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Thoracic wall anatomy & physiology:

The thoracic wall is formed by the thirteen pairs of ribs, the thoracic vertebrae dorsally and the sternum and costal cartilages ventrally. Ribs 1-9 articulate with the sternum via a costal cartilage, ribs 10-12 form the costal arch. The thirteenth rib is a floating rib. The superficial thoracic wall consists of combined muscles: the latissimus dorsi, the serrates, the scaleneus, and the external abdominal oblique and the overlying subcutaneous tissue and skin. The deep thoracic wall consists of the ribs and the external and internal intercostal muscles. The intercostal muscles receive segmental innervation and blood supply from the spinal cord and aorta respectively. These nerves and vessels run down the caudal aspect of each rib.

The thoracic wall has a combination of active muscular and passive elastic structures. The action of the intercostal muscles is to draw the ribs in a cranial direction, which, because of the “bucket handle” effect results in an increase in thoracic volume.

Thoracic wall trauma:

Pathogenesis and pathophysiology:

Non-penetrating thoracic wall trauma is most commonly the result of a motor vehicular accident, fight injury or malicious treatment. Penetrating trauma is frequently the result of big dog/little dog interactions or the action of ballistic missiles.

The pathophysiology of acute thoracic wall injury per se is often minimal and relates the pain associated with the trauma and the influence of that pain on thoracic wall movement. In addition, if the trauma creates multiple rib fractures resulting in a free floating or “flail” segment, this segment can move paradoxically during breathing, thereby reducing ventilation by virtue of the pendulous movement of air within the airways.

Most importantly, animals that have sustained thoracic wall trauma have a high frequency of pulmonary, bronchial, pleural and myocardial traumatic lesions that have far greater potential to be life threatening than the thoracic wall disease. Pulmonary contusions, pneumothorax, hemothorax, diaphragmatic rupture, post-traumatic myocardial disease are all commonly seen in these patients. The hypoxia seen in thoracic trauma patients is primarily due to pulmonary and pleural disease and the pain associated with ventilation rather than the thoracic wall injury itself.
The clinician must adopt a global approach to the trauma patient. The immediate aim of emergency therapy is to ensure or confirm an adequate airway and effective ventilation. Deficits in circulating blood volume should be replaced and ongoing circulatory support initiated. Analgesia should be provided and the patient should have any external wounds covered with sterile bandages and obviously fractured limbs should be immobilized using support bandages. Thoracic radiographs should be made to further evaluate the intrathoracic pathology and determine the need for pleural drainage. Frequent re-evaluation using objective (arterial blood pressure, arterial blood gas, ECG PCV, TS etc) and subjective (capillary refill time, mucus membrane color, pulse quality, thoracic auscultation etc.) measurements should be done. For bite wound victims and massive trauma patients broad spectrum antibiotic cover should be provided. In general, specific therapy for the thoracic wall is postponed until adequate patient stability has been achieved. Rapid surgical placement of temporary thoracostomy tubes under local anesthesia may be necessary. Rapid surgical thoracic exploration may be indicated for animals with massive, uncontrollable intrathoracic hemorrhage or pneumothorax that exceeds the capacity of thoracostomy tube drainage.

**Non-penetrating thoracic trauma:**

Animals with single or small numbers of rib fractures and associated thoracic wall muscular contusions may be managed conservatively. Animals with superficial bite wounds or skin avulsion wounds should undergo surgical exploration and wound debridement in accordance with established wound management protocols when patient stability permits.

**Penetrating thoracic trauma:**

Animals that have sustained penetrating thoracic trauma should undergo exploratory thoracotomy based around the traumatic thoracic opening. The aim of surgery should be: the removal of injured or devitalized tissue, the provision of pleural drainage and closure of the thoracic wall using either native tissues or, if tissue loss is extensive, synthetic (polypropylene) mesh.

**Multiple rib fractures and flail chest:**

In general, it is unusual to normalize pulmonary function in a post trauma patient by simply stabilizing a deranged thoracic wall. Stabilization of loose ribs and flail segments can, however, relieve pain and, thereby improve ventilation. The overall stability of the patient is paramount. Because of the progressive nature of massive pulmonary contusions, a period of mechanically assisted ventilation (24 – 48 hrs) and medical therapy may be beneficial before attempts at definitive rib repair. Flail segments and unstable ribs may be successfully immobilized by percutaneously placed circumcostal sutures secured to an external splint. Open exploration of unstable ribs following massive bite wounds should be done. Ribs may be stabilized by suturing to adjacent ribs, or may be resected if damage is severe. Closure of the wound with native tissues is ideal but massive trauma may necessitate reconstruction with synthetic implants.

**Thoracic wall reconstruction:**

Careful consideration should be given to the provision of preemptive analgesia and postoperative analgesia for these patients. A thoracostomy tube should be placed prior to closure. Options for thoracic wall reconstruction depend on the anatomical location. For caudal thoracic wall tumors, advancement of the diaphragm can recreate the thoracic cavity. Closure of the remaining abdominal wall defect may be achieved by mobilization of local tissue such as the external abdominal oblique muscle and the latissimus dorsi muscle. Skin coverage can be achieved using local subdermal plexus advancement and
rotational flaps or axial pattern flaps based around the cranial superficial epigastric artery and the dorsal and ventral branches of the deep circumflex iliac artery, for example.

Closure of the thoracic wall, following resection of three or more ribs may be more involved. In the absence of pulmonary parenchymal disease (as seen in accidental thoracic wounds), the need for absolute rigidity of the thoracic wall is unclear. Ideally, the defect should be closed with native tissue such as the latissimus dorsi and external abdominal oblique muscle. If insufficient local muscle remains, polypropylene mesh may be used to complete the closure. Large wounds, especially those containing synthetic materials, will benefit from the additional blood supply and support for the overlying tissues, provided by omentalization. The omentum should be exposed by a separate laparotomy incision (made with clean instruments) lengthened, as needed, and mobilized into the thoracic wound via a subcutaneous tunnel. The omentum should be sutured to the periphery of the wound and the laparotomy incision closed, leaving an exit hole for the omentum large enough so as not to strangulate the omental pedicle. Again, closure of the overlying skin can be achieved using local subdermal plexus advancement and rotational flaps or axial pattern flaps.

**Postoperative acute lung injury:**

This is a rare phenomenon which may be mediated by endotoxemia, systemic inflammation and rapid reinflation of collapsed lung. It is characterised by acute pulmonary edema causing respiratory failure and frequently death of the patient. The surgeon and anesthesiologist have control over the rate of pulmonary re-expansion and should take measures to ensure this does not happen too rapidly.

**Further reading:**


