Factors associated with survival to hospital discharge for cats treated surgically for thoracic trauma

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OBJECTIVE
To determine the most common types of injuries in cats surgically treated for thoracic trauma, complications associated with surgical treatment, and factors associated with mortality rate and evaluate the effectiveness of the animal trauma triage (ATT) scoring system for predicting outcome.

DESIGN
Retrospective case series with nested observational study.

ANIMALS
23 client-owned cats surgically treated for thoracic trauma at 7 veterinary teaching hospitals between 1990 and 2014.

PROCEDURES
Medical records were reviewed to collect data on signalment, medical history, clinical signs and physical examination findings at initial evaluation, clinicopathologic findings, initial emergency treatments and diagnostic tests performed, type of trauma sustained, imaging findings, surgery details, postoperative complications, duration of hospitalization, and cause of death, if applicable. All variables were evaluated for associations with survival to hospital discharge.

RESULTS
Types of trauma that cats had sustained included dog bite or attack (n = 8 [35%]), motor vehicle accident (6 [26%]), other animal attack (2 [9%]), impalement injury or fall (2 [9%]), projectile penetrating trauma (1 [4%]), or unknown origin (4 [17%]). Intrathoracic surgery was required for 65% (15/23) of cats. The overall perioperative mortality rate was 13% (3/23). Mean ± SD ATT scores for surviving and nonsurviving cats were 6.4 ± 2.2 and 10.0 ± 1.7, respectively. Nineteen of 20 cats with no cardiopulmonary arrest survived to discharge, compared with 1 of 3 cats with cardiopulmonary arrest. Only these 2 variables were significantly associated with outcome.

CONCLUSIONS AND CLINICAL RELEVANCE
The perioperative mortality rate was low in this series of cats with thoracic trauma; however, those with cardiopulmonary arrest were less likely to survive to hospital discharge than other cats. Cats with a low ATT score were more likely to survive than cats with a high ATT score. (J Am Vet Med Assoc 2018;259:598–605)

Trauma is a common reason for companion animals to be brought to veterinary emergency hospitals, representing approximately 12% of all admissions.1,2 In cats with traumatic injuries, the thoracic region is one of the most commonly affected areas.3-7 However, similar to the situation in human medicine,8 accurate assessment may be challenging because of the variety of injuries that can be sustained.

Thoracic trauma is frequently categorized by whether the trauma is blunt or penetrating in nature. In cats, blunt trauma to any anatomic region is a common type and may be due to motor vehicle accidents, falls from heights (so-called high-rise syndrome), or unknown causes.7,9-13 In a report7 concerning high-rise-associated injury in cats, 90% of the cats had thoracic trauma. Bite wounds or interactions with animals are considered a leading cause of penetrating trauma.1,9-11,14 Bite wounds to the thoracic region can result in severe injuries such as rib or sternum fractures, so-called flail chest (minimum of 2 adjacent rib fractures resulting in loss of costal arch support with asynchronous movement of the thoracic wall with respiration14), traumatic body wall herniation, diaphragmatic hernia, pneumothorax, hemothorax, pulmonary contusions, and puncture or tearing of lung lobes.10,15-17

The decision to pursue surgery for cats and dogs with thoracic trauma is not clear cut. Some authors suggest that conservative management (vs an invasive approach) reduces the risk of death, whereas...
others recommend full surgical exploration of all bite wounds to the thorax.\textsuperscript{3,5,6,18,19} Although diagnostic imaging may help determine the extent of injury, results of standard radiography are not correlated with surgical outcome and can underestimate the amount of body wall damage.\textsuperscript{15,16} Additionally, 17% to 60% of cats and dogs with penetrating injuries have damage to deep structures.\textsuperscript{10,16}

Trauma scoring systems have been developed in human medicine to better predict prognosis and outcome, determine diagnostic plans, and monitor the impact of medical interventions for patients with thoracic trauma. Historically, these scoring systems have been based on anatomic injuries and parenchymal disease.\textsuperscript{20} The injury severity score is a validated numeric description of the overall severity of injury in people who have sustained injury to more than 1 anatomic region\textsuperscript{21} and is a significant predictor of the likelihood of survival.\textsuperscript{22,23} The ATT scoring system was developed specifically for cats and dogs with trauma\textsuperscript{2} and includes evaluation of 6 variables, including perfusion; cardiac function; respiratory disease; eye, muscle, and integument disease; skeletal disease; and neurologic abnormalities.\textsuperscript{3}

Many reports\textsuperscript{9,14,16,27} of trauma in cats include information pertaining to dogs as well, without clear distinction between species in treatments performed and mortality rates. The choice to combine data for the 2 species may have been attributable to cats representing a smaller portion of the overall patient population, as found in 2 studies in which cats represented only 11% of the general hospital population\textsuperscript{4} and 18% of all patients admitted to an intensive care unit.\textsuperscript{2} Thoracic involvement (vs no thoracic involvement) in traumatic injuries has been associated with an increased mortality rate.\textsuperscript{5,5,6} Reported prognostic factors for people with thoracic trauma include age, number of fractured ribs, flail chest, pulmonary contusions, need for mechanical ventilation, and injury severity score.\textsuperscript{25} The veterinary literature lacks information on factors associated with mortality rate in cats requiring surgical intervention for thoracic trauma.

The primary objective of the study reported here was to determine the most common types of injuries in cats surgically treated for thoracic trauma, complications associated with surgical treatment, and factors associated with mortality rate. A secondary objective was to determine whether ATT score was associated with outcome; we hypothesized that ATT score would predict survival to hospital discharge in cats surgically treated for thoracic trauma.

**Materials and Methods**

**Case selection criteria**

All cats with thoracic trauma that underwent surgical intervention at 7 veterinary teaching hospitals between January 1, 1990, and February 1, 2014 were considered for inclusion in the study. Teaching hospitals included those of the University of California-Davis, University of Tennessee, Kansas State University, University of Illinois, University of Guelph, Oregon State University, and University of Georgia. Cats were excluded from the study if their thoracic trauma was left untreated or was treated conservatively, without surgical intervention.

**Medical records review**

Data were obtained from the medical records of each cat regarding signalment, medical history, clinical signs and physical examination findings at initial evaluation, clinical laboratory test results (CBC, serum biochemical analysis, blood lactate concentration, acid-base status, and coagulation profiles), initial emergency treatments and diagnostic tests performed, type of trauma sustained, imaging findings (thoracic, skeletal, and abdominal radiography and thoracic and abdominal ultrasonography), complete details of the surgical procedure (procedure type, location of surgery within the hospital, extent of surgery, postoperative use of any drains, microbial culture results for any tissue or fluid samples obtained during surgery, and intraoperative findings), postoperative complications, duration of hospitalization, and cause of death, if applicable.

The terms flail chest and pseudoflail chest were electronically searched and recorded when identified.\textsuperscript{14,15} Pseudoflail chest was defined as paradoxical movement of a segment of the thoracic wall, with only 1 or no rib fractures present.\textsuperscript{15} Pulmonary parenchymal lesions were classified as contusions or congestion, atelectasis, and damage or puncture of a lung lobe requiring lobectomy. Rib lesions were categorized as <3 or ≥3 rib fractures and as whether (yes or no) surgical reconstruction of the lesion was required. The perioperative period was defined as the interval from admission to the hospital until death or discharge from the hospital, and all perioperative complications were evaluated.

Medical records were also evaluated for whether signs of SIRS were evident before or after surgery. For this assessment, SIRS was defined as ≥3 of the following criteria on the same day during hospitalization: \textsuperscript{28}

- Rectal temperature, <37.8°C (100°F) or >39.7°C (103.5°F); heart rate, <140 beats/min or >225 beats/min; respiratory rate, >40 breaths/min; total WBC count, <5×10^9/µL or >10.5×10^9/µL; and band cell proportion, >5%.
- Blood pressure determination methods and SAP readings were recorded; hypertension was defined as an SAP >150 mm Hg, and hypotension was defined as an SAP <90 mm Hg. Hypoxia was defined as an oxygen saturation as measured by pulse oximetry of <94%. Coagulopathy was defined as ≥3 of the following criteria at the same assessment point: thrombocytopenia, prolonged prothrombin time, prolonged partial thromboplastin time, or prolonged activated clotting time.\textsuperscript{29} Acute kidney injury was defined as an increase of at least 1.5 times in serum creatinine concentration from the preoperative value.\textsuperscript{30} Hepatopathy was defined as increases from
were spayed females, and 3 were sexually intact females; 5 were castrated males, and 1 was sexually intact male (13 [57%] males in total); 7 cats were owner-referred for traumatic injury. Nine cats were castrated males, and 4 were sexually intact males (13 [57%] males in total); 7 cats were spayed females, and 3 were sexually intact females.

### Results

#### Surgical procedures

Complete details of the surgical procedures performed were available. Surgical intervention was defined as a procedure requiring debridement of tissue, stabilization of tissues, or placement of surgical drains over the thoracic wall or a procedure performed within the thorax. Laparotomy approaches were included if entry of the thorax occurred with exploration of the thoracic cavity (diaphragmatic approach to thoracotomy), a diaphragmatic hernia was identified and the thoracic cavity was explored, or laparotomy was performed concurrently with thoracotomy. The nature of the intraoperative procedures was recorded, including muscular, sternal, or rib reconstruction; excision of traumatized tissue or lung lobectomy; and any abdominal procedures performed concurrently.

#### Statistical analysis

Descriptive statistics were calculated with the aid of statistical software. Continuous data are reported as mean ± SD (normally distributed data) or median and range (nonnormally distributed data). Categorical data are summarized as counts and percentages. The ATT score was calculated by 1 study investigator (CLN) for each cat on the basis of data recorded at initial evaluation and by reviewing lesions noted in surgical reports to confirm trauma sustained. For this calculation, each of the 6 lesion categories (perfusion, cardiac, respiratory, eye-muscle-integument, skeletal, and neurologic) was assigned a score ranging from 0 (slight or no injury) to 3 (severe injury) by use of predetermined criteria for each category. Scores were then summed to yield a total score with possible values ranging from 0 to 18.

#### Preoperative findings

Types of trauma that cats had sustained included dog bite or attack (n = 8 [35%]), motor vehicle accident (6 [26%]), other animal attack (2 [9%]), impalement injury or fall (2 [9%]), projectile penetrating trauma (1 [4%]), or unknown origin (4 [17%]). Physical examination revealed puncture wounds from animal attacks or open wounds in 15 (65%) cats. Swelling and edema surrounded the wounds in 9 (39%) cats, subcutaneous emphysema in 9 (39%) cats, and external bruising in 4 (17%) cats. Flail chest and pseudoflail chest were suspected during physical examination and confirmed via radiography in 4 (17%) and 2 (9%) cats, respectively. Abnormal respiratory patterns consistent with respiratory distress were recorded for 13 (57%) cats. Auscultation of the thoracic cavity revealed muffled lung sounds in 8 (35%) cats, muffled heart sounds in 4 (17%) cats, crackles in 3 (13%) cats, and wheezes in 1 (4%) cat but no evidence of cardiac arrhythmia in any cat. Abnormal mentation, including stupor, obtundation, and coma, was noted in 6 (26%) cats.

Seven (30%) cats had tachycardia at initial evaluation, whereas 3 (13%) had bradycardia. Nine (39%) cats were hypothermic, and 18 (78%) had tachypnea. Oxygen saturation was measured by pulse oximetry in 6 cats, 1 of which was considered hypoxic. Arterial blood pressure, measured indirectly via Doppler ultrasonic flow detector (n = 11) or oscilometry (2), was recorded for 11 cats, 5 of which were considered hypotensive and 1 of which was considered hypertensive.

Mean or median values and ranges for cats with available data indicated several abnormalities in clinicopathologic test results relative to respective reference ranges (Table 1). No cat had leukopenia. A regenerative and degenerative left shift were recorded for 5 and 1 of 8 cats, respectively. Six of 20 (30%) cats with a recorded PCV value had anemia, and 11 of 13 cats with a recorded serum albumin concentration had hypoalbuminemia. Hyperlactatemia was identified in 10 of 15 cats with a recorded serum lactate concentration, and hypoglycemia was identified in 1 of 20 (5%) cats with a recorded serum glucose concentration. Seventeen cats had a venous blood gas analysis performed (2 also received arterial blood gas analysis), and 7 of these cats were acidic.

Thoracic radiography was performed for 19 (83%) cats, revealing pulmonary contusions in 7 (37%) cats, pneumothorax in 7 (37%), pleural effusion in 5 (26%), diaphragmatic hernia in 5 (26%), sternal fracture or avulsion injury in 5 (26%), rib fractures in 4 (21%),
atelectasis in 4 (21%), and pneumomediastinum in 2 (11%). Thoracic ultrasonography was performed for 8 cats, revealing pleural effusion in 5. Thoracocentesis was performed for 4 cats, most commonly to evacuate air attributable to pneumothorax (n = 3). Nine of the 23 (39%) cats had abdominal radiographic abnormalities, and 5 (22%) had skeletal radiographic abnormalities. Abdominal abnormalities included evidence of diaphragmatic hernia (n = 4), abdominal body wall hernia (2), subcutaneous emphysema (2), and pneumoperitoneum (1). Skeletal abnormalities included fractures of the long bones (n = 2), manus or pes (1), pelvis (1), and scapula (1).

Eleven (48%) cats had multiple traumatic injuries (polytrauma). Trauma was categorized as abdominal in 5 of 23 (22%) cats, appendicular in 5 (22%), involving the head in 3 (13%), involving the face or neck in 2 (9%), pelvic in 2 (9%), and pericardial in 1 (4%). An ATT score could be calculated for all 23 cats, and the mean ± SD score was 6.8 ± 2.5 (range, 3 to 11). Thirteen (57%) cats met the diagnostic criteria for SIRS before surgery.

**Preoperative treatments**

Oxygen supplementation was provided for 10 (43%) cats; 2 (9%) cats required endotracheal intubation to aid in stabilization prior to surgery, and no cat required mechanical ventilation prior to surgery. The type of sedation or anesthesia that may have been required specifically to maintain endotracheal intubation was not recorded.

Antimicrobials were administered to 22 (96%) cats, with multiple antimicrobials administered to 11 (48%). Thirteen (57%) cats received cefazolin IV, 11 (48%) received amoxicillin–clavulanic acid PO, 5 (22%) received enrofloxacin IV, and 4 (17%) received ampicillin-sulbactam IV. Analgesics were administered to 20 (87%) cats, including oxymorphone (n = 9 [39%]), fentanyl (6 [26%]), hydromorphone (4 [17%]), and NSAIDs (3 [13%]). Blood products were administered to 8 (35%) cats, including packed RBCs (n = 6 [26%]), fresh-frozen plasma (5 [22%]), and whole blood (3 [13%]). Fluids were administered IV to 20 (87%) cats, including isotonic crystalloid (n = 20 [87%]) and hetastarch (2 [9%]) solutions. No cat received hypertonic saline solution.

**Surgery**

Surgical procedures were performed in a sterile operating room (n = 19 [83%]), a room dedicated to minor surgical procedures (3 [13%]), or an emergency room (1 [4%]). General anesthesia was provided for surgery in 20 (87%) cats, and the remaining 3 (13%) cats received moderate to heavy sedation instead. Surgical procedures required or resulted in entry into the thoracic cavity for 15 (65%) cats and entry into the abdominal cavity for 11 (48%) cats. The most common procedures performed in the abdominal cavity consisted of diaphragmatic herniorrhaphy or repair of diaphragmatic rents (n = 8), abdominal body wall herniorrhaphy (3), and exploratory surgery with resection or repair of damaged tissues (2).

### Table 1 — Results of a CBC, serum biochemical and blood gas analyses, and blood coagulation tests at initial evaluation for cats surgically treated for thoracic trauma.

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of cats evaluated</th>
<th>Value</th>
<th>Reference range*</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBCs (X 10³/µL)</td>
<td>14</td>
<td>13.1 (6.9–32.3)</td>
<td>4.7–15.3</td>
</tr>
<tr>
<td>Neutrophils (X 10³/µL)</td>
<td>14</td>
<td>11.6 ± 6.2</td>
<td>2.0–9.2</td>
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<tr>
<td>Band neutrophils (X 10³/µL)</td>
<td>8</td>
<td>0.96 ± 0.81</td>
<td>0–2</td>
</tr>
<tr>
<td>Platelets (X 10³/µL)</td>
<td>10</td>
<td>276 ± 191</td>
<td>169–480</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>20</td>
<td>33.4 ± 8.1</td>
<td>30–45</td>
</tr>
<tr>
<td>Total protein (g/dL)</td>
<td>22</td>
<td>6.1 ± 1.0</td>
<td>6.5–8.6</td>
</tr>
<tr>
<td>Hct (%)</td>
<td>17</td>
<td>30.7 ± 9.2</td>
<td>34–48</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>20</td>
<td>178.0 ± 67.9</td>
<td>88–183</td>
</tr>
<tr>
<td>BUN (mg/dL)</td>
<td>17</td>
<td>27.0 (9.4–57.0)</td>
<td>10–30</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>17</td>
<td>1.1 (0.3–6.4)</td>
<td>0.8–2.0</td>
</tr>
<tr>
<td>Albumin (g/dL)</td>
<td>13</td>
<td>2.4 ± 0.5</td>
<td>2.8–4.3</td>
</tr>
<tr>
<td>Creatine kinase (U/L)</td>
<td>2</td>
<td>8.526 ± 9.091</td>
<td>21–275</td>
</tr>
<tr>
<td>Prothrombin time (s)</td>
<td>2</td>
<td>11.3 ± 2.5</td>
<td>6.8–8.7</td>
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<tr>
<td>Partial thromboplastin time (s)</td>
<td>2</td>
<td>31.8 ± 2.2</td>
<td>10.4–12.9</td>
</tr>
<tr>
<td>Activated clotting time (s)</td>
<td>1</td>
<td>116</td>
<td>&lt; 100</td>
</tr>
<tr>
<td>pH</td>
<td>17</td>
<td>7.22 ± 0.09</td>
<td>7.24–7.40</td>
</tr>
<tr>
<td>PCO₂ (mm Hg)</td>
<td>2</td>
<td>44.8 ± 4.7</td>
<td>25–45</td>
</tr>
<tr>
<td>PVO₂ (mm Hg)</td>
<td>15</td>
<td>42.3 (21.6–61.7)</td>
<td>25–45</td>
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<tr>
<td>Pao₂ (mm Hg)</td>
<td>15</td>
<td>524.0 ± 25.1</td>
<td>80–100</td>
</tr>
<tr>
<td>PVO₂ (mm Hg)</td>
<td>13</td>
<td>43.3 (26.1–209.2)</td>
<td>40–60</td>
</tr>
<tr>
<td>Lactate (mmol/L)</td>
<td>15</td>
<td>4.3 ± 3.4</td>
<td>0–2</td>
</tr>
</tbody>
</table>

Data for multiple cats represent mean ± SD for normally distributed values and median (range) for nonnormally distributed values.

*Reference ranges will vary slightly among clinics.

PCO₂ = Arterial partial pressure of CO₂. Pao₂ = Arterial partial pressure of O₂. PVO₂ = Venous partial pressure of CO₂. PVO₂ = Venous partial pressure of O₂.
The most common pathological findings at the time of surgery included skin wounds requiring debridement or drain placement (n = 17 [74%]), muscular defects within the thoracic or abdominal body wall (13 [57%]), tears or defects within the diaphragm (11 [48%]), fractures or luxations of the ribs (8 [35%]), lung lobe lesions (5 [22%]), and fractures or avulsions of the sternum (5 [22%]). Pulmonary parenchymal lesions were further defined as puncture or trauma to the lung lobe requiring partial or complete lung lobectomy in 2 (9%) cats, atelectasis of lung lobes in 2 (9%), and contusions or congestion of lung lobes in 1 (4%). Rib lesions were further defined as < 3 rib fractures (n = 6 [26%]), trauma to the rib cage that required stabilization or rib reconstruction (5 [22%]), and ≥ 3 rib fractures (2 [9%]). Other surgeries not involving the thorax or abdominal cavity included wound exploratory procedures with debridement of devitalized tissue (n = 2), resulting in placement of Penrose drains (1) or a Jackson-Pratt drain (1).

Surgical drains were placed in 16 (70%) cats. Thoracostomy tubes were placed in 11 (48%) cats, active suction Jackson-Pratt drains were placed within wound beds in 5 (22%) cats, passive Penrose drains were placed within wound beds in 2 (9%) cats, and vacuum-assisted drainage of wounds was provided to 1 (4%) cat. No active suction Jackson-Pratt drain allowing evacuation of the abdominal cavity was placed in any cat.

Bacterial culture of deep tissue wound samples obtained during surgery was performed for 5 (22%) cats, 3 of which had positive results. One of these 3 cats was infected with multiple bacteria, including Streptococcus sp., Pseudomonas sp., unspecified Enterobacteriaceae, and Bacillus sp.

Complications

Intra- or postoperative complications were recorded for 10 (43%) cats and included incisional complications (n = 4 [17%]), cardiopulmonary arrest (3 [13%]), gastrointestinal disturbances (2 [9%]), cardiac arrhythmia (2 [9%]), and aspiration pneumonia (1 [4%]). One of the 3 cats with cardiopulmonary arrest survived with successful resuscitation performed during anesthesia. Following surgery, 14 (61%) cats developed nonthoracic disease such as anemia (n = 10 [44%]), hepatopathy (3 [13%]), coagulopathy (2 [9%]), and acute kidney injury (2 [9%]). When postoperative complications and development of nonthoracic disease were considered, some cats were classified into > 1 disease category. Five (22%) cats met the diagnostic criteria for SIRS following surgery, and 4 of these same cats met these criteria both before and after surgery.

Outcome

All 23 cats survived the surgical procedure; however, 3 (13%) cats failed to survive to hospital discharge. For surviving cats, discharge from the hospital occurred a median of 4 days (range, 1 to 18 days) after surgery. For cats that failed to survive, 2 died of cardiopulmonary arrest, and 1 was euthanized because of persistent supplemental oxygen dependence and refractory ventricular arrhythmia. Mean ± SD number of days from conclusion of surgery to death for nonsurviving cats was 0.4 ± 1.3 days (range, 0 to 6 days). Mortality rates per disease state (excluding cardiopulmonary arrest) were as follows: flail chest, 0 of 4; lung lesions requiring lung lobectomy, 1 of 2; ≥ 3 rib fractures, 0 of 2; rib lesions requiring rib reconstruction, 0 of 5; muscular defects of the body wall, 2 of 13; preoperative SIRS, 3 of 13; postoperative SIRS, 0 of 5; aspiration pneumonia, 1 of 1; coagulopathy, 1 of 2; and acute kidney injury, 0 of 2.

Physiologic values were statistically similar between survivors and nonsurvivors (Table 2). Of all evaluated variables, including all clinical and other findings, treatments, and surgical variables, the only 2 variables associated with survival to hospital discharge after adjustment for multiple comparisons were ATT score at initial evaluation and intra- or postsurgical cardiopulmonary arrest. Mean ± SD ATT score for survivors was 6.4 ± 2.2 (95% CI, 5.3 to 7.4), which was significantly (P < 0.001) lower than the mean ATT score for nonsurvivors (10.0 ± 1.7; 95% CI, 5.7 to 14.3). Cats with no cardiopulmonary arrest (19/20 [95%; 95% CI, 75% to 100%]) were significantly (P = 0.03) more likely to survive to hospital discharge than cats with cardiopulmonary arrest (1/3 [33%; 95% CI, 1% to 91%]).

Discussion

Published information about outcomes and variables associated with mortality rate for cats following surgical treatment of thoracic trauma is lacking. Although a small number of cats was included (n = 23), the present study represented the first of cats surgically treated for thoracic trauma. The mortality rate was 13%, and factors identified as associated with survival to hospital discharge were limited to ATT score and intra- or postoperative cardiopulmonary arrest.

Little information exists regarding any sex predisposition of cats with thoracic trauma. In the study reported here, males comprised 57% of included cats, and no association was identified between sex and survival to hospital discharge. Median age of included cats was 24 months, which is consistent with other
defined by specific physical examination and CBC values. The most common causes of trauma were dog bite wounds (35%), motor vehicle accident (26%), and unknown cause (17%), and these data are similar to previously reported findings for cats with trauma.1,4,10,12,34 Interestingly, no cat had sustained a fall from heights.

Previous reports35–37 have described outcomes of cats requiring thoracic surgery for various reasons, including chronic pyothorax, neoplasia, and vascular anomalies. In the study reported here, many procedures were performed during thoracotomy that may have reflected severe trauma, such as repair of muscular defects in the body wall, reconstruction of the rib cage, and lung lobectomy. Diaphragmatic hernia was the most common reason for thoracic exploratory surgery in cats in a previous report,38 and diaphragmatic tears were common findings in the present study. Despite the severity of trauma that the cats in the present study had sustained, no surgical procedures or pathological findings noted at the time of surgery were associated with survival to hospital discharge.

Cats with trauma to the thorax often lack clinical signs of thoracic disease, which is likely related to a large pulmonary reserve allowing the cats to compensate for the injuries sustained.39 Studies4,10 of cats with thoracic trauma have revealed that although radiographic evidence of thoracic disease may exist, only 55% to 60% of cats may have related clinical signs. This was noted in the present study, in which 83% had evidence on thoracic radiographs confirming thoracic trauma, but only 57% had respiratory distress. Only 2 cats required endotracheal intubation for respiratory distress, and these 2 cats had a mean arterial partial pressure of oxygen value of 524 mm Hg owing to inhalation of 100% oxygen even though no mechanical ventilation was performed before surgery.

Since the ATT score was first introduced in 1994, a few reports4,10,40 have been published regarding the use of this system to predict survival in cats with trauma. These reports include many forms of trauma in cats, including blunt trauma, bite wound trauma, unknown trauma, and traumatic body wall herniation, and indicate ATT scores are predictive of outcome.9,5 Mean ATT scores for cats in 2 studies4,10 ranged from 3.0 to 6.4. Mean ATT scores for surviving and nonsurviving cats in 1 study40 were 6.0 and 8.0, respectively. In another study4 involving 70 cats, higher ATT scores were associated with a greater likelihood of nonsurvival than lower scores. In the present study, mean ATT scores for surviving and nonsurviving cats were 6.4 and 10.0, respectively, and cats that survived to hospital discharge had significantly lower ATT scores than cats that failed to survive. Further evaluation of the usefulness of ATT score for prognostic purposes in a larger number of cats with thoracic trauma is needed, and use of ATT scores should be considered cautiously to inform decisions regarding euthanasia for the individual cat until further information is available.41,42

Systemic inflammatory response syndrome is a severe state of inflammation throughout the body that is defined by specific physical examination and CBC values and is often associated with sepsis.28 In the present study, 57% of cats met the diagnostic criteria for SIRS before surgery, and 22% met those criteria after surgery; all but 1 cat with postoperative SIRS also had SIRS before surgery. However, no association was identified between SIRS classification and survival to hospital discharge. Similarly, in another study,43 no difference in survival rates was identified between cats with septic peritonitis and those with and without SIRS.43 Systemic inflammation, severe tissue trauma, and metabolic acidosis are reportedly associated with acute traumatic coagulopathy in cats and dogs,44 and these factors were represented among cats in the present study. Additionally, mean values of clinicopathologic tests indicated anemia (low Hct) and hypoproteinemia within this group. Mean PCV was within the reference range; however, this hemato logic test is rapid and may have been performed prior to complete fluid resuscitation, leading to a higher PCV in cats with dehydration and hemoconcentration. The cause of anemia and hypoproteinemia in the cats of the present study was likely blood loss at the time of injury as well as loss through effusive fluids from open wounds.

Cardiopulmonary cerebral resuscitation of cats with cardiopulmonary arrest has been evaluated.45–47 Return of spontaneous circulation has occurred in 44% to 57% of cats treated with cardiopulmonary cerebral resuscitation; however, only 3% to 7% of treated cats survived to discharge from the hospital in those studies.46,47 Three of the 23 cats in the present study had cardiopulmonary arrest during or after surgery; and this variable was significantly associated with nonsurvival. Previous reports48–47 indicate that cardiopulmonary arrest at the time of anesthesia or during anesthetic recovery is associated with a better likelihood of return of spontaneous circulation during cardiopulmonary cerebral resuscitation, compared with arrest events at any other time associated with the patient’s care, including conservative management of a disease process, preanesthetic care, or postanesthetic recovery.49–47 It is reasonable to suggest that 1 of the 3 cats with cardiopulmonary arrest had return of spontaneous circulation, which is similar to previous reports.45,47 Interestingly, the only cat that survived to hospital discharge had cardiopulmonary arrest during anesthesia rather than after surgery.

Reported mortality rates for cats with general trauma range from 19% to 32%.4,2–4,10,5 Reported mortality rates in relation to thoracic trauma specifically in cats range from 12.5% to 37%.11,12,33,34 Previous studies have shown that thoracic involvement in cats with trauma leading to subsequent surgical intervention significantly increases the risk of nonsurvival, with the mortality rate reaching 100% in 1 study5 over cats with injuries in other locations or with conservative management.5,6,14 The percentage of cats with thoracic trauma requiring intra thoracic surgical intervention in the present study was 65%, and the overall mortality rate for all cats was 13%.

The main limitations of the present study were its retrospective nature and the small number of included cats. Although evaluation of medical records was sufficient for data collection, some cats lacked recorded surgical findings, pre- and postoperative care data,
and preoperative diagnostic test results. No information could be obtained regarding time from trauma to hospital admission or surgery, and such information could have been valuable for analysis. Because cats appear to represent a small subset of patients treated in veterinary hospitals for trauma, accumulation of a large number of cases is difficult to achieve. Indeed, the present study included cases encountered over a 24-year period at 7 academic institutions, yet only 23 cats qualified for inclusion. Another limitation was that medical and surgical treatments likely varied from case to case owing to advances or differences in care, clinician preference, and institutional management, further limiting the ability to detect significant associations with outcome.

Although results of previous studies have suggested that thoracic trauma generally results in a poor prognosis for affected cats, the mortality rate for the surgically treated cats in the present study was rather low. Findings suggested that ATC score may be useful in determining the severity of disease and extent of diagnostic testing required for cats with trauma. No imaging finding, surgical finding, or surgical procedure was associated with survival to hospital discharge, suggesting that neither trauma severity as judged via imaging nor surgical findings would predict perioperative nonsurvival in similar cat populations; however, cardiopulmonary arrest, as a severe complication or reaction to trauma, was associated with outcome and could be useful for predicting outcome.

Footnotes

a. Stata, version 13, StataCorp, College Station, Tex.


References


From this month’s AJVR

**Retrospective analysis of corrosion and ion release from retrieved cast stainless steel tibia plateau leveling osteotomy plates in dogs with and without peri-implant osteosarcoma**

Christoph M. Sprecher et al

**OBJECTIVE**

To evaluate and compare surface and cross-sectional structure as well as localized electrochemical corrosion and ion release for cast stainless steel (SS) tibia plateau leveling osteotomy (TPLO) plates retrieved from dogs with and without osteosarcoma (OSA) and to compare these findings with similar variables for forged SS TPLO plates retrieved from dogs.

**SAMPLE**

47 TPLO plates explanted from 45 client-owned dogs (22 cast plates from dogs with OSA, 22 cast plates from dogs without OSA, and 3 forged plates from dogs without OSA).

**PROCEDURES**

Histologic evaluations of tissue samples collected from implant sites at the time of plate retrieval were performed to confirm implant site tumor status of each dog. Surfaces and metallographic cross sections of retrieved plates were examined, and the microcell technique was used to obtain local electrochemical corrosion and ion release measurements.

**RESULTS**

Findings indicated that all cast SS plates demonstrated high spatial variability of their electrochemical surface properties and inhomogeneous superficial and cross-sectional composition, compared with forged plates. Greater metal ion release was observed in cast plates than forged plates and in cast plates from dogs with OSA than from dogs without OSA.

**CONCLUSIONS AND CLINICAL RELEVANCE**

Results suggested that accumulation of metal ions from implants could be a trigger for neoplastic transformation in neighboring cells. Metal ion release caused by corrosion of implants that do not comply with recommended standards of the American Society for Testing and Materials International or the International Organization for Standardization could potentially place patients at increased risk of tumor development. (*Am J Vet Res* 2018;79:970–979)