Penetrating Thoracic Wounds in Small Animals

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Introduction

Penetrating thoracic wounds are uncommon but life-threatening injuries and often require quick and decisive action to treat. A penetrating thoracic wound is defined as wound that extends from outside thoracic cavity to the inside.[2,3] In dogs and cats, they are most commonly the result of bite wounds. [1] Other reported causes include, but are not limited to, gunshot and other missile injures, impalement, vehicular injuries, and stabbing injuries. Regardless of the cause, they should always be considered a serious presenting complaint. [2]

Bite wounds most commonly occur in small dogs and account for approximately 30% of all chest injuries in small animals.[1] Thoracic involvement in bite wounds can significantly increase the mortality rate of dogs.[4] Gunshot wounds are the most common projectile injury in veterinary medicine. In a retrospective study of one hospital, animals with gunshot wounds represented 0.8% of patients examined on a yearly basis over 5 years.[2] They tend to have a greater amount of internal trauma compared to bite wounds.

Among penetrating thoracic wounds, arrow and crossbow bolt wounds are rare or underreported. There were not many studies available in animals that reported on arrow and crossbow bolt wounds in dogs or cats. This report discusses the pathophysiology, diagnosis, and treatment of penetrating thoracic wounds. It also goes into the case of Skeeter Mills, a cat that presented on emergency with a crossbow bolt that penetrated through his thoracic cavity.

History and Presentation

On October 17, 2017, around 9 pm, Skeeter Mills, an 8-year-old male neutered domestic longhair cat was found by his owners in their driveway with an Gold Tip Ballistic Crossbow Bolt penetrating through his chest. The tip of the bolt was protruding through his left shoulder, close to his thoracic inlet, and the other end protruded through his right lateral thorax. According to the

owners, he was behaving normally and did not appear in distress. He was presented to a local emergency clinic, where he was put on oxygen and thoracic radiographs were taken. He was given robenacoxib and butorphenol and referred to MSU-CVM Emergency Service.

On presentation to the MSU-CVM Emergency Service, Skeeter was bright, alert and responsive and was stable. His vital parameters were within normal limits. He had light pink mucous membranes with a CRT<2s. His temperature was 99.5 °F and pulse was 190 beats per minute. His respiratory rate was slightly elevated at 50 breaths per minute.

Pathophysiology

The pathophysiology of penetrating thoracic trauma is complex and largely dependent on the extent of organs involved. They can result in pneumothorax, pulmonary and myocardial contusions, hemothorax, and other serious conditions.[1] Trauma from the penetrating object to the chest wall alone can damage parietal pleura, ribs, and intercostal nerves. The severe pain from this trauma can result in hypoventilation, tachypnea, and shallow breathing. This, coupled with pulmonary contusions or pneumothorax, can lead to respiratory compromise.[5]

Pulmonary contusions result from the mechanical forces (i.e. the blow of a bullet, car, or missile) to the thorax caused tearing and hemorrhage of the lung parenchyma. Also, lung injured from the penetrating object can bleed into healthy lung further impairing ventilation.[6]

Tension pneumothorax is a common occurrence in gunshot wounds to the thorax. In a retrospective study, 27% of dogs that survived thoracic gunshot wounds had a tension pneumothorax.[11] Tension pneumothorax occurs when a one-way valve forms from injured pulmonary parenchyma or chest wall, allowing air to enter the thorax but preventing it from escaping. Pressure builds in the thorax causing atelectasis and vena cava collapse. This decreases blood return to the heart and leads to cardiovascular collapse and death, left untreated.[12]

Hemothorax is defined as pleural fluid with 10-50% the hematocrit of whole blood.[14] Hemothorax can occur from blunt trauma from an impact like a vehicle or the pressure wave of a bullet or from an object penetrating the lungs, heart or major vessels. Often, it can also lead to other serious conditions like respiratory failure, retained clots, and fibrothorax. Also, blood is an excellent medium for bacterial growth. With introduction of bacteria to the thorax through a penetrating object, the bacteria can flourish and a pyothorax can develop.

The pathophysiology of projectile wounds, such as gun and arrow injuries, varies based on the type of weapon and ammunition used and type of tissue hit. Bone and liver can absorb more kinetic energy and thus, are more likely to fracture and splinter. Bone fragments can become secondary projectiles hitting surrounding tissue and causing more soft-tissue damage. Lung and skin have better elastic properties and can spread out the force more; overall, sustaining less tissue damage.[7] Arrows and crossbow bolt have more penetrating power in soft-tissue and flat bones, like sternebrae and ribs. They have the capacity to enter the thoracic cavity and damage lungs, heart, and major vessels.[8]

Diagnostic Approach/Considerations

The main diagnostic challenge with penetrating thoracic wounds is determining the organs and tissues affected by the injury. Blood work is essential to monitor organ function and assess the animal's ability to undergo anesthesia. In cases of pneumothorax and hemothorax, a thoracocentesis is warranted for therapeutic purposes. An electrocardiogram should be performed to evaluate for traumatic myocarditis. Patients with hemothorax will often develop hyptotension secondary to hypovolemia so, taking blood pressures can help assess the patient's perfusion status.[1]

Ultrasonography is another useful tool in evaluating patients with penetrating thoracic trauma. The thoracic focused assessment with sonography for trauma (TFAST) technique assesses the heart and the lungs from the standard views.[1] One study found that through use of the TFAST, pneumothorax, pleural effusion, and pericardial effusion can be diagnosed in minutes. The median time for TFAST in the study was 3 minutes.[10]

If the patient is stable, a complete set of thoracic radiographs is always warranted. Additional radiographs can be added to assess damage cranial and caudal to entry and exit wounds. Abdominal radiographs can be added if there is concern that the abdomen is involved.[7] Radiographs can help determine if thoracic wounds communicate with the thoracic cavity. They can identify subcutaneous emphysema, rib fractures, pleural effusion, pneumothorax, and hemothorax.[1,2]

However, studies have noted that there are cases of thoracic wounds that entered the thoracic cavity that showed no visible signs of pneumothorax or pleural effusion on radiographs.[9] Also, the degree of external skin damage often does not correlate the to the amount of underlying tissue damage and it is not always obvious that the injury has opened the thoracic cavity.[1,2] In cases of continued hemorrhage, air leaks, and injury to vital structures, surgical exploration via thoracotomy should be considered to determine the extent of the internal damage.[4]

On presentation, Skeeter's blood pressure was within normal limits with 3 successive blood pressure readings as follows: 181/102 (128), 150/98 (115), and 143/84 (104). A chemistry and complete blood count were run and revealed a severely elevated CK. He was mildly anemic with a PCV of 27%. A coagulation profile revealed a slightly elevated PT at 12.3 seconds. His lactate was normal at 1.4. Looking at the thoracic radiographs provided by the referring emergency clinic, the bolt entered his thorax from the right dorsocaudolateral thorax, fractured

the third and fourth sternebrae, and exited from the left ventrocraniolateral thorax. It was unclear what vessels or lung segments the bolt had punctured as it traveled through his chest so, he was taken to surgery.

Treatment and Management

The first step of treatment should be initial stabilization. Stabilization will be dependent on the extent of the injury and status of the patient. This can include oxygenation, hemorrhage control, intravenous fluids, and monitoring.[4] Intravenous isotonic fluids are essential in improving perfusion and treating hemorrhagic shock. Blood products also need to be considered as the first fluid of choice if significant blood loss is evident.[1] A thoracentesis or thoracostomy tube may be needed to remove air or blood buildup in the thorax.[7] One study found that in human medicine, 80% of chest wounds are treated by chest tube alone because it can evacuate their chest and allow their lungs to expand. Re-inflation of the lungs can control bleeding in the pulmonary vessels.[16] External wounds should be clipped, cleaned, and covered with sterile bandaging to keep them clean until they can be surgically repaired. Projectiles that penetrate a body cavity should not be removed prior to surgery. They should be secured in place (with a bandage, cup, etc.) to prevent migration until the patient is in surgery. Penetrating thoracic wounds can be sealed with a sterile water-soluble gel before bandaging to prevent further air from being trapped in the thorax.[1] Broad spectrum antimicrobials should also be administered pending a culture and sensitivity for any wound that penetrates the thoracic cavity.[17]

As mentioned earlier, in cases of continued hemorrhage, air leaks, and injury to vital structures, surgical exploration via thoracotomy should be considered to determine the extent of the internal damage and repair any structures that were affected.[4] A median sternotomy is the

preferred choice for bilateral exploration of the thorax. It also is the best approach if the cranial abdomen needs to be explored as well.[13]

In Skeeters case, on the night of initial presentation, he was started on Plasmalyte (20 ml/hr), a dexmedetomidine CRI (0.04 ml/hr), and a fentanyl CRI (4 mcg/kg/hr IV) for sedation and pain control. He was given clindamycin (15 mg/kg IV q12h) and ceftazidime (30 mg/kg IV q8h) for full spectrum antibiotic coverage. The end of the bolt that was protruding out of his caudal right flank was cut and covered. Since he was stable, surgery was delayed until the next morning.

At 8:00 am on 10/19/17, under general anesthesia, Skeeter underwent a median sternotomy. Upon opening the thoracic cavity, it was discovered that the bolt had fractured ribs on both sides of his chest, punctured a small section of lung in the right cranial lung lobe, and fractured the forth sternebrae. The heart and major vessels had not been damaged. After determining the extent of the damage the bolt had caused, the bolt was slowly pulled from the tip cranially, out of the thorax and a partial lung lobectomy of the right cranial lung lobe was performed. His entry and exit wounds were thoroughly explored and closed and chest-tube was placed. A soaker catheter was placed in his subcutaneous tissues just ventral to his sternum. After surgery, more thoracic radiographs were taken to confirm the correct placement of the chest tube and Skeeter was returned to ICU.

Over the next few days, Skeeter was quiet but alert and responsive but continued to improve a little every day. He was continued on Plasmalyte (60 ml/kg/day), clindamycin (15 mg/kg IV q12h) and ceftazidime (30 mg/kg IV q8h). For systemic pain control, he was given buprenorphine (0.02 mg/kg IV q8h) and, for local pain control, bupivacaine (1 mg/kg q6h) through his soaker catheter. He was continued on and his chest tube was aspirated every 6 hours.

robenacoxib (0.78 mg SQ q24h) was added as an anti-inflammatory and more pain control. Two days post-surgery, he began hypersalivating and refused all food. He was given maropitant citrate (1 mg/kg IV q24h) as an antiemetic and mirtazapine (0.5 mg/kg PO q72h) as an appetite stimulant.

Although he was not eating Skeeter continued to improve and became more bright and active. His chest tube and bandages were removed and his wound were healing well. CBC and chemistry revealed an elevated total bilirubin, indicating a potential for hepatic lipidosis due to his inappetence. On 10/23/17, esophagostomy tube was placed. On 10/24/17, Skeeter was well enough to be discharged. He was sent home with instructions on how to feed him through the feeding tube.

Case Outcome

Skeeter returned on 10/30/17 for a recheck of his wounds and incision site. He was doing well at home and had started eating without the assistance of his feeding tube. That day his esophagostomy tube was removed and he was sent home again. He returned for his 8-week recheck on 12/5/17. He had continued to do well and his wounds were healed. On 4/30/18, Skeeters owners report that he is doing great and his hair is all grown back. He is back to being a normal outdoor cat.

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