

CASE REPORT

Management of a 3-year-old with an unstable C6–C7 diastasis without quadriplegia

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Abstract

Background Caring for pediatric spine trauma patients places spine surgeons in situations that require unique solutions for complex problems. Recent case reports have highlighted a specific injury pattern to the lower cervical spine in very young children that is frequently associated with complete spinal cord injury.

Methods This report describes the presentation and treatment of a C6–C7 dislocation in a 3-year-old patient with an incomplete spinal cord injury. The highly unstable cervical injury and the need to prevent neurologic decline added complexity to the case.

Results A multi-surgeon team allowed for ample manpower to position the patient; with individuals with the requisite training and experience to safely move a patient with a highly unstable cervical spine. Initial closed reduction under close neurophysiologic monitoring, posterior fusion and immediate anterior stabilization lead to a successful patient outcome with preserved neurologic function. A traumatic cerebrospinal fluid leak, while a concern early on during the procedure, resolved without direct dural repair and did not complicate the patient's fusion healing. Additional anterior stabilization and fusion allowed long-

term stability with bone healing that may not be achievable with posterior fixation and/or soft tissue healing alone.

Conclusions Familiarity with the challenges and solutions presented in the case may be useful to surgeons who could face a similar challenge in the future.

Keywords Pediatric spine trauma · Cervical spine diastasis · Surgical management · Cervical spine fusion · Closed reduction

Introduction

Caring for pediatric spine trauma patients places spine surgeons in situations that require unique solutions for complex problems, often in an emergent or urgent time frame [1–5]. Spinal instrumentation options for pediatric patients with anatomy too small to accommodate many commercially available devices are limited. Recent case reports have highlighted a specific injury pattern to the lower cervical spine in very young children that is frequently associated with complete spinal cord injury [4, 5]. The current case demonstrates an injury similar to previously reported C6–C7 dislocation in a 3-year-old patient without complete spinal cord injury. The highly unstable cervical injury and fear of neurologic decline added to the complexity of the case. Initial posterior reduction followed by immediate anterior stabilization lead to a successful patient outcome with preserved neurologic function. Follow-up confirmed an anatomically aligned, functionally stable spine with neurologic improvement. Familiarity with the challenges and solutions presented in the case may be useful to surgeons who could face a similar challenge in the future.

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Case report

History and physical examination

A 3-year-old female presented to a Level-1 pediatric trauma center following a motor vehicle accident. She was reported to be a restrained back seat passenger. On initial evaluation, a seat belt sign on the abdomen and multiple facial lacerations and contusions were noted. Her Glasgow Coma Scale on presentation to the Emergency Room was 7 and she was urgently intubated for airway protection and ventilation. Computed tomography (CT) of her chest, abdomen and pelvis showed only questionable iliac wing fractures. She was taken to the Intensive Care Unit for continued resuscitation. Initial cervical spine radiographs were interpreted as negative by the radiologist which delayed the diagnosis of the cervical spine injury (Fig. 1). The patient became more responsive and by post-injury day 3, she was noted to have decreased movement of her right arm and leg compared to her left side and pediatric neurosurgery was consulted. Evaluation with CT and magnetic resonance imaging (MRI) revealed a dislocation of C6/C7 without obvious cord injury (Fig. 2). The orthopedic spine service was consulted and the two services took the patient urgently to the operating room that evening for reduction and stabilization.



Fig. 1 Initial trauma lateral radiograph in Emergency Department. Although the initial interpretation was straightening of normal lordosis with no fracture, the C6/C7 diastasis is obvious in retrospect



Fig. 2 **a** Parasagittal computed tomography shows diastasis of the facets at C6/C7 without obvious fracture. **b** Midsagittal T2-weighted MRI shows anterior and posterior diastasis of C6/C7 with disruption of the disc from the inferior endplate of C6. Posteriorly, there is complete disruption of the facets and posterior interspinous ligaments. No obvious cord contusion

Closed reduction with neuro-monitoring

The operating room was prepared with a radiolucent table and eight-pin halo crown for positioning. Intra-operative fluoroscopy was immediately available. Neuro-monitoring consisted of motor-evoked potentials and somatosensory evoked potentials which showed poor right-sided and good left-sided signals prior to patient positioning. These remained stable throughout the case with no evidence of

improvement or deterioration. The patient was placed first in an 8-pin halo crown. With the cervical collar still in place, the attending surgeons stabilized the head and neck while the patient's body was lifted to place gel pads underneath her body to facilitate placement of the halo crown. With multiple attending surgeons, there was robust understanding and manpower to safely transition the patient between positions. She was gently rolled into a prone position on the radiolucent table with a table extension holding the head in the halo. Lateral fluoroscopy was used to confirm that the spine was in good closed reduction (Fig. 3). Motor-evoked potentials and somatosensory evoked potentials at this time were unchanged from baseline.

Posterior procedure

A standard midline posterior cervical exposure was centered over C6–C7. There was an unambiguous spinal fluid leak which tapered off during exposure without intervention. The durotomy was believed to be traumatic as there was no evidence of direct injury during exposure. The C6 and C7 levels were exposed. There was an obvious, approximately 1 cm gap between the lamina with complete tearing of the facet capsules and ligamentum flavum, as well as, the interspinous ligaments. These were trimmed as needed to allow for reduction. Pediatric anatomy limited the posterior instrumentation options: it was clear that the available lateral mass screws were much too large, as were standard sub-laminar cables. Therefore, two 0 vicryl

sutures were passed (with the needle tip removed) in reverse direction bilaterally underneath the laminae of C6 and C7. The vicryl sutures were then used to position a 2 Ethibond suture bilaterally under these laminae. Prior to reduction the facet cartilage was decorticated with a high-speed burr to facilitate fusion. Careful manual tying of the knots led to a nice reduction of the diastasis. The subluxed and dislocated facet joints reduced. Prior to reduction, no additional spinal fluid leak was noted and no dural exploration was attempted. The lamina and lateral masses were decorticated with the high-speed burr. Bone grafting consisted of local autograft shavings in addition to a DBM. Fluoroscopic images showed a nice reduction and monitoring was stable.

Anterior procedure

Upon completion of the posterior reduction and stabilization, the patient was carefully flipped to a supine position on a hospital bed then re-transferred to a supine position on the OR table. A bump was placed under her shoulders and back to allow for her head and halo to remain in an anatomically neutral position. Lateral C-arm images demonstrated a gapping of the anterior C6–C7 disc which reduced even with mild flexion of the neck. Due to a large body habitus, multiple neck rolls and careful positioning in extension under live fluoroscopy allowed for enough access to her anterior cervical spine without displacing her unstable fracture. Motor-evoked potentials and somatosensory evoked potentials at this time were unchanged from baseline.

A standard right-sided approach through the Smith-Robinson interval was made to the anterior cervical spine. The discectomy was completed. There was obvious diastasis of the disc space with endplate avulsion. The disc material was removed leaving bleeding endplates on the inferior surface of C6 and superior surface of C7. There was a very nice decompression with the dura visible in the posterior disc space without any impingement noted. Using a high-speed burr, the width and height of the 5 mm pre-machined allograft was reduced. The disc space was easily distracted despite the posterior sub-laminar suture; one surgeon manually reduced the C6/C7 diastases while the other surgeon placed the plate. A 2.0-mm locking plate from a maxillofacial set, cut to approximately 15 mm in length, was used for anterior instrumentation to accommodate the patient's anatomy. One plate was placed on each side of the vertebral body and 10 mm locking screws were used to secure them rostrally to C6 and caudally to C7. All four screws locked snugly into the plate and maintained reduction of the disc space with the graft in place. Fluoroscopic images confirmed good alignment and hardware placement (Fig. 4). After wound closure, the



Fig. 3 Positioning radiograph with patient in halo crown on radiolucent table

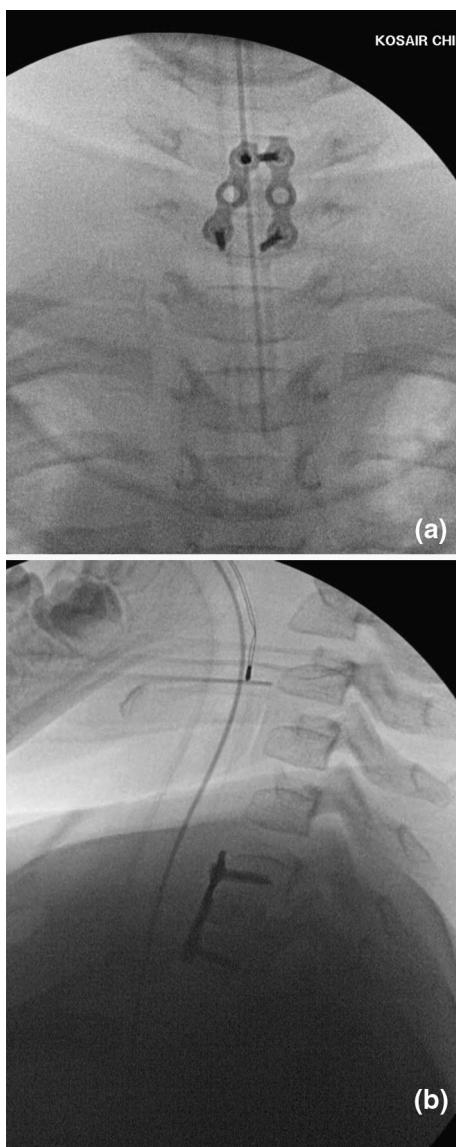


Fig. 4 Intraoperative **a** anteroposterior and **b** lateral fluoroscopic image following posterior and anterior stabilization

patient was placed into the halo vest with gentle flexion of the neck to add to axial loading of the anterior fusion. The patient was taken back to the ICU in stable condition. Although the neuro-monitoring potentials remained unchanged at the end of the case, her neurologic exam slowly improved during the post-operative period. She was discharged to inpatient rehabilitation. By 3-month follow-up she was walking, and showed evidence of bony fusion on CT (Fig. 5). Her halo vest was removed. Follow-up radiographs demonstrate spinal stability and anatomic alignment (Fig. 6). At 12-month follow-up she was continuing to show neurologic recovery, although she maintained an abnormal gait with dorsiflexion weakness of the right ankle. She completely recovered her upper extremity function.



Fig. 5 Sagittal computed tomography 3 months post-operation shows bridging bone anteriorly and posteriorly at C6/C7, in addition to anatomic alignment with no bony stenosis

Discussion

Because of the unique characteristics of the pediatric cervical spine, injury patterns differ from those seen in adults [1–5]. The non-ossified cartilaginous tissue and propensity for soft tissue injury patterns in the pediatric spine may lead to injuries that are more difficult to appreciate on radiographs. A high index of suspicion along with advanced imaging techniques such as CT and MRI can aid in the diagnosis. As in the current case, maintaining the cervical collar and spine precautions until the cervical spine is formally cleared can minimize risk of additional injury. Although many pediatric cervical spine injuries can be managed non-operatively [2–4], injuries with significant spinal instability are typically treated with surgical stabilization to maximize stability and protect neurological function [1–5]. Among the unique injury patterns in very young children, C6/C7 distraction injuries have been previously reported. Two case studies recently published in the literature highlight the typically associated complete quadriplegia, along with the difficulties of surgical reduction and stabilization [1, 5]. The current case is significantly different because of the incomplete spinal cord injury, requiring great care to protect and maintain neurologic function. The benefits of a multiple surgeon team cannot be understated. This allowed for ample manpower to position the dependent patient from individuals with the requisite training and experience to safely move a patient with a highly unstable cervical spine. This was also useful intra-operatively for required reduction prior to anterior

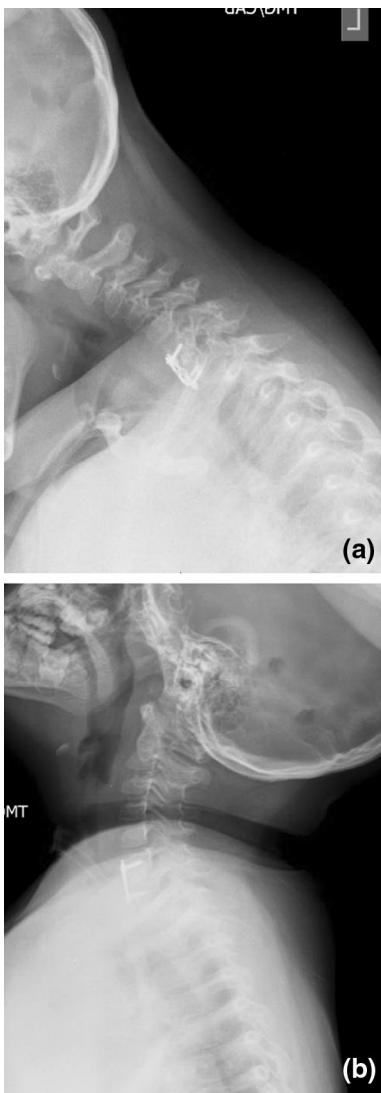


Fig. 6 **a** Flexion and **b** Extension radiographs shows no instability 5 months post-operation

instrumentation. Initial posterior approach facilitated reduction in a manner that is very difficult, if not impossible, to achieve from an initial anterior approach [1]. The traumatic CSF leak, while a concern early on during the procedure, resolved without direct dural repair and did not complicate the patient's fusion. Additional anterior stabilization and fusion allowed long-term stability with bone healing that may not be achievable with posterior fixation and/or soft tissue healing alone.

Conflict of interest None.

References

1. Davern MS, Garg S, Hankinson TC (2014) Operative management of traumatic cervical spine distraction and complete cord transection in a 3-year-old patient. *J Neurosurg Pediatr* 21:1–6 (Epub ahead of print)
2. Knox JB, Schneider JE, Cage JM, Wimberly RL, Riccio AI (2014) Spine trauma in very young children: a retrospective study of 206 patients presenting to a level 1 pediatric trauma center. *J Pediatr Orthop* 34(7):698–702
3. Leonard JR, Jaffe DM, Kuppermann N, Olsen CS, Leonard JC; Pediatric Emergency Care Applied Research Network (PECARN) Cervical Spine Study Group (2014) Cervical spine injury patterns in children. *Pediatrics* 133(5):e1179–e1188
4. Murphy RF, Davidson AR, Kelly DM, Warner WC Jr, Sawyer JR (2015) Subaxial cervical spine injuries in children and adolescents. *J Pediatr Orthop* 35(2):136–139
5. Ha SY, Lee SH, Kim ES, Shin HJ, Eoh W (2015) Highly unstable cervical spine injury in an infant: a case report. *Childs Nerv Syst* 31(2):341–346