Unrecognized ligamentous instability due to high-energy, low-velocity mechanism of injury

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A B S T R A C T

We report a unique mechanism of injury and illustrate the difficulties of diagnosing purely ligamentous injuries to the cervical spine. To our knowledge, there have been no previous reports of this type of high-energy, low-velocity mechanism of injury. The pattern of injury is also unusual, consisting of anterolisthesis of L4 on L5 with bilateral perched facet joints, atlantoaxial instability and bilateral lower limb fractures. We present a 49-year-old man who experienced a high-energy, low-velocity crush injury that led to extreme hyperflexion of his spine. Standard trauma protocols were carried out, yet atlantoaxial instability was not diagnosed until 3 days post-operatively, when the patient went into respiratory failure due to high spinal cord compression. We fused the C1/2 vertebral bodies using Harm’s technique; the patient exhibited no long-term spinal cord dysfunction. Although uncommon, if left undiagnosed or not considered, purely ligamentous injuries to the cervical spine can result in catastrophic complications. Such injuries are an important subgroup to be considered at the time of initial assessment. Furthermore, when managing the multi-trauma patient, clinicians must not overlook the atlantoaxial joint, as high-energy, low-velocity injury to the cervical spine may lead to silent, life-threatening instability that may not be apparent on routine imaging.

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1. Introduction

Purely ligamentous injuries of the cervical spine (C-spine), while uncommon, represent a critical subgroup of C-spine injuries and are very difficult to diagnose.1–3 As a result, there is limited evidence available to aid clinicians in determining the high-risk mechanisms of injury and the “at-risk” patient groups. Furthermore, there is no consensus on the optimal method for clearing the C-spine to be free of injury.4–10 We report on a patient who presented to our facility with an unusual mechanism of injury that led to a purely ligamentous C-spine injury missed on initial screening, and review the recent literature.

2. Case report

A 49-year-old male sustained a high-energy, low-velocity crush injury. A hydraulic tray (~500 kg) malfunctioned and lowered slowly on top of his head and neck, which forced the patient into a sitting position. This caused extreme hyperflexion of his entire spine and his lower limbs were crushed (Fig. 1). On examination the patient was alert, had marked swelling over his lumbar spine (L-spine), bilateral compound fractures of the distal tibia and fibula, and cauda equina syndrome as manifested by absent sensation in the sacral region with loose anal tone. There was no neck tenderness and no neurological signs of a C-spine injury. A standard trauma imaging series was performed, which consisted of a 64-slice helical CT scan of the head, neck, chest and abdomen, as well as plain radiographs of the lower limbs (Fig. 2). No plain radiographs of the C-spine were taken. The major CT finding was anterolisthesis of L4 on L5 with bilateral perched facet joints. No abnormalities of the C-spine were detected at the time, despite specialist review. The C-spine was cleared to be free of injury and the hard collar removed.

The patient underwent treatment for the L4/5 dislocation and was hemodynamically stable during the general anesthetic. The patient remained intubated until day 1 post-procedure. On post-operative day 2 the patient had a brief episode of non-responsive-ness, and a CT scan of the head was again performed. Soon after, he became confused and his blood oxygen saturations decreased to critical levels. Rapid sequence induction, incubation and ventilation initiated and respiratory control regained. The scout-view radiograph and the low axial slices of the head CT scan obtained earlier showed posterior displacement of the odontoid process into the vertebral canal of C1 (Fig. 3).

3. Results

The patient was transferred to a spinal unit under the care of the senior author (RM) and internal fixation performed using Harm’s technique (Fig. 4). Subsequently, there were no clinical signs of brainstem or cervical spinal cord dysfunction.

4. Discussion

The respiratory compromise experienced by the patient was probably caused by the unstable atlantoaxial ligamentous injury which, in turn, resulted in high spinal cord compression by the odontoid process. This injury was clearly visualised on the second CT scan of the head; however, it was missed on the initial standard trauma series despite retrospective review of the initial C-spine CT scan suggesting abnormality. This illustrates the difficulty in diagnosing purely ligamentous injuries to the C-spine when the high-risk mechanisms of injury and the “at-risk” patient groups remain undefined.

To our knowledge, the mechanism of injury of high-energy, low-velocity hyperflexion of the spinal axis has not been reported previously. Likewise, there have been no reported cases of this particular pattern of injury (that is, ligamentous injury to both the C-spine with atlantoaxial instability and the L-spine with bilateral perched facet joints).
The reported incidence of injury to the C-spine following trauma ranges from 2.0% to 4.2%, while that of significant missed C-spine injuries depends on the studied population and the duration of follow-up, although this is generally low.\textsuperscript{11,12} The incidence of missed spinal fracture after trauma is estimated to be between 0.001% and 4.6%.\textsuperscript{3,13,14} Purely ligamentous injuries represent 10% of all injuries to the C-spine.\textsuperscript{1} Despite its relatively low incidence, purely ligamentous injury to the C-spine is a well-recognized concern due to the potentially catastrophic consequences of misdiagnosis.\textsuperscript{2}

There is little evidence on the injury mechanism that is likely to result in a purely soft-tissue injury. Therefore, it is difficult to identify high-risk patients based solely on the mechanism of injury. The risk factors identified for having a C-spine injury missed on standard protocol assessment include high-energy trauma, older age and closed head injury.\textsuperscript{3} Obtunded blunt trauma patients who have high injury scores are also more likely to have positive soft-tissue findings on MRI assessment.\textsuperscript{15} However, further research is needed to identify the high-risk mechanisms of injury and the “at-risk” patient subgroups to enable a more accurate prediction of such injuries on clinical grounds.

Although many publications describe an institution’s policy for clearing the C-spine of injury based on retrospective analyses of individual experiences,\textsuperscript{4–10} there is no consensus on the optimal

Fig. 1. Schematic of the mechanism and pattern of injury. The large arrows indicate the high-energy, low-velocity downward force causing hyperflexion of the spinal column, while the small arrow indicates L4/5 dislocation. The atlantoaxial injury and lower limb fractures are also shown.

Fig. 2. Standard trauma imaging series taken at admission. (A, upper left) Mid-sagittal CT scan of the cervical spine displaying a mildly widened atlantodental interval, initially reported as having no abnormalities detected. (B, upper right) Mid-sagittal CT scan of the lumbar spine showing dislocation of L4/5. (C, D, lower left and right) Plain radiographs showing the bilateral compound fractures of the distal tibia and fibula.

Fig. 3. Repeat imaging taken on day 2 post-procedure. (A) Scout-view lateral head radiograph and (B) low-slice axial CT scan of the head showing the posterior displacement of the odontoid process of C2, causing marked canal stenosis. White arrows (on magnified insets) showing the widened atlantodental interval.
The two most commonly used adjuvant modalities for imaging the C-spine are dynamic fluoroscopy and MRI, the use of which remain controversial. The major criticisms of fluoroscopy are its potential to worsen the degree of injury and its instability without fracture of the C-spine has not been clearly identified in the literature. One possible mechanism is related to delayed clearance of the C-spine.25

5. Conclusion

Purely ligamentous injury to the C-spine is uncommon; however, the resultant complications of missing such an injury can be catastrophic. The mechanism of injury that leads to ligamentous instability without fracture of the C-spine has not been clearly identified in the literature. One possible mechanism is related to high-energy, low-velocity trauma, as observed in this patient. Clinicians should be mindful not to overlook the atlantoaxial joint when multiple, distracting injuries are present. High-energy, low-velocity injury to the C-spine may lead to silent, life-threatening instability that may not be obvious on routine imaging.

References