Penetrating injuries in dogs and cats

A study of 16 cases

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Summary

The objective of this retrospective study was to assess radiographical and surgical findings, surgical management and outcome of penetrating injuries in dogs and cats by evaluating patient records. Sixteen patients were identified (15 dogs and one cat), four with gunshot wounds, and 12 with fight wounds (11 with bite wounds, one struck by a claw). The thoracic cavity was affected in six patients, the abdominal cavity in three cases. Both cavities were affected in five dogs and the trachea in two cases. All of the patients with fight wounds were small breed dogs. Multiple injuries to internal organs that required intervention were found surgically after gunshot wounds and a high amount of soft tissue trauma requiring reconstruction was present after fight wounds. Radiography diagnosed body wall disruption in two cases. All of the affected thoracic body walls in the fight group had intercostal muscle disruptions which was diagnosed surgically. Fourteen patients survived until discharge and had a good outcome. In conclusion, penetrating injuries should be explored as they are usually accompanied by severe damage to either the internal organs or to the body wall. A high level of awareness is required to properly determine the degree of trauma of intercostal muscle disruption in thoracic fight wounds.

Keywords

Fight wounds, gunshot wounds, surgical exploration, dog, cat

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Introduction

Penetrating wounds can be defined as any wound that extends from the outside of a cavity or lumen to the inside. The majority of these injuries are bite wounds and frequently involve the chest wall (1). The degree of skin damage in these cases does not give a good indication of the underlying tissue damage (1–3). In most patients, severe damage to the body wall and internal organs is present (1, 3–7); therefore, exploration and debridement of the underlying tissues is recommended (3, 7–9).

Gunshot wounds are another cause of penetrating injuries (10). In human medicine, surgical exploration after penetrating abdominal gunshot wounds is considered mandatory because of the high incidence of internal organ injury (11). This guideline has also been employed in veterinary medicine (10, 12). Other causes of penetrating injuries, for example, are impalement injuries (13).

Our objective was to search the hospital records for injuries that penetrated the cavities and/or internal organs from the outside and to compare management and outcome between the different aetiologies of penetrating injuries within our study population and between our patient group and the existing veterinary literature.

Material and methods

The medical records between December 2001 and February 2006 were searched for traumatic penetrating injuries. Injuries that had been caused by the ingestion of foreign bodies which subsequently penetrated the thoracic or abdominal cavity from within the gastro-intestinal tract were excluded. Only patients that had undergone treatment and that had a complete case file were included. The data retrieved included: breed, age, body weight (BW) and gender of the patient, cause of the injury, radiographical abnormalities, associated injuries, surgical or conservative management, type of interventions, duration of hospitalisation, complications and final outcome. A Fishers exact test was performed in order to ascertain whether the number of dogs of specific breeds that were included in the patient group were significantly higher than the normal hospital population for the same time period.

Results

Sixteen patients were identified that matched the inclusion criteria. This group comprised 15 dogs and one cat: four patients with gunshot wounds, 12 with fight wounds (of which 11 had suffered bite wounds, and one had a penetrating injury after a fight with a cougar). All of the patients that had been injured in a fight were small breed dogs (n = 12). Eleven dogs had been bitten by larger dogs; one dog had been struck by a front claw of a cougar. Three female dogs and nine male dogs were included. Their body weight ranged from 3.6 kg to 13 kg (mean: 7.1 kg, median: 6.6 kg). Four Jack Russell Terriers (33.3%), three Dachshunds (25.0%) and one cross breed (9.1%) were included. The number of Jack Russell Terriers and Dachshunds included in the patient population were found to be significantly higher than in the hospital population over the same time period ($p<0.001$). A difference was not found for cross breeds. Whilst

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Table 1 Patient signalment, etiology of the injury and outcome.

	Breed	Age	BW	Sex	Etiology	Sx	Area	Complications	Hosp.	Outcome
1a	Engl. Springer Spaniel	20	21.8	M	Gunshot (pellets)	y	thorax	none	6	Good
1b						y	abdomen	none		Good
2a	Dsh	36	3.9	Mc	Gunshot (pellets)	y	abdomen	none	6	Good
2b					Gunshot (pellets)	n	thorax	none		Good
3	Mastino Napoletano	48	70	F	Gunshot	y	abdomen	n/a	n/a	Died
4a	Braque Francais	84	30	F	Gunshot (pellets)	n	abdomen	VPCs	3	Good
4b						n	thorax			
5	Duitse Jachtterrier	120	8.8	F	Fight wound	y	thorax	none	3	
6	JRT	24	6	F	Bite wound	y	thorax	acute renal failure	12	Good
7a	JRT	30	7.3	M	Bite wound	y	thorax	none	6	Good
7b						n	tetraplegia			Good
8	YT	48	6	M	Bite wound	y	thorax		6	Good
9	JRT	48	6.6	F	Bite wound	y	thorax	none	4	Good
10a	Miniature Keeshond	156	3.6	M	Bite wound	y	abdomen	esophagitis	15	Good
10b						y	thorax	none		Good
11a	Dachshund	72	13	M	Bite wound	n	thorax	pyothorax	15	Good
11b						y	abdomen	none		Good
12	Dachshund	48	5.3	M	Bite wound	y	neck	none	5	Good
13	Dachshund	154	6	M	Bite wound	y	neck	none	2	Good
14	JRT	71	7.5	M	Bite wound	y	abdomen	none	6	Good
15	X-breed	36	6.5	M	Bite wound	y	abdomen	n/a	n/a	Euth
16	Maltese	96	8	M	Bite wound	y	thorax	none	8	Good

Breed: DSH: Domestic shorthaired cat; JRT: Jack Russell Terrier; YT: Yorkshire Terrier; X-breed: Cross Breed; Age: patient age in months; BW: body weight in kg; Sx: Surgery performed? yes or no; Complications: a/n: not applicable, VPC's: Ventricular Premature Contractions; Hosp: number of days hospitalised; Outcome: euth: euthanatized intra-operatively.

Jack Russell Terriers were 14 times more likely to be included in the patient group than in the normal hospital population, for Dachshunds this likelihood was even higher (nearly 25 times).

The thoracic cavity was affected in six cases, the abdominal cavity in three cases, both cavities in five cases and the trachea in two cases (Table 1). There were gunshot wounds to the abdomen in one case (25%) and to both the thoracic and abdominal cavity in three cases (75%). Two dogs had been shot during hunting with shotguns. The third dog had a single perforating gunshot wound with a 3–5 mm diameter entrance wound on the left side and a 3–5 cm diameter exit wound on the right side. Within the fight wound group, the thoracic cavity was affected in six cases (50%), the abdominal cavity in two cases (16.6%), both cavities in two cases (16.6%), and the trachea in two cases (16.6%). Rib fractures were present in eight of the patients: one rib was fractured in 3 dogs; and 2, 3 and 4 ribs were fractured in one case each.

A pneumothorax was radiographically evident in seven patients, and a pneumoperitoneum in one. Subcutaneous emphysema was evident radiographically in all but one patient. Body wall disruption was radiographically evident in two cases: a paracostal herniation in one case and a leftsided abdominal herniation in the second case. In the gunshot wound group, shotgun pellets were seen radiographically in three cases while no bullet or pellets were found in the fourth patient [3/4]. No rib fractures were seen radiographically [0/4]. Pneumothorax, pneumomediastinum or pneumoperitoneum, depending on the area, was seen in two patients [2/4]. Effusion was present in all four patients [4/4]. Subcutaneous emphysema was present in one patient [1/4]. Body wall disruptions or organ displacement were not noted radiographically. In the fight wound group, shotgun pellets were not seen radiographically [0/12]. Rib fractures, either single or multiple, were diagnosed in eight patients [8/12]. Pneumothorax, pneumomediastinum or pneumoperitoneum, depending upon the area, was present in 11 patients [11/12]. Effusion was noticed in seven patients [7/12]. Subcutaneous emphysema was present in 11 patients [11/12]. Two abdominal muscle discruptions were evident radiographically with organ herniation in one case, no intercostal muscle disruptions were suspected or seen radiographically. The lack of clear radiographical signs of intercostals muscle disruption is illustrated by

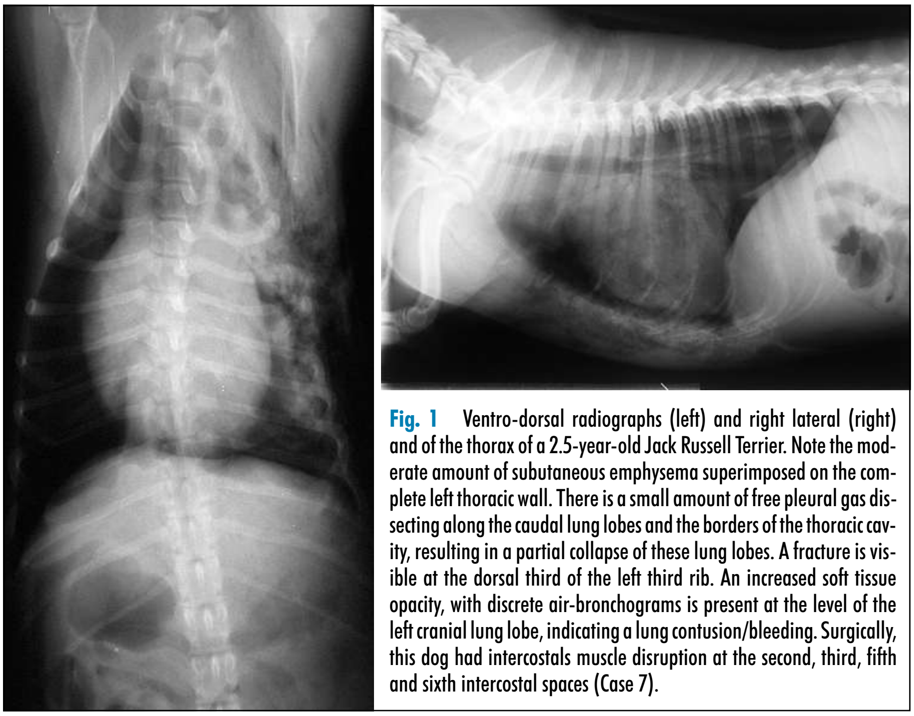

Fig. 1 Ventro-dorsal radiographs (left) and right lateral (right) and of the thorax of a 2.5-year-old Jack Russell Terrier. Note the moderate amount of subutaneous emphysema superimposed on the complete left thoracic wall. There is a small amount of free pleural gas dissecting along the caudal lung lobes and the borders of the thoracic cavity, resulting in a partial collapse of these lung lobes. A fracture is visible at the dorsal third of the left third rib. An increased soft tissue opacity, with discrete air-bronchograms is present at the level of the left cranial lung lobe, indicating a lung contusion/bleeding. Surgically, this dog had intercostals muscle disruption at the second, third, fifth and sixth intercostal spaces (Case 7).

the radiographs from one case (Case 7) (Fig. 1).

Upon surgical exploration, 10 body wall disruptions were found: a paracostal abdominal herniation, a diaphragmatic herniation, a caudal abdominal wall disruption and intercostal muscle disruptions in all surgically treated thoraxes. Intercostal muscle disruptions ranged from one intercostal space to five intercostal spaces. Reconstruction of the body wall was necessary in nine cases (seven times in the thoracic wall and twice in the abdominal wall) and the trachea had to be reconstructed in two cases. Two additional reconstructive procedures were also necessary, namely the repair of a diaphragmatic herniation and an avulsed sartorius muscle. Therefore, a total of 13 reconstructive procedures were performed. In one case the flail chest was managed conservatively. Thoracostomy tubes were placed during exploratory thoracotomy and were maintained for several days to check for the development for pyothorax. The tube was maintained until fluid production had ceased or dramatically decreased (range: 1–5 days, median and mean: 2 days). The patient with the perforating abdominal shot wound had an abdominal drain placed during surgery.

Surgical exploration in the gunshot wound group did not show any body wall disruptions that required surgical reconstruction [0/4]. Additional procedures were performed in all three explored patients and included: partial lung lobectomy [2], enterotomy [1], enterectomy [1], cystotomy [1], ligation of traumatized vessels [2] and pericardiotomy [1]. One dog with a hemoabdomen and pneumothorax was managed conservatively (Table 2). In the fight wound group, body wall disruption was evident surgically in eight patients. Eleven separate reconstructive procedures were performed in the eight patients with body wall disruptions. In one dog, polypropylene mesh (Prolene, Ethicon, Piscataway, NJ, USA) was used for thoracic wall reconstruction. All other reconstructions were performed using autogenous tissue only. Tracheal repair was required in one case and tracheal resection and anastomosis in another. Therefore, a total of 13 separate reconstructive procedures were performed in 10 patients. Additional procedures included: partial lung lobectomy [1], bladder repair [1] (Table 2). In one dog with both a ruptured bladder and a flail chest, the flail chest was managed conservatively without splintage after an exploratory celiotomy and bladder repair was performed. The radiographical and surgical findings are summarized in Tables 2 and 3.

Postoperative patient management was up to the discretion of the treating veterinarian, but consisted of IV fluids, antibiotic therapy and analgesia in each of the cases. All of the patients were placed on antibiotics prior to surgery and antibiotic therapy was continued postoperatively during hospitalisation. Analgesic therapy was provided by opioids (IV injections, continuous rate IV, or a patch with IV injections as needed) with or without non-steroidal anti-inflammatory drugs. Intravenous fluids were calculated individually in order to correct for deficits and ongoing losses on top of the maintenance rate. Blood products and colloids were given if needed.

Hospitalisation duration was between two and 15 days (mean: 6.6 days, median: 6 days) for the entire surviving group. The median time of hospitalisation was six days for the gunshot wounds group and the fight wound group, respectively.

Non-fatal complications were seen in four patients: one in the gunshot wound group and three in the fight wound group. Two of the dogs did not survive until discharge: one dog (bite wound) with severe pancreatitis was euthanatized intra-operatively at the owner's request. Another dog that had a single perforating gunshot wound died immediately post-operatively. All of the other patients survived to discharge (12.5% mortality rate) and had a good outcome. Median hospitalisation time for patients with complications was 13.5 days (mean: 11.25), whereas median time of hospitalisation for those without any complications was six days (mean: 5.3).

Discussion

Penetrating injuries are considered to be a serious presenting complaint, irrespective of the aetiology. A high number of surgical interventions and reconstructive procedures were necessary during exploratory surgery in our patient group. Dogs and cats with penetrating injuries should be radiographed

Table 2 Radiographical findings, surgical findings and additional surgical procedures.

	Etiology	Sx	Area	Radiographical findings	Surgical findings	Procedure(s)
1a	Gunshot (shotgun)	y	thorax	4 pellets; effusion	Laceration L Cd lung lobe; damaged Cd part L Cr lung lobe; pericardial hemorrhage, pellet in epicard; suspicious (unrelated) lesion in Cr part L Cr lung lobe	L lateral exploratory thoracotomy; pericardiotomy, partial lobectomy of Cd part of L Cr lung lobe; excision of lesion of the Cr part of the L Cr lung lobe.
1b		y	abd	2 pellets; effusion	Full thickness perforation of L lateral liver lobe; avulsion of short gastric arteries; perforation of jejunum (antimesenteric side only).	Midline exploratory celiotomy; ligation of avulsed short gastric arteries; enterototomy for pellet removal
2a	Gunshot (shotgun)	y	abd	7 pellets; effusion; also 10 pellets in pelvic area	Pellet in bladder lumen	Midline exploratory celiotomy; cystotomy
2b		n	thorax	1 pellet	Pellet in subcutis of L thoracic wall	No surgery
3	Gunshot	y	abd	Pneumoperitoneum; effusion; SCE	Perforated jejunum (10 perforations); ruptured L ovary, avulsed artery in mesocolon	Midline exploratory celiotomy; enterectomy; ovariohysterectomy; ligation of avulsed colonic artery
4a	Gunshot (shotgun)	n	abd	4 pellets; effusion	Hemoabdomen, managed conservatively	
4b		n	thorax	5 pellets; pneumothorax	Managed conservatively.	
5	Fight wound	y	thorax	Pneumothorax; SCE	IC muscle disruption:: IC 7 R	R lateral exploratory thoracotomy, reconstruction using autogenous tissue
6	Bite wound	y	thorax	Rib fracture (R9); pneumothorax; Effusion; SCE	IC muscle disruption: IC 5,6,8,9 R; lung laceration	R lateral exploratory thoracotomy, reconstruction using autogenous tissue; partial lung lobectomy
7	Bite wound	y	thorax	Rib fracture (L3); pneumothorax; SCE	IC muscle disruption: IC 2,3,5,6 L	L lateral exploratory thoracotomy, reconstruction using autogenous tissue; rib resection
8	Bite wound	y	thorax	Rib fracture; pneumothorax; SCE	Pneumothorax, IC muscle disruption: IC 3,4,5,6,7 L	L lateral exploratory thoracotomy, reconstruction using polypropylene mesh
9	Bite wound	y	thorax	Rib fracture (L4,L5); pneumothorax; effusion; SCE	Ribfracture, IC muscle disruption: IC 4,5; lung laceration	L lateral exploratory thoracotomy, reconstruction using autogenous tissue
10a	Bite wound	y	abd	Effusion; SCE; herniation	Paracostal abdominal wall herniation, diaphragmatic hernia	Midline exploratory celiotomy, reconstruction using autogenous tissue; repair of diaphragmatic hernia
10b		y	thorax	Rib fracture (L10,L11,L12,L13); SCE	Flail chest, IC muscle disruption: IC 9,10 L	Temporary external splintage; L lateral thoracotomy, debridement and surgical splintage on day 3
11a	Bite wound	n	thorax	Rib fracture (R9,R10, R11); effusion; SCE(R>L)	Flail chest	Managed conservatively
11b		y	abd	Effusion; SCE	Ruptured bladder	Midline exploratory celiotomy; bladder repair
12	Bite wound	y	neck	Pneumothorax; pneumomediastinum; SCE	Tracheal perforation	Exploration; tracheal resection and anastomosis
13	Bite wound	y	neck	Fracture transverse process C5; pneumo-mediastinum; SCE	Tracheal perforation	Exploration; primary tracheal repair
14	Bite wound	y	abd	Pneumoperitoneum; effusion; SCE; body wall disruption	Abdominal herniation, avulsion of sartorius muscle, lacerations duodenum (partial thickness)	Midline exploratory celiotomy, reconstruction using autogenous tissue; reconstruction of Sartorius m., omentopexy duodenum
15	Bite wound	y	abd	Rib fracture (R10); effusion	Peritonitis, pancreatitis	Euthanatized intra-operatively
16	Bite wound	y	thorax	Rib fracture (L7,L8,L9, L10,L11); pneumothorax, effusion; SCE	Flail chest, IC muscle disruption: IC 8,11	L lateral exploratory thoracotomy, debridement and surgical splintage

Radiographical findings: rib fracture; side (L = left ,R=right) and number in parentheses; SCE = Subcutaneous Emphysema present. Surgical findings: Cr = Cranial, Cd = Caudal; IC =InterCostal space; L= left; R =right.

in order to assess the extent of the injuries as well as to establish whether additional injuries are present. The comparison of radiographical findings between the two groups revealed some differences, namely that pellets were only found in the gunshot wound group and rib fractures were only seen in the fight wound group (in eight of the 12 patients). The usefulness of radiographs for the initial work-up was clearly demonstrated as all of the patients had two or more radiographic abnormalities. This is in accordance with a recent article that assessed clinical and radiographical parameters with surgical results (3). However, intercostal muscle disruptions or herniations were not diagnosed radiographically, whereas intercostal muscle disruptions were present in

Table 3 Summary of patient, radiographical and surgical findings between the two groups.

	Gunshot group	Fight wound group
General		
Number of patients	4 (3 dogs, 1 cat)	12 (12 dogs)
Median BW in kg	26	7.05
Radiographical findings		
Ribfractures present	0	8
Pneumo- (thorax/peritoneum/mediastinum)	2	9
Effusion	4	7
Subcutaneous emphysema (SCE)	1	11
Radiographically evident body wall disruption	0	2
Presence of bullets	3	0
Clinical findings and therapy		
Non-surgically managed	1	0
Body wall disruption evident on surgery	0	8
Reconstruction required during surgery	0	13*
Additional procedures	8	4*
Non-fatal complications	1 in 3 patients**	3 in 11 patients*
Mortality	1 (died postoperatively)	1 (euthanatized intra-operatively)
Hospitalisation : mean (median) days	5 (6) days**	7.5 (6) days*

Reconstruction required on surgery: Reconstructive surgery necessary during the exploratory surgery, both tracheal repairs were considered reconstructive surgeries; Additional procedures: total number of non-reconstructive procedures necessary during exploratory surgery. *The patient that was euthanatized intra-operatively was not included; **nor was the patient that died postoperatively.

the thoracic body wall of all surgically treated thoracic fight wounds. Therefore, radiography would not appear to be a suitable modality in order to assess the extent of the thoracic body wall damage. Subcutaneous emphysema was the most common radiographic abnormality (12 occurances in 16 patients) and was more common in dogs that had suffered a fight wound than in patients that had been shot. Effusion was the second most common abnormality (11 occurances in 16 patients). Pneumothorax and pneumoperitoneum were the third, and rib fractures the fourth most common abnormalities. Bjorling et al. (13) found that all of the animals in their study had two or more abormalities and that seven animals had four or more abnormalities (n=33). Subcutaneous emphysema was the most common feature in their study followed by pneumothorax.

A comparison of surgical findings between the 'fight wound group' and the 'gunshot wound group' revealed a greater amount of body wall damage requiring reconstruction in the fight wound group, and a greater amount of internal organ damage requiring surgical management in the gunshot wound group. The majority of patients in the fight wound group with penetrating injuries into body cavities required body wall reconstruction. This is in agreement with earlier studies on bite wounds and is most likely caused by the combination of crush, tear and avulsion that accompanies a dog bite wound. Extensive damage to subcutaneous tissues, body wall muscles, ribs and intercostal muscles is usually present (1, 3–5, 14). The dog that had been struck by a claw also had a large intercostal muscle disruption and significant damage to the underlying tissue although no rib fractures were present. Surprisingly, injury to internal organs requiring treatment was only found in a small number of fight wound patients (two in 12 cases; 16.6%). This is in contrast to previous studies that found high incidences of significant additional injuries in 75% of patients (n=12) (13), or in six out of 14 patients (42%) (9).

The animals that had sustained gunshot wounds suffered a greater amount of internal organ damage. This is consistent with both the veterinary and human literature. In a retrospective human study, internal injuries were found in 67 out of 75 patients (89%) with penetrating abdominal gun shot wounds (11). In a retrospective veterinary study, intra-abdominal injuries were found in 67% of patients, while gastrointestinal perforation was confirmed in 55% of patients (13). In a more recent veterinary study, all five of the animals that showed signs of peritoneal penetration had intraabdominal injuries that were identified during surgery (10). One animal in the present study had shotwounds in the thoracic and abdominal region, but was managed conservatively due to financial constraints of the owner. This dog had a good outcome. Radiographically, effusion and the presence of pellets were the most common abnormalities in this group.

All of the patients in the fight wound group were small breed dogs (one weighed 13 kg, the remainder weighed less than 8 kg). This is consistent with findings of previous studies. In a study of 196 bite wounds, the authors found that small dogs (≤ 10 kg BW) were the most common victims (8). In a study on thoracic bite wounds, all but one of the dogs weighed less than 8 kg (1). In a study that investigated traumatic body wall herniations, those dogs that had been bitten weighed significantly less than the other dogs included in the sudy (6.7 kg versus 24.3 kg BW) (9). The mean body weight of bitten dogs in a recent paper was also low: 5.2 kg (3).

There was a large representation of Jack Russell Terriers and Dachshunds in the fight wound group (33.3 and 25.0%, respectively). Statistical analysis revealed that significantly higher percentages of both Jack Russell Terriers and Dachshunds were present in the fight group population. A high proportion of Terriers (5%) in dogs with fight wounds has previously been described (8). They also found a very high number of cross breeds (37%) and Pinschers (27%) and concluded these breeds of dogs might, by nature, have an increased readiness to fight along with a small body size. In the paper by Scheepens et al., a high incidence of Yorkshire Terriers (27%), Jack Russel Terriers (20%) and Maltese (22%) was described (3).

The distribution of the fight wounds in this case series showed a very high percentage of thoracic injuries (50.0% thorax only, and 16.6% thorax and abdomen). Shamir et al. also found that the most common region for a dog to be bitten by another dog was the thorax (64 dogs out of 185; 34.5%) (8). The combination of thorax and abdomen was seen in 17 out of 185 dogs (9%). The difference between the two results most likely comes from the lower number of dogs included in our study.

There was a predominance of male dogs in the fight wound group. Shamir et al. (8) found significantly more males than females and the vast majority of males were intact, leading the authors to the hypothesis that the male predominance was most likely to be related to the influence of sex hormones. A similar finding was described in a recent paper (3). Our study group was too small to evaluate whether the same significance would be reached.

One dog with a fight wound that had been inflicted by a cougar was included in the fight wound group. Although the aetiology of the wound differed from that of the bite wounds, the appearance of the wound and muscle disruption were similar to the other cases, hence the decision was made to include this case as well.

The median number of hospitalised days was six for the entire group of patients (range: 3 to 15 days). This is comparable with a study of 24 cases of flail chest (dogs and cats) (15), but longer than a group of 36 patients with traumatic body wall herniation (9) or a group of 12 cases with thoracic bite wounds (range of hospitalisation one to seven days; two patients treated as outpatients). The mortality rate of this retrospective study was 11.7%. Previous studies showed mortality rates of 11% for bitten dogs (8), 17.78 and 25% for thoracic bite wounds (3, 4), 19% for patients with traumatic body wall herniation (9), 33% for bite wounds and 39% for gunshot wounds (13).

In conclusion, exploration is highly recommended in cases of gunshot wounds and fight wounds. The patients that were injured in fights appeared to have more body wall damage and less damage to internal organs than patients that were shot. Radiography severely underestimated the amount of body wall damage present in fight wounds.

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