Ricardo Vieira Botelho
Adriana Maria de Souza Palma
Carla Maria Balieiro Abgussen
Emilio Afonso França Fontoura

Traumatic vertical atlantoaxial instability: the risk associated with skull traction. Case report and literature review

Received: 21 September 1999
Revised: 31 March 2000
Accepted: 3 April 2000

R. V. Botelho (✉)
Rua Haberbeck Brandão 68- ap. 122,
04027-040, Indianópolis-São Paulo,
São Paulo, Brazil
e-mail: bitbot@uol.com.br,
Tel./Fax: +55-11-5390313

R. V. Botelho · A. M. de S. Palma
C. M. B. Abgussen · E. A. F. Fontoura
Conjunto Hospitalar do Mandaqui,
São Paulo, Brazil

R. V. Botelho
Department of Neurosurgery,
Hospital do Servidor Público do Estado
de São Paulo, São Paulo, Brazil

Abstract Traumatic overdistractive between C1 and C2 may occur when all the ligaments connecting C2 to the skull are ruptured, and may be manifested when an attempt to reduce C1-C2 subluxation is made by means of traction. We describe here the case of a patient with traumatic anterior atlantoaxial dislocation, who developed atlantoaxial vertical dissociation after skull traction using a Gardner-Halo with lb 4.02 (1.5 kg) of weight. The identification of patients who are susceptible to this complication is difficult. In this case, it might have been prevented by avoiding spinal

traction. The aim of this report was to show that vertical dissociation may occur in C1-C2 anterior dislocation submitted to spinal traction, and that other forms of reduction must be considered to treat these pathologies and avoid this potentially fatal complication.

Key words Longitudinal atlantoaxial dissociation · Spinal traction · Overdistractive

Introduction

The stability of the atlantoaxial motion segment is unique. The lack of typical vertebral bodies and the arrangement of articular facets without protection against horizontal gliding make the articular system dependent mostly on the ligaments. Anterior C1-C2 dislocation is a rare and severe lesion in distraction caused by a predominantly ligamentous lesion, leading to displacement of the atlas on the axis [13].

Vertebral displacements require reduction for neural decompression and stabilization. The most frequently used reduction mode is traction. This creates an unusual kind of stress in the craniocervical transition, called vertical distraction. Without ligamentous integrity, even a simple cranial traction can not be counterbalanced and may cause overdistractive among the vertebrae, with its consequences. Recently, traumatic vertical (longitudinal) dissociation between C1 and C2 has been described [8, 15, 19]. It is extremely difficult to predict which patient will develop this

lesion after being subjected to the traction. Here, we describe the case of a patient with traumatic anterior atlantoaxial dislocation who developed a vertical dissociation after skull traction, studying its complications and how they are related to the skull traction.

Case report

A 16-year-old female patient, E.C.S., who was run over by a vehicle on 5 May 1997, was immediately taken to the first aid clinic of Conjunto Hospitalar do Mandaqui, São Paulo, Brazil.

Cardiorespiratory arrest was detected upon examination. She was submitted to resuscitation attempts. The patient was hemodynamically stabilized, and remained in a coma without opening her eyes and with no motor response, with a score of 3 on the Glasgow coma scale. She was submitted to computed axial tomography (CAT) of the skull, which permitted visualization of the high cervical column and identification of an anterior C1-C2 dislocation (scout view) (Fig. 1). The CAT scan showed a wide separation between the odontoid and the anterior C1 arch and a minimal bilateral displaced fracture of the anterior C1 arch (Fig. 2).

Fig.1 Craniocervical transition – computed axial tomography (CAT) scout view (note the wide separation between the C1 anterior arch and the dens. There is no atlantoaxial vertical dissociation)

Fig.2 C1-C2 subluxation. The odontoid process became displaced at the back and on the left side related to the C1 arch. Note the non-displaced fracture of the C1 anterior arch

Fig.3 Note a complete separation between C1 and C2. A part of the anterior arch was joined up with the odontoid process (arrow)

The patient started to open her eyes spontaneously and to respond to the environment, with ocular responses stimulated by verbal commands, although she was tetraplegic, apneic, intubated and on mechanical ventilation. There was no intracranial lesion.

Immediately after the diagnostic was made, the patient was submitted to skull traction using a Gardner Halo with lb 4.02 (1.5 kg). Radiological control during the first minutes of traction showed extensive distraction, with C1-C2 vertical dissociation. There was avulsion fracture of part of the anterior C1 arch (Fig. 3). The traction was interrupted, and we tried a reduction of the distraction using axial compression, but were unable to reduce the dislocation. The patient was taken to the intensive care unit and remained tetraplegic and apneic, eventually developing hemodynamic and respiratory instability, which hindered any attempt at surgical or manual reduction of the spinal dislocation. Requiring drugs to maintain blood pressure and heart rate, under continuous mechanical ventilation, the patient died on the 28th day of hospitalization.

Discussion

The major part of occipital-C1-C2 motion is executed by the atlas and the axis, which form the center of motion between the head and the high cervical column, thus being vulnerable to traumatic injury [7].

Craniocervical stability is strongly dependent on the ligament system. Anatomical pathology studies of fatal craniocervical injuries show that the most frequently injured site is C2. Davis and co-workers [5] studied 50 cases of fatal craniocervical trauma. Of these, 36 showed evidence of cervical lesion and 18 presented ligament lesion. In six cases, all the intervertebral ligaments were disrupted.

Most of these ligaments involved the atlantoaxial region [5]. In a postmortem study of 14 patients who presented atlantoaxial displacement, Adams [1] identified three patients with complete rupture of the atlantoaxial ligament and of the tectorial membrane and lesion of atlantoaxial capsulae associated with type II odontoid fracture.

Exclusive distraction of the occipito-atlantoaxial junction frequently results in death [15].

Anterior C1-C2 dislocation is caused by a pure flexion or flexion-rotation mechanism, in which the C1 articular masses are subluxated anteriorly on C2, frequently compressing neural tissue [13].

Reduction of the C1-C2 displacement is essential for spinal cord decompression and vertebral stabilization, for which cranial traction is the standard method although it can also be performed by simple head extension [3]. Five pounds (1.87 kg) is considered a safe weight for traction reduction of atlas misalignments [15].

Crutchfield [4] recommends lb 4–10 (1.492–3.73 kg) for atlantal reduction, and Apuzzo et al. [2] use lb 12–15 (4.476–5.60 kg) for C2 fracture reduction. However, the traction effect on the traumatized column is not predictable due to the variability of ligament lesion in each patient, and to the fact that ligament and muscle lesions are not directly visualized. In patients with complete spinal cord lesion and muscle paralysis, the distraction effect can be potentiated. Distraction of the cervical column can cause spinal cord lesion even when the traction is within safe limits [11, 12, 17].

Table 1 Descriptions of the C1-C2 dissociations

Author	Year	Pathology	Use of traction
Hammer [8]	1991	1. Type III odontoid fracture 2. Vertical dissociation	Traction – weight not specified Without traction
Przyblski and Welch [15]	1996	Type III odontoid fracture	Traction with lb 5 (1.87 kg)
Weiner and Brower [19]	1997	Vertical dissociation (C1 occipitalization)	Without traction

The complications of traction have not been frequently described, probably because of the rarity of longitudinal instability [12, 18]. Few reports about longitudinal distraction vector control in the C1-C2 articulation are available in the literature. In one reported series of fatal lesions [5], there was a case of craniocervical trauma in which the alar ligament was disrupted, showing the effect of longitudinal distraction associated with flexion-extension in severe trauma.

Up to the beginning of this decade, vertical atlantoaxial instability had only been described in autopsy. Since 1991, four cases of C1-C2 vertical instability and vertical dissociation have been described by three authors [8, 15, 19] (Table 1). Two of these cases presented a dissociation evident at the time of the trauma [8,19], and in the other two cases, dissociation only occurred after skull traction [8, 15].

In 1991, Hammer [8] described two cases of C1-C2 traumatic vertical dissociation. In one of the cases, the dissociation occurred at the moment of trauma, and in the other, the dissociation was created by traction; this was a type II odontoid fracture that extended bilaterally through the C2 articular capsulae.

In 1996, Przyblski and Welch [15] described one case of type III odontoid fracture, in which traction with lb 5 (1.87 kg) created a traumatic vertical atlantoaxial dissociation.

In 1997, Weiner and Brower [19] described a case of C1-C2 dissociation, created at the time of trauma, in a patient with congenital fusion between the C1 articular mass and the occipital condyle. The author considered distraction to be the mechanical basis of this lesion, and the fusion to be a factor of stress, developing a distraction overload between C1 and C2.

In addition to these cases, three other cases of posterior C1-C2 subluxation have been described, without odontoid fractures [9, 14, 16]. In these cases, C1 became displaced at the back and lodged behind the axis odontoid process. Although there was no immediate evidence of longitudinal distraction, a certain longitudinal distraction between C1 and C2 is required to produce atlas displacement over and behind the axis odontoid process. However, in spite of the distraction, these patients were also submitted to cranial traction with a maximum of lb 26 (9.70 kg) for reduction, helped by manual traction, including the use of general anesthesia in one of the cases [9]. There were no

complications related to hyperdistraction due to the traction in any of the three cases.

In the present case, hyperdistraction with C1-C2 dissociation was only identified after the traction had been installed. Part of the C1 anterior arch remained in its pre-traction locus, without migration with the rest of the atlas. Fractures of the C1 anterior arch are thought to be avulsions produced by the superior attachment of the longus colli muscle [6]. However, these fractures are smaller, involving only the caudal part of the anterior arch.

C1-C2 dissociation occurs with complete ligament lesion [1,5]. It is possible to speculate that the lesion occurred at the moment of the trauma, well before the traction. The identification of lesions can be difficult in cases in which there is spontaneous reduction after subluxation [10]. Traction may recreate the mechanism of trauma in spontaneously reduced lesions. However, the traction may cause an ulterior ligament lesion in a system that, though previously damaged, nonetheless had a preserved C1-C2 vertical stability [11, 12,17]. A magnetic resonance imaging (MRI) study might have provided additional information about the integrity of the ligament system, but it was not available in the acute phase of the treatment on that occasion.

Przyblski and Welch [15] mention that cranial traction should be avoided when there are wide atlantoaxial separations, even in the presence of great displacements. The reduction of C1-C2 dislocation can also be performed by simple head extension [3]. This maneuver is the preferred choice, as it is quick and does not present a risk of hyperdistraction.

Weiner and Brower reported a case of reduced hyperdistraction using axial compression [19], and Jeanneret et al. reported that traction under fluoroscopic control augments the safety of the method [11].

Conclusion

Skull traction with distractive forces may cause or precipitate vertical atlantoaxial dissociation in patients with C1-C2 dislocations. Therefore, it must be avoided. Other types of reduction, such as simple head extension, under fluoroscopic control or under axial compression, should be considered as an alternative to treat these cases.

References

- Adams VI (1992) Neck injuries. II. Atlantoaxial dislocations – a pathologic study of 14 traffic fatalities. *J Forensic Sci* 37:565–573
- Apuzzo MLJ, Heiden JS, Weiss MH, et al (1978) Acute fractures of the odontoid process. An analysis of 45 cases. *J Neurosurg* 48:85–91
- Cooper PR (1992) Posterior stabilization of the cervical spine. *Clin Neurosurg* 40:286–320
- Crutchfield WG (1954) Skeletal traction in treatment of injuries to the cervical spine. *JAMA* 155:29–32
- Davis D, Bohlman H, Walker E, Fisher R, Robinson R (1971) The pathological findings in fatal craniospinal injuries. *J Neurosurg* 34:603–613
- Eichler ME, Vollmer DG (1996) Cervical spine trauma. In: Youmans JR (ed) *Neurological surgery. A comprehensive reference guide to the diagnosis and management of neurosurgical problems*. Saunders, Philadelphia London Toronto, pp 1939–1968
- Grogono BJS (1954) Injuries of the atlas and axis. *J Bone Joint Surg* 36:397–410
- Hammer AJ (1991) Lower cranial nerve palsies. Potentially lethal in association with upper cervical fracture-dislocations. *Clin Orthop* 266:64–69
- Haralson RH, Boyd HB (1969) Posterior dislocation of the atlas on the axis without fracture. Report of a case. *J Bone Joint Surg* 51:561–566
- Hudgins PA, Hudgins RJ (1989) Radiology of cervical spine trauma. *Clin Neurosurg* 37:571–595
- Jeanneret B, Magerl F, Ward JC (1991) Overdistraction. A hazard of skull traction in the management of acute injuries of the cervical spine. *Arch Orthop Trauma Surg* 110:242–245
- Lee AS, Maclean JCB, Newton DA (1994) Rapid traction for reduction of cervical spine dislocations. *J Bone Joint Surg* 76:352–356
- Maiman DJ, Yoganandan N (1989) Biomechanics of cervical spine trauma. *Clin Neurosurg* 37:543–570
- Patzakis MJ, Knopf A, Elfering M, Hoffer M, Harvey P (1974) Posterior dislocation of the atlas on the axis. A case report. *J Bone Joint Surg* 56:260–262
- Przyblski GJ, Welch WC (1996) Longitudinal atlantoaxial dislocation with type III odontoid fracture. *J Neurosurg* 84: 666–670
- Sassard WS, Heinig CF, Pitts WR (1974) Posterior atlanto-axial dislocation without fracture. Case report with successful conservative treatment. *J Bone Joint Surg* 56:625–628
- Scher AT (1981) Overdistraction of cervical spinal injuries. *S Afr Med J* 25: 639
- Star AM, Jones AA, Cotler JM, Balderston RA, Sinha R (1990) Immediate closed reduction of cervical spine dislocations using traction. *Spine* 15: 1068–1072
- Weiner BK, Brower RS (1997) Traumatic vertical atlantoaxial instability in a case of atlanto-occipital coalition. *Spine* 22: 1033–1035