Traumatic Injuries of the Cervical Cord and Spine

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Summary: Eighteen patients with traumatic injuries of the cervical spine and cord have been treated in our department during the last 15 years. A review of these patients and results of treatment were described. Factors affecting the outcome of traumatic cervical injuries were also analyzed.

Key words: cervical injury—cervical spine—cervical cord—spinal cord injury—Odontoid fracture—atlanto-axial dislocation—myelography

Introduction

Traumatic injuries of the cervical cord and spine are frequently encountered at neurosurgical clinic as an associated lesion with head trauma. 18 patients with traumatic cervical injury have been treated in our clinic during the last 15 years. A review of these patients was undertaken to identify the factors affecting the outcome of traumatic cervical injury and the results of treatment.

Clinical Cases and Method

The study included 18 patients with traumatic injury of the cervical cord and spine who were admitted and treated by our department since 1968. All but one patient was male and the age ranged from 6 months to 83 years with an average 40 years. The time between injury and admission varied from one hour to 3 months. In all patients with acute cervical cord injury, the airways, and blood pressure were immediately stabilized and the patients

were immobilized in skeletal or Glisson traction units. A steroid and mannitol at standard dose were administered to most patients. Following an x-ray examination of the cervical spine, a myelogram was performed when subarachnoid block was suspected from the Queckenstedt test. Surgical treatment was performed in 2 patients with complete subarachnoid block. Conservative treatment consisted of plaster casting or spinal orthosis following traction. Surgical treatment was also performed in patients with unstable odontoid fractures. In this series, the clinical findings, the mechanism of injury, the radiological findings and the managements were analyzed (Table 1). The mechanism of injury was judged by mode of injury, site of soft-tissue lesion and x-ray finding, and divided into hyperextension and hyperflexion injuries. The level of cervical cord injuries were divided into upper (C₁-C₂) and lower (C₃-C₈) cervical lesion. The type of cord lesion was classified as complete cord, incomplete cord, central cord and Brown-Séquard type according to the neurological status. The outcomes of the patients were classified

TABLE 1
Cases with traumatic injury of the cervical spine and cord (1968 - 1982)

No.	Year	Name	Age(yrs)	Sex	Cause of Injury	Possible Mechanism of Injury	Lesions		Associated Injuries
							Spine	Cord	
1.	1968	T. S.	27	M.	collision (motor vehicle accident)	unknown	—	+	head trauma (I)
2.	1973	F. N.	18	M.	rugby foot ball	hyperflexion (?)	+	—	head trauma (I)
3.	1973	W. I.	15	M.	diving	hyperflexion	+	+	head trauma (I)
4.	1973	T. S.	44	M.	bicycle accident	hyperextension	—	+	head trauma (III) facial trauma
5.	1974	D. F.	83	M.	fall from height	hyperextension	+	+	head trauma (III)
6.	1974	K. K.	60	M.	stone fell on head	hyperflexion	+	+	head trauma (II)
7.	1975	N. T.	58	M.	fall from height	hyperflexion	—	+	head trauma (I)
8.	1976	K. K.	59	M.	fall from height	hyperextension	—	+	head trauma (II)
9.	1978	K. T.	47	M.	hit by car	hyperflexion	+	+	head trauma (III)
10.	1979	T. N.	0.6	M.	fall at home	flexion (lateral ?)	+(?)	—	head trauma (I)
11.	1980	K. H.	16	M.	hit by car	unknown	—	+	head trauma (II)
12.	1980	S. Y.	39	M.	fall from moving vehicle	hyperextension	+	—	head trauma (II)
13.	1982	S. H.	59	M.	fall from height	hyperextension	+	+	head trauma (?)
14.	1982	T. S.	62	M.	automobile accident	hyperflexion	+	+	head trauma (II) facial trauma
15.	1982	Y. K.	11	M.	hit by car	hyperflexion	+	—	head trauma (III) hemo-pneumothorax
16.	1982	T. T.	26	M.	diving	hyperflexion	+	+	head trauma (I)
17.	1982	Y. T.	56	M.	fall at home	hyperextension	—	+	head trauma (I) facial trauma
18.	1982	N. M.	58	F.	fall from hight	hyperflexion	+	+	head trauma (I)

head trauma (I-IV): Araki's classification

TABLE 2
Traumatic cervical cord injuries (14 cases)

No.	Name	Age(yrs)	Sex	Time from Injury to Admission	X-P Findings	Level and Type of Lesions	Managements	Outcome
1.	T. S.	27	M.	3 months	normal	C ₄ Brown-Séquard	conservative	fair
2.	W. I.	15	M.	3 hours	fracture dislocation (C ₄ -C ₅)	C ₅ complete cord	conservative	dead
3.	T. S.	44	M.	5 months	normal	C ₅ incomplete cord	conservative	fair
4.	D. F.	83	M.	24 hours	chip fracture (C ₃)	C ₆ complete cord	conservative	dead
5.	K. K.	60	M.	11 hours	fracture of spinous process (C ₄ and C ₅)	C ₄ complete cord	conservative	poor
6.	N. T.	58	M.	3 hours	normal	C ₅ central cord	conservative	good
7.	K. K.	59	M.	5 days	congenital narrow spinal canal	C ₅ complete cord	conservative	poor
8.	K. T.	47	M.	10 days	odontoid fracture AAD	C ₅ central cord	conservative	fair
9.	K. H.	16	M.	3 days	normal	C ₇ incomplete cord	conservative	fair
10.	S. H.	59	M.	1 hour	odontoid fracture AAD	C ₂ complete cord	conservative	dead
11.	T. S.	62	M.	3 hours	chip fracture (C ₆)	C ₅ central cord	conservative	fair
12.	T. T.	26	M.	2 hours	compression fracture (C ₅)	C ₅ complete cord	surgical (laminectomy and anterior fusion)	poor
13.	Y. T.	56	M.	12 hours	widened disc space (C ₅ -C ₆)	C ₆ central cord	conservative	good
14.	N. M.	58	F.	3 hours	fracture dislocation (C ₆ -C ₇) chip fracture (C ₇)	C ₆ incomplete cord	surgical (laminectomy)	fair

AAD: atlanto-axial dislocation

TABLE 3
Cases with upper cervical injuries

No.	Name	Age(yrs)	Sex	Possible Mechanism of Injury	X-P Findings	Neurological Manifestations	Managements	Outcome
1.	F. N.	18	M.	hyperextension (?)	fracture of lamina (C ₂)	radiculopathy	conservative	good
2.	T. N.	0.6	M.	flexion (lateral ?)	subluxation ? (C ₂ -C ₃)	radiculopathy (?)	conservative	good
3.	K. T.	47	M.	hyperflexion	odontoid fracture AAD (anterior)	central cord (C ₅)	conservative	fair
4.	S. Y.	39	M.	hyperextension	odontoid fracture	neck pain and limited neck motion	conservative	good
5.	S. H.	59	M.	hyperextention	odontoid fracture AAD (posterior)	complete cord (C ₂)	conservative	dead
6.	Y. K.	11	M.	hyperflexion	odontoid fracture AAD (anterior)	limited neck motion	surgical (posterior C ₁ -C ₂ fusion)	fair

AAD: atlanto-axial dislocation

into 3 categories as follows; Good: the patient was able to participate in almost normal life without dependence on other person. Fair: the patient was dependent on another person for some activities. Poor: the patient was completely dependent on other people.

Results

Cause of Injury

Traffic accidents including motor vehicle or bicycle accident and falls were the most common causes of injury (14 patients-77.8 %) resulted from them. Two other patients (11.1 %) were involved in diving accident and one was injured while involved in a sporting event (Table 1).

Mechanism of Injury

Ten patients (55.6 %) suffered from hyperflexion injury and 6 patients (33.3 %) from hyperextension injury. There were 2 patients in which the mechanism was unknown (Table 1).

Associated Injuries

All patients had minor or major head trauma as an associated lesions. Severe head injury (type III and IV of Araki's classification) was found in 4 patients. 3 patients suffered from facial trauma in addition to head trauma and hemo-pneumothorax was complicated in one instance (Table 1).

Site and Type of Cervical Injury

Cervical cord injury was observed in 14 patients (77.8 %) of which 10 patients had an associated cervical spine injury. All but one of these patients was male. The time interval from injury to admission varied from one hour to 3 months. A complete cord lesion was found in 6 patients (42.9 %), incomplete cord lesion in 3 (21.4 %), central cord lesion in 4 (28.6 %) and Brown-Séquard type in one patient. 7 of 14 patients

(50 %) had damage at the level of C₅ and 3 (21.4 %) had damage at C₆. Damage in the others was located at C₂, C₄ or C₇ (Table 2). Upper cervical injuries with or without cord lesions occurred in 6 of 18 patients (33.3 %) and odontoid fracture was found in 4 patients. Atlanto-axial dislocation was observed in 3 of 4 patients with odontoid fracture. Cervical cord lesion were found in two patients (Table 3).

Treatment and Outcome

Surgical treatment was performed on 2 patients with cord lesions (case 12 and 14 in Table 2). The others were treated conservatively. The former included decompressive laminectomy with or without fusion. The final outcome of the patients with cord lesions was: 2 good (14.3 %), 6 fair (42.9 %), 3 poor (21.4 %) and the mortality rate was 21.4 % (Table 2). All but one patient with upper cervical injuries were treated conservatively and 5 of 6 patients had an outcome of good or fair. Posterior C₁-C₂ fusion was done in a surgically treated patient (Table 3).

Mechanism of Injury and Cord lesion

Ten of 12 patients (83.3 %) had damage at the C₅-C₆ level, of which 6 patients suffered from hyperflexion injury and the other 4 patients suffered from hyperextension injury. 3 of 4 patients with central cord lesions was caused by hyperflexion injury in the present series (Table 4). However there was no correlation between the mechanism of injury and the outcome.

X-P Finding, Cord Lesion and Outcome

Abnormal findings on plain x-ray film were demonstrated in 12 of 18 patients (66.7 %) and 10 patients (55.6 %) had associated cervical cord lesions. The most common features on x-ray film were fracture dislocation (2 cases), compression or chip fracture (3 cases) and odontoid fracture (4 cases). The latter was found in 2 instances among the patients with cervical cord lesions. No radiological abnormalities were found in 4 of 14 patients (28.6 %). All 6 patients with complete cord lesion had abnormal findings on x-ray film of the spine. The outcome depend upon the pres-

TABLE 4
Mechanism of injury and cord lesion

Level of Cord Lesion	Hyperflexion	Hyperextension	Case No. (%)
C ₂	0	1	1 (8.3)
C ₄	1	0	1 (8.3)
C ₅	5	2	7 (58.3)
C ₆	1	2	3 (25.1)
	7 (58.3)	5 (41.7)	12
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Type of Cord Lesion			
Completed Cord	3	3	6 (50)
Incomplete Cord	1	1	2 (16.7)
Central Cord	3	1	4 (33.3)
	7 (58.3)	5 (41.7)	12

TABLE 5
X-P Finding and cord lesion

X-P Findings	Complete Cord	Incomplete Cord	Central Cord	Brown-Séquard	Case No. (%)
Fracture Dislocation	1	1	0	0	1 (14.3)
Compression and/or Chip Fracture	2	0	1	0	3 (21.4)
Odontoid Fracture	1	0	1	0	2 (14.3)
Spinous Fracture	1	0	0	0	1 (7.1)
Widened Disc Space	0	0	1	0	1 (7.1)
Congenital Narrow Spinal Canal	1	0	0	0	1 (7.1)
Normal	0	2	1	1	4 (28.7)
	6 (42.9)	3 (21.4)	4 (28.7)	1 (7.1)	14

X-P Finding and outcome

X-P Findings	Good	Fair	Poor	Dead	Case No. (%)
Fracture Dislocation	0	1	0	1	2 (14.3)
Compression and/or Chip Fracture	0	1	1	1	3 (21.4)
Odontoid Fracture	0	1	0	1	2 (14.3)
Spinous Fracture	0	0	1	0	1 (7.1)
Widened Disc Space	1	0	0	0	1 (7.1)
Congenital Narrow Spinal Canal	0	0	1	0	1 (7.1)
Normal	1	3	0	0	4 (28.7)
	2 (14.3)	6 (42.9)	3 (21.4)	3 (21.4)	14

ence of abnormal findings on the x-ray film. All expired patients had severe injury of the cervical spine (Table 5).

Level, Type of Cord Lesion and Outcome

The cervical cord lesion were located at the lower cervical level in all but one patient in this series (92.9 %). All patients with complete cord lesions had poor outcomes. Upper cervical cord lesions were also associated with unfavorable outcomes. However central cord lesions and Brown-Séquard type had good or fair outcomes. Fifty percent of the patients with central cord lesions became almost normal. The outcome was definitely related to the level

and the type of cervical cord lesion (Table 6).

Factors affecting the Outcome of Cervical Cord Injury

The age of the patients and the time interval from injury to admission had minimal influence on the final outcome. Neither conservative treatment nor surgical treatment in 3 patients affected the outcome. The most important factors for determining the final outcome were the level and type of cervical cord lesion. The mechanism of injury was also an important prognosticating factor because the type of cord lesion was determined to some degree by the mechanism of the injury.

TABLE 6
Level of cord lesion and outcome

Level of Cord Lesion	Outcome				Case No. (%)
	Good	Fair	Poor	Dead	
C ₂	0	0	0	1	1 (7.1)
C ₄	0	1	1	0	2 (14.3)
C ₅	1	3	2	1	7 (50)
C ₆	1	1	0	1	3 (21.4)
C ₇	0	1	0	0	1 (7.1)
	2 (14.3)	6 (42.9)	3 (21.4)	3 (21.4)	14

Type of cord lesion and outcome

Type of Cord Lesion	Outcome				Case No. (%)
	Good	Fair	Poor	Dead	
Complete Cord	0	0	3	3	6 (42.9)
Incomplete Cord	0	3	0	0	3 (21.4)
Central Cord	2	2	0	0	4 (28.6)
Brown-Séquard	0	1	0	0	1 (7.1)
	2 (14.3)	6 (42.9)	3 (21.4)	3 (21.4)	14

Discussion

Traumatic injury of the cervical cord and spine are commonly associated with head or facial injuries. Cervical trauma is occasionally undiagnosed when the patients have consciousness or when there are severe neurological deficits after head injury. Therefore, a meticulous neurological examination, x-ray of the cervical spine and intracranial investigations are essential for patients with severe head injuries.

The proposed mechanisms of cervical cord injuries are fracture dislocation for complete cord transection, hyperextension for central cord syndrome, unilateral facet subluxation for Brown-Séquard type and burst fracture or disc retropulsion for anterior cord syndrome (Marar, 1974). Schneider (1954) has previously shown that the mechanism of acute central cord syn-

drome is hyperextension. It has also been suggested recently that flexion forces to the spine of children produce more serious neural injuries than extension forces (Pang, 1982). In contrast to their descriptions, we observed no definite correlation between the mechanism of injury and the type of cord lesion except in the patients with central cord lesions where hyperflexion injury was more frequent.

As to the injury site of the cervical cord, cord damage most likely occurred at C₅-C₆ because hyperextension is maximum at thier junction (Scher, 1980) and the fulcrum for maximum flexion is also at this level (Braakman, 1968). Our present results also support this concept and 10 of 14 patients with cord lesion had damage at this level irrespective of the injury mechanism.

The age of the patient and the time of

treatment had no significant effect upon the final outcome. Early surgical therapy, or medical treatments such as steroid or mannitol, also did not influence the outcome. The only important factors were the level and the type of cord lesion, although the mechanism of injury and the presence of abnormal findings on the x-ray of the spine had some relationship to the severity of the cord lesion. Similar conclusions were presented recently stating that the initial injury remained the primary determinant of the neurological outcome (Wagner, 1982). Incomplete injuries of the cord had a significant potential for improvement, but complete lesion seldom improved (Chehrazi, 1981), and complete severe lesions did not recover. Only those with initially mild neural injuries make satisfactory neurological recovery even in the pediatric spinal cord injury (Pang, 1982).

Anderson and D'Alonzo (1974) suggested that the decision to perform early fusion rather than immobilization should be based on the location of odontoid fracture although the optimal management of this fracture remains controversial (Maiman, 1982). They have developed an anatomically based classification system: type 1 with fracture of the tip of the odontoid process; type 2 with fracture through the base of the odontoid process at the junction of the body of C₂-this is the most common type; type 3 with fracture through the body of C₂. Three of four patients with odontoid fracture in our series had Type 2 fractures and surgical treatment was performed in one child. Maiman (1982) recommended traction followed by posterior fusion for Type 2 fractures. This was performed in our patient because the surgical and long term morbidity is low, and satisfactory fusion can be expected.

Immobilization and reduction of fracture-dislocation with skeletal traction are well accepted measures in the management of patients with acute cervical cord injuries (Norrell, 1980) and neuronal compression

is the primary indication for surgical decompression (Jelsma, 1982). We believe that early decompression for patients with complete cord lesion with subarachnoid block on myelogram is effective in preventing secondary cord injury due to edema or swelling from the result of the surgically treated patient (Case 12 in Table 2). This patient suffered a hyperflexion injury from diving which resulted in a complete cord lesion at the level of C₅. Twelve hours after the injury, the patient underwent decompressive laminectomies between C₃-C₆ and a dural opening which was followed by anterior fusion. There was no aggravation of the neurological deficits or the ascending paralysis after the operation in this patient. In comparison a conservatively treated 15-year-old boy (Case 2 in Table 2) also manifested complete cord signs at the same level with complete subarachnoid block. The latter developed progressive neurological aggravation and died because of ascending paralysis due to secondary injury to the cervical cord. Further experience with early decompressive surgery for complete cord lesions with subarachnoid block may clarify the efficacy of this treatment for severe cervical cord injury with disappointing outcome.

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