Internal Decapitation
Survival After Head to Neck Dissociation Injuries

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Previously published in *Spine*, Volume 33, Number 16, pp 1744–1749. Permission to republish granted by Lippincott Williams & Wilkins

Study Design: Case series. **Objective:** To describe survival and outcomes after occipitocervical dissociation injuries. **Summary of Background Data:** Historically, occipitocervical dissociation injuries have a high rate of associated neurologic deficit with a relatively high incidence of mortality. **Methods:** Six patients with occipitocervical dissociation injuries are reported and their management and imaging findings reviewed. Possible contributory factors for survival are discussed. **Results:** All patients had upper neck and head dissociation injuries. The pattern of injury in all of these cases included a distraction type mechanism. All cases demonstrated soft tissue disruption in the zone of injury, which was consistent and apparent on all imaging studies. In these patients, the extent and severity of injury was more apparent on magnetic resonance imaging (MRI) than on radiograph or computed tomography scan. Management of these injuries included immobilization followed by surgery with particular care taken to avoid application of distraction forces to the neck. **Conclusion:** Patients with occipitocervical dissociation injuries may survive their injury and even retain neurologic integrity. Initial in-line head stabilization is emphasized to prevent catastrophic neurologic injury. The resting osseous relationships and vertebral alignment at the time of imaging evaluation may be deceivingly normal, and the damage often primarily or exclusively involves disruption of the perivertebral soft tissue structures. Prevertebral soft tissue swelling was apparent in all cases. For these injuries that involve primarily damage to the ligamentous structures, MRI seems to be the optimal test for revealing the magnitude of the injury. **Key words:** soft tissue spinal injury, MRI, head to neck dissociation, occipitocervical dissociation, upper neck injury.

Historically, occipitocervical injuries have been frequently recognized as catastrophic. If victims initially survive such injuries, then significant neurologic impairment often ensues. Despite the improved trauma care delivery system, there are only occasional case reports of successful management of these injuries.[1–3] We describe a case series of patients with occipitocervical dissociation treated at our facility over the past 12 months with more favorable outcomes, including resumption of functional activity in most cases. Lessons learned through their initial workup, assessment, and treatment are discussed.

Materials and Methods

Case Series

Six patients presented with occipitocervical dissociation. Neurologically, all patients were at least American Spinal Injury Association (ASIA) class D at the time of the initial evaluation. Transportation and initial life sustaining resuscitative treatment was successful in all cases. Tetraparesis occurred in 1 case after arrival to the hospital. Demographic data and trauma-related details are summarized in Table 1. The injury patterns in five cases were the result of high energy motor vehicle accidents. One case resulted from low energy trauma with underlying joint instability. The final event leading to medical evaluation included a distraction type mechanism of injury in all cases.

Clinical findings included limited painful guarding of neck motion in all cases and visible external soft tissue swelling about the upper neck that was apparent in two cases (Figure 1). Five patients arrived to the emergency department (ED) with a high level of neurologic function. Plain radiographs demonstrated either minimal or no evidence of skeletal injury or malalignment (Table 2). However, prevertebral soft tissue shadows were greater than normal. Computed tomography (CT) scan was more revealing, and with critical review, some abnormality was seen in all cases, although, most often the osseous abnormalities were subtle and underestimated the true extent of injury. The hallmark of these injuries was extensive soft tissue disruption of the upper cervical motion segments (Figures 2–4). The scope of the injury and implications relevant to extent of instability were easily recognized on magnetic resonance imaging (MRI), with specific imaging findings detailed in Table 2.

After appreciating the full extent of the injuries, all patients were surgically stabilized with internal fixation and fusion. Positioning of patients was done with extreme care to maintain in-line stabilization. The cervical spine was stabilized using a cervical collar and Mayfield tongs. Care was taken to maintain the head in-line with the torso and to prevent any excessive motion. Although no traction was applied, once the patients were anesthetized and lost their protective muscle tone, abnormal intervertebral distraction caused by the cervical collar in two patients was noticed (Figures 5 and 6). In these cases, removal of the cervical collar and compressive force on the head toward the torso was successful in reducing the deformity until the head was secured in the tongs and Mayfield holder. Surgical stabilization included a posterior occipitocervical fusion and instrumentation in all cases.

One patient suffered a complete neurologic paresis at the level of C1. This occurred sometime between intubation in the emergency room and weaning from sedation the following day. On arrival to the ED, the patient appeared to have a massive trauma burden and up to that point had been very noncompliant and agitated. For pain control and optimal

Table 1. Demographics and Trauma Related Details

Case	LOI	MOI	ISS	Surgical Procedure	COI	Sex	Age
1	Occiput–C1, C1–C2	Flexion distraction	29	Posterior instrumented fusion occiput to C3	MVA	M	31
2	Occipital condyle–C1, C1–C2	Distraction	27	Open reduction, posterior instrumented fusion occiput to C4	Autopedestrian accident	F	19
3	Occiput–C1–C2	Fall from height	NA	Posterior instrumented fusion occiput to C4	Fall from height	M	56
4	Occiput–C1–C2–C3	Distraction		C1–C3 posterior instrumented fusion and Minerva brace	MVA	M	45
5	Occiput–C1–C4	Flexion distraction	12	Posterior instrumented fusion occiput to C5	MVA	M	20
6	Occiput–C1–C2	Flexion distraction	75	Posterior instrumented fusion occiput to C4	MVA	F	20

LOI indicates level of injury; MOI, mechanism of injury; ISS, injury severity scale; COI, cause of injury.

management, this patient was intubated with in-line head stabilization while wearing a cervical collar. Cervical spine precautions were maintained throughout the hospital course. With diagnostic work up, in addition to solid organ abdominal injuries and a femur fracture, an occipitocervical injury was found. At this point, the cervical spine was further immobilized with sandbags and tape up to the time of the patient's cervical spine surgery. It was never determined when the actual neurologic injury occurred, but speculation was that distraction was more likely at fault than some form of rotation.

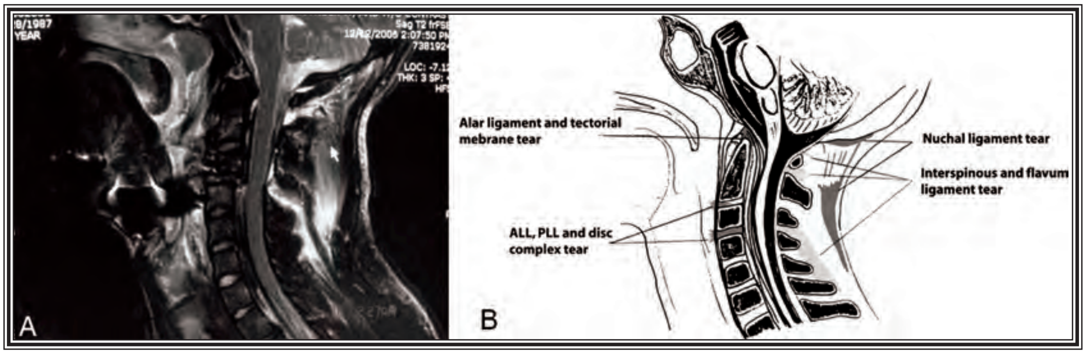

Figure 2. *A Sagittal STIR sequence MRI of patient no. 5 demonstrating extensive prevertebral soft tissue swelling and ligamentous injury at occiput to C4, including the ligamentum nuchae, interspinous ligaments, ligamentum flavum, posterior longitudinal ligament, intervertebral disc complex, and anterior longitudinal ligament (Table 2). Note esophageal rupture anterior to C3–C4. B Drawing of MRI on the left delineating the injured soft tissue structures and ligaments.*

Figure 1. *Posterior appearance of the neck in a 20-year old thin patient (patient no. 5) demonstrating significant soft tissue swelling on the lateral sides of the upper to middle neck.*

Discussion

In trauma victims, cervical spine injuries are not only common, but, because of their association with potentially poor functional outcomes, can also be very costly and functionally devastating. This particularly applies to unstable cervical injuries that can result in neurologic deficits and subsequent significant morbidity or even mortality. It is estimated that 10,000 new cases of spinal cord injury occur each year in the United States, of which 35.9% are caused by vehicle crashes with annual aggregate direct costs of $3.48 billion.[4]

Approximately 5% to 10% of unconscious patients, who present to the ED as a result of a motor vehicle accident or a fall, may have a major injury to the cervical spine.[5]

Proper stabilization of the cervical spine in a neutral position until the true extent of injury is diagnosed can minimize or prevent development of further neurologic sequelae and even death. Over recent decades, standardized protocols and advancing imaging technology have improved diagnosis, speed, delivery of care, and outcomes of cervical injuries. When symptoms are consistent with a cervical spine injury, or when trauma can potentially injure the cervical spine, the Advanced Trauma Life Support (ATLS) protocol mandates assessing the airway, breathing, and circulation with proper manual in-line stabilization of the neck, usually with a cervical collar and eventually a backboard.[6] Intubation may be required, again with emphasis on the appropriate protection of the cervical spine. These precautions continue through the emergency room evaluation until a specific injury is either ruled out or identified, and in some instances, may even extend into the critical care hospitalization period.

Less than 100 severe occipitocervical injury survivors have been reported.[1] The true incidence is uncertain and two series of postmortem evaluation of victims of motor vehicle collisions attributed death to occipitocervical injury in approximately 39% of the cervical injury cases studied.[7,8] Postmortem reports using optimal autopsy technique have documented that up to 94% of blunt trauma fatalities had traumatic injuries that included multiple lesions to the facet joints and the intervertebral discs. The lesions found in these studies were all unique for the traumatized victims, with no similar lesions found in any of the patients in the control group of nontraumatic deaths.[9] Interestingly all patients in our case series had MRI evidence of facet joint and ligamentous injuries despite fairly benign initial clinical and radiograph and CT scan findings (Table 2, Figure 2). Because the main features of these injuries seems to involve ligamentous and other soft tissue injury with subtle osseous abnormalities, a high index of suspicion is warranted and evaluation with MRI should be included when these injuries are suspected.

Figure 3. *Intraoperative picture taken during posterior dissection of patient no. 5 showing fragmentation and destruction of nuchal ligament seen during surgical dissection.*

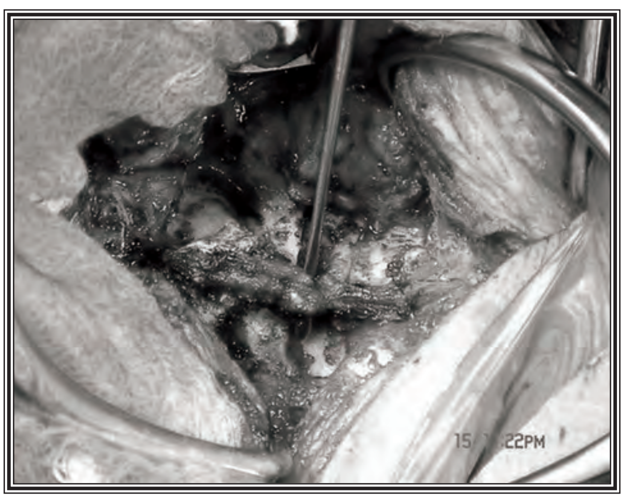

Figure 4. *Intraoperative picture taken during posterior dissection of patient no. 5 showing rupture and avulsion of the interspinous ligament at C3–C4 as seen during surgical dissection.*

A crucial step in the management of patients with severe soft tissue damage to the neck is recognizing the need for an MRI, because it is the MRI that provides the most comprehensive appreciation of the injury. In the patients described in this report, the decision to order an MRI examination was based on general clinical suspicion including a history of high-energy trauma, visible external neck swelling, and subtle evidence of malalignment of the upper cervical spine seen on the CT examination. Any of these should raise suspicion of severe soft tissue damage and suggest careful review of CT findings whereas a cervical MRI should be considered for better appreciation of the soft tissue damage.

This small case series is not sufficient to validate objective measures of alignment. A validated method for detecting malalignment or other findings that represent a significant probability of severe soft tissue damage would be very valuable. Unfortunately, these conditions are likely very dynamic, and the position of the head and neck at the time of imaging may not truly represent the degree of potential malalignment.

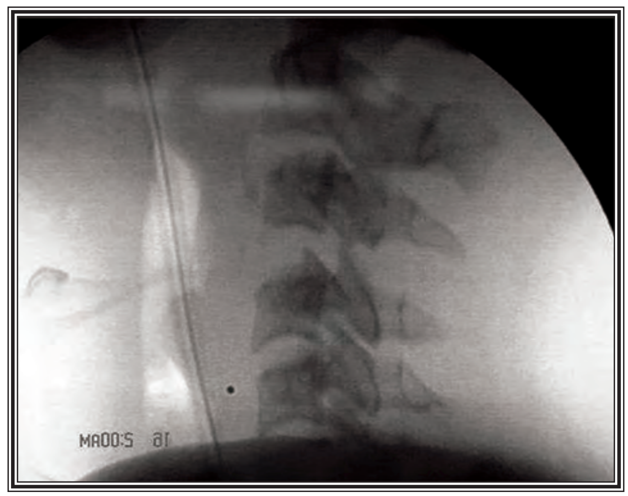

Figure 5. *Intraoperative fluoroscopic picture of patient no. 5 taken once the patient was anesthetized and lost his protective muscle tone. Although no traction was applied and care was taken to maintain the head in-line with the torso and to prevent any excessive motion, the abnormal intervertebral distraction caused by the cervical collar at C3–C4 is noticed which measures four times the normal adjacent caudal disc.*

Our working hypothesis is that application of uncontrolled traction to the head and neck could lead to devastating complications in the presence of severe distractive soft tissue injuries in the upper cervical spine. Although this study does not provide definitive evidence for management guidelines, we believe that a history of high-energy trauma, visible external swelling, or subtle evidence of malalignment of the upper cervical spine should raise suspicion of severe soft tissue damage. In such cases extra steps to avoid any application of uncontrolled traction to the head/neck in the initial resuscitative efforts (*i.e.*, collar application and intubation) should be employed as these can lead to a good outcome even with injuries that can otherwise result in permanent neurologic injury or death.

Table 2. Imaging Findings

Case	X-ray	CT	MRI
1	No osseous abnormality seen	Craniocervical subluxation – minimal anterior translation of the occipital condyle over C1 on the left C1–C2 facet joint widening (7 mm) 15 mm soft tissue swelling between C1 and the orotracheal tube	T2 hyperintensity at atlanto-occipital and C1–C2 junction with: Ligamentum nuchae edema/tear at the skull attachment Interspinous ligament rupture of the C0–C1 and C1–C2 C0–C1 and C1–C2 joint injuries with joint widening and effusion Apical and cruciform ligament, tectorial membrane edema/tear T2 hyperintensity with enhancement around C1 lateral masses, anterior arch, and odontoid process with C1–C2 subluxation Prevertebral soft tissue edema Normal spinal cord
2	Small chip avulsion fragment proximal to the occipital condyle	Small chip fragment adjacent to occipital condyles at the clivus without apparent subluxation	T2 hyperintensity at atlanto-occipital and C1–C2 junction with: Tectorial membrane rupture between occiput and C1 Interspinous ligament rupture between C1–C2 Occiput-C1 joint capsule rupture and avulsion fracture with periarticular soft issue edema bilaterally Transverse ligament insertion avulsion
3	C1–C2 subluxation	Widening of the atlanto-dens interval of 8-mm with odontoid deviation to the left. Significant prevertebral soft issues swelling	Edema and contrast enhancement of the paraspinal muscles bilaterally and prevertebral fascia and ALL from occiput to C5–C6. Disc herniation at C5–C6 with superior migration on the left.
4	Unremarkable	C1–C2 Widening and anterior translation of facet joints 5 mm C2–C3 Widening and asymmetry of facet joints	T2 hyperintensity at atlanto-occipital and C1–C2 and C2–C3 junction C1–C2 and C2–C3 facet joint capsule rupture and excessive joint fluid Apical ligaments and C0–C1 fluid and capsule rupture
5	2.5 mm retrolisthesis of C3 with respect to C2 and C4 20 mm prevertebral soft tissue swelling	Retrolisthesis of C3 with multiple vertebral body avulsion fracture fragments anterior to C2–C3 disc space, 3-mm widening of C3–C4 facets bilaterally with widening of the interspinous processes at that level	ALL, PLL, bilateral facet joint capsule ligaments and the interspinous ligament disruption at C3–C4 T2 hyperintensity with apparent complete rupture of the ligamentum nuchae from the occiput to C4 Interspinous ligament rupture from the occiput-C1 ,C1–C2,C2–C3,C3–C4 Rupture posterior atlanto-occipital membrane and ligamentum flavum from the C1–C4 PLL and ALL rupture at C2–C3 Esophageal rupture Soft tissue edema surrounding the posterior,lateral, and anterior neck soft tissues.
6	25-mm prevertebral soft tissue swelling between C1 and the endotrachael tube. No other bony abnormality seen	Left occipital condyle fx Avulsion fx of the clivus displaced inferomedialy from the cranio-occipital articulation. Cranio-occipital articulation widened 6 mm bilaterally. 3-mm widening of the C1–C2 articulations. 6-mm translation of the occipitoatlantal and C1–C2 facet joints	Left occipital condyle fx with craniocervical dislocation ligmentum nuchae is edematous but intact Rupture of occipito-atlantal and C1–C2 joint capsules Rupture posterior atlanto-occipital membrane and ligamentum flavum C1–C2. Tectorial membrane rupture Diffuse edema of the spinal cord with contusion at C3–C4. Paraspinal musculature edema posteriorly and prevertebral fascia edema and widening anteriorly occiput to C4

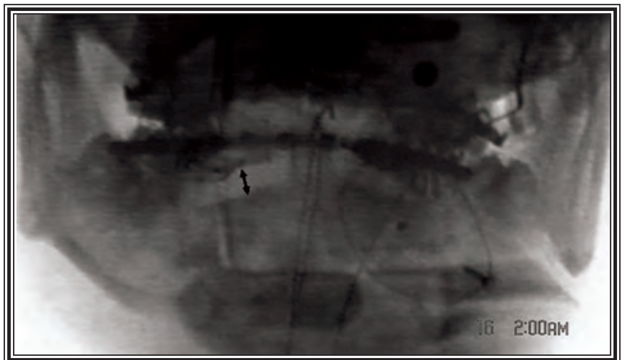

Figure 6. *Intraoperative fluoroscopic picture of patient no. 5 taken once the patient was anesthetized and lost his protective muscle tone. Although no traction was applied and care was taken to maintain the head in-line with the torso and to prevent any excessive motion, the abnormal intervertebral distraction caused by the cervical collar at C1–C2 is noticed (black arrow).*

In the current series, five out of six patients who presented with good neurologic status had no worsening of their neurologic injury and retained a high level of function. One patient suffered a complete spinal cord injury. In this series, all patients were managed similarly in terms of immobilization and evaluation. Patients that required intubation urgently were intubated before knowing the extent of the cervical spine injuries.

It was evident in retrospect that for these injuries, the amount of protection afforded by active muscle control was remarkably substantial, and this stability was completely abolished once the patient was placed under anesthesia. In all cases, during patient positioning for surgery, the head and neck were maintained in compression during attachment of the Mayfield tongs. Despite active effort to maintain compression, in some instances, further adjustments in compression had to be made to optimize anatomic alignment in the Mayfield holder. It was also noted that there was always visibly more distraction in the zone of injury when the patient was asleep than when they were awake, whether prone or supine. Thus, fundamental preoperative management of these injuries is in stark contrast to subaxial cervical injuries, which often require traction for initial reduction and stabilization.

Although this is but a small case series, it helped us appreciate the vital contribution of the paraspinal muscles of the upper cervical spine, which seem to be more essential for stability here than in other areas of the spine. Once this muscle tone is eliminated, these patients become substantially more vulnerable to harmful distractive forces. This is particularly true at the occipitocervical junction where there is relatively little bony coupling and where there is no disc. Stability at this level depends almost entirely on the ligaments and the muscles and is easily subject to adverse translational and/or rotational forces in all six degrees of freedom. Thus initial in-line head stabilization and immobilization is of crucial importance to the survival and treatment of these patients.

The established standard of care from the ATLS protocol mandates the application of a cervical collar and/or in-line stabilization of the cervical spine. However, like many established practices, spinal immobilization has never been studied in controlled, randomized trials.[10] Manual in-line stabilization has been supported by less rigorous investigations, including studies in uninjured volunteers,[11,12] patients in the immediate postmortem period with documented injuries,[13] cadaveric models,[14] and case series.[15–19] Recent data suggest that manual in-line stabilization may increase subluxation at unstable segments.[20] The available literature suggests that direct laryngoscopy and orotracheal intubation is unlikely to cause dangerous cervical spine movement and that manual in-line stabilization does not limit the movement that does occur during intubation.[21] Traction is not an acceptable alternative, because it is ineffective for stabilization and causes significant distraction.[11–13,20] This calls for a clear understanding that true in-line stabilization should be secured in all planes and particular effort should be made to avoid traction or rotation.

Application of cervical collars should take this into consideration as well. Excessively large collars or those strapped tightly around the neck may cause distracting forces that push the head away from the torso. Because traction may be deleterious in the truly unstable upper cervical injuries, cervical collars may have the potential of aggravating the injury by the distractive forces they apply on the spine. It is important that these braces maintain in-line stabilization with minimal traction until the exact nature of the cervical injury is understood.

In summary, although occipitocervical dissociation is a potentially lethal injury, survival is possible, and may be improved by carefully managing the upper cervical spine during the initial evaluation period. This necessitates *in situ* stabilization of the cervical spine with proper sizing and fitting of cervical collars and careful management during the evaluation process. This becomes even more important when patients have no protective muscle tone, either as a result of head injury or from sedation.

Key Points

- Survival after occipitocervical dissociation injuries is rare, but possible with retention of neurologic integrity.
- History of high-energy trauma, visible external neck swelling, and subtle evidence of malalignment of the spine seen on the CT examination should raise suspicion of severe soft tissue cervical damage and an MRI should be considered.
- Initial in-line but nondistractive stabilization should be applied in the emergency setting when cervical spine injury is suspected.
- Proper sizing and fitting of cervical collars, and careful management during the initial emergency evaluation process can prevent aggravation of distractive cervical spine injuries.
- The extent and severity of such injuries particularly the associated cervical soft tissue injury is understated on plain radiographs and CT whereas it is most apparent on MRI.

Acknowledgments

The authors thank Mrs. Merle Husband and Mrs. Lilia Roman for their valuable assistance.

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