Focus on Emergency Surgery Mini Series

Session One: A to Z of Trauma

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Webinar notes: Trauma Surgery

Introduction:

Trauma is a frequent presentation in general practice situations and knowing how to deal with emergency situations and direct your team can significantly reduce patient morbidity and mortality and improve streamlining of diagnostics and treatment. This webinar aims to give participants an overview of initial patient assessment in emergency situations and then looks in more detail at some of the more common soft tissue emergencies seen associated with trauma patients.

Triage:

Triage is the process of prioritising patients based on their need and the severity of their condition. Triage begins with initial owner contact to the practice. The reception team can aid in the prioritisation of patients by asking specific questions to owners during phone contact to determine the severity of the situation. These questions include:

- What is the nature of the injury?
- Is the patient breathing/conscious/ambulatory?
- Can the owner determine mucous membrane colour?
- Is the patient bleeding and if so where from?
- Is there a history of vomiting, diarrhoea/non-productive retching?

It is important that owners are made aware of the risk of sustaining a bite wound when transporting painful patients. Bear in mind the owner's interpretation of situation may be unreliable as they may be very upset. Ensure the advice given is simple advice e.g. apply pressure to stem bleeding, and ensure the owner knows what to do on arrival at the practice and who to report to.

Upon arrival at the practice, an initial assessment should be made to determine if the patient needs to be removed for its owner immediately for emergency treatment or if the patient can remain with the owner during the consultation. This decision is often made by a member of the veterinary nursing team. Initial points for assessment at this juncture include:

- Is the patient conscious, responsive and ambulatory?
- Is there evidence of haemorrhage?
- Is the airway patent?
- Observe respiratory rate, noise and effort (inspiratory versus expiratory)
- Assess heart rate, pulse quality, mucous membrane colour, capillary refill time
- Is analgesia required?
- Is oxygen supplementation required?

Rapid analgesia is essential for the majority of patients presenting post trauma. Analgesia should be tailored to the individual but an opioid (and preferably a full mu agonist e.g. methadone) is usually indicated. Realistically the detrimental effect of pain on normal respiration (e.g. fractured ribs) will usually far outweigh the respiratory depression caused by opioids.

If an opioid alone is inadequate, other options for analgesia include either a ketamine constant rate infusion (CRI) or a lidocaine CRI. Intravenous paracetamol can also be considered (10mg/kg as a slow intravenous infusion over 15-30 minutes). Non-steroidal anti-inflammatory drugs e.g. meloxicam should be avoided in hypovolaemic, hypotensive patients as there is an increased risk of renal toxicity and gastric ulceration. These drugs can be introduced once the patient is stable and any volume deficits have been corrected.

Primary survey:

The primary survey aims to assess the most essential body systems i.e. respiratory, cardiovascular, urinary and neurological systems. Trauma to these systems can lead to significant morbidity and mortality and is unfortunately not uncommon. In one study of 235 dogs experiencing severe blunt trauma, pulmonary contusions were reported in 58% of all patients and pneumothorax in 47% (Simpson et al 2009).

Signs of respiratory compromise include dyspnoea, tachypnoea, increased abdominal effort, stertor/stridor/wheeze, abducted elbows (orthopnea), open mouth breathing and cyanosis. Open mouth breathing in cats is usually a sign of significant respiratory or intra-pleural disease and care should be taken to stress such patients as little as possible as they can deteriorate rapidly. Observing the patient prior to handling can provide you with a significant amount of information regarding the possible source of respiratory distress. Increased noise or effort on inspiration suggests an issue with the upper respiratory tract. Stertor is more commonly associated with pharyngeal obstructions whereas stridor is seen with laryngeal oedema/obstruction. Expiratory effort is more commonly seen with lower respiratory disease.

When presented with a patient in respiratory distress, oxygen should be provided if tolerated by the patient. Ideally a patient will be maintained in sternal recumbency to prevent atelectasis of the dependent portion of the lung. Analgesia should be provided if appropriate. Observe the patient as detailed above and then auscultate the thorax. Lung sounds should be audible in all four quadrants of the thorax and an absence of lung sounds can indicate the presence of free air or fluid within the pleural cavity. Intravenous access should be obtained as soon as it is practical to do so. Ensure you place as large a bore catheter as possible. Some patients experiencing respiratory distress, particularly those with upper respiratory tract obstruction, can become hyperthermic and this can further exacerbate respiratory distress due to panting. Actively cooling such patients through the use of air conditioning, fans or wet towels should be considered. Sedation is also useful in these patients. In trauma patients, however, hypothermia is more common and active warming through the use of warm air blankets such as a Bairhugger or a heated incubator is indicated. The use of heat pads in such patients could lead to thermal burns as patients with significant musculoskeletal trauma may be unwilling or unable to move away from the heat source.

Oxygen supplementation can be provided via a number of routes. Face masks provide a maximum fractional inspired oxygen (FiO2) of 50-60% with oxygen flows of 8-12L/min. More commonly flows of 2-5L/min are used. There is a risk of rebreathing and also a risk of hyperthermia. Nasal prongs/catheters achieve a FiO2 of ~50% can be achieved using flows of 2l per 10kg per minute. However this is often not well tolerated in clinical patients and 2-5 l/min is more commonly used. It is important to humidify gas, if possible, to prevent irritation of the nasal mucosa.

Oxygen cages and incubators can achieve FiO2 of up to 60% (more commonly 40-50%) but there is again a risk of hyperthermia and patient temperature should be closely monitored.

Thoracic ultrasound is a quick and easy way of determining if pleural fluid is present and can be performed with the patient in sternal recumbency and with minimal handling. Thoracic radiography is the imaging modality of choice for the diagnosis of significant pneumothorax as it can be performed relatively quickly in the conscious patient. However, this does require some degree of restraining which may not be tolerated in the unstable patient. Diagnostic needle thoracocentesis can be considered but can be unreliable in very large patients or patients where the fluid or air is compartmentalised.

Basic assessment of the cardiovascular system should include assessment of:

- Mental state
- Mucous membrane colour - pale/cyanotic/hyperaemic
- CRT ↑ or ↓
- Heart rate
- Pulse Quality
- Presence of peripheral (digital) pulses
- Temperature of extremities
- Blood pressure

If possible, a continuous non recording ECG should be attached to the patient. Ventricular premature complexes, ventricular tachycardia and junctional rhythms can all be seen post significant trauma. Minimum bloodwork should include PCV/TP/electrolytes/urea/creatinine/acid base measurements/lactate and glucose if possible. Lactate can be a good indicator of peripheral perfusion and has been shown in some studies to be a predictor of survival in certain emergency situations but there is significant overlap between survivors and non-survivors and thus numbers should be interpreted with care. Normal lactate readings are usually <2mmol/L. However measuring lactate is not essential and should only be done if you intend to act upon the results. Glucose can be low in septic patients.

Potential underlying aetiologies of abnormal cardiovascular parameters include reduced systemic vascular resistance (sepsis, hypovolaemia or anaphylaxis), structural cardiac disease and hypoxic damage to cardiac muscle and pain.

Crystalloids represent the mainstay of initial fluid resuscitation although it should be remembered around 75% of the volume given will be lost to the interstitium within one hour of administration. A balanced electrolyte solution is preferable to 0.9% saline as the latter can lead to metabolic acidosis secondary to elevated chloride levels. Rather than considering “shock-rate” fluids, it is preferable to give intravenous fluids in incremental boluses (10-20ml/kg given over 15 minutes) and monitor heart rate (which should reduce) and blood pressure (hypotension should improve) to assess response.

Please note these doses may not be appropriate in patients with concurrent structural cardiac disease. Hypertonic saline can also be used (although the author has limited experience of it) and causes expansion of circulating volume by dehydration of the interstitium. It must therefore be followed by an isotonic solution.

In patients which are unresponsive to crystalloid therapy or where it is anticipated that improvement of oncotic pressure will be required, colloids should be considered. Options for colloid therapy include hydroxyethyl starches and gelatins. Hydroxyethyl starches come in a variety of molecule sizes and therefore have variable duration of effect. There has been significant research efforts within human medicine over the past few years looking at the morbidity and mortality associated with the use of hydroxyethyl starches in critically ill patients. Recent randomised trials in human medicine have suggested that the use of hydroxyethyl starches in critically ill patients can lead to significant acute kidney injury and mortality; particularly in sepsis. This has led to a move away from the use of such colloids in veterinary medicine also although the same research has not currently been duplicated. At the present time, the use of hydroxyethyl starches in human medicine is limited to management of haemorrhage and certainly there is an argument that the use of such colloids should be avoided in septic veterinary patients also. Coagulopathy is reported as a side effect of hydroxyethyl starches due to a reduction in the concentration of factor VIII and von-Willebrand factor but this is not frequently recognised clinically.

Gelatins are generally smaller sized molecules than those contained in hydroxyethyl starch solutions but are present in larger numbers. As the molecules are smaller, they do not remain in the circulation as long as the hydroxyethyl starch molecules. Increased anaphylaxis is reported in humans treated with gelatins than hydroxyethyl starches but this is not very common in dogs. Gelatins are currently the colloid of choice in human sepsis. Colloids are usually administered in 5ml/kg boluses up to a maximum of 20ml/kg/24 hours.

In patients where significant blood loss is the underlying cause of hypovolaemia, replacement of oxygen carrying capacity and circulating volume is best achieved using either packed red cells (which provide a higher number of erythrocytes/ml and thus will increase oxygen carrying capacity but do not replace clotting factors or plasma proteins) or whole blood which provides all blood components (although there is still reduced survival of platelets in a whole blood transfusion). Since the introduction of the Pet Blood Bank, packed red cells are often more readily available and represent convenience but whole blood continues to have significant benefits in patients where there has been significant haemorrhage. Packed cells can be combined with fresh frozen plasma (usually 10-20ml/kg or 1:1 ratio of bag of packed cells: fresh frozen plasma); however this does not address thrombocytopaenia.

Cardiovascular resuscitation goals:

- **Normalization of heart rate and restoration of peripheral pulses.**
- **Mean arterial blood pressure (MAP) > 65mmHg.**
- **Urine output > 0.5 ml/kg/hr averaged over at least four hours.**
- **Lactate levels < 2 mmol/l.**

Primary neurological assessment can be brief but should be performed in a logical manner. Assessment of demeanour can indicate signs of increased intra-cranial pressure or diffuse brain disease. Perform a basic cranial nerve examination. Is the patient ambulatory? If not, is there still voluntary movement of the limbs (do not confuse this with response to assessment of segmental spinal reflexes)? A patient with voluntary movement will have deep pain sensation and therefore this only needs to be assessed if voluntary movement is not present. When assessing deep pain sensation, ensure your patient makes a visible response to the stimulus you apply. If the reflex arc is intact, a patient with a completely severed spinal cord will still withdraw the limb when an interdigital stimulus is applied.

Secondary survey:

The secondary survey should be performed once your patient has been stabilised as detailed above. A full patient history should also be obtained at this time if this has not already been done. This should include confirming a full physical examination to identify both more subtle lesions and also concurrent disease processes such as cardiac disease or diabetes mellitus which may impact ongoing patient management. Once your physical examination is complete, make a problem list and subsequently a list of differential diagnoses. With this information, appropriate diagnostic tests can be chosen. Obviously, body systems should be prioritised on the basis of the potential morbidity; e.g. pneumothorax is of higher priority than a fracture. Diagnostics can include thoracic and abdominal radiography, ultrasound and advanced imaging techniques such as CT and MRI.

Types of trauma:

Pharyngeal trauma:

Pharyngeal trauma usually occurs at exercise associated with jumping to catch or running on to a stick. In acute trauma cases, the owner may not witness the trauma but will often report hearing the dog cry out or notice haemorrhage from the oral cavity. In more chronic cases, the date of the original trauma may be unknown the dog may present with cervical swelling and pyrexia. After triage as detailed above and the provision of analgesia, general anaesthesia is required to permit thorough oral examination. Bear in mind intubation may be challenging and therefore have a selection of different sized endotracheal tubes available. Suction should be ready to use to remove blood/saliva etc from the pharynx if necessary. A good light source and laryngoscope should also be available. In patients where difficult intubation is anticipated, a rigid 6Fr or 8Fr dog catheter can be connected to a small endotracheal tube connector to facilitate oxygen delivery in to the trachea if an endotracheal tube cannot be passed.

Following induction of anaesthesia, intubation and oral examination, imaging of the cervical region and thorax should be performed. The presence of gas bubbles or gas filled tracts in the soft tissues of the neck surrounding the trachea and oesophagus is often supportive of pharyngeal penetration and warrants further surgical exploration as does the presence of a pneumomediastinum or a pneumothorax. Bear in mind that a pneumothorax can develop secondary to a pneumomediastinum but not vice versa. CT of the neck and thorax is preferred when available.

Small superficial tracts within the oral cavity can be debrided and either left open to drain and granulate or sutured depending on location.

Tracts extending from the peri-laryngeal region should be explored via ventral midline approach to allow debridement and lavage. A closed suction drain should be placed. For shorter or more rostral tracts or where finances are an issue, exploration and flushing using pressurised saline passed through a rigid endoscope is also described (Robinson et al 2014) as an alternative to surgery.

Thoracic trauma

Once stabilised, further diagnostics are usually indicated. Thoracic radiography remains the mainstay of thoracic imaging in trauma patients as it is easily accessible and can be performed in a conscious patient or under a light sedation and does not require the administration of contrast (unlike CT). Radiography permits identification of a pneumothorax or a larger volume haemothorax. Thoracic ultrasound is more sensitive for identifying smaller volumes of pleural fluid and can easily be performed without sedation. Pulmonary contusions may not be immediately evident radiographically post trauma and can progress over the first 24 hours post trauma. The decision to drain or not drain air or fluid from the thorax is based on the patient's respiratory rate and effort. If repeated needle thoracocentesis is required, placement of a thoracostomy tube should be considered. Consider placement of a nasal oxygen catheter in patients with clinically significant pulmonary contusions.

Surgical intervention is often not required for thoracic trauma patients. Small volume leaks from the pulmonary parenchyma will often seal without intervention. However if there is continued drainage of air in to the thoracic cavity which cannot be managed by a thoracostomy tube alone or in the case of penetrating thoracic wounds; particularly those which are contaminated (e.g. thoracic wall bite wounds), surgical exploration of the thorax should be considered. Bite wounds often cause shearing of underlying tissues and therefore the extent of the injury cannot be judged by the surface appearance alone. Bite wounds which cause oesophageal or tracheal trauma close to the thoracic inlet can lead to significant subcutaneous emphysema.

Pneumothorax:

Intarapanich et al (2016) reviewed 426 cases of blunt trauma and reported a 29% incidence of pneumothorax and 44% incidence of pulmonary contusions in patients experiencing motor vehicle trauma. Sources of air leakage include thoracic wall trauma, oesophagus or airway (lung, bronchus or trachea) rupture. This usually occurs secondary to blunt thoracic wall trauma but can be spontaneous due to rupture of pulmonary bullae or blebs (which usually occurs secondary to minimal trauma). Clinical signs of pneumothorax include a restrictive (shallow) breathing pattern, hypoventilation and reduced lung sounds on auscultation (particularly dorsally). Life-threatening dyspnoea is seen in patients with a tension pneumothorax. This occurs when the entry point of air in to the chest cavity acts like a one way valve, leading to a rapid and life-threatening accumulation of free air in the thorax. This represents an emergency and thoracic drainage is required rapidly. Should clinical examination raise suspicion for the presence of a pneumothorax, radiography is the simplest diagnostic tool as previously described.

Management of a pneumothorax depends on the severity of the air leak, likelihood of recurrence and patient stability. A small volume pneumothorax with no ongoing air leakage may not require any drainage if the patient is asymptomatic and any free air will be resorbed over the coming days.

When physical examination findings suggest a clinically significant pneumothorax, options for drainage include needle thoracocentesis and the placement of a thoracostomy tube. The author tends towards needle thoracocentesis in conscious trauma patients in the first instance as this can be performed utilising local infiltration of lidocaine. The needle should be positioned dorsally within the thorax and may need to be repositioned if initial attempts are not successful. In situations where a negative seal cannot be achieved or there is rapid re-accumulation of air within the thoracic cavity, a thoracostomy tube should be placed. This requires general anaesthesia and therefore needle thoracocentesis may need to be performed initially to stabilise the patient. Very infrequently, e.g. in the case of rupture of a bronchus, an emergency thoracotomy may be required to address the underlying cause due to the rapidity of air loss in to the thoracic cavity.

Three main types of thoracostomy drain are available but only two are suitable for closed placement (The third type is reserved for placement when the thoracic cavity is open at surgery). These are the traditional "trochar" drain and Seldinger drains where a peel-away sheath is used to place a guide wire through the thoracic wall over which the drain is threaded. As much of the clipping and aseptic preparation should be performed prior to induction of anaesthesia to reduce anaesthesia time.

Patients with a thoracostomy tube in situ require constant supervision and a rigid protection collar should be in place to prevent interference with the drain. A gate clamp should also be in place as a separate measure of security. Drainage frequency should be determined on the basis of production of either air or fluid. In patients where there is significant air leakage, a Heimlich valve can be considered. This valve is connected to the end of the drain and when pressure in the thoracic cavity exceeds atmospheric pressure, air is discharged from the thorax through a rubber sleeve. This valve is not suitable for use on patients with a body weight of <20kg. The valve can be cumbersome and should be carefully monitored for dislodgement. Furthermore the valve ceases to function if it becomes wet so is not suitable for use in patients with pleural fluid.

Surgical exploration of the thorax should be considered in any patient with significant ongoing air leakage which does not respond to conservative management. However, in the author's experience this is not common.

Diaphragmatic rupture:

Diaphragmatic rupture or herniation is a well-recognised consequence of severe blunt trauma particularly in smaller patients. The mechanism of injury is thought to be a sudden increase in intra-abdominal pressure with the glottis open. The diaphragmatic costal muscles are the most common area of rupture and tears can be circumferential, radial or a combination of both (circumferential tears are more common in cats than dogs). The liver is the most commonly herniated organ followed by small intestine, stomach, spleen, omentum and the pancreas. Herniated organs may become strangulated or obstructed and liver herniation can lead to venous stasis, necrosis, bacterial proliferation, biliary obstruction and the development of pleural effusion.

The chief clinical sign is dyspnoea due to lack of a functioning diaphragm, lung compression by viscera or pleural fluid, dysfunction of the chest wall secondary to trauma/pain and concurrent pulmonary contusions. Other signs include reluctance to lie in lateral recumbency, lethargy, vomiting or diarrhoea (if gastrointestinal involvement) although some patients may be asymptomatic initially.

Examination can reveal muffled or abnormally positioned heart sounds, reduced lung sounds and an "empty" feeling abdomen. **ALL** patients presenting with musculoskeletal injury secondary to blunt trauma should have thoracic radiographs or ultrasound performed. Cardinal radiographic signs (66-97% accuracy of diagnosis is reported with a single lateral projection) include loss of the diaphragmatic contour and visualisation of viscera in the thoracic cavity. Thoracic ultrasound (93% accuracy) is especially useful if pleural fluid is present.

Historically, delaying surgical repair of a diaphragmatic rupture was thought to correlate with increased survival to discharge. However this is not supported by more recent publications. Indeed surgery should be performed as soon as the patient is stable as further delay risks further herniation of organs or incarceration of herniated organs which can be of particular significance with respect to organs such as the stomach where gas distension can lead to a rapid deterioration in the patient's clinical status. Gibson et al 2005 reported 92.6% of cases undergoing surgery within 24 hours and had a 93% survival to discharge rate.

Well managed anaesthesia is the key to successful surgical management of diaphragmatic rupture. Ideally clipping should be performed prior to induction of anaesthesia as insofar as this is tolerated by the patient in an attempt to reduce anaesthesia time. Pre-oxygenation should be performed and once anaesthesia is induced, the thorax should be elevated above the abdomen to reduce pressure on the thorax and discourage herniation of further organs in to the thorax. Ventilation is required for this surgery as the thoracic cavity will be open to the environment via the diaphragmatic defect. High inspiratory pressures (>20mmHg) should be avoided as this can increase the risk of development of re-expansion pulmonary oedema.

Once these patients are anaesthetised you need to move quickly and reduce the hernial contents as quickly as possible. Once there is more room for pulmonary expansion, anaesthesia often becomes much more stable. Sometimes the size of the hole in the diaphragm is too small to allow easy reduction of the herniated organs. In this case, the defect may need to be enlarged with a ventrally (i.e. towards the surgeon) directed incision under direct visualisation. Be careful of the vena cava and oesophagus as they pass through their respective hiatuses in the diaphragm. Incarcerated liver lobes and the spleen are often congested and friable. Careful handling is therefore required if rupture is to be avoided. In more established hernias, adhesions may have formed and a caudal median sternotomy may need to be performed to allow these adhesions to be transected under direct visualisation. Once reduced to a "normal" anatomical location, organs should be inspected for viability. The defect can usually be closed using an absorbable monofilament suture such as polydioxanone (2/0-0) in a simple continuous pattern.

Drainage of the surgically induced pneumothorax needs to be considered prior to closure of the diaphragmatic defect. In acute cases where a reasonable volume of aerated lung remains, the thoracic cavity can be drained via a large bore intravenous catheter which is passed through the muscular portion of the diaphragm under direct visualisation and connected to an extension set and a three way tap for drainage. In more chronic ruptures or in cases where there is very little aerated lung identified on the pre-operative thoracic radiographs, a thoracostomy tube should be placed to allow for more gradual re-expansion of chronically atelectic lung over the first 24 hours post-surgery. Rapid re-expansion can result in reperfusion injury of collapsed vascular beds and the development of pulmonary oedema.

Oxygen supplementation is often required in recovery. The patient should be maintained in sternal recumbency to prevent lung atelectasis. If hypoxia is noted post extubation consider a conscious chest radiograph to assess the degree of remaining pneumothorax and drain more air as required. Approximately 15% of cats die prior to surgery due to multiple comorbidities. Death within the first 24 hours post-surgery is usually secondary to haemothorax, pneumothorax, pulmonary oedema, pleural effusion and cardiac dysrhythmias. Other post-operative complications include ascites, gastric ulceration, oesophagitis, megaoesophagus and recurrence of the hernia.

Body wall rupture:

Another potential consequence of blunt trauma is body wall rupture. Inguinal, prepubic, intercostal and paracostal locations are the most common. Bite wounds can also lead to penetrating abdominal wounds. 44-75% of patients will have concurrent soft tissue or orthopaedic injuries. The hernia may not initially be obvious depending on the degree of soft tissue swelling and volume of abdominal contents which are herniated. Thoracic radiography should also be performed to rule out concurrent diaphragmatic herniation.

In many cases, a diagnosis of body wall rupture can be made on palpation or visualisation of herniated organs in the cases of penetrating injury. However in some more subtle cases, radiography (plain or contrast) or ultrasound is needed to confirm the diagnosis.

Patient stabilisation, surgical timing and preparation have been previously described. Ideally, hernias/ruptures should be explored via a ventral midline celiotomy incision to allow exploration and examination of ALL abdominal organs or directly over the thoracic wall in the case of intercostal rupture/trauma. Incision directly over the herniated contents is also described. Hernial contents should be reduced via gentle traction and any necrotic or friable tissues debrided. The wound and abdominal cavity should be thoroughly lavaged prior to closure. Selection of suture material is important. Ideally a monofilament absorbable suture e.g. polydioxanone should be used as and the hernia should be apposed in anatomical layers. In patients with significant defects in the muscle of the abdominal wall, it is occasionally necessary to use an autogenous muscle flap to reconstruct the abdominal wall. Options include the external abdominal oblique or latissimus dorsi for caudal thoracic or lateral cranial abdominal wall defects. Autogenous tissues have the significant benefit of bringing a blood supply to the area resulting in a much lower complication rate.

In defects where appropriate autogenous tissue cannot be sourced to close the defect, polypropylene mesh can be used for reconstruction of the abdominal wall. Edges of the mesh should be double thickness and it should be attached to surrounding musculature using simple interrupted or horizontal mattress sutures of polydioxanone or polypropylene. Ideally omentum should be sutured in to the defect prior to placement of the mesh to reduce the risk of serosal adhesions. In patients where there is significant necrosis of tissues and wound contamination, mesh should not be used as if bacteria become attached to the implant, it can be very difficult to eradicate this without removal of the implant leading to the development of draining fistulae. In rare cases where there is a large necrotic defect where closure with autogenous tissues is not an option, the use of negative pressure wound dressings to temporarily seal the abdomen until the tissues are healthy enough to permit closure via another route is reported.

In paracostal ruptures, the first priority is always re-establishment of the integrity of the thoracic cavity and therefore efforts should focus on turning caudal thoracic defects in to cranial abdominal defects. This can be achieved by reattaching the diaphragm to the costal arch via circumcostal sutures or by advancing the diaphragm and re-attaching it to a more cranial rib using circumcostal sutures if necessary. This suture placement technique can also be used to re-attach avulsed portion of the abdominal wall musculature.

In pre-pubic tendon rupture, hernial contents are reduced via a ventral midline celiotomy incision as previously described. If there is sufficient soft tissue remaining on the pubis, the defect can be closed using cruciate mattress sutures of polydioxanone. However (and more commonly) holes need to be pre-drilled in the cranial brim of the pubis to facilitate reattachment of the musculature of the body wall to the pubis via simple interrupted or horizontal mattress sutures. Ensure you protect the structures running dorsal (e.g. rectum/urethra) to where you are drilling with a periosteal elevator or swab and avoid interfering with the obturator nerve which runs through the obturator foramen.

Ensure adequate analgesia provision (opioids +/- NSAIDs depending on hydration status) and consider the use of a wound diffusion catheter depending on the extent of the injury. Wound diffusion catheters are flexible fenestrated catheters placed at or near to the site of surgery for the intermittent delivery of local anaesthetics as part of a multi-modal analgesia plan during hospitalisation. Local anaesthetics work by blocking the influx of sodium into the nerve axon and inhibiting the action potential which disrupts the generation and transmission of nerve impulses. This approach provides excellent local analgesia and thus reduces dependence on systemic analgesics which in turn can improve appetite etc. The author uses bupivacaine (1-1.5mg/kg q6 hours) and the dosing frequency should be strictly adhered to if possible as injection in to a wound bed can cause a stinging sensation if the effects of the previous dose have completely worn off. Asepsis should be strictly adhered to when handling the catheter and a bacterial filter should be placed on the end of the catheter which should be changed every 24 hours. In patients with polytrauma, consider placement of a feeding tube.

Skin trauma/ degloving injury

Degloving injury is a type of avulsion injury in which an extensive section of skin is completely torn off the underlying tissue, severing part or all of the vascular supply. In veterinary medicine it usually refers to shearing of the skin overlying the appendicular skeleton but this term could also be applied to avulsion of the skin over the jaw or torso.

Degloving injuries are often associated with significant trauma and it is important to remember that the patient may have sustained other life-threatening injuries. Primary survey in trauma patients aims to assess the most essential body systems i.e. respiratory, cardiovascular, urinary and neurological systems as discussed above. During this initial assessment, any wounds should be kept moist and covered with a sterile dressing to prevent further contamination.

Wound assessment is likely to require sedation or general anaesthesia and therefore will need to be delayed until the patient has been adequately stabilised. In the interim it would be covered with a sterile dressing to prevent further contamination. Ensure adequate analgesia is provided.

The wound should be packed with a sterile water soluble lubricant to prevent further wound contamination and a large area of skin around the wound clipped and cleaned with a dilute chlorhexidine solution. The open area of the wound itself should be lavaged with copious volumes of sterile saline (usually litres will be required). Any larger pieces of debris should be removed using tissue forceps. Lavage can be time consuming so consider the body temperature of your patient and take measures to prevent hypothermia (active warming, preventing the surrounding hair coat becoming sodden etc).

Once the wound appears grossly clean, protective clothing and gloves should be changed. Orthogonal radiographic views should be obtained if trauma to the underlying bony structures is suspected. Any non-viable areas of skin (usually black or very dark purple in colour) should be debrided using sterile instruments. Areas of skin of questionable viability can be left in situ to be monitored unless wound closure is planned immediately. Skin edges can be tacked temporarily to the underlying wound bed where appropriate with a monofilament suture material to prevent retraction of skin edges. In wounds with significant contamination; a wet to dry dressing can be used initially as the primary contact layer although this dressing type should be avoided over delicate neurovascular structures. In wounds in which lavage can be used to remove gross contamination, the author prefers a polyurethane dressing (e.g. Allevyn) as it is absorbent whilst promoting a moist wound environment. Tie-over dressings are useful for securing dressings in tricky locations.

Degloving injuries over vital structures e.g. skin overlying the thorax may require immediate closure but generally speaking; more options exist for closure of skin defects in such locations such as axial pattern skin flaps. For the majority of distal limb injuries, time will be available for open wound management prior to wound closure. Options for closure include free skin grafting, second intention healing, use of skin expanders and local transposition flaps in some cases.

Urinary tract rupture:

The bladder is the most common site of urinary tract rupture. The majority of urinary bladder ruptures occur secondary to major external trauma. Male dogs have a higher incidence of urinary bladder rupture, likely due to a long, narrow urethra with a limited ability to dilate rapidly after a sudden increase in intravesicular pressure. It may also be due to a higher incidence of roaming and motor vehicle trauma in male dogs. Rupture of the urinary bladder in male cats is most often the result of forceful manual compression of a distended bladder in an attempt to dislodge a urethral plug or secondary to road traffic trauma. Trauma to the kidneys and ureters requiring surgical intervention is rare due to the protection afforded by their retroperitoneal location but is seen very occasionally. Bladder rupture leads to uroperitoneum. Few clinical signs may be evident initially but there is rapid progression to azotaemia, dehydration, metabolic acidosis, hyperkalemia and ultimately death. Clinical signs associated with urethral rupture include pain, oedema and bruising secondary to subcutaneous urine leakage.

After performing your initial body system assessment and cardiovascular and respiratory stabilisation, urinary tract trauma should be considered in all patients presenting with major trauma, particularly if affecting the pelvis. Fractures of the ribs, pelvis, or pelvic limbs indicate substantial abdominal trauma and should alert the clinician to the possibility of concomitant urinary tract injury.

Baseline blood work should be performed to look for signs of azotemia and/or electrolyte disturbances; particularly evidence of hyperkalemia or metabolic acidosis. If possible, fluid therapy should be initiated in conjunction with establishing urine diversion. A cystostomy tube may need to be considered if the site of urethral trauma prevents urethral catheterisation. Options for cystostomy tube placement include use of a Foley catheter placed via a flank approach (Bray et al 2009) or use of a locking loop nephrostomy catheter. In rare cases, a peritoneal drainage catheter can be placed to drain fluid from the abdomen.

Potassium is normally excreted into the urine by the kidneys. In cases of uroabdomen, equilibration across the peritoneum occurs as urine accumulates in the abdomen and the potassium concentration increases. Hyperkalemia causes an increase in the resting membrane potential of cells in the body, reducing the gradient between the resting membrane and threshold potential, ultimately causing an increase in cell membrane excitability. Increased membrane excitability in cardiac myocytes results in characteristic ECG findings. Early signs include the presence of spiked T waves; eventually leading to atrial standstill. Bear in mind animals with uroabdomen will have multiple other metabolic abnormalities, including metabolic acidosis, hypocalcemia, and hyponatremia and therefore ECGs do not always follow the textbook pictures. If the patient has mild to moderately hyperkalemia with a serum $K^+ > 5.5$ mmol/L but < 7.5 mmol/L, fluid therapy alone may promote potassium excretion by improving glomerular filtration rate. If serum K^+ exceeds7.5 mmol/L, active steps should be taken to reduce it.

- Insulin and 50% Dextrose
  - Give 0.5 units/kg regular insulin IV and, for every unit of insulin administered, give 2 grams (4 mL) of 50% dextrose diluted IV to prevent hypoglycemia
- 10% Calcium Gluconate
  - Give 0.5–1.5 mL/kg IV slowly over 5–10 minutes. An ECG should be monitored during the infusion for evidence of bradycardia or exacerbation of the arrhythmia

The easiest way of diagnosing bladder rupture is to look for free abdominal fluid using abdominal fluid. Urethral rupture can be more challenging to diagnose although signs such as pain, subcutaneous swelling or bruising and repeated stranguria can raise suspicion for urethral trauma. If free fluid is identified, it should be sampled and the creatinine levels compared between the fluid and serum levels. Creatinine is a large molecule and it cannot equilibrate across membranes once excreted in to urine unlike urea which is smaller and therefore can. If the creatinine level in the abdominal fluid is twice that of serum levels or greater, it is highly likely you are dealing with an uroabdomen. In patients which are stable, contrast radiography is the most definitive way of confirming rupture of the urethral tract via a retrograde (vagino) urethrogram.

Bladder rupture should be managed via a ventral midline celiotomy. Small urethral tears can be managed conservatively using an indwelling silicone urethral catheter for 10-14 days. Larger tears or complete urethral rupture should be managed surgically. Options include perineal urethrostomy, transpelvic urethrostomy and prepubic urethrostomy depending on the location of the rupture.

Feeding:

Provision of assisted feeding should be considered in all polytrauma cases. Options for assisted feeding include naso-oesophageal tubes, oesphagostomy tubes, gastrotomy tubes and jejunostomy tubes. The decision should be made based on the underlying pathology, length of expected tube use, the consistency of the food which you wish to use and co-morbidities which may affect suitability for anaesthesia should all be considered. For many trauma patients, an oesophagostomy tube may be the most sensible compromise.