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Soft Tissue Surgery Case Challenges for Advanced Practitioners Mini Series

Session 2: Blunt and Penetrating Trauma

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Anaesthesia

Animals with penetrating injuries may be critically ill. Hypovolaemia should be corrected prior to anaesthesia unless in exceptional circumstances e.g. if a thoracic wound is likely to be fatal and the animal cannot be handled. In this case, fluid resuscitation will be concurrent with thoracic stabilization. A five-minute period of oxygenation and a calm environment to reduce oxygen demand are ideal. Care is taken with drug choices, to avoid those with cardiorespiratory depression. Pre-emptive analgesia with an opioid (e.g. methadone) will reduce the amount of anaesthetic induction and maintenance agent used, and will calm the animal and reduce pain. Rapid intravenous induction followed by endotracheal intubation is the only safe method; animals should never have mask or anaesthetic box induction. Stable patients can often be safely anaesthetised with drugs such as propofol or alfaxalone, whereas unstable patients may benefit from the use of benzodiazepines, ketamine and fentanyl. Use of total intravenous anaesthesia is advised for animals with ruptured airways or that will have the airways opened surgically, in order to maintain anaesthetic depth and to avoid exposure of personnel to anaesthetic gases. **Further information on anaesthetic regimens can be obtained from anaesthesia textbooks.**

Manual or mechanical ventilation is often necessary from the onset of anaesthesia in animals with penetrating thoracic trauma to achieve acceptable ventilation and oxygenation, but is needed in all cases where the thoracic cavity is opened. The rate and pressure used is based on animal size, visual inspection of the lungs where possible and monitoring oxygen/carbon dioxide levels.

Intra-operative monitoring should include serial monitoring of vital parameters, including respiratory rate and heart rate, core temperature, ECG, blood pressure (usually non-invasive, although invasive blood pressure monitoring via an arterial catheter is more accurate and gives a continuous reading), pulse oximetry and capnography. Use of warming systems are necessary to counter heat loss through the open tissue, e.g. operating in a warm room, use of warm fluids, warm air heating system (e.g. BairHugger), bubble wrapping of extremities, avoiding high fresh gas flows and use of a heat/moisture exchanger (e.g. Thermavent).

Post-operative Care

Patients may be relatively stable or may be more critical with sepsis or SIRS. Management must differ depending upon clinical findings. More information on management of critically ill animals is available in textbooks.

- Fluid therapy:
    - Fluid therapy is required to replace pre-operative losses, intra-operative losses and for the treatment of any septic or hypovolaemic shock that has or may develop.
    - Crystalloids are the first line treatment and are given as boluses initially.

- Blood products and colloids may be required, but be aware of potential complications of their use.

- Pain management
  - The minimum requirement is a pure opiate agonist e.g. methadone 0.2-0.3mg/kg q4h. If surgery is simple, this is required for 12-24 hours before changing to buprenorphine. Animals with severe injuries will need methadone for longer periods of time.
  - Other opioid options are available e.g. transdermal fentanyl (Recuvyra) or transdermal fentanyl or buprenorphine patches (the latter should not be used until pure opioids are no longer needed, as buprenorphine will antagonise their actions).
  - Interpleural local anaesthetic (down chest drain) e.g. bupivicaine 1.5mg/kg diluted in saline q6h.
  - NSAIDS.
  - +/- morphine/lidocaine/ketamine (MLK) or fentanyl/ lidocaine/ ketamine (FLK infusion) – as single CRIs or in combination.

- Antibiotics:
  - Intravenous broad-spectrum bactericidal on presentation e.g. potentiated amoxicillin (Augmentin) or cefuroxime (Zinacef) 20mg/kg tid.
  - Addition of metronidazole or fluoroquinolones is not generally needed on first presentation, but may be indicated based on culture and sensitivity results.
  - Switch to oral antibiotics if the animal is eating
  - Use an intravenous dose if an oral dose cannot be given e.g. under anaesthesia for dressing change.
  - Give an appropriate post-operative course of antibiotics depending on the presentation. At least a week of antibiotics is indicated, but prolonged courses are not needed.

- Alimentation:
  - Ensure that daily calorie requirements are met. If not, a feeding tube should be placed. This is particularly important in animals that will require daily sedation or anaesthesia for dressing changes and wound management.
  - Feeding tubes are not placed on the day of presentation in critical patients, as prolonged anaesthesia may be life threatening.
  - Oesophagostomy tubes are easiest to place and manage, with fewer complications than gastrostomy/PEG tubes. However they cannot be placed in animals with neck bite wounds or oropharyngeal stick injuries where there is marked cervical damage or oesophageal laceration.

- Catheters:
    - Central catheters (jugular lines) are useful in animals with multiple limb injuries that need prolonged intravenous access. They cannot be used with neck trauma.

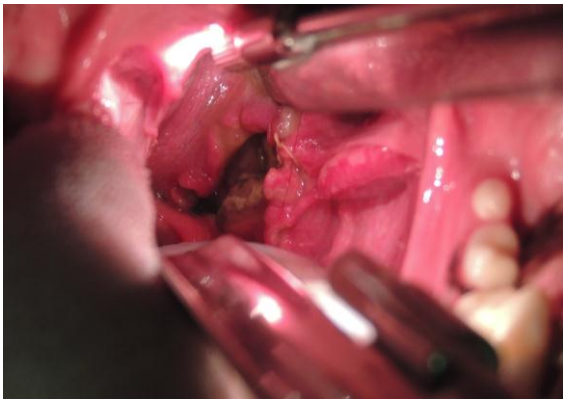
Oropharyngeal Stick Injuries

This is a sporadic injury that occurs when dogs are running with sticks or run onto a thrown stick. About half of injuries are noted by owners; in the others dogs are found on the walk with obvious mouth pain, including drooling, bleeding and sudden onset depression. Studies have shown that owners often ignore the injury, and so these dogs may present as chronic cases.

The acute case must be assessed under anaesthesia – it is difficult to determine whether the injury is confined to the mouth or if it has extended into the neck. Not all dogs with penetration into the neck will have palpable subcutaneous emphysema or obvious neck pain. Failure to investigate a penetrating injury of neck tissues will allow bacteria to multiply, damaging local tissues from infection and leading to sepsis. I have seen several dogs in recent years that died from penetrating injuries, and the delay of several days prior to surgery was most likely the reason, as both were hypovolaemic on presentation and had significant tissue necrosis within the neck.

Dogs are usually cardiovascularly stable, and usually do not require fluid therapy to correct hypovolaemia, but fluids will be of benefit during premedication as the tissues of the neck are likely to be opened. However, some injuries, especially to the tonsils, can result in marked haemorrhage, with dogs being hypovolaemic on presentation. These dogs must therefore be stabilized with crystalloid boluses prior to anaesthesia, and consideration given to blood transfusion if haemorrhage is marked. Opioid analgesia should be used (I typically use methadone 0.2mg/kg), as the injuries are painful, supplemented with NSAIDs assuming there are no contraindications, such as hypovolaemia or underlying co-morbidities. Broad-spectrum antibiotics are given intravenously e.g. potentiated amoxicillin. Note the surgery textbooks advise 20mg/kg for surgery patients, which is higher than the dose given in the formulary.

Under anaesthesia I explore the mouth using a sterile probe e.g. a Spreul's needle (for more superficial injuries) to determine the depth of injury. Typical sites of superficial injury are the lateral oropharyngeal wall, dorsal oropharynx and soft palate. These wounds can be managed by lavage and closure. Lavage of small cavities can be achieved using a Spreul's needle or a catheter. It is important that lavage is thorough prior to closure of tissues to avoid infection. The lacerations can be difficult to close due to limited access. I tend to take cases into theatre to make use of good lighting and hang the head from drip stands via tape around the upper jaw (as for BOAS surgery) to allow easier suturing.



Particular care must be taken in assessing pharyngeal wounds. It is highly likely that these will have penetrated into cervical tissues and a longer probe is needed to ensure that penetration is not overlooked. Consider using an ET tube stylet (sterile) or a stiff dog catheter if a Spreul's needle is too short. However, it is useful to radiograph with a metal or radiopaque marker in place, so that the path of the penetration can be seen, which will aid surgery as it is often hard to find the path of the stick. It is therefore useful to leave this in place during surgery.

Radiographs of the neck (taken before deep probing) will show subcutaneous emphysema of varying degrees. The amount of emphysema does not necessarily match the degree of tissue injury, so exploration is warranted even if emphysema is mild. Pneumomediastinum may occur due to tracking of air along fascial planes and is not uncommon; pneumothorax is uncommon and usually mild. It is important that consideration is given to how you will treat mediastinal penetration if surgically exploring a cervical wound. I clip dogs for thoracotomy, although it is rare that the stick will penetrate this far. It is possible to tell at surgery if the air in the mediastinum is due to tracking or penetration. A stick damages and separates tissues as it moves through them – this will eventually end and if it occurs cranial to the mediastinum, the air is presumed to have tracked along fascial planes and no further caudal exploration is needed. However, if there is a clear track entering the thoracic inlet, further exploration via median sternotomy is needed. Failure to explore and lavage the mediastinum and thoracic cavity could have disastrous consequences. The deepest penetrating oropharyngeal wound I have treated had wood and grass fragments to the level of the caudal thorax. If obvious thoracic inlet penetration has occurred that is clearly seen during surgical exploration, and the surgeon is not able to perform thoracotomy, then the dog should be referred for further surgery. Consideration should therefore be given to referral of cases with pneumomediastinum so that complete surgery can be performed as a single procedure. If finances preclude this, I would consider mediastinal flushing of the tract from the neck, but this would not be considered gold standard treatment (and is not reported in the literature), as it would not allow removal of foreign material and may not effectively lavage the mediastinum.

If there is no obvious penetration within the pharynx or mouth, then it is probable that the oesophagus has been penetrated. If there is palpable or radiographic evidence of subcutaneous emphysema, then this is more likely. The oesophagus can

be assessed by endoscopy. Most penetration occurs in the very proximal oesophagus, so if the oesophagus appears normal then it should be assessed when the endoscope is removed. If the oesophagus is entered but the lumen is not obvious despite air insufflation, then it is likely that the endoscope is within the soft tissues of the neck. Avoid excessive air insufflation and make decisions quickly, as insufflating air into the neck will lead to pneumomediastinum and pneumothorax, and can be fatal if not noticed. Changes in breathing pattern and decreases in oxygen saturation and pulse rate seen with pneumothorax must be determined quickly to avoid the patient crashing. Equipment for thoracocentesis should be readily available and used promptly.

There are reports of endoscopy being used for lavage of penetrating injuries. If used the operator must be confident in his/her technique to ensure that foreign material is observed and that lavage is complete.

The use of rigid endoscopy in the management of acute oropharyngeal stick injuries. Robinson W, Shales C, White RN. J Small Anim Pract. 2014 Dec;55(12):609-14

OBJECTIVE: To evaluate the use of rigid endoscopy in the management of oropharyngeal stick injuries.
METHODS: Retrospective analysis of case records between 2011 and 2013 from a large referral hospital. Data regarding signalment, clinical presentation, treatment options and final outcomes were recorded.
RESULTS: Nine dogs were identified with acute oropharyngeal stick injuries. There were seven males and two females and the dogs were of various breeds, ages (1 · 5 to 9 years) and weights (11 · 9 to 38 · 4 kg). The time from injury to referral was between 1 and 3 days (median: 2 days). All dogs were anaesthetised and the tracts explored using a 30° forward-oblique, 2 · 7-mm-diameter, 18-cm-length rigid endoscope with corresponding 14 · 5 Fr sheath. The endoscopy was performed under saline irrigation. Foreign material (>1 mm in size) was removed using grasping forceps fed through the sheath. Subsequently, the tracts were re-inspected and flushed with further saline to confirm that all foreign material had been removed. All dogs recovered uneventfully and had excellent outcomes with no cases representing with chronic manifestations of oropharyngeal stick injuries.
CLINICAL SIGNIFICANCE: Rigid endoscopy is an effective method for the diagnosis, assessment and, in certain cases, treatment of acute oropharyngeal stick injuries in dogs.

Most oropharyngeal stick injuries penetrating the cervical tissues are explored at surgery. Surgery should be performed on the day of injury, as with all open wounds. Regardless of the lateralization of injury, exploration is always midline. The patient is clipped cranially from the mandible to allow exploration to continue to the pharynx, and caudally to allow for sternotomy. I like to keep a (sterile) probe within the entry site of penetration to help localization of the tract, which can be surprisingly difficult. Incision is from the larynx to the manubrium – the incision can be lengthened as necessary. The muscle bellies are sequentially separated until the tract or probe is

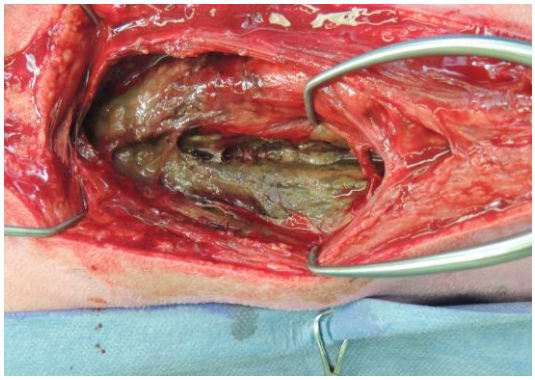
found. Make sure you know the muscles of the neck and the important structures that must not be damaged (e.g. jugular, carotid, recurrent laryngeal nerve). In those cases that I see in referral practice, the start of an abscess is usually apparent within a few hours of injury. Those cases treated more promptly without referral are likely to have minimal fluid. Cases left for several days without surgery usually have large abscess cavities and marked tissue necrosis.

At surgery I separate the tissue planes so that the tract is open along its length. It is unusual to find a large piece of stick, as they rarely break off. Small fragments of wood or other debris may be seen, although most cases I treat do not have material within the wound. It is the bacterial contamination that we cannot see that will cause tissue necrosis and abscessation, so the tissues must be thoroughly lavaged and necrotic tissue debrided, as it may act as a nidus for infection (bacteria grow readily in necrotic tissue). Muscle can be debrided without long-term effects on function (unless entire muscle bellies are removed in large numbers) but debridement must be gentle around vital structures, in particular the recurrent laryngeal nerves. Lavage is difficult in the area between the pharynx and the trachea, as penetration tends to occur dorsal to the larynx, and the muscles holding the larynx in position laterally do not allow for good exploration. I therefore tend to lavage the proximal tract dorsal to the larynx using catheters or syringes to lavage and a Poole suction tip within the tract for drainage. Be aware that fluid will enter the pharynx, so it must be packed with swabs and the ET well inflated. It must also be checked prior to extubation.

Oesophageal injury is usually a laceration of moderate but not excessive length (often about 5cm). My experience is that there is not marked tissue necrosis, and at most just a small amount of tissue needs to be debrided from the torn edges. I usually perform a single layer continuous closure, but I may be more likely to do a 2-layer continuous closure or interrupted sutures if the tissues appear to be more damaged e.g. oedematous or erythematous. The most challenging oesophageal lacerations are those that have occurred dorsal to the oesophagus. In these cases the muscles of the larynx must be transected unilaterally to provide exposure (making sure that if the oesophageal injury is lateralised, the laryngeal dissection is on the correct side). This is extremely difficult to do without damaging nerves and maintaining muscles sufficiently in order to be able to repair them. I caution surgeons to only undertake this is they are very experienced.

After lavage, a decision must be made as to if the wound can be left open. The wound below must clearly be left open and will require repeat surgeries for lavage and debridement, in the same way as you would approach an open skin wound. Bandaging these animals is a difficult challenge as they are open from the pharynx to the manubrium, so partial closure of the skin can be considered at each end. Stay sutures are used to allow packing of moist swabs into large open wounds, but they must be resoaked prior to removal, as wet-to-dry swabs will cause damage to viable tissues. I do not use moist swabs within a wound for more than a few days. An alterative is to use absorbent dressings such as Allevyn. The dressings should be covered with a bandage to avoid contamination, but these must not be too bulky so

that the dog can move. Most of the dressing material is therefore ventral. Babies' nappies are a useful method of absorbing fluid that penetrates dressings and can be changed regularly until the next dressing change. Care must also be taken to avoid airway compromise. These dogs will clearly need a gastrostomy tube as they are usually too ill to eat and will be having daily anaesthesia, but I don't tend to place them on sick dogs on the day of presentation, as prolonged anaesthesia may risk death. PEG tubes can be placed in dogs without oesophageal injury, but abdominal gastrostomy tube placement is probably better. Post-operative management will be centred to managing fluid status, and may need to involve plasma and albumin transfusions if plasma proteins are low. Sepsis will also be a possibility and dogs can be critically ill. Intravenous antibiotics are given, and addition of metronidazole and a fluoroquinolone may be considered in cases with more tissue necrosis.



For cases presenting acutely, open wound management is not necessary. Wounds can be closed with or without a drain. I always use a drain if there is a large dead space, either created by the abscess itself or from debridement. They are useful to be able to assess fluid production and I perform cytology regularly (once daily) to check that infection is not redeveloping. Some fluid will always be produced from any drain, so I remove it when fluid production drops to a steady level and if cytology is not consistent with infection. If cytology from drain fluid notes an increase in degenerate neutrophils or the presence of bacteria, then as with all infected tissues, re-exploration is warranted. This would be unusual if the initial debridement was complete and the correct decision to not leave the wound open was made.

Following cervical exploration, the pharynx must be re-examined. Any pharyngeal wounds should then be sutured if possible. However this may not be possible if the wound is very caudal. In these cases, consideration should be given to an gastrostomy tube, as oral feeding may lead to accumulation of food within the pharyngeal wound and even lead to food accumulation in the tissues of the neck. Be aware that even without feeding, saliva can leak into the pharyngeal wound and neck tissues, and lead to infection.

Swabs for bacterial culture and sensitivity testing are obtained from within cavities and antibiotics may need to be changed when results are available. Negative results may be due to pre-operative antibiotic use or failure to grow low numbers of bacteria. A course of oral antibiotics is always completed even if culture is negative.

Longer courses will be given for animals with more complicated injury and will be for 1-2 weeks beyond hospitalistion. Prolonged courses are reserved for chronic cases.

Post-operative management for a non-critically ill dog will include analgesia (methadone for 12-24 hours, changing to buprenorphine until discharge); antibiotics (intravenous until the dog is eating) and feeding. Feeding is not delayed following neck exploration. I will feed dogs orally, and I am happy to feed past an oesophageal repair, assuming the tissues appeared healthy. A feeding tube is needed in a dog with severe oesophageal damage, a dog that remains inappetant after a few days or a dog that presents in a more critical condition (see above). It is not possible to place an oesophagostomy tube due to local infection, but a PEG tube can be placed, except in cases of oesophageal damage. Having said that, we do sometimes place PEG tubes past an oesophageal repair, but the endoscope operator must be extremely experienced to avoid damage to the repair.

Acute oropharyngeal and esophageal stick injury in forty-one dogs. Doran IP, Wright CA, Moore AH. Vet Surg. 2008 Dec;37(8):781-5.

OBJECTIVE: To report clinical findings, treatment, and outcome in dogs with acute (<7 days) oropharyngeal or esophageal stick injury.
STUDY DESIGN: Retrospective study.
ANIMALS: Dogs (n=41) with acute oropharyngeal or esophageal injury.
METHODS: Dogs had clinical and radiographic examination, and frequently, cervical surgical exploration. The decision to operate was based on radiographic findings of cervical emphysema. Outcome was determined by owner or veterinarian interview.
RESULTS: Of 41 dogs, 27 had oropharyngeal injury and 14 had esophageal injury.
Five dogs with esophageal injury died. All dogs with radiographic evidence of cervical emphysema (n=34) had ventral median cervical exploration or necropsy; 11 had wood fragment(s) retrieved. In 7 dogs without radiographic signs of cervical emphysema, wounds involving the pharynx or soft palate were treated by local debridement and lavage using an oral approach. Mean follow-up time was 36.4 months. All wounds healed without complication; however, 1 dog that was not surgically explored had a piece of wood surgically retrieved 3 months later.
CONCLUSIONS: Radiographic evidence of cervical emphysema is a frequent finding in dogs with acute penetrating oropharyngeal or esophageal injury and indicates trauma to the deeper cervical tissues. Acute penetrating injury of the oropharyngeal region, when treated appropriately, has a better prognosis than acute esophageal penetration.
CLINICAL RELEVANCE: Ventral median cervical surgical exploration is recommended in dogs with acute penetrating injury of the oropharynx or esophagus if there is radiographic evidence of tissue emphysema.

Oropharyngeal penetrating injuries in 50 dogs: a retrospective study. Griffiths LG, Tiruneh R, Sullivan M, Reid SW. Vet Surg. 2000 Sep-Oct;29(5):383-8.

OBJECTIVES: To summarize the presenting complaints and clinical signs associated with traumatic penetrating injuries to the canine oropharynx. To determine how the site of injury, causative agent, and duration of disease affect the presentation and clinical outcome of treatment.
STUDY DESIGN: Retrospective study.
SAMPLE POPULATION: 50 client-owned dogs.
METHODS: The medical records of 50 dogs with oropharyngeal penetrating injuries referred to Glasgow University Veterinary Hospital (GUVH) between 1979-1999 were reviewed. Data regarding signalment, owners' presenting complaint, history, physical examination, radiographic and endoscopic findings, surgical findings, and outcome were recorded and compared with the GUVH population. Estimates of individual breed-specific odds ratios were calculated. Outcome was evaluated by reexamination 6 weeks after surgery with recurrence of disease recorded as failure.
RESULTS: Oropharyngeal injuries occurred most often in medium to large breed dogs. The majority of dogs presented with chronic disease (82%). The common findings on clinical examination were discharging sinus (72%) and swelling (70%). Acute cases typically presented with dysphagia and oral pain. The original site of injury was evident in only 34% of dogs, with the sublingual area the most frequently traumatized. The apparent cause of injury to the oropharynx was most commonly a piece of wood (72%). Other causes were metallic foreign bodies (3 dogs) and bones (2 dogs). In the remaining 9 dogs, the cause was not determined. The clinical signs resolved in all dogs that presented acutely compared with only 62% in dogs with chronic signs.
CONCLUSION: Medium to large breed dogs appear to be prone to oropharyngeal injuries caused mainly by wooden foreign bodies. This may be attributable to stick chewing or retrieving behavior in these animals.
CLINICAL RELEVANCE: History of trauma, stick retrieval, submandibular/cervical swelling, and discharging sinus are commonly encountered in the presentation of this condition. The sublingual area was the most frequent portal of entry recorded, although in chronic cases the initial site of injury was often unclear. Radiography and endoscopy, while offering definitive diagnosis with positive findings, often provide false negative findings. Aggressive surgical debridement of all sinus tracts is essential in obtaining a successful result, but recovery of a foreign body is not necessarily a determinant of success.

I have not covered chronic abscess formation following failure to explore oropharyngeal stick injuries. The prognosis for good long-term outcome is worse in cases managed chronically than those that had acute surgical exploration.

Nicholson I, Halfacree Z, Whatmough C, Mantis P, Baines S. Computed tomography as an aid to management of chronic oropharyngeal stick injury in the dog. J Small Anim Pract. 2008 Sep;49(9):451-7.

OBJECTIVE: To describe the use of computed tomography scanning in the management of dogs with chronic signs after oropharyngeal stick injury.
METHODS: Dogs with a final diagnosis of chronic oropharyngeal stick injury that underwent a computed tomography scan during their investigation were selected retrospectively from case files at the Royal Veterinary College, London.
RESULTS: The six dogs were young (median age 3.1 years) and medium to large breed (19.0 to 42.0 kg). By the time of referral the most common clinical sign was cervical swelling (five dogs). Stick foreign bodies were apparent on the plain computed tomography images in all cases and appeared as well-demarcated, linear abnormalities. A ventral mid-line approach was used for foreign body retrieval, and the computed tomography findings corresponded well with the surgical findings, with stick foreign body length ranging from 1 to 7 cm. Closed suction drainage was used in five dogs, for two to four days. Clinical signs fully resolved postoperatively in all cases, although cervical swelling recurred three weeks after surgery in one case. This dog had the smallest foreign body, the greatest number of surgical interventions before referral (three) and the longest disease course before referral (eight months).
CLINICAL SIGNIFICANCE: Computed tomography scanning is accurate in identifying the presence and location of chronic stick foreign bodies. Recurrence of disease is possible despite successful retrieval of the wood fragments found by computed tomography scan.

Bite Wounds

Bite wounds are typically problematic when a larger dog bites a smaller dog or cat. Cats are bitten less frequently than dogs. Animals that are equally matched in size will cause less damage as they cannot get the mouth around the neck or trunk and so crushing and tearing injuries are less severe. Mild bite wounds should be assessed for depth using a sterile probe – if the bites are not deep, they can be lavaged conscious or under sedation. Large wounds that just penetrate the skin can be lavaged via the bite wound or by enlarging it slightly with a scalpel blade. Sedation will be needed for more extensive lavage, as it is uncomfortable. There is the potential for skin necrosis if large amounts of skin have been elevated from underlying tissues, so owners need to monitor skin for viability and development of abscesses.

The extent of big dog-little dog/cat injuries will depend upon the size disparity of the animals, how long the animal was attacked for, if it was shaken and if the animal was repeatedly bitten or dropped. Some injuries will be instantly fatal and some will be fatal despite treatment, particularly if they involve the neck and thorax. Whilst there may only be a small puncture wound, or even no disruption of the skin, major tissue damage will usually occur in the underlying tissues. Most animals will have obvious puncture marks, although hair may need to be clipped to appreciate them, and bruising is often widespread. There may be palpable rib fractures or a depression in

the thoracic wall due to disruption of intercostal muscles. Subcutaneous emphysema indicates either open wounds or damage to structures that can leak air e.g. lung, trachea, oesophagus.

The main clinical problems that must be addressed on presentation are:

- Shock: due to blood loss, pain, tissue trauma. Place an intravenous catheter and administer fluid therapy (initially crystalloids, may require colloids or blood products depending on clinical findings).
- Pain: administer opioid analgesia unless contraindicated e.g. marked respiratory depression, although remember that pain will cause shallow breathing.
- Hypoxaemia: due to pneumothorax or pleural haemorrhage, lung contusions, lung damage from teeth or rib fractures. Administer oxygen and perform thoracocentesis if pleural fluid/air is suspected.

Regardless of location of injury, bite wounds will damage soft tissue structures. Some injury will be instantly apparent and these tissues should be debrided. In areas where wounds can be left open, open wound management is preferred, as ongoing necrosis can be assessed and necrotic tissues removed sequentially. This means that there is less tissue lost, which may be useful in areas where there is little soft tissue, such as the proximal thigh. In addition, closure of bite wounds can lead to development of abscesses if not all infected tissue is removed or if there is ongoing necrosis that acts as a nidus for residual bacteria. Examples of appropriate locations for open wound management are wounds of the neck, limbs, or superficial wounds of the trunk (i.e. not involving thoracic and abdominal cavities). Open wound management involves lavage and debridement with daily dressing changes for a few days until it is apparent that necrosis has stopped and all infected material has been removed, at which point primary (or delayed primary/secondary) closure can take place.

There are some locations where open wound management cannot be performed, in particular the thorax. In these situations, more aggressive debridement is required so that questionably necrotic material must be removed, whereas for a wound left open it can be left in situ and reassessed the following day. However, debridement must not be too liberal or the wound may not close or be under tension, so care must be taken not to debride tissues that are in fact viable. Severe abdominal wall wounds that penetrate the muscle layers full thickness into the abdominal cavity are usually managed by midline laparotomy to lavage the abdominal cavity and check abdominal structures. Necrotic muscle can be debrided with relative ease as the abdominal cavity has capacity to close even with moderate resection, but do not over debride and consider whether the muscle will close before debridement is started. Use of meshes to close bite wounds may be problematic as implants can be a nidus for infection, and I do not advocate them. I may leave a skin wound open over an abdominal wall repair if I am concerned about viability of tissues.

The use of drains in bite wounds is controversial. They may be useful to control dead space and remove fluid to prevent seroma formation, but they should not be considered an alternative to debridement and lavage.

Antibiotic choice is a broad-spectrum bactericidal drug given intravenously e.g. potentiated amoxicillin. They will be given intravenously if animals are not eating. Consideration should be given to a feeding tube in an animal that does not want to eat or where repeated sedation or anaesthesia means they do not have enough time in the day to meet calorie requirements. This can be an oesophagostomy tube if there are no neck injuries but will need to be a PEG tube if there are neck injuries. Jugular catheter placement is useful if there are multiple limb injuries or if there is a problem with peripheral catheter placement.

Bite wounds in dogs and cats. Holt DE, Griffin G. Vet Clin North Am Small Anim Pract. 2000 May;30(3):669-79, viii.

Bite wounds are a frequent injury in dogs and cats. Some bites are severe, causing crushing, avulsion, and devitalization of tissues beneath the skin. Bites can also crush the airway or penetrate the abdominal or thoracic cavities, resulting in life-threatening injuries. This article reviews the local mechanisms of trauma and systemic mediators involved in severe bite wound injuries and provides a plan for stabilization, injury assessment, and definitive bite would management.

Bullet, bite, and burn wounds in dogs and cats. Pavletic MM(1), Trout NJ. Vet Clin North Am Small Anim Pract. 2006 Jul;36(4):873-93.

Veterinarians are frequently presented with bullet, bite, or burn trauma patients. Injuries can vary from simple minor penetrating skin wounds to major life-threatening soft and hard tissue damage with concurrent complex metabolic ramifications. This article reviews the diagnostic and therapeutic options for each type of injury.

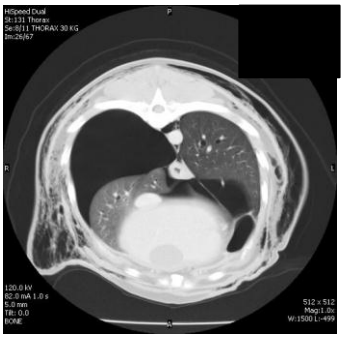
Penetrating Thoracic Injuries

These injuries are rare but may cause devastating trauma. My experience of the cases that have reached me for treatment has generally been positive, and the cases have survived. However, these cases are a real challenge and, to have a good outcome, require a lot of people that are thinking and reacting quickly. Typical injuries are sticks (usually from impalement whilst running) and antler injuries in those dogs that chase stags. Some of the impalement injuries will be rapidly fatal if the heart or a major vessel is punctured or if there is rapid pneumothorax. Penetration by a stick or similar object will cause variable amounts of damage depending upon the length of the stick, angle (some are limited to superficial muscles only or rib fractures only without entering the thoracic cavity, whereas long sticks can pass from thorax into abdomen) and whether any internal organs have been penetrated. Dog bite wounds from big dogs to little dogs can also cause

thoracic penetration, but tend to involve more rib fractures and destruction of muscles.

If a stick is still in the dog, it must not be removed – if it is within the heart or a vessel, removing it will result in rapid haemorrhage. Similarly in the lung it will result in marked and continuous air leakage.

On initial presentation, a number of first aid measures must be considered. If the dog has an open wound, it will have a pneumothorax. Sometimes this is obvious if the wound is wide open. Smaller wounds may suck in air with each breath and can lead to a tension pneumothorax, which will be more rapidly fatal than an open wound. If the stick has entered and remains in place with no gap around it, there may not be a pneumothorax at all. My first concern is usually to re-establish the thoracic wall. An airtight dressing should be placed to stop any more air entering and I place a chest drain on the opposite side to injury or further cranially or caudally on the same side. It may be necessary to perform thoracocentesis first. The contralateral side is usually easier for drain placement if the open wound is being covered as it allows clipping and aseptic preparation. The mediastinum is usually open enough in dogs to allow drainage of air from the contralateral pleural space. I use a narrow gauge MILA drain as it is easily placed conscious. Once the drain is placed, the thorax can be wrapped to maintain an airtight seal, but the thorax should be regularly drained as some air movement into the thorax is still likely to occur. If there is massive and rapid pneumothorax developing despite a thoracic seal, consider the possibility of lung penetration by the stick. This will continue to leak until lung lobectomy has occurred, and so continuous drainage (usually by hand) will be needed until the dog is in theatre. Be careful not to anaesthetize dogs until you are ready to do so. Once under anaesthesia, an open thorax is more difficult to ventilate than in an awake animal (think about the need to ventilate for diaphragmatic rupture), and if not treated surgically it will be difficult to get the dog awake again. Therefore think carefully about whether to refer as soon as the dog is stable.

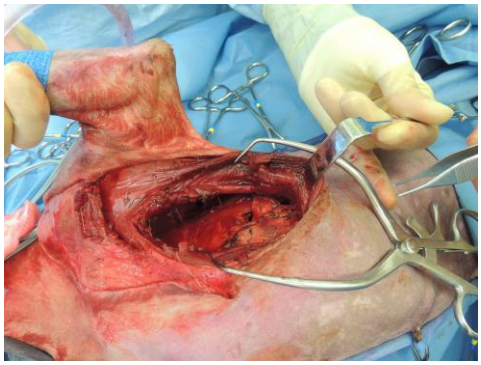


Penetrating injury may lead to haemorrhage. Severe haemorrhage is likely to be fatal. Penetration of smaller vessels will lead to slower haemorrhage but it may be brisk enough to rapidly lead to hypovolaemia. Once the thoracic cavity has been sealed and life-threatening pneumothorax has been treated, an intravenous line can be placed. Boluses of crystalloids will be needed if the dog is hypovolaemic from blood loss. Consideration to transfusion must be considered if blood loss is severe –

referral centres will have stocks of blood, so referral should be considered. Haemorrhage will sometimes stop by itself if the bleeding vessel is small enough for coagulation mechanisms to work, but some vessels will need ligation and only be controlled at surgery. Consideration must be given to how the thorax can be explored to reach a bleeding vessel.

When I have stabilized the thorax and corrected hypovolaemia, I anaesthetise the dog. Ventilation (manual or a ventilator) will be needed as the wound will need to be uncovered for preparation for surgery. Adherence to strict aseptic technique must still be maintained. Depending upon the site of injury, it may be possible to perform intercostal thoracotomy, which is preferred as it is quicker than median sternotomy, and most penetrating injuries have occurred between ribs. However, it is important to know the extent of internal injuries to determine if the surgical approach chosen is sufficient. I will consider use of CT to determine injuries if examination of the wound is not informative enough. This is also useful for assessing extent of rib fractures. Radiographs are very difficult to interpret in the presence of subcutaneous emphysema that accompanies thoracic wall injuries.

The thoracic cavity is examined to determine if there is marked lung damage – if so, individual lobes are removed by lung lobectomy. Consideration must be given to how much lung can be removed – unilateral pulmonectomy (removing either the complete right or left sides) is described in dogs but if performed in dogs without pre-existing lung disease it may be fatal (as there will not have been adaptation of other lung lobes). Haemorrhage must be controlled. Finally the thoracic cavity must be explored for debris and thoroughly lavaged before the thoracic wall is reconstructed. This is usually easy if the penetration has occurred between ribs. If multiple ribs are fractured and are flailing or have no (or minimal) muscle attachments, it is easier to remove them. It is important that ends of ribs are smooth and have attached intercostal muscles, to avoid damage to lung parenchyma. Bite wounds may be harder to close due to damage by crushing and tearing to soft tissues. All damaged tissue must be removed, including muscle and skin. It is usually possible to achieve primary closure, but wounds must be carefully assessed over the following days as abscessation and skin necrosis may occur leading to dehiscence of the wound.



Post-operative care involves analgesia and antibiotics as for oropharyngeal injuries. Chest drains are maintained until pneumothorax is resolved. Usually I will remove

drains as early as possible to avoid iatrogenic infection, but they should be maintained if there is pleural fluid production. As with active suction drains, the volume and cytology should be monitored to determine when they can be removed and to ensure pyothorax secondary to contamination has not developed. I will use active suction drains if there is dead space under skin or muscle secondary to the injury, managed as for oropharyngeal injury.

Management of a chest drain:

- Animals must be supervised 24h/day, wear an Elizabethan collar and have a stockinet or dressing over the wound to prevent self-damage.
- Hand washing and strict aseptic technique is mandatory as iatrogenic pyothorax is potentially fatal. Sterile gloves are worn whenever the drain exit site is handled or if the chest is being drained or lavaged.
- The drain exit site is examined and redressed daily looking for evidence of damage to the suture or drain, subcutaneous air or inflammation. Drains that have slipped out must not be pushed back into the chest as they may introduce infection. New sterile dressings are applied daily. A new sterile syringe and bungs are used each time the chest is drained.
- To drain the chest, a syringe is placed on the end of a 3-way tap before opening the tap and the gate clamp. Gentle suction is applied until the chest is empty. The chest is drained as frequently as required, depending upon the amount of fluid/air produced and the underlying cause. Drainage is usually every 2-4 hours initially but may reduce to 1-2 times daily. Tabulation of the amount of fluid/air produced is important and is assessed every 24 hours for response to treatment.

Chest drain removal is based on the quality and quantity of air or fluid. Fluid production will never stop completely as the tube will incite an inflammatory response which may be as much as 10ml/kg/day. It used to be accepted practice to wait until fluid production was <2-4ml/kg/day; however a recent paper suggests that drains can be removed in the presence of higher fluid production rates. It is prudent to avoid prolonged tube usage (i.e. >7 days) due to the risk of iatrogenic infection, which is potentially fatal.

The following paper gives a good description of how to place a MILA chest drain:

Evaluation of small-bore wire-guided chest drains for management of pleural space disease. Valtolina C and Adamantos S JSAP 50; 6: 290-297.

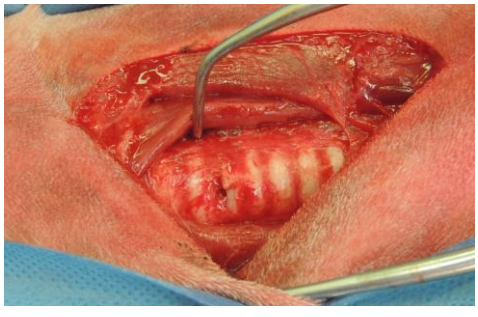
There is significant risk of infection, especially if it has been difficult to remove all contamination, as penetrating injuries may force debris into surrounding tissues and it can be difficult to remove it all. Antibiotic use will not be sufficient to prevent infection if lavage and debridement are not adequate – some dogs will have been contaminated with a resistant organism at the time of injury; others may develop a

resistant infection in hospital. Swabs should be taken after lavage to guide antibiotic use at a later date. If infection occurs, the wound will need to be reopened for further lavage and debridement. Another swab should be taken for bacterial culture and sensitivity.

Bite Wounds and Other Penetrating Injuries to the Neck

There is a risk of airway injury in approximately 20% of animals that suffer bite wounds to the neck. This may include rupture of the trachea or disruption of the larynx. In some animals there may not be any skin disruption – there may be suspicion of airway injury in animals that have abnormal breathing or if there is subcutaneous emphysema. Some subcutaneous emphysema will occur in animals with bite wounds, but marked emphysema that is clinically very obvious, or the presence of pneumomediastinum or pneumothorax, should prompt further investigation. Laryngeal disruption may be seen radiographically as an abnormal laryngeal location, although this is an unusual injury. Intubation can be difficult if the laryngeal muscles have been damaged, as the larynx may be caudally displaced. Intravenous anaesthesia should be performed if tracheal/airway rupture is suspected in order to avoid exposure of personnel to anaesthetic gases and to make anaesthesia more reliable. Exploration of the neck occurs as for oropharyngeal stick injury.

Reconstruction of the larynx can be challenging if muscles are badly disrupted and a tracheostomy tube may be needed postoperatively. Very small penetrating wounds of the trachea can be left unsutured, as closing very small defects can be challenging. If the wound is small and has already been sealed by local tissues, I do not disrupt the tissues, but will consider leaving part of the neck open in case the wound opens again and air leakage recommences (see below). Larger injuries must be sutured, either between or through rings. If there is sufficient local soft tissue, the injury can be patched with muscles to stop air leakage. In some cases there will be leakage of air through the repair – in this case the muscle and skin may need to be partially left open (as for temporary tracheostomy) to avoid development of subcutaneous emphysema, pneumomediastinum and pneumothorax.



Management of the soft tissues of the bite wound is as described above (bite wounds).

There are other causes of penetrating injuries to the neck, such as sticks or sharp objects. This are approached as for bite wounds, but local tissue damage is likely to be less marked.

Penetrating injuries in dogs and cats. A study of 16 cases. Risselada M, de Rooster H, Taeymans O, van Bree H. Vet Comp Orthop Traumatol. 2008;21(5):434-9.

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.

Jordan CJ, Halfacree ZJ, Tivers MS. Airway injury associated with cervical bite wounds in dogs and cats: 56 cases. Vet Comp Orthop Traumatol. 2013;26(2):89-93.

OBJECTIVE: To investigate the frequency of airway injury and damage to other vital structures associated with cervical bite wounds in dogs and cats and the implications for management and outcome.
METHODS: A retrospective search of electronic patient records was used to identify dogs and cats suffering cervical bite wounds that were presented to a large multidisciplinary veterinary hospital over a four-year period.
RESULTS: Complete records were available for 55 animals, with one animal suffering two separate injuries. Fourteen animals (25%) had injuries to vital structures, including airway injury in nine (17%), which was surgically confirmed and treated in six (11%). Airway injuries were associated with either subcutaneous or mediastinal emphysema in all affected animals. Other structures injured included the jugular vein, pharynx, oesophagus and spine. Airway injuries were treated with primary repair in five animals and a fasciomuscular patch in one. Temporary tracheostomy was performed in three animals. Median duration of hospitalisation was one day (0-19) with 53 animals (54 cases) (96%) surviving to discharge. Long-term follow-up (16-114 months) revealed that 43 of 49 animals were alive with six that died due to unrelated reasons.

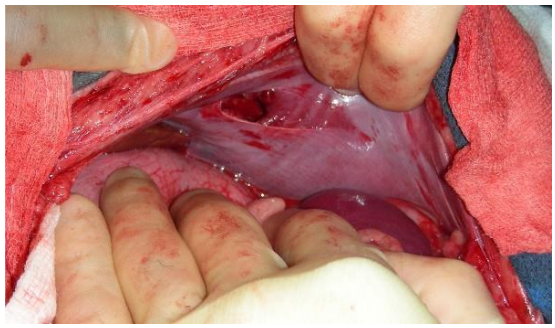
CLINICAL SIGNIFICANCE: Cervical bite wounds are associated with significant injury to vital structures. Up to 17% of animals may have injury to their airway. Identification and treatment of airway injury is vital and was associated with an excellent outcome in six animals.

Prepubic Tendon Injuries/ Body Wall Ruptures

Most of the injuries discussed previously occur secondary to penetrating injuries. Blunt trauma is typically associated with road traffic accidents. The most common rupture is diaphragmatic rupture and will not be discussed in this course.

Rare injuries of the abdominal wall are rupture through part of the abdominal wall or prepubic tendon rupture. These injuries may not be apparent on initial presentation, as there is usually a large amount of bruising and swelling of the abdominal wall.

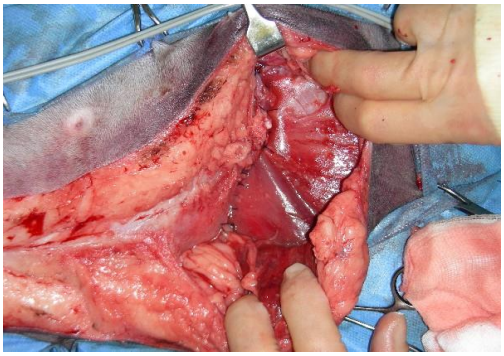
Lateral and ventral abdominal wall ruptures may not be obvious immediately after trauma, but become apparent when swelling has resolved. Their location should be clearly marked on the skin prior to investigation because they tend to reduce under anaesthesia and it can be hard to find a small muscle rupture by palpating the anaesthetized abdominal wall. If there are multiple ruptures, or the possibility of more than one rupture or another injury, I explore via midline coeliotomy and repair the muscle rupture from within the abdomen. A single rupture can be repaired via a skin incision over the rupture. The muscle is repaired routinely with interrupted or continuous sutures.



There should be suspicion for prepubic tendon rupture if there is marked caudal abdominal wall bruising. It is often hard to palpate initially due to the swelling and also because the rupture often leaves a large defect, so it is hard to palpate the edges as one can in an inguinal or umbilical hernia. Radiography may be helpful if abdominal organs are clearly seen ventral to the expected position of the abdominal muscle on the lateral radiograph. In normal animals, the ventral abdominal wall can be clearly seen caudally, but it may not be visible after trauma even if it is intact. Ultrasound can also help to delineate the muscle wall or look for abdominal organs under the skin, but will require good technique to do so. If in doubt, it is best to wait for swelling to resolve, as a rupture will be more obvious after a number of days. A

study has shown there is no difference in outcome in animals having immediate or delayed surgery, so it is beneficial to wait rather than accidently open an animal without a rupture. Personally I like to wait until swelling and bruising has subsided, as it makes tissues easier to handle, and improves the ability of tissues to hold sutures, so making dehiscence less likely. It also allows heart and lungs to recover from the effects of blunt trauma. I do not like to delay for more than 5-7 days as retraction of the abdominal wall can make repair difficult.

Prepubic tendon repair is challenging. The caudal part of the abdominal musculature forms a narrow tendon that attaches to the pubis. This may rupture through the tendon, in which case sutures can be passed through tendinous material. However, it is rarely that easy! It is common for the tendon to be torn from the pubis. Repair must therefore be through small tunnels drilled into the cranial pubis, assuming there are not pubic fractures. This is challenging as there is a limit to the number of holes that can be drilled and the caudal abdominal wall is surprisingly wide given how narrow the prepubic tendon is, so it is hard to fix more than just the centre of the abdominal wall. I preplace sutures, as they are hard to place once a single suture is tied. Laterally the abdominal wall muscles tend to be avulsed from the origins on the transverse processes of the lumbar vertebrae. These cannot be easily reached via ventral coeliotomy, so muscle is sutured with some difficulty to lateral dorsal tissues. The inguinal ring is disrupted and the ventrolateral abdominal wall is hard to reconstruct – I will sometimes place sutures to the adductor and cranial thigh muscles (e.g. cranial sartorius) to reconstruct this tissue. There are also reports of muscle flaps – cranial sartorius and rectus abdominus. Mesh can be used for chronic ruptures where retracting and scarring prevents replacement of the abdominal wall adjacent to the pubis.



Rectus abdominis muscle flap for repair of prepubic tendon rupture in 8 dogs. Archipow W(1), Lanz OI. Can Vet J. 2011 Nov;52(11):1215-8.

The clinical use and outcome of the rectus abdominis muscle flap to repair prepubic hernias were evaluated retrospectively. Medical records (2002-2007) of 8 dogs that had a rectus abdominis muscle flap to repair traumatic prepubic tendon rupture were reviewed. Only minor donor site complications were noted, including self-limiting ventral and hind-limb swelling. No long-term complications including recurrence of hernia were noted. The results of this study indicate that the rectus

abdominis muscle flap is a clinically useful option for repairing prepubic tendon rupture in dogs.

Rupture of the cranial pubic tendon in the cat. Friend EJ, White RA. J Small Anim Pract. 2002 Dec;43(12):522-5.

Seven cats with rupture of the cranial pubic tendon (CPT) were presented to the authors between 1992 and 2001. The causal aetiology was unclear in each case. Diagnosis was made on physical examination (five animals) or surgical exploration (two animals). Concurrent injuries were present in four cats, including injury to the urinary tract and musculoskeletal system. All ruptures were surgically explored and primary repair of the CPT rupture was performed in five cats. Repair was not possible in two cats, and follow-up examination showed that scar tissue had apparently formed to support the deficit. All cats were asymptomatic at follow-up examination. The prognosis for CPT rupture in the cat is favourable.

Traumatic body wall herniation in 36 dogs and cats. Shaw SR, Rozanski EA, Rush JE. J Am Anim Hosp Assoc. 2003 Jan-Feb;39(1):35-46.

Traumatic body wall hernias (TBWH) are serious sequelae to traumatic injury in dogs and cats. During the study period, 26 dogs and 10 cats with surgically managed TBWH were identified. Five cases (four dogs, one cat) did not have their hernias identified during the first 24 hours of hospitalization. Bite wounds were the most common cause of TBWH, accounting for 54% of canine and 40% of feline hernias. Twelve cases (nine dogs, three cats) had serious intra-abdominal injuries diagnosed in addition to their TBWH. Seventy-three percent of dogs and 80% of cats survived to hospital discharge. In addition, the authors report the occurrence of a unique cause of herniation, termed an autopenetrating hernia.

Complications of Penetrating Injuries

The main complication of penetrating injuries is the risk of death from haemorrhage, pneumothorax or damage to vital organs (see penetrating thoracic trauma). Degree of blood loss should be quantified on arrival and ongoing haemorrhage measured. Be aware that internal bleeding may be occurring. Assessment of mucous membrane colour, capillary refill time, pulse rate and pulse quality can be used to assess hypovolaemia secondary to blood loss. Acute blood loss can be initially managed with crystalloid fluid therapy, but transfusion with packed red blood cells will be needed if there is marked and ongoing haemorrhage.

There is a risk of infection following penetrating injuries, which may lead to dehiscence of a sutured wound or abscess formation. The latter is likely to result in more severe systemic clinical signs. Risk of infection is reduced by thorough lavage and debridement at initial surgery. Wounds are left open where possible and closed when the risk of infection is considered to be low. If infection develops, wounds should be reopened and infected/necrotic tissue debrided, as on first presentation. If in a location amenable to open wound management, I always leave an infected wound open for a period of open wound management to avoid the risk of an abscess reforming or of repeat dehiscence. Infected thoracic wounds must be closed, so intense lavage is necessary in conjunction with wound debridement prior to closure.