CASE REPORT

Anterior and posterior fixation for delayed treatment of posterior atlantoaxial dislocation without fracture

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SUMMARY

Posterior atlantoaxial dislocation (PAAD) without fracture of the odontoid process is a rare injury. Authors have variously reported closed or open reduction, followed by either anterior or posterior fixation, but there is no consensus on best treatment. We present a particularly unstable case of PAAD. Open reduction through a retropharyngeal approach with odontoidectomy was required for reduction. Anterior fixation with transarticular lag screws was required prior to posterior fixation with pedicle screws. Despite non-compliance with postoperative immobilisation, imaging at 20-month follow-up confirmed solid fusion. The patient is pain-free with a good range of movement of the neck and has returned to a manual job. Our case had a greater degree of instability than was previously reported, which necessitated 360° fixation. This is the first reported case of this treatment strategy, which provided a very stable fixation allowing fusion despite early movement and without causing undue stiffness.

BACKGROUND

Posterior dislocation of the atlas with regard to the axis without fracture of the odontoid process (OP) is an exceedingly rare injury. To date, there have been very few reported cases of patients surviving this injury and all have been associated with high-energy hyperextension injuries.^{1–10} These cases have been previously managed with either closed or open reduction. Where fixation has been used, this has been done either anteriorly or posteriorly. There is no consensus on the best form of treatment.

We report our experience in managing this rare injury pattern. In our case, the injury was particularly unstable after open reduction. There was significant concern that the spinal cord would become compromised, and therefore the dislocation required anterior and posterior fixation. This is the first case to describe this particular approach to treatment. The rationale for this management strategy and its results will be discussed.

CASE PRESENTATION

A 43-year-old man presented to our emergency department after sustaining a fall from scaffolding from the second storey of a building (approximately 6 m). The patient suffered transient loss of consciousness and arrived at the emergency department 3 h postinjury. On initial assessment, his airway was patent and he had good, spontaneous respiratory effort and was haemodynamically stable. His Glasgow Coma Score (GCS) was 10/15

and he had vomited several times prior to arrival. He was noted to have multiple lacerations over his face and chin and an obvious torticollis, but had spontaneous movement of all four limbs, with normal tone and reflexes. The primary survey and initial management was according to advanced trauma and life support (ATLS) principles, with cervical spine immobilisation.

Investigations (as discussed below) revealed a posterior dislocation of the atlas with respect to the axis. In addition, CT scanning revealed multiple additional injuries including a contusion of the right temporal lobe with intracerebral and sub-arachnoid haemorrhage, a traumatic right-sided haemothorax, a right-sided acromioclavicular joint injury, multiple rib fractures and bilateral traumatic pulmonary contusions.

The patient was initially admitted under the care of the neurosurgical service, in a hard collar, due to the presence of intracranial haemorrhage. The patient had no abnormal limb neurology and no signs of cord compression. After a period of observation, the patient was transferred to the care of the orthopaedic service 17 days postinjury. By this stage, his GCS had improved but he was still intermittently agitated and confused. Clinical examination revealed an obvious torticollis. Power, sensation, tone and reflexes were normal in all four limbs. The patient had a productive cough and was started on antibiotics for hospital-acquired pneumonia. The combination of his numerous chest injuries and respiratory tract infection posed a significant anaesthetic risk and so surgery was delayed until 24 days postinjury. By this time, his agitation and confusion had also settled. The patient was kept in a hard collar until surgery.

INVESTIGATIONS

A lateral radiograph was taken at presentation as part of the primary survey and demonstrated a posterior dislocation of the atlas with respect to the axis, with no evidence of fracture ([figure 1A](#)). A CT scan revealed the presence of multiple additional injuries (as described above) and also confirmed the diagnosis of posterior atlantoaxial dislocation (PAAD) without concomitant OP fracture ([figure 1B–D](#)). MRI revealed mild tenting of the cervical spinal cord, but no compression or compromise. The transverse ligament was noted to be intact ([figure 1E](#)).

TREATMENT

Twenty-four days following his injury, the patient was deemed stable enough to undergo surgery for

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Figure 1 Preoperative imaging showing (A) the appearance of the plain radiograph taken initially; (B) the atlas lying posteriorly to the odontoid process on the axial views and (C) the sagittal CT demonstrating the dislocation. (D) A three-dimensional reconstruction demonstrating the dislocation. (E) An axial MRI slice showing the dislocation and also the intact transverse ligament.

his PAAD. He was given a general anaesthetic and intubated. With the patient supine, closed reduction was initially attempted with gradual manual skull traction applied using Gardner-Wells tongs. We used the procedure described by Wong *et al*, consisting of distraction, realignment and release.⁸ This was unsuccessful and therefore we proceeded to open reduction. We used an anterior retropharyngeal approach. An electric burr was used to perform a partial odontoidectomy. Reduction was achieved by gentle traction and forward flexion of the neck, but the remaining OP was very unstable and was found to redislocate unless constantly held reduced (figure 2A). The reduction was therefore secured by means of two anterior cannulated transarticular lag screws (figure 2B). Given the degree of instability in this

case, anterior fixation alone was not felt to be stable enough, but having achieved a degree of stability the patient could then be safely turned prone. The fixation was supplemented by posterior fixation using C1-C2 pedicle screws and autologous iliac crest bone graft. Fluoroscopy was used during the procedure, but spinal cord monitoring was not available.

OUTCOME AND FOLLOW-UP

Postoperatively, the patient suffered from right hypoglossal nerve neuropraxia, possibly as a result of soft tissue retraction. This completely resolved within 6 weeks. Follow-up MRI scans and radiographs demonstrated resolution of cord tenting and maintenance of fracture position (figures 3 and 4). The patient

Figure 2 Intraoperative imaging demonstrating reduction of the odontoid process. The dislocation was very unstable and the periosteal elevator (A) was required to hold the reduction temporarily until fixed with cannulated lag screws (B).

Figure 3 Postoperative lateral (A) and anteroposterior (B) radiographs demonstrating the fixation anteriorly and posteriorly.

was placed in a hard collar postoperatively, but was non-compliant after 3 weeks. The patient was followed up at 3 months, 6 months and 1 year. At the latest follow-up (at 20 months), he was satisfied with his outcome and had no ongoing pain or restrictions, apart from some residual neck stiffness. He had returned to full-time employment, working 12 h shifts in a manual factory job. His latest imaging and clinical photographs are shown in [figure 5](#).

DISCUSSION

The articulation of the atlas and axis is very mobile, allowing six degrees of freedom, while limiting translation in the sagittal plane.¹¹ The anterior bony arch of the atlas prevents forward translation of the OP, and posterior displacement is prevented by a complex of ligaments which includes the alar ligament, transverse ligament and supporting cruciate ligaments.^{11 12} The spinal cord runs behind the OP in the space formed by the bony ring of the atlas. It has been shown that the OP takes up approximately one-third of this space in the sagittal plane and

that the cord takes up a further one-third. The remaining space is filled with cerebrospinal fluid; this has been termed the 'Rule of Thirds'.¹³ Most commonly, PAAD can only occur when the OP fractures. In order for PAAD to occur in the absence of a fracture, the alar and cruciate ligaments must rupture.¹ In almost all reported cases in the literature (including this case), patients have multiple facial injuries, particularly over the lower face and jaw, suggesting a direct anterior impact, forcing the neck into hyperextension. A majority of the previously reported cases were road traffic collisions.^{1 3 4 6-9} In our case, we surmise that there was a sudden relative deceleration and rotation of the atlas, with respect to the axis, as our patient's face struck some scaffolding during his fall. The extreme hyperextension involved in these high-energy injuries causes the alar and cruciate ligaments to rupture. The anterior arch of the atlas is then able to translate over the OP and dislocation occurs. The transverse ligament may also rupture, although it was intact in our case. It has been suggested that this process is more likely to happen when there is an element of rotation of the atlantoaxial articulation, which allows the OP to slip under the paracentral part of the anterior arch of the axis. The vertical height of the axis is shorter in this region and so the amount of distraction required for dislocation to occur is less than if there were no rotation.¹ We illustrate this proposed mechanism of dislocation in [figure 6](#).

PAAD is a very significant injury and is thought to have a very high mortality rate.^{2 4} Patients who do survive are likely to have some preserved ligamentous stability holding the OP locked against the anterior border of the atlas. Tucker and Taylor¹² have shown that in these circumstances the area of the space enclosed by the atlas reduces to 36%, which is just sufficient to avoid cord compromise. In our patient, and in other cases described in the literature, the neurological deficit is consequently mild.^{3 4 10} The exception to this is the case described by Chaudhary *et al* where the patient suffered a hyperextension injury followed by hyperflexion. The authors surmise that the flexion injury was the key mechanism resulting in the reported neurological deficit.²

Authors have previously managed this injury by closed reduction using a method described by Wong *et al* as discussed above.^{2 6 8} However, in these cases, the patients were

Figure 4 Comparison of preoperative (A) and postoperative (B) MRIs. Postreduction, there was no tenting of the cervical cord.

Figure 5 Clinical photos and CT scan taken at 20 months. (A and B) Clinical photos demonstrating the range of movement of the neck. (C and D) Sagittal CT scan images showing the fixation and that solid fusion has occurred.

definitively managed within 48 h of injury before much swelling/scarring could occur. Between 7 and 10 kg of traction has been used to successfully reduce PAAD.^{2 3 8} In these cases, the dislocation was stable once reduced and could be managed in a hard collar or cervicothoracic orthosis for a period of 3 months. It was felt in these patients that the transverse ligament was partially intact, conferring some stability.² In two cases, there was persistent instability requiring delayed posterior fusion of C1-C2.^{3 8} In all other cases, open reduction and fixation were required. Closed reduction, however, is not without its dangers. Since the supporting ligaments have ruptured, there is less control of the cervical spine and excessive distraction carries the risk of fatal injury.^{1 14} Authors have previously carried out traction with the patient awake in order to detect any neurological changes.⁷ It is advised that spinal cord monitoring be used if attempting to carry this out under anaesthesia.⁹

In our patient, there was a significant delay to surgery which would have resulted in increased swelling and localised scarring of soft tissues and the remaining transverse ligament. This made reduction more difficult and increased the risks. In addition, we did not have spinal cord monitoring available; hence, only a single controlled trial of reduction was attempted. Amirjamshidi *et al*¹ describe a cardiorespiratory arrest as their patient was being turned prior to fixation. It was therefore our preference to achieve reduction prior to posterior fixation. We preferred the retropharyngeal approach as it is common practice in our unit and has a lower associated rate of infection than the transoral approach.⁴ The presence of an intact transverse ligament may have made the reduction more difficult and so an odontoidectomy was required to reduce the dislocation. Although previous authors have proceeded to posterior fusion directly after odontoidectomy,^{1 7 10} we found that our reduction was very unstable. Constant manual pressure was required to maintain reduction. This is most likely due to loss of both ligamentous stability at time of injury and loss of bony stability as a large

Figure 6 Illustration depicting the series of steps occurring in posterior atlantoaxial dislocation. The anteroposterior (AP) and lateral views of the atlas and axis are shown. The lateral view is shown in the mid-sagittal plane and for clarity, only the right half of the atlas has been shown. (A) The normal relationship of atlantoaxial articulation. (B) When a frontal impact occurs to the face/lower jaw, the atlas hyperextends in relation to the axis, and the supporting ligaments (not shown) rupture during this stage. The odontoid process (OP) cannot, however, translate under the central portion of the anterior arch of the atlas. (C) When rotation occurs, the OP then becomes aligned with the shorter, paracentral portion of the anterior atlas. (D) The atlas can then slide over the OP and dislocate posteriorly. (E) Finally, as the head returns to the normal position, the OP becomes locked onto the anterior surface of the atlas by the remaining intact ligaments.

proportion of the OP had to be excised to achieve reduction. We therefore proceeded to insert two anterior intra-articular lag screws to secure the position.

Although two previous authors have treated this case with anterior fixation alone,^{4 9} we felt that in this case the injury was particularly unstable. Pedicle screw fixation of C1-C2 has been shown to be the stiffest construct in biomechanical studies¹⁵ and has been the preferred choice of most authors in treatment of this injury, as it is often familiar.⁴ Furthermore, there was inadequate space for sufficient bone graft and so we were concerned that the anterior fixation alone may fail to unite. We therefore proceeded to do a posterior stage with pedicle screws during the same operation and supplemented this with a bone graft. We felt this provided a stiffer construct and increased the chances of successful union.

We are the first to report anterior and posterior fixation for PAAD without fracture. Our case is unusual in that surgery was

performed after a significant delay and the injury was particularly unstable. Odontoidectomy has been used by previous authors to aid reduction,^{1 7 10} but although required in our case as well, it resulted in further instability. Despite this, we achieved solid fusion and good return of function, with minimal stiffness, despite non-compliance with postoperative immobilisation.

Patient's perspective

I had a very serious injury. I do not remember much of the beginning, but I was worried that I might not be able to walk or go back to work. I was very happy with the treatment. I am now back to work. My neck sometimes gets a bit stiff, but I can do all my normal activities. I am happy for my experience to be shared and published in a journal.

Learning points

- ▶ Posterior atlantoaxial dislocation (PAAD) is an exceedingly rare injury and there are scarce data on the best method of treatment.
- ▶ In cases of delayed presentation/surgery, open reduction should be considered as attempts at closed reduction are unlikely to be successful and run the risk of neurological injury or death.
- ▶ In fractures which are particularly unstable, it may be appropriate to perform open reduction through an anterior approach, rather than risk turning the patient prone.
- ▶ Posterior fixation should be considered in all patients requiring open reduction, but anterior fixation may also be required in cases where the reduction is not stable.
- ▶ Combined anterior and posterior fixation for treatment of PAAD results in a solid construct without compromising the postoperative range of movement.

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