominal and skeletal injuries.

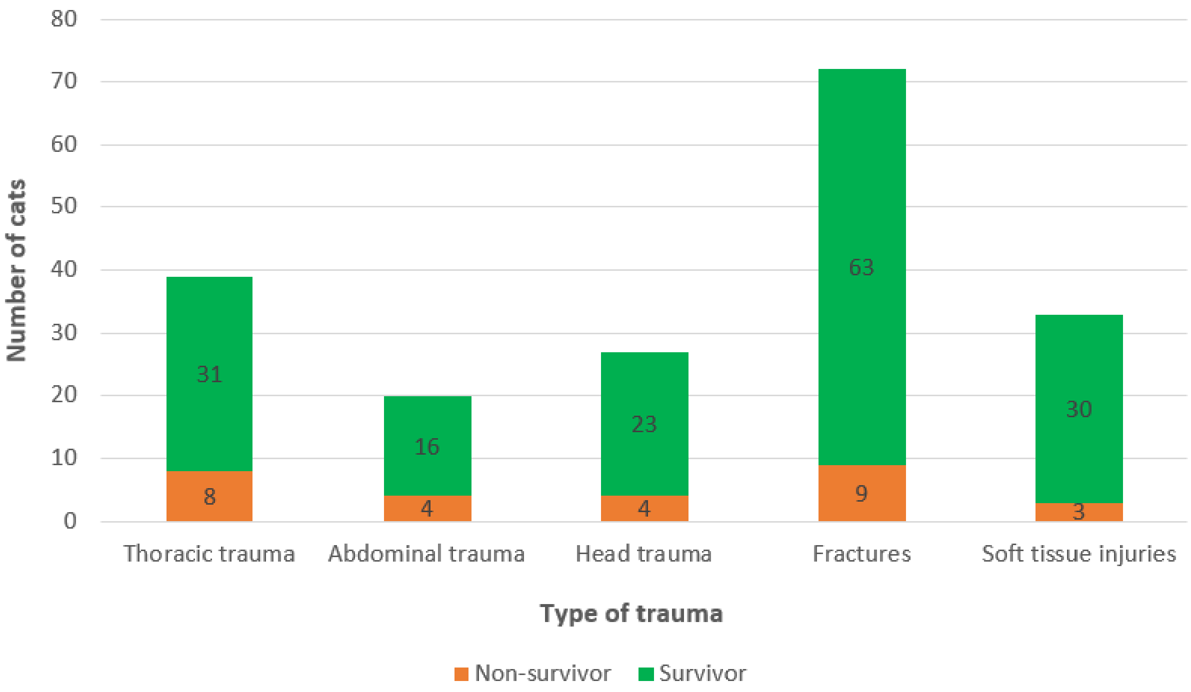


Figure 35: Distribution of injuries in the feline population with motor vehicle accident, divided in non-survivor (orange histogram) and survivor (green histogram).

The survival rate was 89% (153/172 cats). Out of the 19/172 cats died, 6/19 (31,5%) cats have been euthanized. Among these 19 cats, only 6/19 (31,5%) polytraumatized patients died. Regarding the etiology of trauma, 15/19 (79%) died for motor vehicle accident, 3/19 (15,7%) died for unknown trauma and 1/19 (5,3%) died for fall from heights (Figure 30).

Even in this study population, the body region with higher mortality was abdomen, counting 16% of mortality rate. Among them, 1/6 (16%) cats died with hemoabdomen, 3/7 (42,8%) cats with abdominal hernia, 1/15 (6%) cats with hepatic contusion and 1/2 (50%) cats with urinary tract rupture (Figure 33). Moreover, among cats with abdominal trauma and concomitant skeletal trauma only 2 cats died. The second type of trauma with higher mortality is head trauma, amounting to 14,7% of mortality rate. Even thoracic injuries had a mortality rate of 14% and among thoracic injuries, 4/36 (11%) cats with pulmonary contusion died, 4/23 (17%) cats with pneumothorax died, 1/6 (50%) cats with diaphragmatic hernia died and 1/8 cats with hemothorax died. No one of the cats with rib fractures died (Figure 32). Furthermore, among cats with thoracic trauma and concomitant abdominal trauma, only one of these died (1,6%). Regarding soft tissue injuries, only 8/63 died (13%) but every dog presented a concomitant injury to at least another body region.

Skeletal trauma, at the end, had a mortality rate of 11%. Among the 12 cats died with skeletal trauma, 6/51 (17%) cats had pelvic or sacral fractures/luxation, 3/9 (33%) had spinal trauma, 3/21 (14%) had skull fractures and 1/8 (12,5%) had forelimb fractures/luxation (Figure 34).

In Table 9 are reported the main anamnestic and clinical variables in the feline population.

Variable	Cats	Survivor (n = 153)	Non-survivor (n = 19)	P value
Age (months)	33 (2 – 240)	25 (2 – 240)	40 (4 – 180)	0,14
Body weight (kg)	3,8 (0,6 – 7,4)	3,74 ± 1,17	4,07 ± 1,22	0,73
Sex	76 F – 96 M	70 F – 83 M	7 F – 12 M	0,62
Etiology				
Motor vehicle accident	113	98	15	
Fall from heights	24	23	1	
Animal interaction	12	12	0	
Unknown trauma	20	17	3	
Crush injury	2	2	0	
Injury				
Thoracic trauma	62	53	9	
Abdominal trauma	31	26	5	
Head trauma	34	29	5	
Fractures	105	93	15	
Soft tissue injuries	63	55	8	
Polytrauma patients	32	26	6	

Table 9: Summary of the main anamnestic and clinical variables in cats.

8.2.2 Clinical-pathological findings and gravity score system

With the clinical findings recorded at the admission, the shock index (SI) score of cats with available data was retrospectively calculated. It was possible to determine the SI in 65/172 (37,7%) cats. The Shock Index had a median value of 1,24 (range 0,54 – 3,2).

In the study population, blood samples were collected to carry out blood gas analysis, complete blood count and biochemical profile when possible. In Table 8 are reported the main clinical-pathological findings that result statistically significant between survived and dead cats. .

Variable	*RI*	*Cats*	*Survivor*	*Non-survivor*	*P value*
Hematocrit (%)	24,0-45,0	34,3 ± 9,23	34,7 ± 9,21	31,28 ± 9	0,14
ALT (U/L)	32-87	111 (19-2135)	110 (19 – 2135)	206 (51 – 614)	0,25
Total protein (g/dL)	6,0-8,0	6,2 (3,78-10,6)	6,2 (4 – 10,6)	5,8 (3,8 – 7,9)	0,39
Albumin (g/dL)	2,1-3,3	2,8 (1,1-4,5)	2,8 (1,1 – 4 ,5)	2,8 (1,2 – 3,4)	0,65
Creatinine (mg/dL)	0,8-1,8	1 (0,2–5,9)	1 (0,2 – 5,9)	1 (0,4 – 5,3)	0,74
pH	7,27-7,46	7,7 (6,9-7,48)	7,27 (7,02 – 7,48)	7,2 (6,9 – 7,3)	**0,006**
Glycemia (mg/dL)	72-136	178 (11-496)	178 (72 – 496)	192 (11 – 469)	0,77
Lactate (mmol/dL)	0,0-1,5	2,2 (0,4-22,6)	2,1 (0,4 – 22,6)	3,1 (0,5 – 8)	0,06
Shock Index	-	1,24 (0,54 – 3,2)	1,25 (0,54 – 3,28)	1,22 (0,7 – 1,8)	0,48

Table 8: Descriptive statistic of the measured variables between survivor and non-survivor in the feline population. The values of each parameter are reported as median with respective ranges or as mean with the respective standard deviation.

The only variable that results statistically significant in the discrimination between survivor and non-survivor was pH. Thus, it was included in a univariate logistic regression model (Table 9) and it resulted significant.

Variable	Odds Ratio	IC	P value
pH	0,001	0 – 0,003	0,0017

Table 9: Result of the univariate logistic regression of the variable associated with the exitus (survivor/non-survivor) of the feline population. CI, confidence interval.

9 DISCUSSION

This retrospective study is based on a population of 103 dogs and 172 cats admitted at Ospedale Veterinario Universitario Didattico (OVUD) in University of Parma with diagnosis of trauma in a period between January 1st 2018 and March 31st 2022.

The population of dogs included in the study is composed by adult dogs of medium-size, with a median age of 6,5 years. There was no widely difference in the sex, and this is partially in contrast with literature in which adults and male dogs are the main subjects to be involved in a traumatic event, with a median age of 4,1 years. The same observation can be made on cats, in which there was no difference between females and males, and the population consisted in adult cats with a median age of 4,75 years, compared to 3,4 years in literature. It has been hypothesized that males are more exposed to trauma because of the action of sex hormones that predispose them to wandering and interact with other animals (Hall, 2018). However, we are not able to analyze this aspect because of the lack of data about the neutered status in several medical records.

In agreement with what has been reported in literature, the main cause of the traumatic event was found to be motor vehicle accident, amounting to 60% of traumatized dogs and 65% of traumatized cats (Hall et al., 2014; Kolata, 1980; Simpson et al., 2009). The main type of injury described in both species was skeletal fractures/luxation, counting 61% of dogs and 63,7% of cats, followed by thoracic injuries with 38% in dogs and 34,5% in cats. This is contrast with the study of Simpson et al., in which on a population of 235 dogs hit by car, 72,3% had thoracic trauma and 41,7% has skeletal trauma (Simpson et al., 2009).

Polytrauma is considered one of main cause of morbidity and mortality in small animal (Butcher et al., 2009; Simpson et al., 2009). Despite this, in this study polytrauma patients were respectively 36,8% of dogs and 18% of cats, less than what reported in a study of feline trauma in which polytrauma patients result to be 62% of the total (Hernon et al., 2018).

Even considering all types of trauma, skeletal trauma was the main type of trauma involved in the study population, affecting 51% of dogs and 61% of cats. The main representative injuries in this body region were hindlimb fractures or luxation in dogs affecting 41% of the total and pelvic/sacral fractures or luxation in cats, involving the 48% of cats. Among these, 12,5% of dogs and 23% of cats had concomitant abdominal injuries, and this agrees with literature in which dogs with abdominal trauma had concomitant skeletal injuries. In particular, the percentage is similar to a study in which hemoabdomen was associated with pelvic fractures in 11-44% of cases but also it is less than what reported in another study in which urinary tract rupture was associated for 37-85% with pelvic fractures (Anderson et al., 2006; Hoffberg et al., 2016).

The thorax is the second main involved body region following the traumatic event, interesting 30% of dogs and 36% of cats with a mortality rate of 10% in dogs and 14% in cats. The most representative injuries in thoracic trauma were pulmonary contusion and pneumothorax, involving respectively 50% and 43% of versus 58% and 37% of cats. This percentage is comparable to several studies in which pulmonary contusion and pneumothorax involved 36% - 50% of traumatized patients (Hall, 2018; Simpson et al., 2009; Lisciandro, 2008; Boysen et al., 2004). Even in this case, this type of injuries occurs frequently associated with skeletal trauma. In two different studies, the 32% and 36,3% of dogs had concurrent fractures or luxation. The same percentage can be seen in our study in which the concomitant presence of thoracic trauma and skeletal trauma occurred in 30% of dogs with thoracic trauma (Powell et al., 1999; Selcer et al., 1987).

Abdominal injuries presented similar results of thoracic injuries, involving 23% of dogs and 17% of cats with a mortality rate of, respectively, 17 % and 16%. The most frequent recorded injuries were hepatic contusion (45% for dogs and 50% for cats), abdominal hernia (17% for dogs and 42,8% for cats) and hemoabdomen (25% for dogs and 20% for cats). These results are lower than what found in a prospective ultrasound-based study on focus assessment with sonography for trauma in dogs in which the percentage of dogs with hemoabdomen was 38% (Boysen et al., 2004). However, this study has a retrospective nature and the result of the A-FAST are not available for every patient.

Head trauma was different in the study population, involving the 7% of dogs with an excellent survival rate (100%) and the 20% of cats with a mortality rate of 14,7%. This is in contrast with the literature in which the percentage of head trauma for dogs resulted in 25% (Simpson et al., 2009). In literature, it has been reported a mortality rate between 18% and 24% for dogs, and this is in contrast with our results, probably because of the poor number of cases of head trauma in our population dogs.

Survival for traumatized dogs and cats was excellent with 87,5% for dogs and 89% for cats. Only 13/103 dogs and 19/172 cats died and, among these, 8 dogs and 6 cats were euthanized. As seen as the choice of euthanasia was associated with poor prognosis, these patients were considered in the non-survivor group. This is in agreement with several studies in which the survival rate ranged between 87% and 92% (Hall, 2019; Hall et al., 2014; Kolata, 1980). It must be considered that in this study the percentage of euthanized dog is lower than what reported in literature: in fact, in this canine population the mortality rate excluding euthanized dogs amounted to 4,8%, whereas in the feline population amounted to 7,5%. In the studies mentioned above, almost the total of non-survivor patients was euthanized. Again, comparing the population of survivors and non-survivors in dogs, it was found that non survivors had a median age widely higher compared to survivors, and this, added to the high percentage of euthanized dogs, can be a sign of the lack of owners' motivation. This has not been noted in the feline population.

Although the skeletal trauma was the most common diagnosis in our study, the presence of skeletal trauma was not associated with the outcome. In both feline and canine population, the abdominal trauma had the mortality rate higher than other groups.

Some clinical-pathological findings have been studied in relation to the exitus of the traumatized patients. In particular, the following parameters have been evaluated: hematocrit, albumin, total protein, creatinine, ALT, glycemia, lactate and pH. Several studies attest that these values are used as prognostic factors in traumatized patients (Kerby et al., 2012; Bilgic et al., 2014; Rosentein et al., 2018). Unfortunately, these values could not be associated with mortality in this study population because they resulted not statistically relevant. This could be caused by the heterogeneity of the population, comparing a group of survivors with a great number of animals with the group of non-survivor, that was quite poor of patients.

The only variable that was statistically significant was lactate for dogs and pH for cats. In the canine population, lactate was a negative prognostic factors for traumatized patients, resulting higher in non-survivor patients. In fact, in agreement with the literature, plasmatic lactates are indicative of altered tissue perfusion (Rosenstein et al., 2018). Regarding feline population, pH resulted statistically relevant between survivors and non-survivors but it cannot be used as a prognostic value as seen as the logistic regression resulted not reliable, probably due to the poor number of cases in non-survivor group. Despite this, metabolic acidosis is frequently found in a traumatized patient and, if associated with hypothermia and traumatic coagulopathy, it may have a strong impact on the patient's outcome (Floccard et al., 2012). Unfortunetely, corporal temperature and coagulation tests could not be assessed in this study population.

In order to establish a severity score system for the traumatized patients referred to OVUD, the APPLE FAST score for dogs and the SHOCK INDEX score for both cats and dogs was retrospectively performed. These scores are increasingly used with the aim of completing the clinical picture and guiding the initial approach to treatment (Hayes et al., 2010). The APPLE FAST score was performed in 68% of dogs. According to literature, an APPLE FAST score higher than 25 had a specificity of 85% in predicting death (Hayes et al., 2010). However, in this study population, the APPLE FAST score had a mean value of 19,58 ± 7,04 and there was no difference between survivor and non-survivors, and this is in contrast with literature. In cats, the determination of the APPLE

FAST score was not possible as the blood pressure measurement was performed with the Doppler method and therefore it was not possible to detect the mean arterial pressure, necessary for the calculation of this score in the cat.

Regarding the Shock Index, for dogs it had a median value of 0,77 (range 0,34 – 2,31) whereas for cats it had a median value of 1,24 (range 0,54 – 3,2). This score is defined as the ratio of heart rate (HR) to systolic arterial blood pressure (SBP) and it was developed as a simple mean of quantifying the severity of shock (Rady et al., 1994). In the canine population of this study, the SI for non-survivor dogs (median 1,16; range 0,85 – 1,5) was higher than SI for survivors (median 0,76; range 0,34 – 2,31). Even if in veterinary medicine published studies have reported many limitations in maintaining the same reference value, the values in this study find support in a study on 38 dogs with hemorrhagic shock, in which the SI was significantly higher in patients with hemorrhagic shock (median 1,37, range 0,78-4,35) than healthy patients (median 0,91, range 0,57-1,53). However, in this study population, SI for dogs could not be used as a prognostic factor.

This study presents some limitations that must be considered during the interpretation of the results. First of all, the retrospective nature of this study makes cause and effect relationships impossible to determine and there was a degree of subjectivity in the interpretation of some aspects of the medical records. Secondly, the difference in numbers between survivors and non-survivors groups may have influenced the statical analysis and the results on relationship with the outcome. Again, the exclusion of some traumatized patients referred to OVUD, due to uncomplete medical records, may have caused an underestimation of the real mortality rate in this population. In the current study, survival was defined as survival to discharge, but this is an important issue in species in which euthanasia is an option.

Also, diagnostic test obtained at admission may have been performed after some medical intervention such as fluid therapy, that could have an impact on the values and play a role of confounding factors.

10 CONCLUSIONS

This study helps to describe the typical manifestation of the trauma in a large population of dogs and cats.

The principal cause of trauma in both feline and canine population is motor vehicle accident and the most common injured body region is skeletal trauma.

This study evidenced that the general prognosis after trauma is good for both dogs and cats, with a mortality of 12,6% in dogs and 11% in cats. The principal cause of death is abdominal trauma, despite the poor number of cases included in this injured body region.

Among all the clinical-pathological variables analyzed, the presence of hyperlactatemia was the only predictor of negative outcome in dogs. Whereas, there were no prognostic variables in cats.

This study provides useful information about traumatized dogs and cats, moreover it identifies potential prognostic values that can be evaluated at admission in the Emergency Room. These data have to be considered a preliminary analysis to lead a larger prospective study with more cases of polytraumatized dogs, according to the considered criteria. In this sense, it would be interesting to evaluate with a prospective study any prognostic factors on traumatized patients, considering the days of hospitalization in the Intensive Care Unit.

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