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CASE REPORT

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# Traumatic atlanto-occipital dislocation with successfully bystander resuscitation after cardiopulmonary arrest: A case report

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**Key Clinical Message**

This case report describes successful bystander cardiopulmonary resuscitation after a cardiopulmonary arrest due to a traffic accident, followed by early diagnosis and treatment of a traumatic atlanto-occipital dislocation, resulting in successful community reintegration.

**KEYWORDS**

atlanto-occipital joint, cardiopulmonary resuscitation, fracture fixation, multiple trauma, spinal cord injuries

## 1 | INTRODUCTION

Traumatic atlanto-occipital dislocation (AOD) is a high-energy injury in which the skull base and cranium separate, with serious complications, including traumatic brain and spinal cord injury, multiple organ damage, shock, and cardiopulmonary arrest (CPA). Furthermore, AOD has been problematic because of its delayed diagnosis and high fatality rate.[1–3] We report a case of successful bystander cardiopulmonary resuscitation (CPR) after CPA due to a traffic accident, followed by early diagnosis and treatment of AOD, leading to successful reintegration into the community.

## 2 | CASE HISTORY

A 43-year-old man was injured in a car collision while driving a motorbike, which resulted in CPA. The patient underwent immediate bystander CPR. Upon arrival of the rescue team, the patient had no respiration or carotid pulsation. The patient had a Glasgow Coma Scale (GCS) score of 3. He received nonstop CPR throughout prehospital transport and was resuscitated at a local hospital. He was transported to our hospital for the treatment of unconsciousness and multiple traumas. A thoracic drain was placed at the left chest to treat the tension pneumothorax caused by multiple rib fractures. Being unconscious, he could not communicate with others, although he opened his eyes when called. Therefore, it was difficult to evaluate his neurological findings in detail. He did not respond to pain or stimulation of his extremities and had quadriplegia. In addition, he had multiple left scapular fractures, open fractures of the left radial shaft, and open fractures of the left distal femur.

Whole-body computed tomography (CT) was performed (Figure 1). CT showed a subarachnoid hemorrhage at the craniovertebral junction. CT showed a malalignment of the atlanto-occipital joints with posterior widening of the Occipal/C1 facet joints. Magnetic resonance imaging (MRI) of the cervical spine showed a high signal around the occipital bone, C1, and C2 on T2-weighted and STIR images, and a significant retropharyngeal space hematoma was observed (Figure 2).

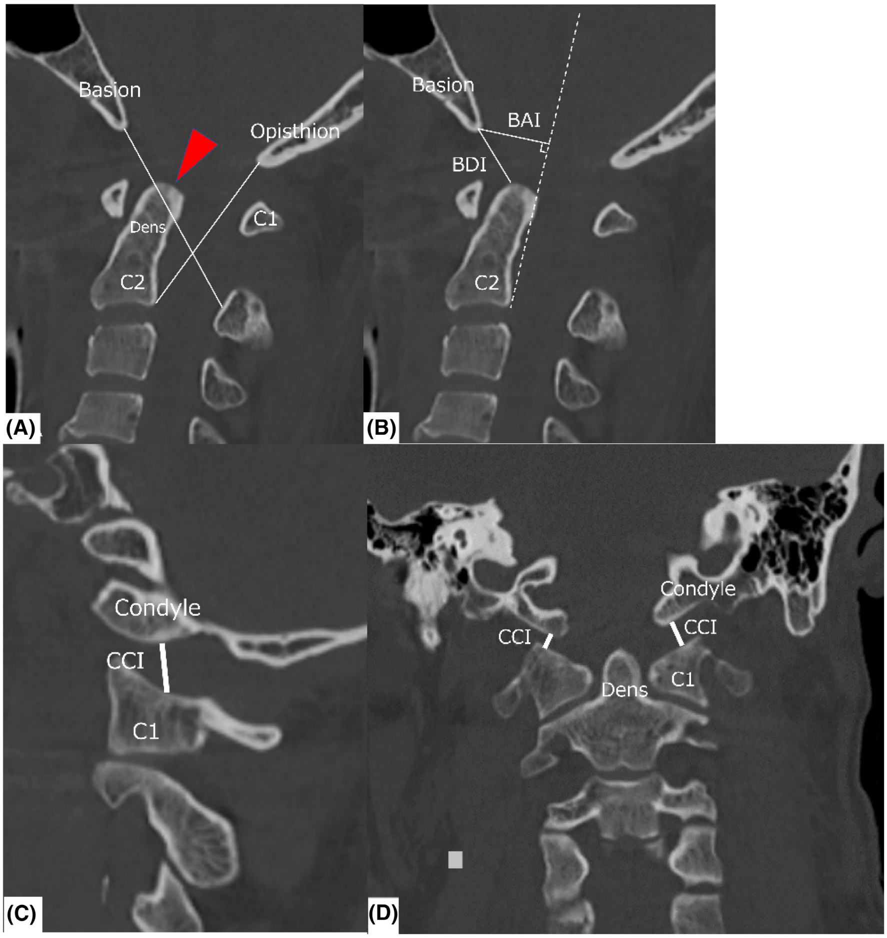


FIGURE 1 Preoperative cervical spine multi-detector CT. (A) X-line method: failure of a line from the basion to the axis spinolaminar junction to intersect C2, or a line from the opisthion to the posterior inferior corner of the body of the axis to intersect C1. In our case, both X limbs were displaced forward from the reference points. (B) Basion-dens interval (BDI): distance between basion and tip of dens. BAI (basion-axial interval): distance between the basion and posterior C2 lines. In our case, BDI was 19 mm, and BAI was 16 mm, indicating AOD (normal 12 mm). (C, D) Condyle-C1 interval (CCI): the distance between the occipital condyle and C1 lateral mass perpendicular from the surface of lateral mass to the surface of the occipital condyle. In our case, CCI is 13 mm on sagittal plane and 12 mm on coronal plane, indicating AOD (normal <4 mm).

The cervical spine was protected with a Philadelphia collar, and occipitocervical fixation was performed on the 14th day after the injury when the patient's general condition was stable. Postoperatively, all parameters improved (Figure 3). Multiple left rib fractures and tension pneumothorax were treated with thoracic drainage. Open fractures of the left radius and femur were treated with external fixation.

## 3 | OUTCOME AND FOLLOW-UP

The patient's GCS score gradually improved to 15 (E4V5M6) on the 44th day after injury. Despite experiencing mild dysarthria and dysphagia, his verbal communication improved, and he was able to ride a wheelchair with help. Eight weeks after the injury, he was transferred to another hospital near his home for further rehabilitation. The last follow-up was 1.5 years after the injury. The patient walked independently with a Lofstrand cane and returned to full-time work. He had mild dysarthria and dysphagia. His muscle strength was MMT5 in the right upper and lower extremities and MMT4 in the left upper and lower extremities.

## 4 | DISCUSSION

Historically, AOD has been considered a fatal injury, with early studies reporting mortality rates of 69%–79%.[4,5] However, this may be a low estimate because some of the deaths in multiple trauma cases may have been undiagnosed cases of AOD.

Recently, the fatality rate of AOD has improved owing to a combination of improved trauma resuscitation, a shift from simple radiographs to whole-body CT for initial imaging, improved diagnostic imaging rates, shorter time between CT and treatment, and advances in surgical management.[1,6]

In this case, whole-body CT was performed according to the trauma protocol during the initial examination to establish a definitive diagnosis. In the diagnosis of AOD, several parameters should be checked that lead to a definitive diagnosis, including the Powers' ratio,[6] X-line method,[7] basion-dens interval (BDI), basion-axis interval (BAI),[8,9] and occipital condyle-C1 interval (CCI).[10,11] Hall et al. recommend utilizing at least two complementary methods to help compensate for the shortcomings of any single method.[12]

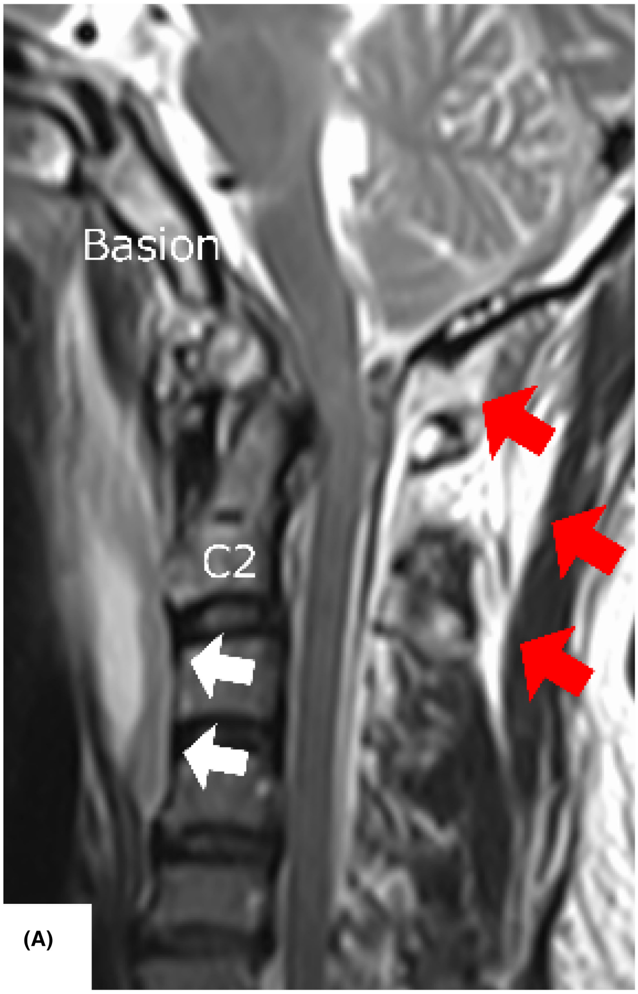


FIGURE 2 Preoperative cervical spine MRI (sagittal). (A) MRI demonstrates an abnormally high signal intensity in the atlanto-occipital joints, nuchal ligament (red arrow), and retropharyngeal space (white arrow).

### 4.1 | Trauma resuscitation

In a study querying the National Trauma Database, Schellenberg et al. reported that 38% of patients with AOD were deceased upon arrival, indicating the importance of early trauma resuscitation, including bystander CPR and better prehospital care.[13]

In the present case, the patient was successfully resuscitated using bystander CPR. A study by Lee et al., published in 2022, demonstrated that bystander CPR was associated with higher rates of survival to discharge (adjusted odds ratio [aOR] = 2.16) and favorable neurological outcomes (aOR = 4.98).[14] Recent reports indicate that the survival rate for out-of-hospital cardiac arrest has increased from 9.1% to 17.5% in 30 years, attributed to factors such as increased rates of bystander CPR.[15] This case is a valuable example of the usefulness of bystander CPR. The patient was resuscitated using bystander CPR and was able to return to society. Therefore, the mortality rate and neurological prognosis of AOD can be improved by the widespread use of bystander CPR.

### 4.2 | Standardization of trauma whole-body CT and diagnostic clue for AOD

Patients correctly diagnosed with AOD at the time of initial trauma have a very low mortality rate.[16] Early diagnosis, appropriate care to prevent worsening of neuropathy, and early rehabilitation after occipitocervical fixation have been shown to improve functional outcomes in patients with AOD, even in those with severe neurological symptoms.[3,17,18]

Brain injury, altered level of consciousness, and multiple traumas complicate the diagnostic process and lead to missed AOD cases at the time of initial evaluation.[1] Therefore, relevant head and facial wounds and clinical clues (high-energy trauma and loss of consciousness) are of paramount importance for the correct initial diagnosis of AOD.[1,3]

Table 1 includes a full list of pearls and pitfalls of AOD diagnosis and treatment. Regarding diagnostic imaging, the systematic and historical diagnosis of AOD was described by Powers et al. based on radiography. In addition, the presence of the vacuum phenomenon in soft tissues near the foramen magnum serves as a clue supporting a diagnosis of atlanto-occipital dislocation.[19]

However, the difficulty of radiographic analysis of anatomic relationships within the craniocervical junction can make diagnosis difficult.[20] In recent years, the initial diagnosis has shifted from radiography to standardized trauma whole-body CT. Moreover, the increased awareness of AOD and standardization of measurement techniques of AOD have reduced the time to diagnosis.[3,21] On the contrary, some reports have highlighted cases of trauma patients with AOD diagnosed using MRI, even when CT scans are normal or close to normal.[21,22] Therefore, to prevent missed AOD cases, the addition of MRI in patients with associated head and facial injuries and clinical clues (high-energy trauma and loss of consciousness) contributes to proper diagnosis and treatment.

## 5 | CONCLUSION

AOD is a devastating traumatic injury with a high mortality rate. Recently, more patients with AOD have been transported alive to the emergency room owing to improved prehospital care, including bystander CPR.

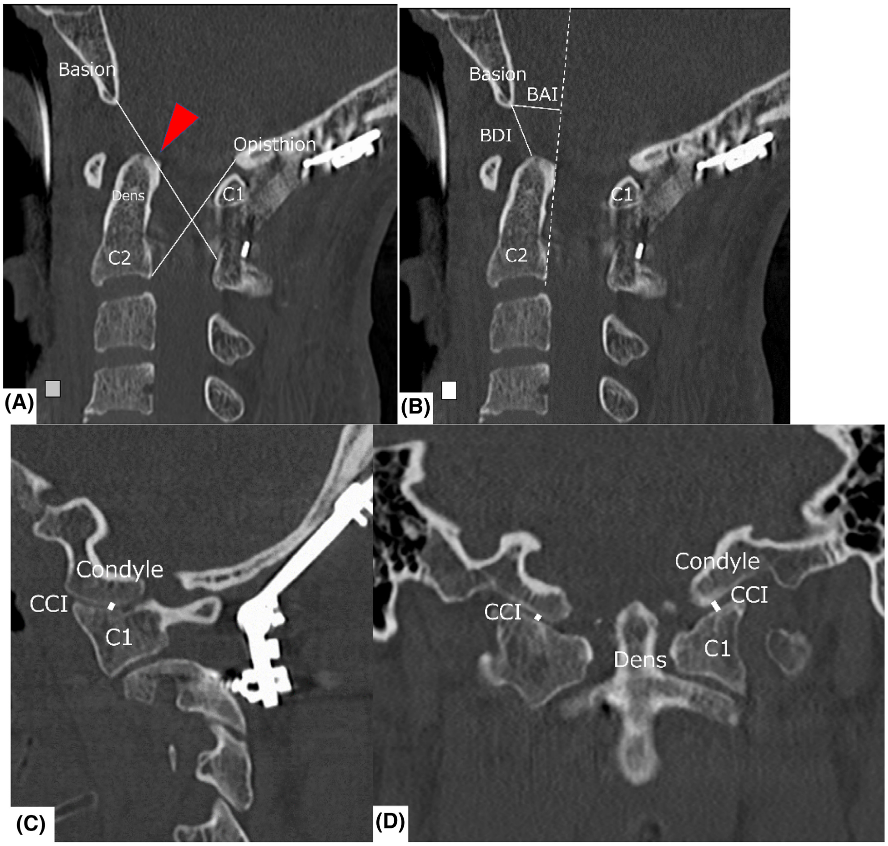


**FIGURE 3** Postoperative cervical spine MDCT. OC2 fusion is successfully performed. (A) X-line method is normal. (B) BAI is 12 mm, and BDI has shortened to 7 mm. (C, D) sagittal and coronal CCI is less than 2 mm.

**TABLE 1** Pearls and pitfalls in AOD diagnosis and treatment.

| Pearls | Pitfalls |
|---|---|
| Increasing resuscitation rate | High mortality rate |
| AOD is being increasingly recognized as a potentially survivable injury as a result of improved prehospital management of polytrauma patients and increased awareness of this entity, leading to earlier diagnosis and more aggressive treatment.[12] | AOD has historically been considered a fatal injury. |
| Bystander CPR may improve outcomes.[14] | |
| A high index of suspicion of AOD | Frequently underdiagnosed |
| Patients involved in high-energy trauma, including high-speed motor vehicle accidents or falls from heights, should be suspected of having AOD.[12] | Lack of recognition<br>Severe brain injuries and unconsciousness |
| Relevant head and facial wounds. | |
| Neurological assessment | |
| Survivors of AOD often have neurological impairment, including lower cranial nerve deficits, unilateral or bilateral weakness, or even quadriplegia.[12] | Concomitant traumatic injuries to the brain, chest, abdomen, and extremities can further blur the clinical picture, masking weakness.[12] |
| Lower cranial nerves, such as abducens, vagus, and hypoglossal, may also be involved in AOD.[12] | |
| Up to 20% of patients with AOD may have normal neurological examinations at presentation. Severe neck pain may be the only symptom in such patients.[23] | |
| Radiographic evaluation | |
| Improved diagnostic protocols with more uniform computed tomography-based imaging.[1] | Difficulty in radiographic analysis based on X-rays of anatomic relationships and inexperience can make diagnosis difficult.[20] |
| Radiographic parameters (Powers ratio, X-line method, BDI, BAI, and CCI) and vacuum phenomenon in soft tissues near the foramen magnum.[19] | |
| Treatment | Conservative therapy |
| Halo immobilization for AOD is essentially limited to temporary pre-operative stabilization pending definitive occipitocervical fusion. | Cervical traction should be avoided since it is associated with a 10% risk of neurological deterioration.[12] |
| Early surgical stabilization is required to confer long-term craniocervical stability and facilitate neurological recovery.[12] | External immobilization has been used successfully in selected patients but has a high failure rate.[24] |

Abbreviations: AOD: atlanto-occipital dislocation, BAI: basion-axis interval, BDI: basion-dens interval, CCI: condyle-C1 interval, CPR: cardiopulmonary resuscitation.

Whole-body CT and MRI may improve diagnostic imaging rates. Early diagnosis and treatment are crucial for this trauma because it is possible for adults to survive and reintegrate when they receive precise and effective treatment.

## AUTHOR CONTRIBUTIONS

**Takayuki Inoue:** Conceptualization; data curation; writing – original draft; writing – review and editing. **Tadatsugu Morimoto:** Conceptualization; supervision; writing – original draft; writing – review and editing. **Hirohito Hirata:** Conceptualization; writing – original draft; writing – review and editing. **Tomohito Yoshihara:** Resources; validation; visualization. **Masatsugu Tsukamoto:** Resources; validation; visualization. **Masaaki Mawatari:** Supervision; validation; writing – review and editing.

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None.

## CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

## DATA AVAILABILITY STATEMENT

The data used to support the findings of this study have been included in this article.

## CONSENT

Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

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