Scientific Works. Series C. Veterinary Medicine. Vol. LXIX (1), 2023
ISSN 2065-1295; ISSN 2343-9394 (CD-ROM); ISSN 2067-3663 (Online); ISSN-L 2065-1295

THORACIC WALL RECONSTRUCTION WITH POLYPROLENE MESH IN A DOG WITH SEVERE FLAIL CHEST

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Abstract

Blunt force traumas that are caused by hit-by cars, animal abuse and bite wounds on the thoracic region can end up with flail chest in dogs. Flail chest, is one of the serious injuries with presence of two or more continuous ribs fractured. As a result, a portion of the thoracic wall with fractured ribs moves paradoxically in inspiration and expiration. According to many previous case reports, mortality rate is high in this life-threatening situation. Patients present in emergency with thoracic pain and shortness of breath (SOB).
9 years old, female Shih-Tzu breed dog clinically presented with severe dyspnea, pain and paradoxical movement of the chest on the left side of the thorax. 24 hours after the patient's stabilization, CT scans revealed loss of the intercostal muscle integrity and 5 ribs fractures on the left thoracic region. After the imagistic certain diagnosis, the dog was taken to reconstructive thoracic surgery.

Key words*: blunt force trauma, flail chest, mesh, reconstructive surgery.*

INTRODUCTION

Bite wounds commonly seen in small dogs and are mostly crushing the tissues. Even some bite wounds cause small dehiscence or lacerations, those bites can end up with severe crushing, avulsion and devitalization of the tissues underneath the skin. The severity of the situation may vary depending on the bitten area. This blunt force trauma can be life-threatening when the bites crush the airways or thoracic region (Sharar et al., 1997; Holt and Thawley, 2015).
Flail chest manifests paradoxical movement during respiration with fractured two or more ribs (Olsen et al., 2002; Orton, 2003). However, the severity of the flail chest also depends on the tearing of the intercostal tissues and the deterioration of their integrity.
Besides the degree of the thoracic damage can easily misdiagnosed while physical examination. Therefore, it is mandatory to provide thoracic radiographs and/or computed tomography to evaluate the severity once the patient stabilized. Various emergency procedures and methods can be used in a combination of supplemental oxygen, thoracentesis, mechanical ventilation, pain management, antibiotic therapy and cage rest. Surgical management of flail chest requires external splint or internal fixation with the combination of latissimus dorsi muscle flap.
In human medicine many surgical techniques has introduced in past years including intramedullary fixation (Moore, 1975), Judet strut (Judet, 1973), using plates with combination of cerclage wires (Moore, 1975).
Even more recent reports the use of absorbable plates (Mayberry et al., 2003).
Yet in veterinary medicine the reports are less than human medicine due to the breed size limitation (Anh et al., 2016).
This case report describes the clinical presentation and successful surgical stabilization of flail chest with cerclage wire and polypropylene mesh, Lene - Vetsuture (Noévia SAS, France).

CASE PRESENTATION

A 9 years old, 5 kg neutered female Shih-Tzu breed dog was brought to the University Veterinary Emergency Hospital of USAMV Bucharest, ≈30 minutes after bitten by a crossbreed large dog. On the physical examination no puncture wounds were observed. Paradoxical respiratory movement on the left thoracic wall diagnosed clinically with severe respiratory destress.

Moderate subcutaneous emphysema also clinically diagnosed. Peripheral oxygen saturation (SpO2) levels measured between 89 and 90%. Mucus membranes (MM) were pale and capillary refill time (CRT) was ≥ 2 sec. For stabilization dog directly placed on sternal position and supplemental oxygen was provided via mask. For local pain management, intercostal nerve block provided on the level of 4^{th}, 7^{th}, 9^{th} and 11^{th} ribs with Lidocaine, (Zentiva S.A. Bucharest/Romania) injection and 0.33 ml IV Buprenorphine (Richter Pharma AG Austria) was administered.

Fast abdominal (A-FAST) and fast thoracic (T-FAST) ultrasounds were performed and no free liquid diagnosed in both thoracic and abdominal cavities but pneumothorax was diagnosed and thoracentesis procedure was performed. Via thoracentesis 150 ml of free air retrieved. Simple Ringer solution (Fresenius Kabi Germany) with the dose of 15 ml/h was given, and antibiotic therapy also provided. The dog kept in oxygen cabin for 24 h with monitoring the vitals.

COMPUTERIZED TOMOGRAPHY (CT) SCAN

After stabilization CT scans were provided. On the left thoracic region 5^{th}, 6^{th}, 7^{th}, 8^{th} and 9^{th} broken ribs were confirmed with mild pneumothorax and pulmonary contusions as well as subcutaneous emphysema. (Figures 1a, 1b; Figures 2a, 2b; Figures 3a, 3b). After CT scans 3D construction of the thoracic cage also provided (Figure 4).

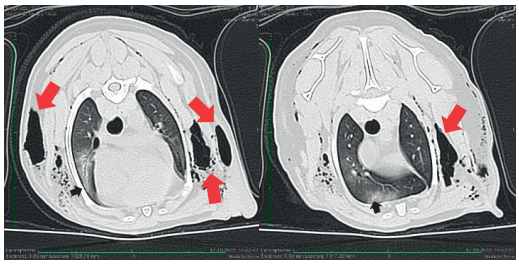

Figure 1a. Red arrows are showing subcutaneous emphysema bilaterally. Black arrow is showing atelectasis on the ventral part of the cranial right lobe

Figure 1b. Red arrow is showing subcutaneous emphysema and black arrow is showing pulmonary contusion on the cranial right lobe.

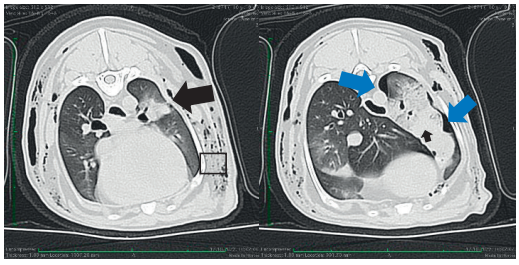

Figure 2a. Black arrow is showing pulmonary contusion and the square is howing the rib fracture

Figure 2b. Black arrow is showing pulmonary contusion on the left cranial caudal lobe and blue arrows are showing the pneumothorax

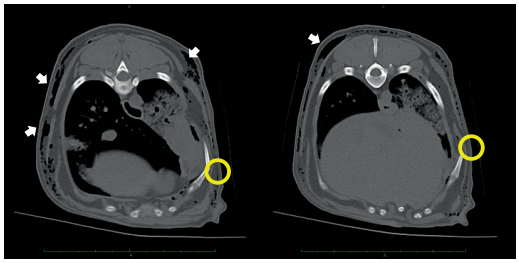

Figure 3a. White arrows are showing the subcutaneous emphysema and yellow circle is showing the fracture on the 6^{th} rib.

Figure 3b. White arrow is showing the subcutaneous emphysema and yellow circle is showing the fracture on the 7^{th} rib.

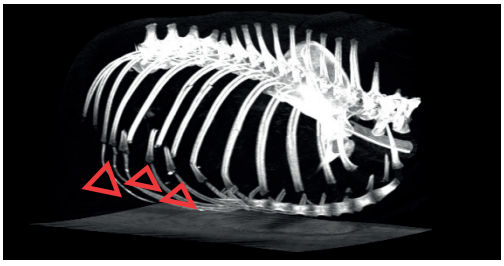

Figure 4. Red arrows are showing the fractures on the 5^{th}, 6^{th}, 7^{th}, 8^{th} and 9^{th} ribs

SURGERY

After the CT scans, the patient prepared for left thoracotomy. Patient was premedicated with butorphanol (Butomidor 10 mg/ml, Richter Pharma, Austria) 0.3 mg/kg and Diazepam (Terapia S.A. Cluj-Napoca/Romania) 0.2 mg/kg. For induction Propofol (Propofol Lipuro 10 mg/ml, Braun Germany) 2 mg/kg was given IV and after intubation with 5 mm et tube, for the maintenance isoflurane 1.5-2% (Anesteran, Rompharm S.A., Romania), O_2 and lidocaine (Zentiva S.A. Bucharest/Romania) Continuous rate infusions (CRI) are used. After second skin preparation with aseptic technique, skin marked on the level of 7^{th}, 8^{th} and 9^{th} ribs with sterile surgical marker (Figure 5). On the level of hearth, last rib and abdominal region several skin contusions were observed in detail which reflects the severity of the trauma.

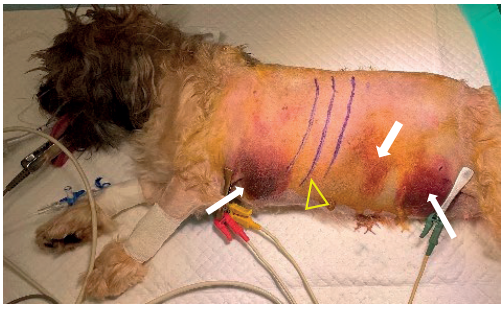

Figure 5. White arrows show the contusions and yellow triangle shows the marking which was drawn via sterile surgical marker

The skin incision was made on the level of 8^{th} rib with n:10 scalpel blade.

After the skin incision subdermal multiple traumas revealed, including *Latissimus dorsi* muscle tears, disruption of integrity of intercostal muscles as well as devitalized muscle parts created by the crushing bites (Figures 6 and 7).

Pulmonary contusion and adherent parts of caudal left lobe were observed during the surgery. However, lung lobectomy was not performed due to lobe regained normal color and expansion during the mechanical ventilation.

After debridement of the soft tissues, subcutaneous tissues, parts of *Latissimus dorsi*, intercostal muscle the fracture line on the 8^{th} rib revealed. Normally the fractures of the ribs can be fixed with small titanium plates like in the humans, or with cerclage wire by performing "X" shape (Orton and Monet, 2018) to have better fixation. Unfortunately, this was not feasible due to patients rib width.

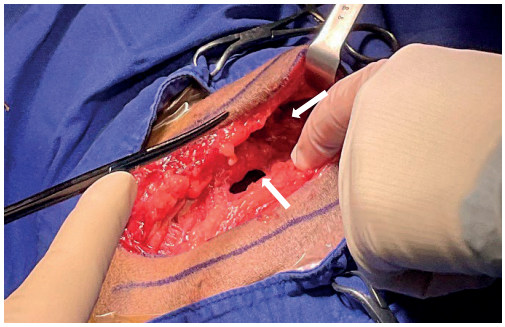

Figure 6. Intraoperative appearance. White arrows are showing the ruptures of the intercostal muscles

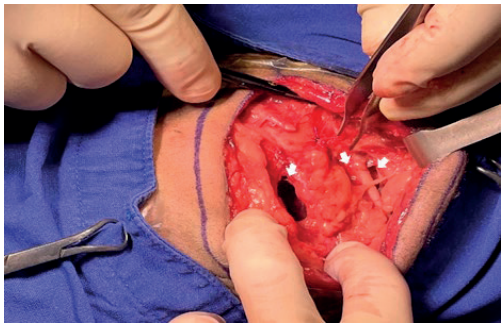

Figure 7. Intraoperative appearance. White arrows are showing the ruptures and disruption of integrity of intercostal muscles between 7^{th} - 6^{th} - 5^{th} ribs and also between 9^{th} and 8^{th} ribs

The dog's rib width was 0.5 cm. For this reason, only two holes drilled approximately 3-4 mm away from the fracture line and 0.4 mm diameter cerclage wire was introduced through the holes and secured with twist knot. After repairing the 8^{th} rib, 7^{th} and 9^{th} rib fractures aligned in their natural position. For this reason, the same technique was not required for fixation. Those rib fractures' alignment were stabilized with the help of sutures.

After orthopedic fixation of the rib, the surgery continued with 12 gauge x 30 cm (12 inch) Mila Catheter (MILA International Inc., USA) chest tube placement. The catheter was introduced to thoracic cavity between 9^{th} and 10^{th} intercostal space. This type of chest tube

has a guiding wire. After introducing the catheter guide wire was inserted and through the guide wire, the chest tube was introduced into the thoracic cavity and secured (Figure 8).
The polypropylene mesh placed in place of the intercostal tissues which integrity was impaired. As polypropylene mesh 7.6 cm x 15 cm (3" x 6") Lene Vetsuture® was used. The mesh was measured in the surgery on the thoracic wall and shaped with Metzenbaum scissors to ensure proper closure. The mesh was secured with 4/0 monofilament Nylon suture, Vetsuture® from four corners first, to maintain the tension.

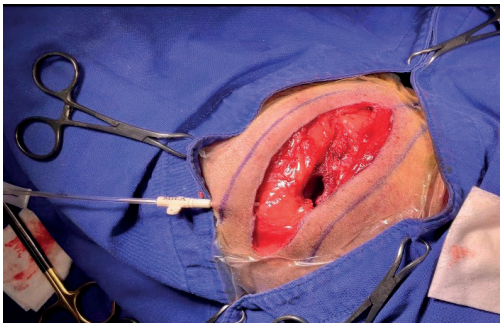

Figure 8. Placing the chest tube

After securing the mesh from the corners, another eight sutures were placed on the several points of the mesh (Figure 9).
With the mesh all the gaps between the intercostal spaces from 6^{th} to 10^{th} ribs were successfully closed.

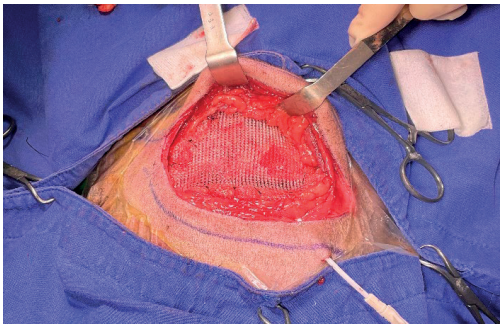

Figure 9. Intraoperative appearance after the suture of the mesh

The polypropylene mesh was covered with latissimus dorsi muscle flap (Figure 10) and before the closure of the skin, free air in the thoracic cavity was evacuated via chest tube until $ETCO_2$ 42% was provided. Afterwards, Heimlich valve attached to the tube.

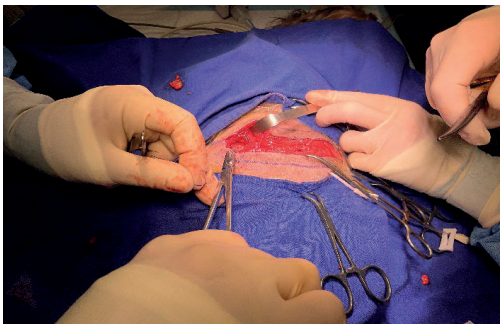

Figure 10. Intraoperative appearance before closing the skin

Skin closure was made with 3/0 monofilament PDX suture material, Vetsuture® with routine fashion technique. After the surgery, Thoracic bandage was performed and the patient placed in the Intensive Care Unit (ICU) unit with supplemental oxygen and monitor.

POST-OP. MANAGEMENT

In the first 24h, each 8 hours the chest tube was controlled and care provided. For the first 72 hours Methadone (Richter Pharma AG, Austria) 0.3 mg/kg in each 8 hours and for five days Meloxicam (Dopharma Resaerch B.V. Raamsdonksveer/NL) 0.2 mg/kg was given to the patient.
The dog was kept in oxygen cabin for the first 24 h and monitored for possible arrhythmias. Vitals checked in every 8 hours no remarkable changes were observed.
24 hours after the surgery control radiographies were provided (Figure 11). In the control radiographies pneumothorax not observed and the rib fractures were aligned. 72 hours after the surgery chest tube was removed without any local or general anesthesia needed. Thoracic bandages were changed each 48 hours and the patient discharged home after 6 days with the recommendation of antibiotics and anti-inflammatories.
The sutures were removed 14 days after the surgery. No respiratory distress was observed during the consultation and removal of the sutures. 60 days after the surgery the patient called back for control radiographies (Figure

12). After the control radiographies, the patient was fully discharged.

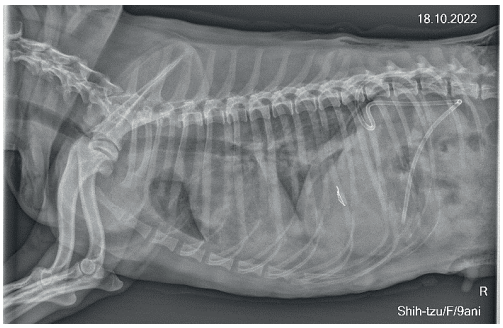

Figure 11. Radiographic image 24 hours after the surgery

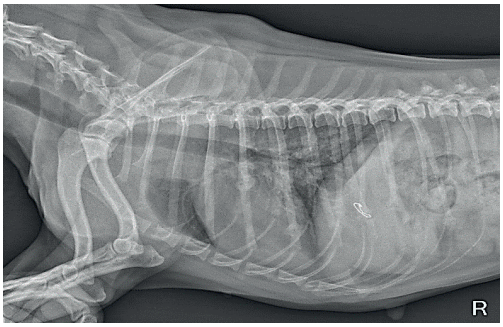

Figure 12. Radiographic image 24 hours after the surgery

DISCUSSIONS

Thoracic bite wounds can result with severe crushing and penetrating injury, both of which can tear subdermal tissues, muscles and internal organs. Those bite wounds even can result with life threatening injuries, yet remarkable skin defects may not be observed in many of them (Davidson, 1998; Shamir et al., 2002). Flail chest in dogs, mostly caused by bite wounds (Olsen *et al*., 2002). With the existence of internal organ damage, patients can have severe respiratory distress (McKierman et al., 1984). In this case report, the dog showed severe respiratory distress with peripheral oxygen saturation (SpO_2) levels were measured between 89 and 90% after being bitten by another dog. It is well known that paradoxical respiratory movement of thorax is also seen in pseudo-flail chest. Pseudo-flail chest manifests paradoxical respiratory movement due to complete tear of the intercostal muscles with only one or without any rib fracture (Scheepens et al., 2006). It is crucial to determine if the patients' present paradoxical respiratory movement due to flail chest or pseudo-flail chest. Because the conservative and surgical treatments can show difference. In this case, the dog had flail chest with five rib fractures (5^{th}, 6^{th}, 7^{th}, 8^{th} and 9^{th} left ribs).

As an addition, diagnostic techniques are also important to define all the traumatic injuries of the tissues and organs.

CT scans are more sensible and effective. It's detailed impact on radiographic diagnosis cannot be indisputable. In this case, once the patient was stabilized, CT scans preferred to have fast surgical planning as well as to determine all the traumatic injuries that the dog knowledged.

Flail chest is considered life threatening emergency situation in human medicine and regarded as a marker of significant injuries (Ciraulo et al., 1994). Most of the therapies for flail chest in veterinary medicine are based on the methods developed in years in human medicine.

The treatment for flail chest can be conservative or surgical. Yet the studies in veterinary medicine associated with flail chest are rare.

Methods of thoracic reconstruction can be classified as: internal fixation, external fixation, or *Latissimus dorsi* muscle flaps. Internal fixations involves intramedullary pins, cerclage wires or plates.

In this case intramedullary pinning or using plates was not possible due to the size of the dog and the diameter of the ribs. Choosing internal fixation via wiring has been used as a surgical method for the rib fractures in dogs of many sizes (Shahar et al., 1997; Olsen et al., 2002).

Thoracic wall reconstruction techniques mostly involves with *Latissimus dorsi* flaps (Byong-Su Min et al., 2016). However, some other authors also reported surgical mesh usage in their cases. Xiong Qin used degradable polymer, collagen coated polydioxanone (CCP) mesh and chitin fiber reinforced polycaprolactone (CFRP) strut. (Xiong et al., 2008) and pointed that the CFRP material kept its tensile strength for a long time after surgery and had an advantage of lower reactivity than other short-term re-absorbable copolymer such as poly-L-

lactide (PLA). Some other authors focused on usage of polypropylene mesh usage after oncologic surgeries especially involving thoracic wall and pointed the use of flexible synthetic polypropylene mesh especially in cases where there is excision of several ribs (Castro et al., 2015.

In this case for the reconstruction, polypropylene mesh was chosen due to huge defects were observed in intercostal muscles. The polypropylene mesh was covered with *Latissimus dorsi* muscle flap. The second reason of choosing polypropylene mesh was also related to reduce the tension on the thoracic wall after the surgery.

Although there are some advantages and disadvantages of polypropylene mesh usage. The most advantages reported in human medicine as: durability, low infection risk and being comfortable for the patient while disadvantages reported as; lack of flexibility, high adhesion risk and shrinking. The other consideration of the polypropylene mesh usage is the result in rejection as a foreign body after implantation (Anderson, 2001). Yet those studies are regarding polypropylene mesh implantation in hernia surgeries in human medicine. In our case, not any side-effects or rejection was observed in hospitalization period after the surgery as well as in re-controls after 30, 60 and 90 days.

However, we need more studies in veterinary medicine so that we can have more information about the short and long-term effects of the polypropylene meshes.

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