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Clinical findings and diagnostic value of post-traumatic thoracic radiographs in dogs and cats with blunt trauma

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Abstract

Objective: To characterize the clinical findings in dogs and cats that sustained blunt trauma and to compare clinical respiratory examination results with post-traumatic thoracic radiography findings.
Design: Retrospective clinical study.
Setting: University small animal teaching hospital.
Animals, interventions and measurements: Case records of 63 dogs and 96 cats presenting with a history of blunt trauma and thoracic radiographs between September 2001 and May 2003 were examined. Clinical signs of respiratory distress (respiratory rate (RR), pulmonary auscultation) and outcome were compared with radiographic signs of blunt trauma.
Results: Forty-nine percent of dogs and 63.5% of cats had radiographic signs attributed to thoracic trauma. Twenty-two percent of dogs and 28% of cats had normal radiographs. Abnormal auscultation results were significantly associated with radiographic signs of thoracic trauma, radiography score and presence and degree of contusions. Seventy-two percent of animals with no other injuries showed signs of thoracic trauma on chest radiographs. No correlation was found between the radiographic findings and outcome, whereas the trauma score at presentation was significantly associated with outcome and with signs of chest trauma but not with the radiography score.
Conclusion: Thoracic trauma is encountered in many blunt trauma patients. The RR of animals with blunt trauma is not useful in predicting thoracic injury, whereas abnormal chest auscultation results are indicative of chest abnormalities. Thorough chest auscultation is, therefore, mandatory in all trauma animals and might help in the assessment of necessity of chest radiographs.

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Introduction

Thoracic injuries are a major cause of morbidity and mortality in human[1] and veterinary[2–5] blunt trauma patients. Early detection and treatment of thoracic injuries is crucial, since blunt chest trauma has been shown to negatively affect outcome in human patients with multiple injuries.[6] Radiographic imaging of the thorax plays an important role in the workup of the patient with blunt trauma[1] and thoracic radiographs obtained in the emergency room at the bedside are accepted as an essential procedure in the initial assessment of human trauma patients because of the morbidity and mortality associated with chest injuries.[7,8] In veterinary medicine, obtaining thoracic radiographs during the initial evaluation and resuscitation period is limited by the fact that animals must be

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transported to the radiology area, and movement and restraint can increase the stress and oxygenation requirement of the injured animal. Despite improved radiology facilities at universities and private clinics, immediate clinical evaluation of the trauma patient remains the cornerstone of rapid recognition of thoracic injuries. Significant thoracic injury following blunt trauma in the dog and cat may be missed on initial physical examination, and the association of clinical parameters in animals with blunt thoracic trauma and radiographic signs of thoracic trauma as well as outcome is unknown.

The objectives of this retrospective study were to: (1) determine the prevalence and extent of thoracic injuries in dogs and cats with blunt trauma and (2) compare clinical abnormalities with thoracic radiograph findings and assess the diagnostic value of chest radiography in dogs and cats suffering blunt trauma.

Material and Methods

A computer search was performed on the medical records of all dogs and cats presented to the Small Animal Clinic of the University of Berne, Switzerland, between September 2001 and May 2003. The files were searched for the keywords ''HBC'' (hit by car), ''vehicular accident'', and ''high-rise syndrome''. Only animals that had post-trauma thoracic radiographs performed at the Small Animal Clinic of the University of Berne were included in the study. Records were then evaluated for availability and completeness. Records were excluded if there were missing reports (i.e., radiology report, intensive care unit (ICU) sheets), if the trauma occurred more than 5 days prior to presentation, or if animals received less than optimal treatment due to financial concerns or other reasons (i.e., immediate euthanasia at the owner's request, animals with unknown owner).

The following data were extracted from the records: age, sex, weight, species (dog or cat), time since the trauma happened, prior stabilization by the local veterinarian, initial heart rate (HR), initial respiratory rate (RR), thoracic auscultation results, signs of labored breathing, perfusion status at presentation, RR after administration of analgesic medication, thoracic radiograph findings, time of thoracic radiographs following trauma, presence of additional injuries, and outcome at the time of discharge.

The initial HR was categorized as normal (canine 60–120 beats per minute (bpm); feline 120–180 bpm), moderately increased (canine 140–180 bpm; feline 180–200 bpm) or severely increased (canine >180 bpm; feline >200 bpm).[8] Animals already sedated at the time of presentation were excluded from HR grading.

The RR at presentation and after analgesia was also graded into normal (12–32 breaths per minute (bm) for dogs and 20–44 bm for cats), moderately increased (32–60 bm for dogs and 44–64 for cats), severely increased (>60 bm for dogs and >64 bm for cats), and panting (dogs only).[9] Panting cats were defined as having signs of labored breathing. Chest auscultation results at presentation were categorized as normal, moderately or severely abnormal. Based on the initial and post-analgesic respiratory examination findings (RR and chest auscultation findings), animals were categorized as having a normal or abnormal respiration. Animals with normal auscultation findings but panting were treated as a separate group. Analgesics (methadone[a] (0.1 mg/kg IV or IM), butorphanol[b] (0.02–0.04 mg/kg IV or IM), and buprenorphine[c] (0.01 mg/kg IV or IM) were given at the discretion of the emergency clinician.

Perfusion status at presentation was quoted as being normal or suggestive of compensated shock or early decompensated shock, depending on mucous membrane color, capillary refill time, and HR.[10] Additional injuries were categorized as head trauma, intra-abdominal trauma, skeletal trauma to the front or back legs, isolated skin wounds, spinal disorders, and combinations of the above.

Abnormal thoracic radiograph findings (pneumothorax, pneumomediastinum, pulmonary contusions, chest wall trauma, chronic disease, and/or other abnormalities) were extracted from the written radiology reports made by board-certified radiologists. Each finding was graded and assigned a value: normal (0), slight (1), moderate (2), or severe (3). The sum of all points produced a radiography (XR) score. The XR score was then divided into 4 groups: normal (0 points), slight (1–2), moderate (3–4), and severe (>5) lung abnormalities. In order to decrease the influence of chronic lung disease, the radiographic findings were graded into a second XR-score (XR-score2) as described before, however, the points given for chronic disease were excluded. Thoracic radiographs were further graded as showing signs of chest wall trauma or not. Time from trauma to chest radiographs was categorized as less than 6, 6–12, 13–24, and more than 24 hours.

From these data, the animal trauma triage score (ATT score), a trauma localization system that indicated the location of the trauma (i.e., head or neck, thorax, abdomen, extremities), and the severity of the injury (i.e., none to minimal to significant) were retrospectively established on each animal.[8] Parameters at the time of presentation were evaluated. If animals were already stabilized by the referring veterinarian or if the trauma happened more than 48 hours prior to presentation, cases were excluded from the trauma scoring. ATT score results were further summarized into mild trauma (ATT score 1–3), moderate trauma (ATT score 4–7), and severe trauma (ATT ≥ 8).

Statistical Methods

For the continuously measured variables, the median and range were reported as they were not normally distributed.

The frequency distributions of the categorical or ordinal (score) variables were derived. The association between categorical variables was evaluated using the χ^2 test statistic. When both variables were binary and expected cell frequencies were below 5, a two-sided Fisher's exact test was used.

Clinical parameters (RR at presentation and after analgesia, auscultation results, clinical assessment of respiration at presentation and after analgesia) were compared with the XR-score, XR-score2, signs of chest trauma, contusions, pneumothorax, and chronic disease using cross-tabulation and χ^2 testing. This analysis was repeated excluding dogs that were panting but had otherwise normal auscultation results. As some of the groups in the cross-tabulation testing contained less than 5 values, groups with abnormal findings were combined and two-proportion testing using χ^2 testing was used to compare animals with chest abnormalities with and without clinical signs of abnormal respiration. Correlation between linear scores (ATT score at presentation, non-categorized XR-score) were determined using Spearman rank correlation testing. RR prior to and after analgesic therapy was correlated using the non-parametric paired *t*-test. Animals that received therapeutic procedures other than oxygen supplementation in order to improve respiration (i.e., thoracocentesis) were excluded from post-analgesic RR evaluation.

All analyses were performed with the statistical software program NCSS.[d] A value of $P < 0.05$ was considered significant.

Results

A total of 6192 dogs and cats were presented as new patients to the Small Animal Clinic of the University of Berne during the 21-month study period. Four hundred and sixty-seven animals were found using the keyword search. Of these, 248 presented because of a recently sustained trauma and had thoracic radiographs performed. Of these 248 animals, 159 (96 cats and 63 dogs) met the inclusion criteria and were enrolled in the study.

Descriptive findings of study population

The feline population had a median age of 1.5 years (range 0.2–13 years) and a median weight of 4 kg (range 0.5–7.5 kg). The canine population had a median age of 3 years (range 0.5–14 years) and a median weight of 25 kg (range 2–72 kg) (Table 1). Fifty-seven percent of all animals were males whereas 43% were females.

Respiratory clinical findings are summarized in Table 2. Significantly more cats (27%) than dogs (8%) showed labored breathing at the time of presentation ($P = 0.003$). One hundred and thirty-six animals received analgesics. After analgesia, there was a significant difference in normal RR between cats (58%) and dogs (35%) ($P = 0.001$). The reduction in RR after analgesic therapy was significant ($P = 0.001$). No difference was seen between the different analgesics used. Assessment of respiration after analgesic therapy (Clinresp2) was abnormal in 112 of 136 animals (82.4%). Fifteen of 51 dogs (21.2%) were panting after analgesic therapy. If the panting dogs were excluded, 101 of 125 animals (80.8%) showed an abnormal respiration. The HR at presentation and perfusion status are summarized in Table 3.

Forty-eight of 159 animals (30%) had been stabilized by the local veterinarian prior to referral.

One hundred and one animals were retrospectively assigned a trauma score: 34 (33.7%) of the animals presented with mild trauma, 52 (51.1%) with moderate trauma, and 15 (14.9%) with severe trauma. More cats (19.4%) than dogs (5.9%) showed severe trauma but that difference was not statistically significant.

Thoracic radiography findings are summarized in Table 4. Significantly more dogs (33.3%) than cats (15.6%) showed radiographic signs of chronic lung disease ($P = 0.03$). The median XR-score was 2 (range 0–6)

Table 1: Descriptive statistics of the continuously measured variables of dogs and cats with blunt trauma involved in the study

	Dogs				Cats			
	n	Median	Min	Max	*n*	Median	Min	Max
Age	63	3.0	0.5	14	96	1.5	0.2	13
Weight	63	25.0	2	72	96	4.0	0.5	7.5
ATT score*	34	4	1	8	67	4	1	11
XR-score†	63	2	0	6	96	1.5	0	8

*Animal trauma triage score (ATT score)[8] at time of presentation. If animals were already stabilized by the referring veterinarian or if the trauma happened more than 48 hours prior to presentation, they were excluded from the trauma scoring. Mild trauma = ATT score 1–3, moderate trauma = 4–7, and severe trauma $\geqslant 8$.

†Abnormal thoracic radiograph findings (pneumothorax, pneumomediastinum, pulmonary contusions, chest wall trauma, chronic disease, and/or other abnormalities) were graded as normal (0), slight (1), moderate (2), or severe (3). The sum of all points produced a radiography (XR) score. The XR-score was then divided into normal (0 points), slight (1–2), moderate (3–4), and severe (>5) thoracic abnormalities.

Table 2: Frequencies of the levels of all categorical variables of dogs and cats with blunt trauma regarding respiratory parameters

	Dogs		Cats		All animals	
	n	%	*n*	%	*n*	%
Initial RR						
Normal	14	22.2	30	31.6	44	27.6
Moderately increased	18	28.6	27	28.4	45	28.5
Severely increased	9	14.3	38	40.0	47	29.6
Panting	22	34.9			22	13.9
Total†	63		95		158	
Labored breathing	5	8.0*	26	27.1*	31	19.5
Auscultation						
Normal	31	50.0	35	36.5	66	41.8
Moderately abnormal	23	37.1	39	40.6	62	39.2
Severely abnormal	8	12.9	22	22.9	30	19.0
Total‡	62		96		158	
Initial respiration						
Normal	12	19.0	16	16.8	28	17.7
Abnormal	51	81.0	79	83.2	130	82.3
Total§	63		95		158	
RR after analgesia						
Normal	18	35.3*	44	57.9*	62	48.8
Mild increase	13	25.5	24	31.6	37	29.1
Severe increase	5	9.8	8	10.5	13	10.2
Panting	15	29.4	0	0	15	11.8
Total¶	51		76		127	
Respiration after analgesia						
Normal	9	17.3	15	17.9	24	17.7
Abnormal	32	61.5	69	82.1	101	74.3
Panting	11	21.2	0	0	11	8.1
Total¶	52		84		136	
Respiration w/o panting ‖						
Normal	9	17.9	15	22.0	24	19.2
Abnormal	32	82.1	69	78.0	101	80.8
Total	41		84		125	

RR, respiratory rate; XR, radiograph.
*$P < 0.05$.
†Initial respiratory rate was missing in one cat.
‡Auscultation results were not available in one dog due to missing data.
§Respiration could not be assessed in the one cat missing the initial respiratory rate because auscultation was normal. The respiration of the dog that missed auscultation results was assessed as abnormal since RR was abnormal.
¶RR and respiration after analgesia was not available in all animals receiving analgesia.
‖Clinical evaluation of respiration without the group of panting dogs.

in dogs and 1.5 (range 0–8) in cats (Table 1). Forty-three of 157 (27.4%) animals were radiographed within 6 hours after the trauma. Seventy-seven of 158 (48.7%) animals showed fractures of the rear legs, 13.9% had fractures of the front legs, and 10% showed signs of head trauma (Table 5). Fourteen of 159 (8.8%) animals died or were euthanized during the hospital stay.

Animals were presented within 0.5–100 hours post-trauma (median 6 hours) and were radiographed within 0.5–100 hours (median 10 hours) (Table 1).

Table 3: Frequencies of the levels of categorical variables of dogs and cats with blunt trauma regarding heart rate and perfusion status at presentation

	Dogs		Cats		All animals	
	n	%	*n*	%	*n*	%
Initial heart rate*						
Normal	10	16.7	26	29.6	36	24.3
Moderately increased	30	50.0	25	28.4	55	37.2
Severely increased	20	33.3	37	42.0	57	38.5
Initial perfusion†‡						
Normal	29	46.8	39	40.6	68	43.0
Compensated shock	21	33.9	37	38.5	58	36.7
Early decompensated shock	12	19.4	20	20.8	32	20.3

*Sedated animals were excluded from initial heart rate grading.
†Perfusion at presentation was assessed using heart rate, mucuous membranes, and capillary refill time.[10]
‡One dog was excluded because determination of perfusion was not possible due to missing parameters.

Associations

Associations between clinical parameters of respiration and thoracic radiography findings are summarized in Table 6. RR at presentation was significantly associated with the degree of pneumothorax or pneumomediastinum on chest radiographs ($P = 0.002$). Auscultation findings at presentation were significantly associated with all radiographic findings except those associated with chronic disease. Clinical assessment of respiration at presentation (Clinresp1) was significantly associated with radiographic signs of thoracic trauma ($P = 0.03$). RR after analgesic therapy (RR2) was significantly associated with degree of contusions ($P = 0.04$) and pneumothorax ($P = 0.0003$). Clinical assessment of respiration after analgesic therapy (Clinresp2) was significantly associated with the XR-score ($P = 0.02$), the XR-score2 ($P = 0.03$) and with the presence of radiographic signs of chest trauma ($P = 0.005$). If those animals that were panting but otherwise showed normal auscultation findings were excluded from the analysis, only the association with the XR-score remained significant ($P = 0.04$). The animals that were panting showed either no (27.3%) or a mildly (72.7%) increased XR-score. Nine of 11 (82%) panting dogs with a normal auscultation finding showed no radiographic signs of chest trauma.

Two-proportion testing using χ^2 testing showed a significant association between abnormal auscultation results and thoracic radiographic findings. Auscultation results remained significantly associated with the XR-score ($P = 0.02$), XR-score2 ($P = 0.001$), radiographic signs of chest trauma ($P = 0.002$), and presence of lung contusions ($P = 0.03$).

Table 4: Frequencies of the levels of all categorical and ordinary variables of dogs and cats with blunt trauma regarding chest radiography findings

	Dogs		Cats		All animals	
	n	%	n	%	n	%
XR findings						
Pneumothorax	15	24	32	33	47	29.6
None	48	76.2	64	66.7	112	70.4
Mild	11	17.5	23	24.0	34	21.4
Moderate	3	4.8	7	7.3	10	6.3
Severe	1	1.6	2	2.1	3	1.9
Total	63		96		159	
Contusions	24	38.7	44	45.8	68	43.0
None	38	61.3	52	54.2	90	57.0
Mild	9	14.5	19	19.8	28	17.7
One side	13	21.0	23	24.0	36	22.8
Bilateral	2	3.2	2	2.1	4	2.5
Total†	62		96		158	
Chest wall trauma	11	17.7	14	14.6	25	15.8
None	51	82.3	82	85.4	133	84.2
Mild	7	11.3	7	7.3	14	8.9
Moderate	4	6.5	7	7.3	11	7.0
Severe	0	0	0	0	0	0
Total†	62		96		158	
Chronic disease	21	33.3*	15	15.6*	36	22.6
None	42	66.7	81	84.4	123	77.4
Mild	14	22.2	11	11.5	25	15.7
Moderate	7	11.1	4	4.2	11	6.9
Severe	0	0	0	0	0	0
Total	63		96		159	
XR-score findings						
Normal	14	22.2	27	28.1	41	25.8
Slight	31	49.2	40	41.7	71	44.7
Moderate	13	20.6	22	22.9	35	22.0
Severe	5	7.9	7	7.3	12	7.6
Total	63		96		159	
Signs of trauma on XR	31	49.2	61	63.5	92	57.9
Time to XR (hours)						
<6	25	39.7	18	19.1	43	27.4
6–12	16	25.4	37	39.4	53	33.8
13–24	10	15.9	16	17.0	26	16.6
>24	12	19.0	23	24.5	35	22.3

XR, radiograph; XR-score, score consisting of points given to severity of lung contusions, pneumothorax, chest wall trauma, and chronic disease.
*$P<0.05$.
†One dog was excluded since contusions and chest wall trauma could not be ruled out due to the severe pneumothorax.

The outcome showed a significant association with the trauma score at presentation ($P=0.04$). There was no association between XR-score and time to radiographs after trauma ($P=0.06$). There was also a significant association between the trauma score at presentation and signs of trauma on chest radiographs ($P=0.003$) and XR-score2 ($P=0.01$), but with the XR-score it could not be noted. No significant correlation between the ATT score at presentation and the XR-score was noted.

Table 5: Frequencies of the levels of categorical variables of dogs and cats with blunt trauma regarding other injuries than chest trauma

	Dogs		Cats		All animals	
	n	%	n	%	n	%
Other diagnoses						
None	5	7.9	6	6.3	11	7.0
Rear legs	29	46.0	48	50.5	77	48.7
Front legs	11	17.5	11	11.6	22	13.9
Head trauma	3	4.8	13	13.7	16	10.1
Spinal injuries	4	6.4	3	3.2	7	4.4
Tracheal injury	1	1.6	1	1.1	2	1.3
Abdomen	3	4.8	2	2.1	5	3.2
Skin wounds	3	4.8	5	5.3	8	5.1
Polytrauma	4	6.4	6	6.3	10	6.3

Eight of 11 animals (72.2%) with no other injuries showed thoracic trauma as well as 5 of 7 (71.4%) animals with spinal injuries, 9 of 16 (56.3%) animals with head trauma, 12 of 22 (54.5%) animals with fractures of the front legs, 4 of 8 (50%) animals with skin wounds, 38 of 77 (49.4%) animals with fractures of the rear legs, and 8 of 10 (80%) animals with more than one injury. The association between the diagnosis other than chest abnormalities and signs of thoracic trauma on chest radiographs was not significant.

Discussion

Thoracic injuries account for 14% of pediatric trauma-related deaths[11] and 20–30% of trauma-related death in adults.[6,12] In human medicine, chest radiography is, therefore, the initial diagnostic test for the identification of thoracic injuries.[13] Forty-two percent of polytraumatized human patients showed therapy-relevant findings on chest radiographs or computed tomography (CT).[12] The most important lung alterations in humans associated with blunt trauma are pulmonary contusions, followed by lacerations resulting in pneumothorax, rib fractures, and diffuse alveolar damage.[14,15]

Lung contusions represent a concussive loss of vessel integrity resulting in intraparenchymal and alveolar hemorrhage, edema, decreased pulmonary compliance, and increased shunt fraction, therefore, contributing to morbidity and mortality.[16] Pape et al.[17] reported an overall rate of pulmonary contusions in trauma patients as 2.2%, whereas the incidence of contusions increased to 38% in patients with severe polytrauma. In a study of 143 dogs showing various degrees of pulmonary contusions due to motor vehicle accident, mortality rate was 7%.[18]

Fifty-eight percent of the animals in our study showed signs of chest trauma on thoracic radiographs.

Table 6: Associations between clinical parameters of respiration and chest radiography findings in dogs and cats with blunt trauma using cross-tabulation and χ^2 testing

	XR-score	XR-score2	XR trauma	Pneumo-thorax	Contusions	Chronic disease
RR1	0.21	0.27	0.7	**0.002**	0.14	0.15
Auscultation findings	**0.005**	**0.01**	**0.003**	**0.01**	**0.02**	0.76
Clinresp1	0.07	0.08	**0.03**	0.28	0.22	0.72
RR2	0.8	0.65	0.13	**0.003**	**0.04**	0.06
Clinresp2	**0.04**	0.09	0.13	0.48	**0.03**	0.41

Statistically significant *P*-values are given in bold.
RR1, respiratory rate at presentation; RR2, respiratory rate after analgesic therapy (excluding panting dogs); Clinresp1, clinical assessment of respiration at presentation; Clinresp2, clinical assessment of respiration after analgesic therapy (excluding panting dogs); XR-score, score consisting of points given to severity of lung contusions, pneumothorax, chest wall trauma, and chronic disease; XR-score2, XR-score independent of signs of chronic disease; XR trauma, signs of trauma on chest radiographs.

Other veterinary studies reported 39–60% incidence of thoracic trauma concurrent with several fracture types.[2,19–21] In our study, lung contusions were seen most frequently (43%), followed by pneumothorax/pneumomediastinum (30%), and chest wall trauma (16%). There are several reports that describe radiographic findings in dogs and cats with blunt trauma, including injuries seen in canine and feline high-rise syndrome[3,4] and pulmonary injuries in dogs with fractures as a result of motor vehicle accidents.[2,18,22] Cats with high-rise syndrome showed a higher prevalence of thoracic injury (82 of 91 cats, 90%) than seen in our feline population, which included 20% of the cats with high-rise syndrome and 80% of the cats experiencing vehicular accidents. Dogs with high-rise syndrome showed a similar number of thoracic injuries (44 of 70 dogs, 63%) as our canine population consisting of vehicular accidents only. Spackman et al.[2] described thoracic injuries in 39% of dogs (104 of 267 dogs) with trauma due to vehicular accidents. One would have expected a higher incidence of thoracic trauma in that study since all cases had sustained one or more fractures. Cook et al.[21] found 50% concurrent chest injuries with scapular fractures in dogs. In contrast, our study population showed a high incidence of thoracic trauma and, very interestingly, 72% of the animals without any other injuries showed thoracic trauma.

Our study population was retrospectively assigned an Animal-Trauma-Triage score (101 of 159 animals).[8] Animals that were already stabilized by the local veterinarian (48 of 159) were excluded from scoring since measures to stabilize were already instituted. Animals that sustained a trauma more than 48 hours prior to presentation, or if time of trauma was unknown, were also excluded from ATT scoring (10 of 159). This score was used to evaluate parameters with respect to their severity of injury. Cats tended to show more severe trauma than dogs but the difference was not significant, and the median ATT score was the same in both dogs and cats. The majority of the animals (85%) showed mild or moderate trauma, with an ATT score <7. Rockar et al.[8] found that non-survivors had an ATT score of 7–8. In our study, there was a significant association between the ATT score at presentation and radiographic signs of chest trauma, but not with the XR-score. This might also explain the low incidence of diaphragmatic hernias in this study (2 of 159), since animals that presented to the local veterinarian with a diaphragmatic hernia most probably showed a high ATT score and might have been radiographed by the local veterinarian due to severe respiratory distress. Even though 30% of the animals were stabilized by the local veterinarian prior to referral and were, therefore, not included in the ATT scoring, we believe that these animals most likely had a similar ATT score at presentation to the local veterinarian. Since these animals were only stabilized by the veterinarian and were then referred and had radiographs performed at our institution, they were included in the study population.

Twenty-five percent of our study population had normal thoracic radiographs. This is comparable with human studies, demonstrating 11–36% normal thoracic radiographs at presentation,[6,23,24] but contrasts with other veterinary studies, in which 40–61% had normal thoracic radiographs, despite all of these animals having at least one fracture.[2,19,21]

It may, however, take up to 48 hours for thoracic injuries, predominantly pulmonary contusions, to become visible on chest radiographs in human patients with blunt chest trauma[17,25,26] and dogs with experimental chest trauma.[27,28] Lung contusions are often not seen on initial chest radiographs in human patients[12] or may be underestimated.[14,29] Interestingly, the time from trauma to radiography was not associated with a higher radiography score in our study. Only 8 of 43 animals radiographed within 6 hours showed normal radiographs. These results might be influenced by the fact that animals presented with respiratory distress and abnormal lung auscultation are probably radiographed earlier than those that are clinically stable. In another study looking at blunt trauma in dogs that were radiographed within 4 hours after trauma, only 17% of all dogs showed lung contusions.[18]

Seventy-two percent of our study population that presented with no other injuries showed signs of chest trauma on radiographs. Ninety-three percent of the animals showed concurrent injuries. Virtually all animals with abdominal injuries showed concurrent chest abnormalities. Thoracic injuries concurrent to fractures of several types are well documented.[19,22,30–32] These studies, together with our results, underline the high risk of chest abnormalities in trauma patients. Lung contusions should be suspected in every traumatized animal.[33] In our study, we did not find a difference in chest abnormalities between animals with concurrent injuries to the front legs or the rear legs as seen by Spackman et al.[2] This is in accordance with another veterinary study looking at animals with fractures and concurrent thoracic trauma.[19]

One goal of this study was to evaluate the association between clinical parameters of respiratory function and chest radiography findings. There are no known absolute clinical parameters that predict the presence and extent of thoracic injuries in traumatized animals. Predictors of thoracic injuries in one study including children with blunt torso trauma were shown to be low systemic blood pressure, elevated RR, abnormal chest auscultation findings, and abnormal results on examination of the thorax.[15] Children with blunt trauma, normal chest auscultation, normal blood pressure, and tachypnea did not show thoracic injuries in 84%. On the other hand, 4% (33 of 783) of children with blunt trauma, normal auscultation results, normal blood pressure, and normal RR still showed signs of thoracic injuries on further diagnostic examinations.[15]

Tachypnea was also shown to be a predictive value for chest injuries in children with blunt trauma.[15,26] In our study, RR alone at presentation or after analgesic therapy was significantly associated with the degree of pneumothorax. None of the animals with severe radiographic findings had a normal RR at presentation, and the RR at presentation was no longer significantly associated with the presence of a pneumothorax after categorizing the animals into having a normal or abnormal RR, making the RR a sensitive but not very specific clinical parameter for the presence of a pneumothorax. RR is also influenced by non-respiratory factors such as stress, temperature, acid–base disorders, and especially pain.[34] We, therefore, re-evaluated animals after analgesic therapy. Analgesia had a significant effect on the RR. After analgesia, 49% of all animals showed a normal RR, despite the same degree of pulmonary abnormalities seen on chest radiographs. Cats with open mouth breathing were assessed as having labored breathing, and analgesic therapy resulted in resolution of this clinical sign, underscoring the importance of analgesia in feline trauma patients with signs of labored breathing. On the other hand, many dogs still showed panting after analgesic therapy. Since 82% of the dogs that were panting after analgesic therapy showed no abnormalities on chest radiographs, panting may not reflect lung abnormalities and might be due to stress or adverse effects of opioids.[34]

Our data demonstrated a significant association between chest auscultation results and radiographic presence and degree of chest trauma signs, despite the fact that 42% of the animals were assessed as having a normal chest auscultation on presentation. In children with blunt trauma, abnormal chest auscultation findings showed to be an independent predictor of thoracic injury in 91% of cases.[15] In that study, 45% of children with blunt trauma and an abnormal chest auscultation result showed no thoracic injuries (false positives) on further chest examinations (radiographs, CT), whereas 7% with normal chest auscultation showed thoracic injuries (false negative). In another study of 103 human trauma patients with clinical signs of chest trauma (mostly chest wall contusions), 11% did not show signs of chest injuries on radiographs and thoracic CT scanning.[6] While RR seems to be influenced by several factors, chest auscultation findings depend mostly on the skills of the emergency clinician. According to our results, lung contusions seem to be auscultated easier than pneumothorax or chronic disease, probably due to the fact that chronic disease usually does not severely increase lung sounds and pneumothorax decreases lung sounds, therefore, giving a false sense of normality.

In order to include all clinical parameters of the respiratory tract examination, we looked for an association between the clinical assessment of respiration (e.g., RR and auscultation findings) and radiographic findings. Clinical assessment of respiration at presentation was significantly associated with the presence of chest trauma signs but was not useful in predicting type and degree of chest trauma, probably due to the non-specific elevation of the RR. Clinical assessment of respiration after analgesic therapy would be expected to better predict lung injuries, as there was a significant decrease in RR after analgesia. We excluded the group of panting dogs for reasons mentioned above from clinical assessment after analgesic therapy and found that RR was significantly associated with the XR-score and degree of lung contusions, but not with signs of chest trauma. As some of the groups tested by cross-tabulation had values less than 5, all abnormal findings were combined in one group in order to increase the statistical value. Further reducing the clinical assessment and radiography findings to either normal or abnormal and testing using 2-proportion testing, no significant association was found. These inconsistent results do not make the overall clinical assessment of the respiratory system a useful clinical parameter to predict signs of chest trauma, regardless of analgesic therapy. Analgesic therapy only minimally increased the percentage of normal animals despite the significant decrease in RR, therefore, an increase in the RR of those animals that were breathing normally at presentation has to be suspected. One explanation might be the delayed occurrence of clinical signs with time, even though we did not find a statistically significant difference regarding the XR-score over time.

Several human studies have shown that radiography is not a valuable diagnostic tool to detect chest injuries in trauma patients. Major chest injuries can be present despite a normal initial chest radiograph, especially if they are of suboptimal quality or made in the supine position.[7] As high as 36% of contusions in human blunt trauma patients are not seen on admission chest radiographs.[24] In another study, only 63% of pediatric patients with chest injuries had an injury visualized on initial chest radiographs. Injuries that were missed included pneumothorax, pulmonary contusions and rib fractures.[15] Several reports have documented thoracic CT as being more sensitive than conventional chest radiographs, identifying up to 66% more thoracic injuries and requiring change in the therapeutic plan in up to 20% of patients with blunt thoracic trauma.[6,12,23,35,36] These results are comparable with an experimental model of lung contusions in dogs.[37] In veterinary practice, CT scanning is usually not available on an emergency basis, emphasizing the importance of chest radiography and clinical evaluation of the veterinary trauma patient. In our study, we could show a clear association between auscultation findings, and the presence and degree of radiographic signs of chest injuries; therefore, immediate chest radiographs may not be justified on a routine basis in animals with normal chest auscultation findings. However, chest radiographs may still be very valuable in animals with abnormal auscultation findings as the differentiation between different chest abnormalities may not be possible by auscultation. Although chest radiography is non-invasive and relatively inexpensive, it becomes costly if universally applied to animals with low risk for thoracic injuries. In addition, chest radiography exposes the animal and the veterinarian to radiation and increases stress in an animal that should be handled as non-stressed as possible.

Mortality in young human individuals with blunt chest trauma is reported in the range of 10% and up to 40% in elderly patients and reaches 60% in severely injured patients.[6,38,39] Pulmonary contusions on admission chest radiographs, >3 rib fractures, pneumothorax, and age were shown to be related to poor outcome.[24,38] Isolated pulmonary contusions in young healthy blunt trauma patients were not associated with increased mortality, but bilateral involvement of the chest injury increases the mortality rate in these young patients.[17,24] In a population of cats with traumatic rib fractures, 78% survived.[30] Powell et al.[18] found a mortality rate of 7% in dogs showing pulmonary contusions secondary to motor vehicular accidents. In our study, the outcome was defined as the animal having left the hospital or having died. Nine percent of the animals died or were euthanized, but it is not consistently documented if they were euthanized due to disease severity or financial concern. The outcome correlated with the initial ATT score and is representative of the median ATT score of 4, which represents mild-to-moderate trauma. Neither the XR-score nor the auscultation findings were associated with outcome. The impact of radiographic findings on further diagnostics or therapeutic interventions, therefore, could not be evaluated. We could show a significant association between the trauma score at presentation and signs of thoracic trauma on chest radiographs, therefore, the ATT score might be another reliable tool in assessing chest injuries besides auscultation results. In human medicine, a standardized thoracic trauma severity score for the evaluation of patients with blunt chest trauma was developed but has not yet been tested in a clinical setting.[17] Blostein and Hodgman[35] concluded that repeated physical examinations, arterial blood gas analysis and plain chest radiographs will always be the cornerstone of the management of blunt chest trauma, with chest CT offering additional information in selected cases.

One limitation of this study was its retrospective manner. Assessment of clinical signs was very subjective, and categorization of auscultation results were not possible. This retrospective evaluation might not have been a limiting factor as we could demonstrate a significant association between the auscultation abnormalities and radiographic chest abnormalities. We additionally included a large number of animals in the study, therefore, reducing the influence of extreme observations and increasing representations. The study population was comprised only of animals that were radiographed after trauma. It is not an official policy to perform chest radiographs on all trauma patients at our institution, therefore, many animals with a normal clinical chest examination may not have been included in the study, as well as those animals that had already been radiographed by the referring veterinarian.

A prospective, multicenter study evaluating all trauma patients would help in further establishing rules of post-trauma chest radiography and the impact on chest radiography on morbidity and outcome.

Conclusion

In human medicine and most veterinary hospitals, routine chest radiography is part of the initial assessment of trauma patients. In our study, we showed that clinical parameters might be predictive of radiographic chest trauma signs. RR and clinical assessment of respiration were only partly useful in the prediction of thoracic abnormalities, whereas chest auscultation results were predictive of radiographic signs of thoracic trauma. Analgesia was shown to significantly decrease RR and analgesics should be given to all trauma patients with respiratory distress. Clinical parameters may not be helpful in differentiating the cause of respiratory abnormalities. Radiographic examination may be restricted to patients with abnormal respiratory auscultation findings in order to differentiate and grade thoracic abnormalities in dogs and cats with blunt trauma.

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Footnotes

[a] Ketalgin®, Streuli AG, Uznach, Switzerland.
[b] Torbutrol®, Fort Dodge Animal Health, Fort Dodge, IA.
[c] Temgesic®, Reckitt Beckiser, West Ryde, NSW.
[d] Number Cruncher Statistical Systems, Kaysville, UT (http://www.ncss.com).

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