CASE REPORT

# Surgical management of a traumatic dislocation of the sternum in an English bulldog

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**A nine-year-old English bulldog presented with an acute history of dyspnoea, tachycardia and discomfort localising to the ventral thorax following a fall down the stairs that morning. After the dog was stabilised, thoracic radiographs revealed a luxation of the third and fourth sternebrae with dorsal displacement of the caudal segment. The sternum was reduced and stabilised with a contoured 12-hole 3·5-mm dynamic compression plate applied to the ventral surface of the sternum. The dog's initial recovery was rapid, cardiorespiratory parameters returning to normal in the first 24 hours. For 2 weeks postoperatively the dog exhibited difficulty in rising from a prone position. After this time there was a full recovery. Clinical examination at 8 months postoperatively did not reveal any abnormalities. Telephone follow-up was performed at 18 months and no complications or cardiorespiratory compromise were reported. To the authors' knowledge, this is the first reported case of a traumatic dislocation of the sternum and its management in the dog.**

*Journal of Small Animal Practice* (2015) **56**, 407–410
DOI: 10.1111/jsap.12289

Accepted: 18 September 2014; Published online: 6 November 2014

## INTRODUCTION

Traumatic dislocation of the sternum in dogs appears to be rare with one reference to a fracture through the sternebral body in a search of the veterinary literature (Newton 1985). However, although a widely referenced injury in human trauma medicine (Attanassiadi *et al.* 2002), traumatic dislocation of the sternum does not appear to have been previously reported in dogs.

In human trauma medicine, the most common cause of sternal fractures and dislocation is road traffic accidents (67%) (Heyes & Vincent 1993, Athanassiadi *et al.* 2002, Kapisiz *et al.* 2010) although there are cases reported following various other traumatic and spontaneous events (Heyes & Vincent 1993; Culp *et al.* 2010). Treatment of sternal dislocation is generally conservative (Athanassiadi *et al.* 2002). Surgery is only indicated in patients when there is significant displacement, uncontrolled pain, cardiorespiratory compromise or clinical non-union (Queitsch *et al.* 2011).

Traditional surgical treatment in human medicine involves the use of cerclage wire; however, this method of fixation has been shown to be insufficiently stable in some patients (Athanassiadi *et al.* 2002, Velissaris *et al.* 2003, Richardson *et al.* 2007). As a consequence, a number of methods and implants have been described to stabilise these injuries, including adaption of mandibular and cervical spinal plates (Ciriaco *et al.* 2009), and more recently, using plates designed specifically for this purpose (Queitsch *et al.* 2011).

In dogs, there is a paucity of information regarding the management of traumatic dislocation of the sternum. Closure of elective median sternotomy has been reported using cerclage wire or polypropylene sutures (Chou & Sena 2011, Guiot & Allman 2011, Hunt 2012).

This report describes a clinical case in which a sternal dislocation with displacement was resolved by applying a dynamic compression plate (DCP) to the ventral surface of the sternum.

## CASE REPORT

A nine-year-old English bulldog (24 kg) presented with an acute history of dyspnoea and discomfort localised to the ventral thorax following a fall down the stairs that morning.

Physical examination revealed dyspnoea, tachycardia and discomfort localising to the ventral thorax. Abnormal movement of the sternum was visible and instability was confirmed by palpation of the area. Other general physical parameters were within normal limits.

The patient was initially managed with intravenous (iv) fluid therapy using 10 mL/kg initially and 5 mL/kg/hour lactated Ringer's solution (Lactato-RingerVet; BBraun) for the following 24 hours, oxygen therapy and pain management with 5 mg/kg pethidine (Dolantina; Kern Pharma) intramuscularly (im) every 2 hours until the time of surgery (approximately 6 hours). A complete blood count and a serum biochemistry panel were unremarkable. Six lead electrocardiography confirmed sinus tachycardia and no other abnormalities. Orthogonal thoracic radiography revealed a cranio-dorsal dislocation of the caudal sternum at the fourth sternebra (Fig 1). Dorsal displacement of the caudal fragment resulted in mild dorsal displacement of the cardiac silhouette (Fig 1).

The anaesthetic protocol consisted of premedication with 0·2 mg/kg midazolam (Dormicum; Roche Pharma) intravenously (iv) combined with 5 mg/kg pethidine (Dolantina; Kern Pharma) im, induction with 3 mg/kg propofol (Propofo, Lipuro; BBraun) iv and anaesthetic maintenance with 1·5% isofluorane (IsoVet; Piramal Healthcare). Initial dose 2 µg/kg and infusion 5 µg/kg/hour fentanyl (Fentanest; Kern Pharma) iv was administered throughout the surgical procedure. The patient was maintained under anaesthesia using intermittent positive pressure ventilation (IPPV) with a mechanical ventilator (AS/3, Datex-Ohmeda monitor).

The surgery was initiated through a ventral approach to the sternum. A midline longitudinal incision was made in the skin on the ventral aspect of the sternum; after dissecting the subcutaneous tissue, the bony surface of the sternum was exposed. The pectoralis musculature was elevated from the sternum and the dislocated sternum was reduced using a traumatic reduction forceps. A 12-hole 3·5-mm DCP was contoured and fixed in position with seven 3·5-mm screws, one per sternebra (from the first to the seventh) (Figs 2 and 3). Decisions regarding the lengths of screws were taken from the measurements made on radiographic projections before surgery (dorso-ventral depth of the relevant sternebra plus 2 mm) to avoid iatrogenic trauma to thoracic soft tissues using a depth gauge. Closure involved apposition of the deep and superficial pectoralis muscles ventral to the bone plate, subcutaneous and skin were closed routinely. Postoperative radiographs revealed correct alignment of both sternum fragments and position of the implants. Mild bilateral pneumothorax was apparent. However no respiratory difficulties were noted during the postoperative period (Fig 3), thus no treatment was performed.

Postsurgical treatment consisted of 20 mg/kg cephalexine (Rilexine; Virbac) orally every 12 hours for 7 days, 0·2 mg/kg meloxicam (Metacam; Boehringer Ingelheim) orally every 24 hours for 14 days, 5 mg/kg pethidine (Dolantina; Kern Pharma) im every 2 hours for the first 24 hours and 0.006 mg/kg buprenorphine (Buprex; RB Pharmaceuticals) subcutaneously every 8 hours for 3 days after withdrawing the pethidine.

The dog recovered uneventfully from anaesthesia. The dog's comfort level appeared to improve very rapidly following surgery.

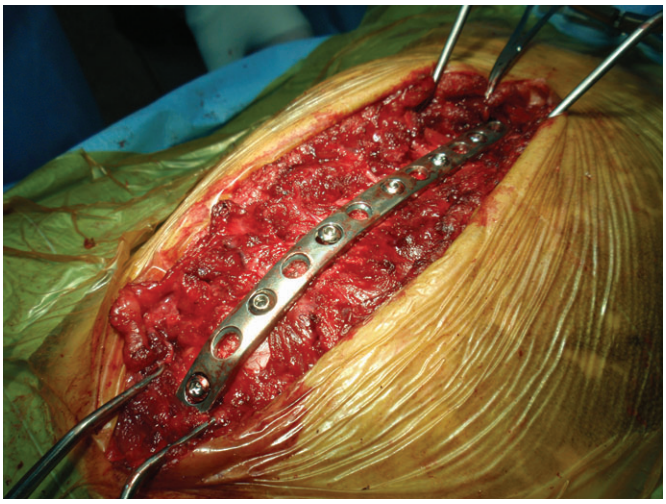

**FIG 2. Photographic image of the ventral aspect of the sternum showing plate positioning**

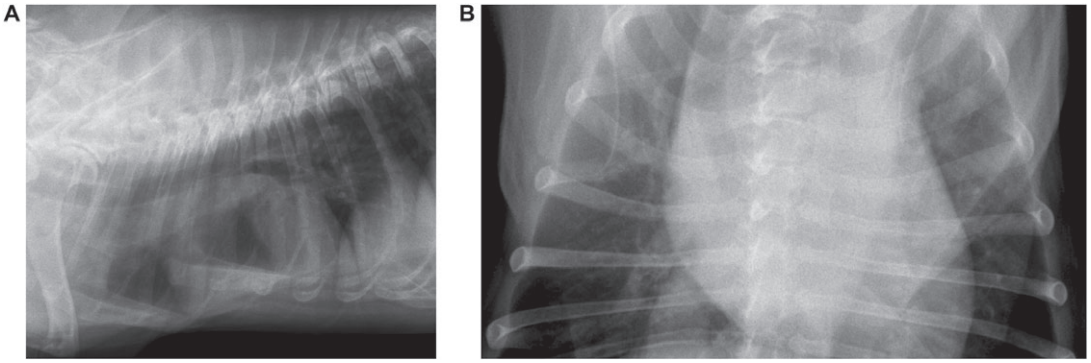


**FIG 1. Lateral (a) and ventro-dorsal (b) radiographic projections of the thorax before surgery revealing dorso-ventral displacement of the caudal fragment of the sternum**

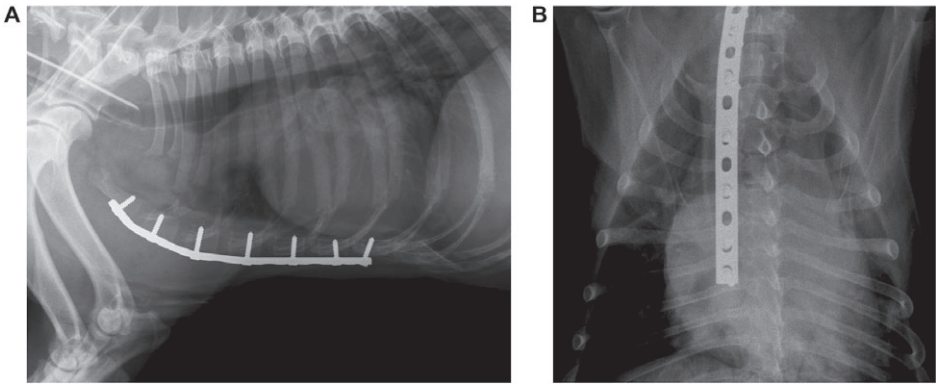


**FIG 3. Lateral (a) and ventro-dorsal (b) radiographic projections of the thorax following surgery showing satisfactory implant positioning and mild bilateral pneumothorax apparent as marginal collapse of the caudal lung lobes**

For the first 2 weeks postsurgery, the patient demonstrated some difficulty in rising from a prone position, otherwise there were no significant complications noted.

Physical examination (cardiovascular and respiratory parameters, including heart rate and rhythm, pulse quality, mucous membrane colour, capillary refill time, respiratory rate and respiratory pattern) at the 4th, 8th, 16th and 32nd post-operative weeks, suggested no abnormalities. Follow-up radiography was declined by the owner who wished to avoid further sedations. Telephone follow-up with the owner 18 months following the surgery revealed no concerns related to this incident.

## DISCUSSION

To the authors' knowledge, this is the first report of sternal dislocation in a dog (a previous report of sternal fracture was made by Newton in 1985) and the first report of surgical management of the condition in a dog. In contrast, sternal injuries are common in humans, most often due to road traffic accidents (Culp *et al.* 2010). In the majority of these fractures, displacement of the fragments does not occur so they are amenable to conservative management (Queitsch *et al.* 2011). Nevertheless, there are a small number of patients who require immediate surgical treatment.

The clinical signs associated with this type of injury in humans are related to the degree of displacement. The case presented here had associated signs of dyspnoea, tachycardia and thoracic pain. These clinical signs are often reported following this type of injury in humans. Other reported injuries associated with traumatic dislocation of the sternum in humans include: concomitant fractures (53.5%), pulmonary (24.4%), head (14.2%) and cardiac injuries (3.1%) and death (0.7%) (Athanassiadi *et al.* 2002). Isolated cases of haemothorax have also been described (Culp *et al.* 2010, Kapisiz *et al.* 2010, Sahin & Guler 2011).

The diagnosis of sternal injuries is based on physical examination; after thorough thoracic auscultation, the sternum and thoracic wall must be assessed for pain and/or instability. Thoracic radiography and an electrocardiogram are indicated to rule out the possibility of internal thoracic injury caused by blunt trauma. Computed tomography (CT) is indicated if concurrent injury to the thoracic organs is suspected. CT can be used to gain additional information on the sternal fracture/luxation (Velissaris *et al.* 2003). In cases of suspected cardiac injury, creatine kinase B or troponin measurements as well as cardiac ultrasound must be performed (Schober *et al.* 1999, Sahin & Guler 2011, Sleeper *et al.* 2001, Velissaris *et al.* 2003).

In humans, management of sternal injury is typically conservative, consisting of rest, analgesia and thoracic splintage (Queitsch *et al.* 2011). Only in patients with non-union, displacement of fragments or when the pain is refractory to medical management, is surgical treatment then considered (Ciriaco *et al.* 2009). Surgical alternatives described in humans are the application of cerclage wire, cervical and mandibular plates, titanium mesh plates and more recently, the application of several titanium locking plates (LPs) (Richardson *et al.* 2007, Ciriaco *et al.* 2009, Kapisiz *et al.* 2010, Queitsch *et al.* 2011, Sahin & Guler 2011). Newton (1985) suggested that treatment for sternebral fractures is only required in cases of "severe cosmetic deformity". Nonetheless, in the present case, it was decided that surgical intervention was warranted owing to the degree of displacement and instability. Open reduction and plate fixation were performed. To that end, open reduction of the dislocation and a DCP plate stabilisation was performed. Application of a long plate to span most or all of the length of the sternum has been reported, in one (Sahin & Guler 2011) and eight cases (Dogan 2010), for patients with sternal dehiscence or non-union complications, resulting in a full recovery. However, there has been a suggestion that spanning the entire sternum may adversely affect thoracic movement (Chou & Sena 2011) and other reports suggest that it is preferable to only stabilise the affected sternebrae (Queitsch *et al.* 2011). The decision for a long plate in this case was made to maximize the benefits of robust fixation with multiple screws (cranial and caudal to the luxated joint), despite the potential discomfort concerns. It was hoped in this case that the resultant rigidity of the plated sternum would not adversely affect respiration and comfort. This was confirmed in the long term, although during the first few postoperative weeks the dog had some difficulty in standing. Use of a long plate for fixation of the sternum, as had been reported in human cases (Dogan 2010, Sahin & Guler 2011), assumes

that movement at the intersternebral synchondroses is negligible. This assumption allows the surgeon to consider the sternum as a single functional unit with a single point of instability at the level of the dislocation. This assumption was made in the present case, such that fixation with one screw per sternebra resulted in three screws in the cranial segment and four screws in the caudal segment. Studies to support the biomechanics of this assumption are lacking in the dogs.

The use of LPs could have been an alternative to a DCP. Advantages of LP are that accurate contouring is of less importance and that the periosteal blood supply is preserved, potentially improving rates of healing. In the case of the ventral sternum, accurate contouring of the implant (DCP or LP) is important as the plate is situated rather superficially and the dog lies down on it. At the same time, LP technology reduces the plate-screw strain which might be advantageous in cancellous bone (as in the sternebrae) (Chou & Sena 2011). The use of a DCP rather than an LP was made on financial grounds.

Intra-operative complications occur in humans in 9% of surgical cases, the most serious being screw misplacement and inadequate fracture reduction (Kapisiz *et al.* 2010). In the post-operative period, complications have been described in 18% of patients, such as delayed union and non-union due to the lack of stability, soft tissue infection and long-term discomfort of surgical implants that require their removal (Kapisiz *et al.* 2010). In the present case implant positioning was satisfactory; however, pneumothorax may have indicated trauma to the pleura, perhaps during drilling. Follow-up radiographs were not acquired, so union could not be evaluated; however, no long-term complications were reported by the owners.

It is hypothesised that healing of the traumatised inter-sternebral synchondrosis is by bone healing. However, it is not clear that the stabilised (but not traumatised) synchondroses would form bony unions. Healing by ankylosis rather than arthrodesis might result in continued instability, with the potential for ongoing micromotion and cyclical failure of the implants in the long term. In humans it is reported that the mode of healing of traumatised inter-sternebral synchondrosis is by ossification (Queitsch *et al.* 2011). How remodelling of immobilised intersternebral synchondroses in the absence of trauma might progress is unclear.

One limitation of this case report is the absence of follow-up radiographs. In the absence of radiographs follow-up could only be evaluated by clinical function. In the case presented, the only complication was temporary difficulty in rising from a sitting position. This was thought to be associated with discomfort in the healing soft tissues, and resolved over approximately 2 weeks.

In this case, the application of a bone plate to the ventral surface of the sternum proved to be a valid method for resolving a sternal dislocation. Full clinical recovery was achieved within 4 weeks of surgery.

## Acknowledgements

The authors wish to acknowledge Dr. Mark Bush for his help and contribution.

## Conflicts of interest

None declared.

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