How to Repair Fractured Ribs in Neonatal Foals Using Nylon Cable Ties

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This paper describes a new method of internal fixation for rib fractures of the equine neonate. The objective of this paper is to show that this technique may provide a safe, easy, cost effective, and efficient way to repair fractured ribs in the neonatal foal. Authors’ addresses: Department of Clinical Sciences, College of Veterinary Medicine, Auburn University, 1500 Wire Road, Auburn, AL 36849 (Downs); and Hagyard Equine Medical Institute, 4250 Ironworks Pike, Lexington, KY 40511 (Rodgerson); e-mail: cgd0001@auburn.edu. © 2008 AAEP.

1. Introduction
Rib fractures in the equine neonate may result from trauma sustained during parturition or shortly after birth. Thoracic trauma in the equine neonate is relatively common; one study states that 21% of foals <3 days of age have suffered thoracic trauma, which may include rib fractures or costochondral dislocation.1 Although not all of these foals have serious complications from thoracic trauma, rib fractures and resulting trauma may contribute significantly to the morbidity and mortality of the affected foal.2 Hemothorax, pneumothorax, diaphragmatic hernia, pulmonary contusion, hemoabdomen, myocardial laceration, and sudden death are all possible sequelae to rib fractures in the neonate. Of 56 foals with rib fractures that presented to a referral center, 14 died as a direct result of their rib fractures.3 Clinical signs may include asymmetry of the thoracic cavity, groaning during respiration, subcutaneous emphysema overlying the thorax, or crepitation/pain on palpation of the ribs.

Current treatment recommendations may be divided into conservative or surgical. Conservative treatment includes confinement, supportive care as dictated by clinical assessment, analgesic medication, antibiotics, and anti-ulcer medication. Surgical correction is indicated when sufficient displacement of fracture fragments imminently threatens vital thoracic or abdominal structures and the normal function of the thoracic wall is impaired. External coaptation has been performed by placing suture material around the affected rib percutaneously and fixing the suture to rigid material externally. Internal fixation has been achieved using cerclage wire, Steinman pins with cerclage wire, 2.7-mm reconstruction plates with 2.7-mm self-tapping cortical screws with or without the use of cerclage wire, and a nylon strand suture repair technique.5–5 The most current recommended method of internal fixation is a method using reconstruction plates, self-tapping cortical screws, and cerclage wire.4 Direct complications of attempted rib-fracture stabilization include prosthesis or implant failure, post-operative displacement of the fracture ends, damage to underlying structures, infection, and seroma formation.

The technique described here stabilizes the fracture of the neonatal rib through internal fixation with a commercially available, gas-sterilized nylon cable tie placed as a single prosthesis through both...
fracture fragments to achieve apposition and stability. After refinement on neonatal cadaver ribs, this method has been found to be safe, efficacious, economically advantageous, and quickly performed on single or multiple rib fractures of the neonatal hemithorax. Additionally, there are few direct complications in the small number of clinical cases. Seven foals that presented to the Davidson Surgery Center between January 2007 and February 2008 for evaluation and subsequent surgical treatment of fractured ribs sustained in the first 48 h of life were treated with the following proposed method of internal fixation of rib fractures with a nylon cable tie.

2. Materials and Methods

The foal is routinely anesthetized using diazepam and ketamine as a single IV injection, and the affected hemithorax is routinely prepared for aseptic surgery with the affected side facing up. The appropriate plane of anesthesia is maintained with isoflurane inhalant delivered through endotracheal intubation. A vertical incision ~5 cm (2 in) in length is made between the two most cranial fractured ribs, and a combination of blunt and sharp dissection is used to expose the fractures. This incision and dissection process is repeated as above for each subsequent 2–3 fractured ribs until adequate exposure is attained. Retraction of the skin and musculature is beneficial in allowing access to multiple fracture sites through a single incision, which increases the final soft tissue covering over each implant. A nylon cable tie is used as the prosthesis in this procedure. In ribs wide enough to accommodate the 4.5-mm drill bit, a nylon cable tie measuring 4 mm in width and 15.24 mm (6 in) in length is used. As the caudal ribs become more narrow, a 3.2-mm drill hole is required, and a nylon cable tie measuring 2 mm in width and 10.16 mm (4 in) in length is used. The distal fragment is commonly found to be overridden by the proximal fragment; this distal fragment is carefully elevated with a towel clamp with minimal disruption to the pleural tissues underneath and placed on top of the proximal fragment. Based on the rib width, a 4.5- or 3.2-mm drill bit is used to carefully drill through the distal fracture fragment 5–10 mm from the fracture line. The proximal fragment is then elevated to lie on top of the drilled distal fracture fragment. A 4.5- or 3.2-mm drill bit is used to drill a hole in the proximal fragment in exactly the same manner as used for the distal fracture fragment. The drilling is performed in the above manner to decrease the risk of inadvertent penetration of the thorax. The appropriately sized nylon cable tie is then passed through the hole in the distal fragment from abaxial to axial using instrument assistance in the form of needle holders. The free end of the cable tie is then guided through the hole in the proximal fragment from axial to abaxial. After the tie is placed, the fracture is checked for adequate reduction; then, the cable tie is tightened. The free end of the cable tie is trimmed off closely to avoid penetration of the overlying soft tissues with a remaining sharp edge. The procedure is repeated until all rib fractures requiring fixation are treated as described. The muscle and fascial layers are closed with #2/0 or #0 absorbable suture in a simple continuous pattern, whereas the SC tissue is closed with #3/0 absorbable suture in a simple continuous pattern. Before the skin closure, intrathoracic suction is applied through a teat cannula to alleviate a pneumothorax, if present. The skin is apposed with surgical staples followed by application of an antibacterial gel to the incisions. The incisions are covered with sterile gauze and an iodine-impregnated adherent drape for recovery.

Post-operative care is the same as the current recommendations for any method of rib-fracture repair. Monitoring the foal for dyspnea or incisional/
Implant infections is performed as with any other procedure. This consists of some period of confinement followed by a gradual return to turnout activity. Antibiotic and anti-inflammatory therapies are recommended and used based on individual veterinarian preference.

3. Results
The above technique has been used to repair multiple rib fractures in one hemithorax of seven foals over a period of 14 mo. Of the above mentioned seven cases, none have experienced death or other serious complications directly related to this method of repair. One foal has experienced significant seroma formation that was resolved with minimal therapy. Three of the foals died post-operatively for reasons that were not directly related to the technique of the fracture repair. All serious complications have been a result of the critical status in which the foals presented for evaluation pre-operatively. One foal was euthanized 3 wk after surgery because of severe adhesions within the pleural cavity thought to be the result of the hemothorax present at admission. One foal died in the recovery stall after repair of rib fractures and a concurrent diaphragmatic hernia. The third foal died as a result of serious aspiration pneumonia thought to be caused by inhalation of meconium and/or amniotic fluid during a complicated delivery. In the above three cases, post-mortem examination found the repaired rib fractures to be correctly apposed. The remaining four foals survived and are currently doing well without apparent complication. All serious complications thus far have been a result of the critical status in which the foals presented for evaluation pre-operatively; however, the risk for fatal implant failure with resulting fracture displacement is present as with all fixation methods.

4. Discussion
Rib fractures occur more commonly in foals born to maiden mares, and they often occur in conjunction with dystocia secondary to natural or iatrogenic trauma.1 These fractures are commonly located in the cranial ventral one-half of the thorax, which strengthens the argument for surgical correction because of the proximity of critical anatomy.1,6 The ribs of the left hemithorax, especially the fourth through sixth ribs, and their associated costochondral junctions are considered by some to carry greater risk of life-threatening injury.4 The benefit of surgical stabilization versus non-surgical therapy for extensive rib fractures has been documented in man and includes benefits such as less time hospitalized in intensive care, lower medical costs, less time on ventilation, and a more rapid return to work.7 The most current recommended method of internal fixation in the equine neonate is a method using reconstruction plates, self-tapping cortical screws, and cerclage wire.4 The technique described here may be superior to current methods of fixation in terms of ease of procedure, decreased risk of significant post-operative displacement of the fracture ends, relatively shortened surgical time compared with other methods, less foreign material implanted in the body, and possibly, less implant failure that can be caused by pull through at fracture ends. Performed on ribs of the neonatal chest wall, the technique is easy to perform and rapidly concluded. The average rib width of the cranial ventral thoracic wall easily accepts the 4.5-mm drill bit, whereas more caudal ribs may require the use of the 3.2-mm bit. Theoretically, the cable tie should resist pulling through the soft neonatal rib better than suture as well as resist recurring displacement of fracture ends to a potentially fatal location because of its flat, wide shape; however, this requires further study to substantiate. The benefit of using retraction of soft tissues also allows more complete coverage of the im-
plant, which provides a better barrier to implant infection. The inherent risk of operating so close to the thoracic cavity is present with this method of fixation as it is with all methods. Care must be taken not to press the drill bit into the thoracic cavity when drilling the implant hole, and minimal dissection on the axial surface of the rib is preferred to avoid creation of a pneumothorax. The use of nylon implants has been shown to be safe in the adult horse and is anticipated to cause minimal tissue reactivity in the neonate as well. Although gas-sterilization methods may not be available to all practitioners, it is unknown how this material will withstand traditional steam autoclave techniques. Impingement on the intercostal neurovascular bundle by implants is recognized in man. However, because this method does not encircle the rib around its caudal border, this should not be of concern. At this time, it has not been shown that internal implants used for rib-fracture fixation cause any form of interference with the girth of a saddle or rider leg pressure in the riding horse; this novel method is not anticipated to be different from currently accepted methods in this regard.

In conclusion, the method described of internal fixation of rib fractures in neonatal foals using commercially available, gas-sterilized nylon cable ties placed through a drilled hole in the fracture fragment ends may offer the veterinarian a safe, expedient, relatively easy, and economically advantageous procedure to use when surgical intervention is deemed necessary. The single greatest concern post-operatively is displacement of the fracture ends located directly over the heart, which may lead to death; this may still occur with this method as with other methods. Surgeon discretion and intra-operative evaluation may dictate a combination of fixation techniques, including the above method, for the best outcome. Further work is required to evaluate any unforeseen long-term complications; however, these complications are not expected.

References