

Repair of flail chest using interfragmentary wiring and stability augmentation with basket-weave fashion sutures in a toy breed dog: a case report

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ABSTRACT: We report here the clinical presentation and successful surgical management of flail chest caused by bite wounds in a toy breed dog. Surgery was decided on, based on physical, radiographic and computed tomography (CT) examination findings which included thorax deformity, inward displacement of the end of a fractured rib and suspected lung injuries. Interfragmentary wiring, basket-weave fashion sutures and latissimus dorsi flap for thoracic wall reconstruction were performed to correct the flail chest and augment the thoracic wall stability. There was no evidence of respiratory distress 16 months post-operatively. This is the first case report describing detailed clinical information together with computed tomography evaluation and a successful surgical procedure to correct flail chest in a toy breed dog using interfragmentary wiring and basket-weave fashion sutures.

Keywords: rib fracture; chest wall; scaffolding; bite wound

Flail chest occurs when two or more adjacent ribs suffer segmental fractures and show paradoxical movement during respiration (Olsen et al. 2002; Orton 2003). This condition is not commonly observed in dogs and cats because of the compliance and anatomical shape of the thoracic cage, but the paradoxical movement accompanying pulmonary contusions may be life-threatening (Craven et al. 1979; Orton 2003). Human medicine has introduced several methods including plates with wire cerclage (Moore 1975), intramedullary fixation (Moore 1975), Judet strut (Judet 1973), U-plate (Sales et al. 2008) and absorbable plates (Mayberry et al. 2003), as surgical techniques for rib fractures and the goal of ongoing research is to develop a minimally invasive form of therapy (Nirula et al. 2009). However, in veterinary medicine, especially toy breeds, only a small number of reports are available dealing with the surgical treatment of rib fractures and available surgical techniques are limited because of small rib size (Knecht 1973; Shahar et al. 1997; Olsen et al. 2002). This case report describes the clinical presentation and successful surgical stabilisation of flail chest

using interfragmentary wiring and basket-weave fashion sutures in a toy breed dog.

Case description

A 3.25 kg, 10-year-old, castrated male Maltese dog was presented at the Veterinary Medical Teaching Hospital of Konkuk University after the dog sustained bite wounds from a Jindo dog an hour previously. On physical examination, four puncture wounds accompanying haemorrhage were discovered on the right side of the thoracic and abdominal walls. Paradoxical respiratory movement of the right thoracic wall and severe respiratory distress were obvious during breathing. Multiple fractures of the right ribs between the 6th rib and 11th rib and increased opacity of the right middle and caudal lung lobes were revealed on thoracic radiographs (Figure 1). Stabilisation of the dog was accomplished by oxygen support, bandage, antibiotics, analgesics and fluid therapy for six days. After stabilisation, computed tomography (CT) images, obtained with a four-row multidetector helical

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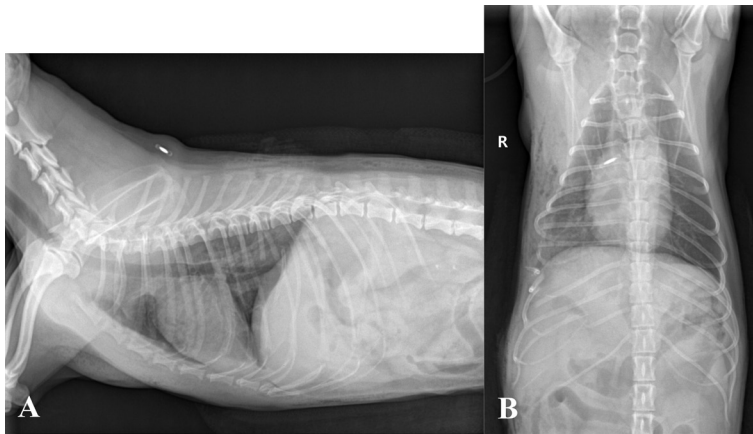


Figure 1. Thoracic radiographs at the time of admission. Unclear multiple fractures of the right ribs between the 6th rib and 11th rib are detected in both lateral (A) and ventrodorsal (B) radiographic views. Note the increased opacity of the right middle and caudal lung lobes and the obvious emphysema on the right subcutaneous tissue (B)

CT unit (GE Lightspeed 4 scanner, GE healthcare, Milwaukee, USA), showed segmental fractures of the right 7th and 8th ribs, single fractures of the right 6th, 9th, 10th and 11th ribs, inward displacement of the right 11th rib and suspected contusion of the

right middle and caudal lung lobes together with adjacent thoracic wall injuries (Figure 2).

Exploratory thoracotomy was performed on the right 6th intercostal space. After skin incision, subdermal traumas were revealed, including latissimus dorsi muscle tearing, intercostal muscle defects, devitalised muscles and fibrosis of adjacent tissues. Some parts of the right middle and caudal lung lobes were adhered not only to each other but also to adjacent thoracic wall, thus interfering with the full expansion of the lungs during inspiration. The attached parts of the right middle and caudal lung lobes looked more reddish than normal (Figure 3). However, lung lobectomy was not performed because the lung lobes regained normal colour during mechanical ventilation after smooth detachment by cotton swab. After debridement of the devitalised soft tissues including some parts of latissimus dorsi muscle, intercostal muscle and subcutaneous tissues, fixations of the 6th, 9th and 11th rib fractures and 8th proximal rib fracture were performed (Figure 4). Each fixation technique was determined by fracture type. Interfragmentary wiring was applied to the 6th rib fracture and 8th proximal rib fracture (transverse fracture) and two full-cerclage wires were placed on the 11th rib fracture (long oblique fracture). Interfragmentary wiring combined with full-cerclage wiring was applied to the 9th rib fracture (short oblique fracture). To place interfragmentary wires, holes were drilled approximately 3 mm away from the fracture lines using 0.8-mm-diameter Kirschner wire. Orthopaedic wire (0.4-mm-diameter) was then driven through the holes and secured by twist knot. Orthopaedic wire (0.4-mm-diameter) was also used for full-cerclage wiring and secured by twist knot. The 7th rib segmental fracture fragment was removed and repair of the 8th distal rib fracture and 10th rib frac-

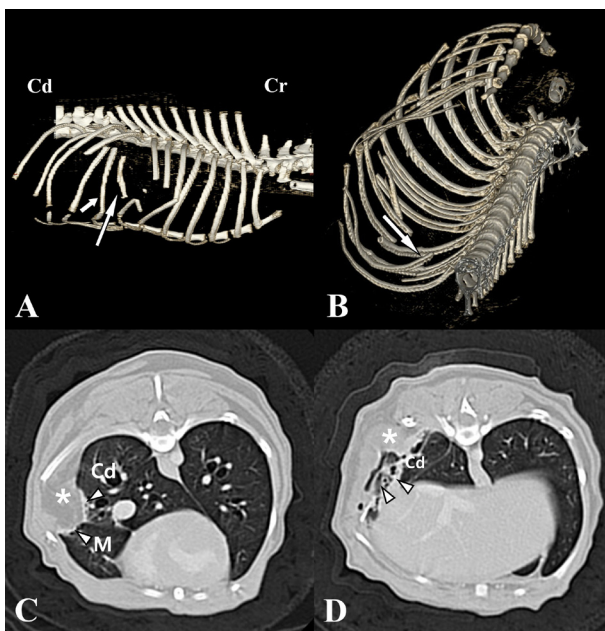


Figure 2. Preoperative computed tomographic images of the right side of the rib cage which is three-dimensionally reconstructed (A and B) and the transverse section at the level of the 8th rib (C) and 10th rib (D). A: Note that the 7th rib fracture segment (long arrow) is dislocated caudally and the 8th rib fracture segment (short arrow) is separate from the proximal rib fragment and close to the distal rib fragment. Single fractures are identified on the 6th, 9th, 10th and 11th ribs. B: The distal fragment of the 11th rib shows inward displacement (arrow). C and D: The thoracic wall injuries (asterisks) with suspected contusion of middle (M) and caudal (Cd) lung lobes (arrow heads) are identified

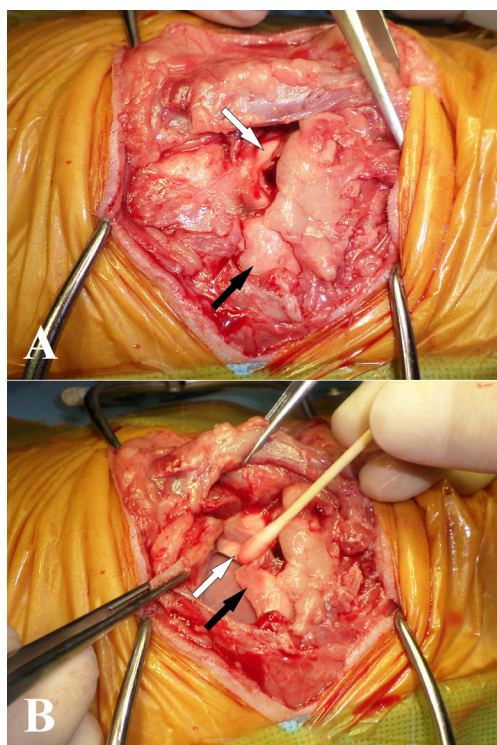


Figure 3. Intraoperative views of the exploratory thoracotomy. **A:** The right middle lung lobe (black arrow) and caudal lung lobe (white arrow) are adhered to each other and to the adjacent thoracic wall. **B:** The adhered lungs are smoothly detached by cotton swab (white arrow). After detachment, a slightly reddish portion of the middle lung lobe is identified (black arrow). This portion of the lung would regain normal colour in a few minutes after mechanical ventilation

ture was not performed since there was evidence that fracture union had begun. To augment the stability of the thoracic wall, basket-weave

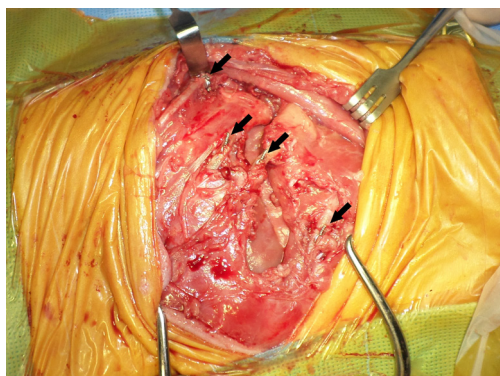


Figure 4. Intraoperative view of the ribs reduced by wiring. From right to left, the 6th, 8th, 9th, and 11th ribs are shown in order (black arrows). Orthopaedic wire (0.4-mm-diameter) is used and secured by twist knot

sutures using 0 polyglyconate (Maxon, Covidien, Mansfield, MA, USA) were placed on the ribs from the 5th to the 12th ribs so as to encircle each rib (Figure 5). Thoracic wall was reconstructed using latissimus dorsi muscle flap above the basket-weave fashion sutures. The evacuation of postoperative pneumothorax induced by thoracotomy was performed routinely by thoracostomy tube placement. Skin was closed by skin staplers.

The paradoxical respiratory movement disappeared postoperatively and the trunk of the dog was supported in external coaptation using cotton roll and self-adherent wrap for eight weeks. Radiography revealed mild displacement of fractured lines of the right 8th and 11th ribs two weeks postoperatively (Figure 6). However, there was no evidence of respiratory distress sixteen months postoperatively.

DISCUSSION AND CONCLUSIONS

Flail chest in dogs is described to be mostly caused by dog bite wounds (Olsen et al. 2002). Damaged thoracic wall shows large areas of devitalised muscle tissue, fractured ribs, pneumothorax and internal organ damage, and the victim may exhibit severe respiratory distress (McKiernan et al. 1984). In this case report, the dog also showed severe respiratory distress with paradoxical respiratory movement at the time of admission after being bitten by a dog. It is known that paradoxical respiratory movement is also observed in pseudo-flail chest, which is defined as paradoxical movement of a chest wall segment during respiration caused by a complete tear of the intercostal musculature

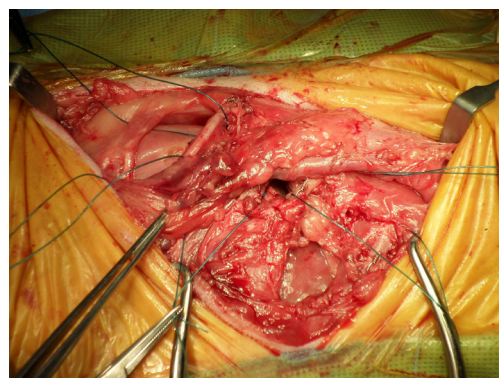


Figure 5. Intraoperative view of installation of the basket-weave fashion sutures. The series of 0 size polyglyconate sutures are placed on the ribs from the 5th to the 12th rib in such a way so as to encircle each rib

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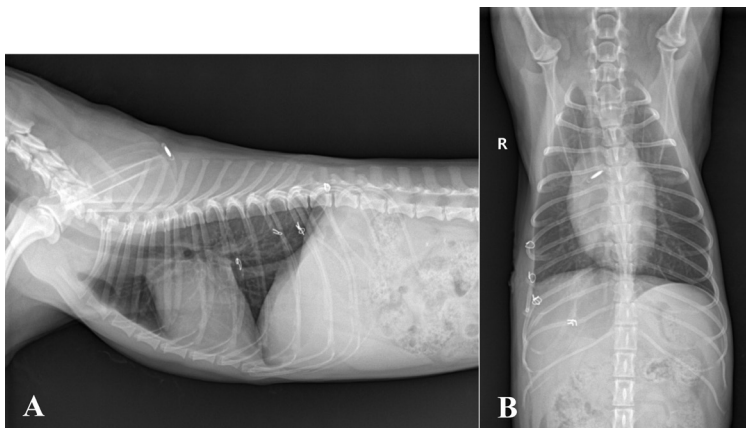


Figure 6. Thoracic radiographs two weeks postoperatively. All of the fractured ribs are reduced and maintained in normal position anatomically except for mild displacements of the right 8th and 11th ribs. The opacity of the right middle and caudal lung lobes has disappeared

with only one rib fracture or in the absence of any rib fractures (Scheepens et al. 2006). Making a definitive discrimination between flail chest and pseudo-flail chest is critical, since treatments for these conditions can be different. In the case reported here, segmental fractures of two adjacent ribs (the right 7th and 8th ribs) were confirmed by CT examination and the surgical plan was established on the basis of the diagnosis.

In human medicine, flail chest has been regarded as a marker of significant injuries (Ciraulo et al. 1994). Flail chest is also considered as a serious injury in veterinary field but the optimal treatment method is still controversial (Olsen et al. 2002), and can involve either conservative or surgical treatment. The reason for the controversy is that, in veterinary field, the majority of therapies for flail chest are based on methods developed in human medicine and reports of flail chest and associated studies are rare. Olsen and colleagues have stated that each flail chest case must be evaluated individually with respect to each aspect of flail chest syndrome and then treated using an optimal course of therapy (Olsen et al. 2002). A gross deformity of the thoracic wall, displacement of the rib fragment causing ongoing damage to the lung and instability of the rib fragment interfering with ventilation are generally accepted as indications for surgical treatment in cases of rib fractures (Bjorling 1998). In the case reported here, we chose surgical treatment for flail chest based on the gross deformity of the thoracic wall, inward displacement of the end of the fractured 11th rib and suspected lung injuries that were identified by CT. Computed tomography can be recommended to aid in the decision of treatment method for flail chest.

While non-displaced rib fractures can be treated in a conservative manner, severely displaced frag-

ments must be surgically treated in dogs (Knecht 1973; Bjorling 1998; Orton 2003). Choosing an appropriate surgical technique to treat rib fractures can be challenging. The currently available options include wiring, pinning and plating. Wiring has been used as a surgical method for rib fractures in dogs of many sizes (Shahar et al. 1997; Olsen et al. 2002). Pinning and plating have been used most frequently in large breed dogs and humans as surgical methods to correct rib fractures (Olsen et al. 2002; Sales et al. 2008; Nirula et al. 2009). However, there is no published report dealing with pinning and plating for rib fracture repair in toy breed dogs because of the small size of their ribs. In the case reported here, the dog was a toy breed dog weighing 3.25 kg and the fractured ribs were too small to be fixed by pinning or plating. Therefore, wiring (interfragmentary and full cerclage) was used to repair the rib fractures and resulted in successful outcome, although there were mild displacements of the 8th and 11th rib fractures which did not affect the clinical signs.

The general stabilisation method for flail chest involves securing the segmental rib fragment to an external splint such as an aluminium frame, polyvinyl plastic splint or tongue depressors which are synchronously moved with an intact chest wall (McAnulty 1995; Bjorling 1998; Orton 2003). However, this method was not appropriate for the dog in this case report because the 7th and 8th segmental rib fragments were severely displaced caudally and adjacent chest wall damage (6th, 9th, 10th and 11th rib fractures) complicated the synchronous movement of the splint with the chest wall. Alternatively, the 7th segmental rib fragment which was difficult to surgically reduce was removed and internal fixation using wiring and basket-weave fashion suture technique were performed to augment the stability of the thoracic wall. Basket-weave

fashion sutures have been described as scaffolding sutures which provide stability to weakened thoracic wall caused by multiple rib fractures, severe laceration of intercostal muscles and surgical debridement of devitalised intercostal muscles (Shahar et al. 1997). The scaffolding, which is made by encircling adjacent pairs of ribs together using surgical suture, restricts the motion of the fractured ribs thereby augmenting the stability of a weakened rib cage (Shahar et al. 1997). To the authors' knowledge, since the first description by Shahar in 1997, clinical case reports applying this technique are rare in veterinary medicine (Scheepens et al. 2006). In the case reported here, basket-weave fashion sutures were applied to the thoracic lesion involving the multiple rib fractures which caused flail chest and intercostal muscle laceration. This method is thought to provide an additive effect for fracture healing as well as an augmentation of the weakened thoracic wall stability.

In conclusion, determination of the correct treatment plan for flail chest can be challenging and CT evaluation of flail chest patients is recommended because some indications for surgical treatment are more easily found by CT than by other techniques. General surgical methods for flail chest using external splints may be inapplicable for flail chest accompanying multiple rib fractures and severe chest wall damage. In such cases, basket-weave fashion sutures combined with interfragmentary wiring can be a good option for surgical treatment, especially in toy breed dogs.

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