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Prognosis of neurological deficits associated with upper cervical spine injuries

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We investigated the type of injury and neurological prognosis in 82 patients with an upper cervical spine injury with neurological deficits, from a total of 247 such patients that we treated, from which 11 patients who were dead on arrival had been excluded. The incidence of neurological deficits in upper cervical spine injury was 33%. They were classified into three signs; cord, upper cervical nerve root, and cranial nerve signs. The types of injury accompanied by neurological deficits were burst fracture of the atlas, type II dens fracture, body fracture of the axis, type II traumatic spondylolisthesis of the axis, atlanto—occipital dislocation, and atlanto-axial dislocation. Most were unstable vertebral injuries. The four patients who died after arrival at hospital had complete tetraplegia with respiratory distress. The neurological deficit was one of paresis in the 78 patients who survived; in many, the paresis was mild with a resulting good neurological prognosis.

Keywords: upper cervical spine injuries; neurological deficit; unstable injury; respiratory distress; paresis; prognosis

Introduction

The type of injury and the clinical manifestations associated with an upper cervical spine injury differ greatly from those associated with a lower cervical spine injury because of the difference between the upper and lower cervical spine in its functional anatomy. Upper cervical spine injury with a severe neurological deficit results in death.[1-13] In those who survive an upper cervical spine injury is occasionally overlooked due to lack of characteristic clinical symptoms and sometimes mild or absent neurological deficit,[1-3,8,10-19] and to clouding of consciousness caused by an associated head injury.[1-5,8,10-13,16,19] However, even a mild neurological deficit may likely be a sign of an unstable injury.[3,10,11,15,16] It is very important as it may lead to early diagnosis and an ability to determine the therapeutic plan. It is vital to have a thorough knowledge of the type of injury and the clinical manifestations associated with an upper cervical spine injury in order to diagnose and treat this injury at an early stage. It is also important to have good knowledge of the characteristics and prognosis of the neurological deficits that may be associated with an upper cervical spine injury. The object of this study is to clarify the characteristics and prognosis of the neurological deficits associated with an upper cervical spine injury by investigating the type of injury and the therapeutic outcome.

Methods

During the 27 year period from 1966 to 1992, with the exception of 11 patients who were dead on arrival (DOA), 247 patients with 275 injuries of the upper cervical spine were treated at the Keio University Hospital and affiliated hospitals (Table 1). Ninety-one out of 247 cases showed neurological deficits. In this study, 82 patients who presented with neurological deficits observed immediately after injury were reviewed, whereas seven patients with neurological deficits caused by concomitant injury to other locations of the spine and two patients with a delayed myelopathy were excluded from our study. The subjects consisted of 60 males and 22 females. The age averaged 29 years, ranging between 3 and 71 years, including six children who were under 10 years of age. Fifty-four had injuries caused by traffic accidents, 22 by falls, and six by a sport accident. The time from injury to arrival at the hospital was 30 min to 8 days. Sixty-nine of the patients arrived on the day of their injury.

Upper cervical spine injury cases were separated into those with fractures and pure dislocations depending on the type of injury. Fractures were classified as posterior arch fracture, burst fracture or lateral mass fracture of the atlas, or as dens fracture, body fracture, traumatic spondylolisthesis (hangman's fracture) or spinous process fracture of the axis. Pure dislocations were classified as atlanto-occipital dislocation (AOD), atlanto-axial dislocation (AAD) or C2–3 dislocation. Furthermore, dens fracture of the axis were subclassified into four subtypes: Anderson and D'Alonzo[3] type I, II or III, or pediatric traumatic epiphyseal separation. Hangman's fractures were subclassified into four types: Levine and Edwards[16] type I, II, IIa or III. AAD cases were divided into anterior dislocation, posterior

Table 1 Types of upper cervical spine injury in 258 patients with 286 injuries

Type of injury	*Dead on arrival*	*Survived on arrival*	*Associated neurological deficit*		*Short term survival*
			Isolated injury	*Combined injury*	
Fracture of the atlas					
Posterior arch fracture		11		3	
Burst fracture		18	3	2	
Lateral mass fracture		1	1		
Fracture of the axis					
Dens fracture					
Type I		2			
Type II	3	61	23	2	1
Type III		30	8	4	
Traumatic epiphyseal separation		7	2		
Body fracture		31	8	4	
Hangman's fracture					
Type I		37			
Type II	1	14	6	3	
Type IIa		1	1		
Type III	1	1	1		
Spinous process fracture		2			
Atlanto-axial dislocation	2	3	3		2
Anterior dislocation		26	12		
Posterior dislocation	3	1	1		
Rotatory dislocation	1	1	1		
Atlanto-axial rotatory fixation		19			
C2–3 dislocation		9	3		1

Table 2 Relationship between types of injury and neurological deficits in 82 patients

Type of injury	*Neurological deficit*	*Spinal cord injury*	*Upper cervical nerve root injury*	*Cranial nerve injury*
Burst fracture of the atlas	3	2	1	1
Lateral mass fracture of the atlas	1	1	1	
Dens fracture				
Type II	23	15	11	1
Type III	8	7	7	1
Traumatic epiphyseal separation	2	2	2	
Body fracture of the axis	8	6	3	4
Hangman's fracture				
Type II	6	6	4	4
Type IIa	1	1		
Type III	1	1	1	
Atlanto-occipital dislocation	3	2	1	1
Atlanto-axial dislocation				
Anterior dislocation	12	9	4	2
Posterior dislocation	1		1	
Rotatory dislocation	1	1		
C2–3 dislocation	3	2	1	
Posterior arch fracture of the atlas and type II dens fracture	1	1		
Posterior arch fracture of the atlas and type III dens fracture	2	1	1	
Burst fracture of the atlas and type II dens fracture	1	1	1	1
Burst fracture of the atlas and type II hangman's fracture	1		1	
Body fracture of the axis and type III dens fracture	2		2	2
Body fracture of the axis and type II hangman's fracture	2	2	1	

dislocation, rotatory dislocation or atlanto-axial rotatory fixation (AARF). According to our classification, 73 patients had isolated injuries and nine had combined injuries (Table 2).

Treatment
Thirty-two patients were treated conservatively and 50 had an operation. The halo vest was the main method used in conservative treatment. Skull traction and a cast were applied before using the halo vest. A few patients only had a cervical orthosis. The surgical procedures used were transoral anterior fusion in seven cases, anterior screw fixation (Figure 1) in 21 cases, C2–3 anterior fusion (Figure 2) in 10 cases, occipito-cervical posterior fusion in two cases, and atlanto-axial posterior fusion in 10 cases.

After excluding the four patients who died, the follow-up period in the 78 patients who survived averaged 26 months, ranging between 11 and 146 months. Neurological deficits were evaluated when the patient arrived at hospital, at 1 month after injury, and at final follow-up.

Results

The types of injury of the four patients who died after arrival at the hospital were; two with AOD (Figure 3a), one with a type II dens fracture with posterior displacement, and one patient with a C2–3 dislocation (Figure 3b). All died 2–54 h after injury because of complete paralysis causing respiratory failure. Including patients who were DOA, four of five patients with AOD and three out of four with posterior dislocation of the atlas on the axis died. Only one patient in each type of these injuries survived (Figure 4).

Among the 247 patients with an upper cervical spine injury, 82 (33%) had neurological deficits, of which 60 (24%) had cord signs, 43 (17%) had upper cervical nerve root signs, and 17 (7%) had cranial nerve signs (Table II). Fifty-two patients presented with only one symptom and 30 presented with multiple symptoms. Cord signs in the four patients who died were Frankel[20] A, complete paralysis with respiratory tetraplegia. In the 56 patients who survived, cord signs were Frankel C or D paresis of whom two had respiratory distress (Figure 5). According to the classification of paralysis by Crandall and Batzdorf,[21] 19 patients had a central

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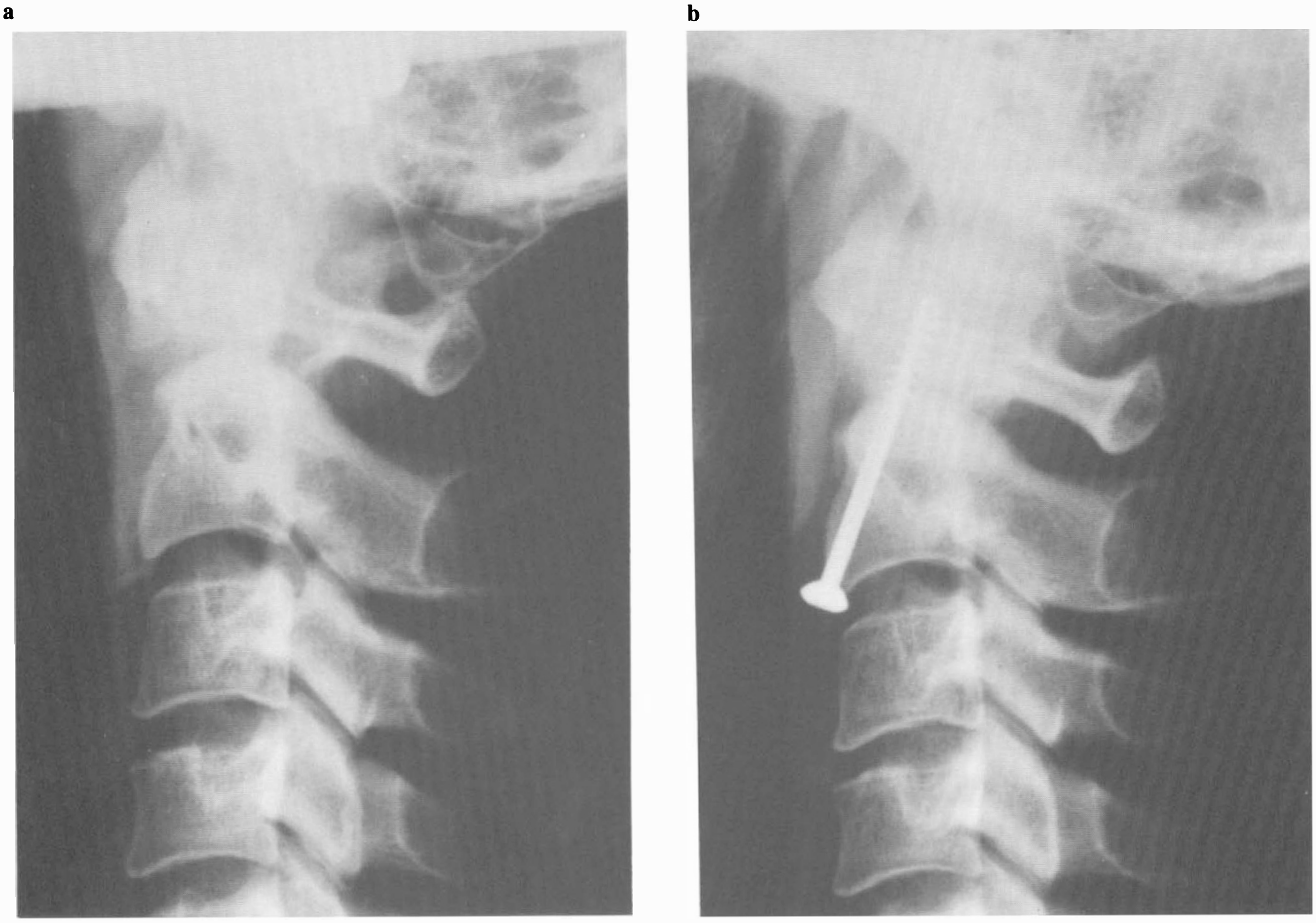

Figure 1 Anterior screw fixation for type II dens fracture. (a) This 40-year-old man had a transient quadriparesis. Preoperative lateral roentgenogram showed a type II dens fracture with anterior displacement. (b) Postoperative lateral roentgenogram showed an anatomical reduction and solid bony union

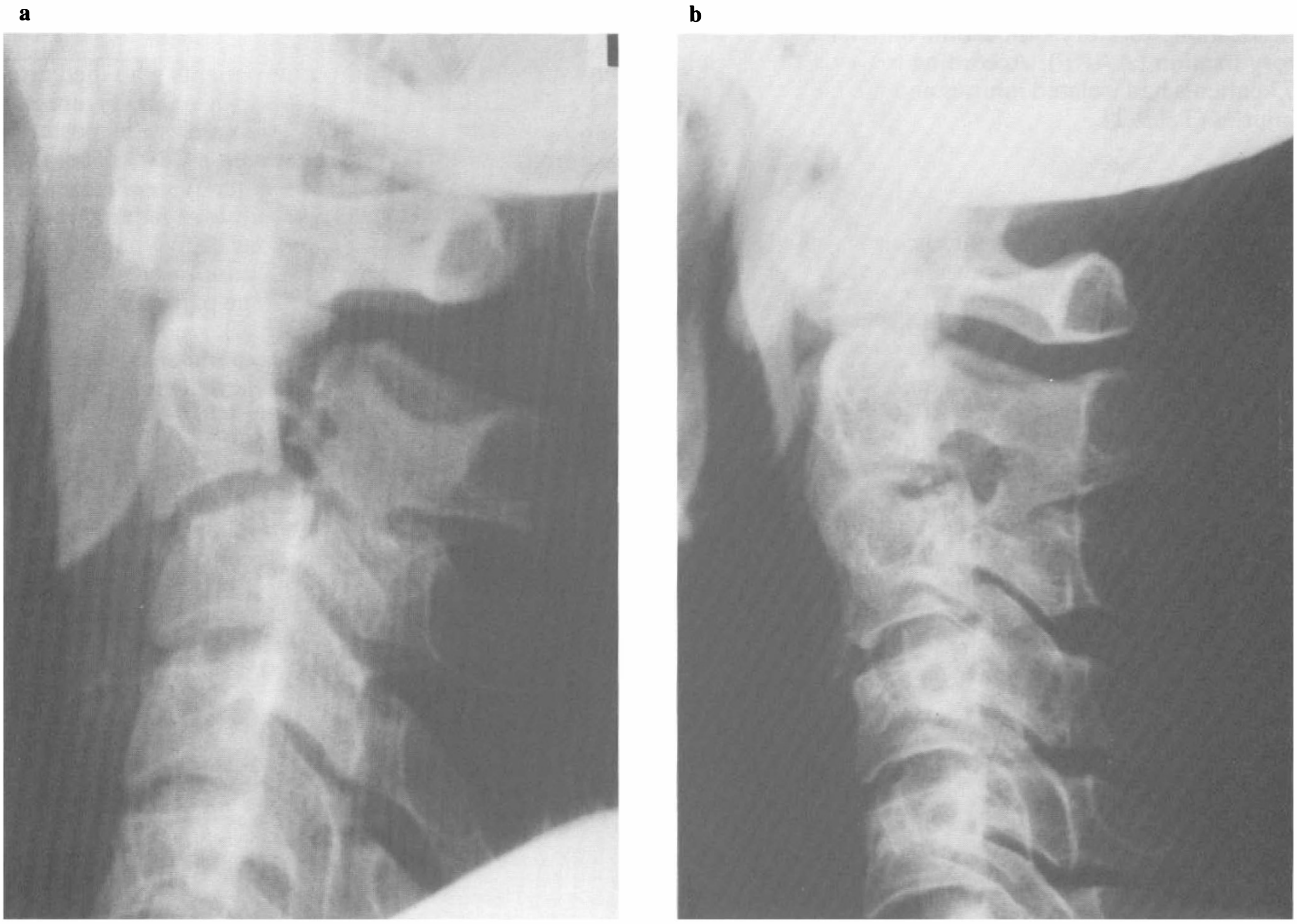

Figure 2 Anterior interbody fusion of C2–3 for type II hangman's fracture. (a) This 31-year-old man had Brown-Séquard syndrome and C2 neuralgia. Preoperative lateral roentgenogram showed a type II hangman's fracture. (b) Postoperative lateral roentgenogram showed solid bony union of the hangman's fracture

cord syndrome, 13 had a motor system syndrome, 22 had a transverse lesion syndrome, and three a Brown-Séquard syndrome. Three patients who could not be classified using the above classification had a cruciate type of paralysis.[22] Most of the upper cervical nerve root symptoms consisted of hyperalgesic neuralgia of the C2 and C3 dermatomes. Cranial nerve involvement was of the V and IX–XII nerves, and 10 of 17 patients had unilateral deficits.

The types of injury causing neurological deficits were studied in relationship to the symptoms they presented. In isolated injuries, the types of injury with cord signs were burst or lateral mass fractures of the atlas, type II or III dens fracture, traumatic epiphyseal separation, body fracture of the axis, type II, IIa or III hangman's fracture, AOD, AAD, and C2–3 dislocation. But in those with combined injuries, the types of injury with cord signs were posterior arch fracture, burst fracture of the atlas, or body fracture of the axis combined with either dens fracture or hangman's fracture (Table 2). The types of injury causing upper cervical nerve root signs were almost identical to those with cord signs, and one third of the patients with neurological deficits had both nerve root and cord symptoms. The types of injury causing cranial nerve signs did not differ much from those causing other neurological deficits. Neurological deficits did not occur in patients with only a posterior arch fracture of the atlas, type I dens fracture, type I hangman's fracture, spinous process fracture of the axis, or AARF.

Neurological recovery at 1 month after injury and final follow-up were considered in four grades, as dead, unchanged, improved or cured, based on the degree of the initial neurological deficit. Neurological recovery at 1 month after injury in the 60 patients with cord signs was evaluated as dead in four (7%), unchanged in nine (15%), improved in 17 (28%), and cured in 30 (50%). At the final follow-up, the result was: four had died (7%), unchanged in two (3%), improved in nine (10%), and cured in 45 (75%). Neurological recovery at 1 month after injury in the 43 patients with upper cervical nerve root signs was evaluated as unchanged in 10 (23%), improved in 15 (35%), and cured in 18 (42%). At the final follow-up, it was evaluated as unchanged in four patients (9%), improved in five (12%), and cured in 34 (79%). Neurological recovery a b

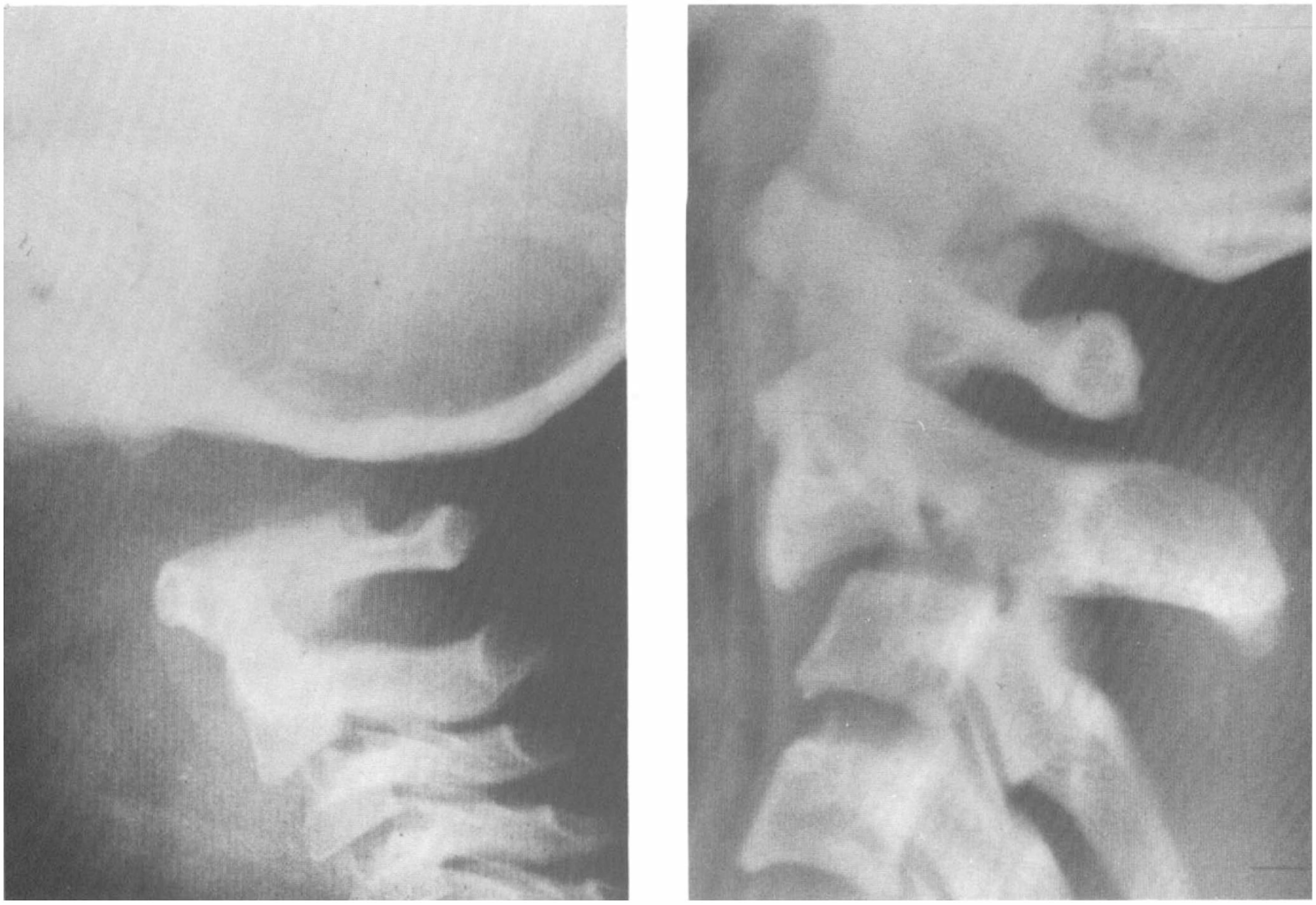

Figure 3 Upper cervical spine injury with short term survival. (a) This 5-year-old girl had a complete quadriplegia with severe respiratory distress. The lateral roentgenogram showed a dislocation of the atlanto-occipital articulation. Despite immediate intubation and control of general condition, she died 2 h after the injury. (b) This 25-year-old man had a complete quadriplegia with respiratory distress. The lateral roentgenogram showed a dislocation of C2–3. Despite immediate intubation, reduction of the dislocation using skull traction and control of general condition, he died 54 h after the injury

at 1 month after injury in the 17 patients with cranial nerve signs was evaluated as unchanged in five (29%), improved in eight (47%), and cured in four (24%). At the final follow-up, it was evaluated as unchanged in one patient (6%), improved in two (12%), and cured in 14 (82%). Neurological recovery was achieved in 70% or more of the patients at 1 month after injury, and in 90% or more at the final follow-up independent of the type of neurological deficit (Table 3). Furthermore, many of the patients were cured by the time of the final follow-up, which indicates that the neurological prognosis had been good.

Discussion

The characteristics of the neurological deficits associated with an upper cervical spine injury are lethal in severe cases. However, in patients who survive, neurological deficits occur infrequently and, if they do occur, they are often mild.[1–19] The reason for this lies in the anatomical relationship between the upper cervical spine and the cervical spinal cord. Severe cervical spinal cord injury above C4 spinal cord segment is frequently associated with respiratory failure and is lethal.[4–6] However, the sagittal diameter of the spinal canal in the upper cervical region becomes wider above C2–3 relative to the lower cervical region.[23] In addition, the spinal cord can move up and down according to the movement of the cervical spine, and the spinal cord itself can expand and contract.[24] This should allow the upper cervical spinal cord to resist injury to some extent despite narrowing of the sagittal diameter of the spinal canal, or the cervical spine being vertically dislocated. Thus neurological deficits can be absent or be mild. Neurological deficits that occur under these circumstances, although mild, may be a consequence of an unstable injury which may result in death if left unattended.[9,13,25] Therefore it is necessary to have sufficient knowledge of the neurological deficits that are characteristic of these types of injury. The results of the investigation presented in this study clarify the characteristics of the neurological deficits associated with an upper cervical spine injury according to the type of injury and its neurological prognosis.

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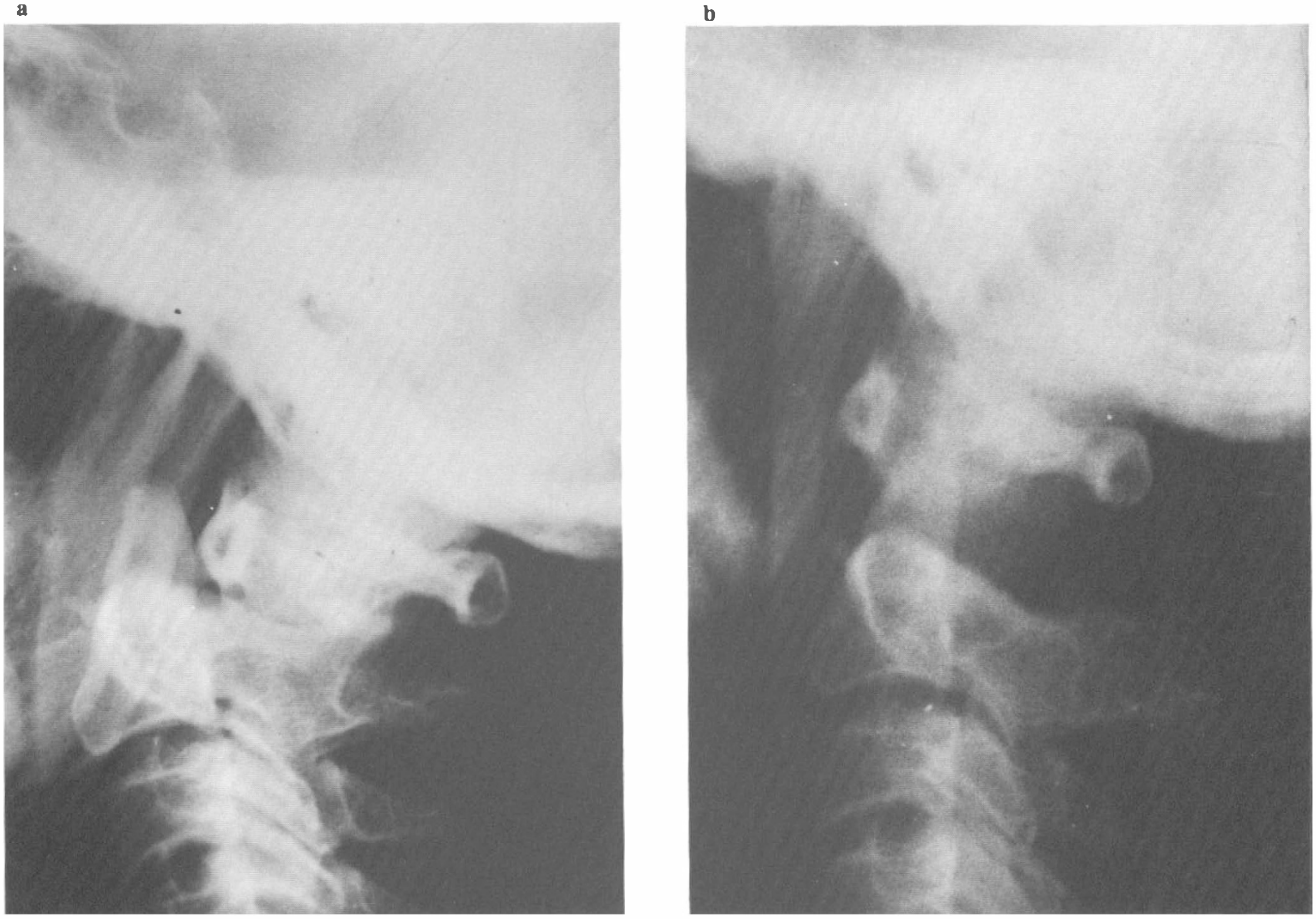

Figure 4 Posterior dislocation of the atlas on the axis with survival. (a) This 54-year-old man complained of only a C2 neuralgia. The lateral roentgenogram on admission showed a posterior dislocation of the atlas on the axis. (b) Skull traction was applied and manual closed reduction of the dislocation was performed under image intensifier control. The lateral roentgenogram after reduction showed a normal position of the atlas with respect to the axis

Very severe neurological deficits associated with an upper cervical injury can cause respiratory failure, with a fatal outcome. Including those who were DOA, four out of five with AOD and three out of four with a posterior dislocation of the atlas on the axis died.

Regarding pure dislocations, two types were frequently lethal. These results are in accordance with the reports of many previous studies.[4,5,7,9,13,26–29] The result that 20–50% of patients with neurological deficits which survived were cured at 1 month after injury indicates that the neurological deficits were transient in many of these patients. All who had cord signs were limited to paresis which was quite mild. The types of injury that were associated with neurological deficits were burst fracture of the atlas, type II and III dens fractures, body fracture of the axis, type II hangman's fracture, AOD, and AAD. Most of them were unstable injuries. However, 50% of the unstable injuries were not accompanied by neurological deficits. Posterior arch fracture of the atlas, type I dens fracture, type I hangman's fracture, spinous process fracture of the axis, and AARF were not accompanied by neurological deficits. These facts suggest that even transient or mild neurological deficits associated with upper cervical spine injury may be a sign of unstable injury. Since many of these patients had only mild paresis, a good neurological prognosis can be expected. Thus it is important to reach an accurate diagnosis and to select an appropriate treatment for patients with an upper cervical spine injury with associated neurological deficits.

Conclusions

Eighty-two patients with an upper cervical spine injury associated with neurological deficits were studied. Very severe neurological deficits caused respiratory failure—which often led to a fatal outcome. In patients who survived, the neurological deficits were a sign of an unstable injury; many had a mild paresis, with a good neurological prognosis.

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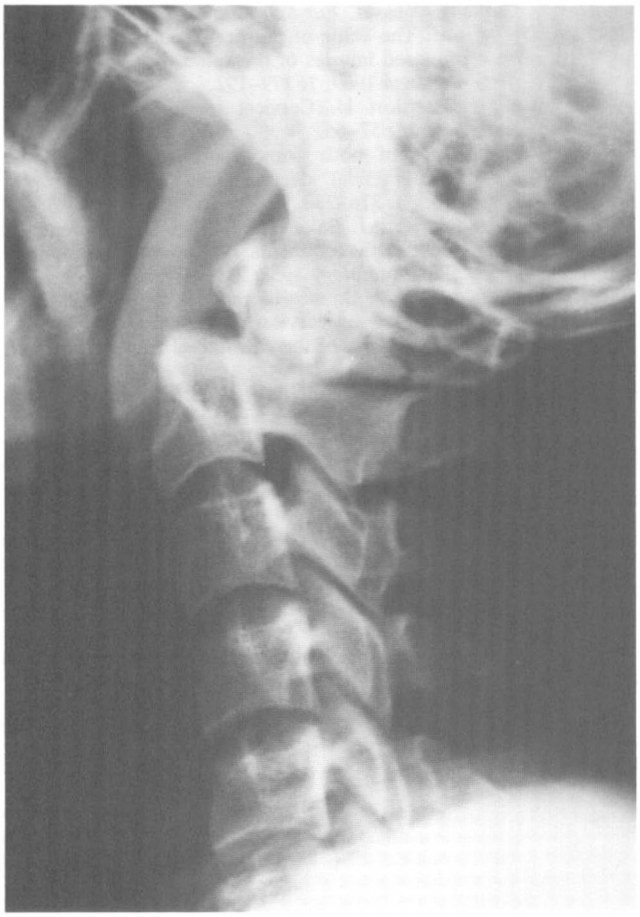

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Figure 5 Quadriparesis with respiratory distress due to type II dens fracture. (a) This 17-year-old woman had a quadriparesis with respiratory distress. The lateral roentgenogram showed a type II dens fracture with posterior displacement and posterior arch fracture of the atlas. (b) The fracture was reduced and neurological deficit was fully recovered after applying a halo vest. The lateral roentgenogram showed an anatomical reduction and solid bony union

Table 3 Neurological recovery

Neurological deficit	*1 month after injury*				*Final follow-up*			
	Dead	*Unchanged*	*Improved*	*Cured*	*Dead*	*Unchanged*	*Improved*	*Cured*
Spinal cord injury ($n = 60$)	4 (7%)	9 (15%)	17 (28%)	30 (50%)	4 (7%)	2 (3%)	9 (15%)	45 (75%)
Upper cervical nerve root injury ($n = 43$)	0 (0%)	10 (23%)	15 (35%)	18 (42%)	0 (0%)	4 (9%)	5 (12%)	34 (79%)
Cranial nerve injury ($n = 17$)	0 (0%)	5 (29%)	8 (47%)	4 (24%)	0 (0%)	1 (6%)	2 (12%)	14 (82%)

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