The Influence of the Mechanism of Cervical Spine Injury on the Degree of the Spinal Cord Lesion

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Summary

In the years 1965 to 1988, 1687 patients with cervical spine injury were treated in the acute post-traumatic period. In the analysed material commonest cause for the injury was by a flexion mechanism (48%), less frequently compressive (26%), and by a hyperextension mechanism (26%). Radiological changes were related, to some extent, with the patients age. Compression and flexion fractures occur most often in young people, dislocations in older ones, and injuries caused by hyperextension in, most often, elderly age (average age 53 years). The mechanism of the injury influences the degree of the nervous system injury. Serious consequences usually occur with crushing of a vertebral body. Serious neurological disturbance may occur with a flexion mechanism; and rarely such serious neurological disturbances accompany injuries caused by a compression mechanism. There was a complete lesion of the spinal cord in only 11% of patients. Neurological improvement was achieved in 51% of patients; 31% had no improvement, and 18% of patients died during treatment. The best results were observed in the group of typical compression fractures (neurological improvement—81%), whereas the poorest was found in patients with a crush type of fracture (improvement in 17%, mortality 18%), and in those with dislocation (improvement in 25%, mortality rate—23%).

Key words: Mechanism of spinal injury; Spinal cord injury; Neurological improvement; Mortality rate.

Since the introduction of the classification of spinal fractures into stable and unstable by Nicoll (1949), it has been generally assumed that injuries due to a flexion mechanism leading to posterior ligamentous rupture and loss of spinal stability usually result in a severe lesion of the spinal cord (Holdsworth, 1970; Gertzbein, 1986). Contrary to unstable spinal injuries, stable injuries, particularly resulting from a compression mechanism, are regarded as less dangerous, and are usually not associated with severe damage to the spinal cord (Decoulx, 1981; Kiwerski, Kuli-

kowski, 1986). Clinical experience, however, shows that both flexion and compression fractures are not homogenous (Denis, 1983; Kiwerski, 1989; Kiwerski, in press; Louis, 1987). On the other hand, even considerable displacement of vertebrae may not be accompanied by significant neurological changes (Baker and Grubb, 1983; Bovill, 1971; Kiwerski, 1984; Pitman *et al.*, 1977), and serious spinal cord lesions not infrequently occur despite only slight post-traumatic radiological changes or even in the absence of symptoms of spinal damage.

Based on the analysis of clinical material I wish to evaluate the interdependence between the degree of the spinal cord lesion and the mechanism of cervical spine injury.

Clinical material

A series of 1687 patients with cervical spine injury treated at the early post-traumatic period within 1965 to 1988 has been analysed. The material does not include patients who either showed no spinal radiological post-traumatic changes, or had a spinal cord lesion due to a cause different from a direct spinal injury (by sharp objects, missile injuries, etc), as well as patients where there is no clear identifiable mechanism of injury.

Spinal injuries from a flexion mechanism have been divided into two subgroups: fractures and dislocations. The latter also includes fractures of the vertebral bodies with vertebral displacement. Injuries from a compression mechanism have been divided into: typical compression fractures of the vertebral body, and crush fractures involving fragmentation of the vertebral body with, as a rule, displacement of the posterior part of the body into the lumen of the vertebral canal. Table I shows the mechanisms of spinal injury in relation to the age of the patient. Most patients sustained their spine injury through a flexion mechanism (48% of cases), with dislocations being dominant (33% of all cases). Injuries from an extension mechanism occurred as frequently as those arising from a compression mechanism (26% each group). In injuries from a compression mechanism, typical fractures were noted more frequently than in patients with a crush fracture (14 and 12%, respectively).

The average age of the investigated patients was 42.9 years. Least numerous are the first and the last age groups: 13 and 14% of the younger and the older patients (over 65 years) respectively. Most patients were in the age group 21 to 35 years (27%), the remaining age groups were equal in number (23% each). Certain differences were noted with respect to age and the mechanism of injury. Injuries with vertebral body fracture are more frequent in young individuals, particularly so in

Table I Mechanism of injury

Mechanism of injury		Age of patient					Total
		up to 20	21-35	36-50	51-65	over 65	
Flexion	fracture	69	108	59	12	10	258
	dislocation	41	76	164	178	100	559
Compression	fracture	53	99	43	27	15	237
	crushing	54	116	19	4	2	195
Extension		8	52	105	163	110	438
Total		225	451	390	384	237	1687

Table II Level of spinal injury

Mechanism of injury		Level of spine injury			Total
		C ₁ -C ₃	C ₃ -C ₅	C ₅ -Th ₁	
Flexion	fracture	27	115	116	258
	dislocation	20	126	413	559
Compression	fracture	8	92	137	237
	crushing	—	94	101	195
Extension		120	141	177	438
Total		175	568	944	1687

those cases with crush fractures, of which 87% were sustained by patients aged up to 35 years. In crush fractures the average age was 27·2 years being the lowest. Similar tendencies are noted in patients with typical compression fractures and flexion fractures (average age of 34·6 and 31·8 years, respectively). Dislocations resulting from a flexion mechanism are more frequently sustained by older people (50% of patients over 50), with an average age of 48·2 years. Elderly patients most frequently sustain spinal injuries because of an extension mechanism (age average 53·1 years).

Table II presents the relation between the mechanism of the injury and the level of the spinal injury. The commonest group was patients with damage to the lower part of the cervical spine. Injuries to the C₅-Th₁ segment made up 56% of the whole group. The least numerous was the group who had upper cervical spine injuries (C₁-C₃), and made up only 10% of the injuries. A study of the Table shows that there are certain predispositions as to the level of injury associated with certain mechanisms of injury. Flexion-dislocations are rare in the uppermost cervical spinal segment (3%), relatively rare within the middle segment (23%), but are particularly frequent in the lower cervical spine (74%). Equally rare in the upper cervical segment were compression fractures (3%), while crush fractures were not noted at all. Damage to the upper cervical segment was relatively frequent from an extension mechanism (27%).

Mechanism of injury and degree of the spinal cord lesion

Table III shows the relation between the mechanism of injury and the degree of the spinal cord injury assessed on admission to hospital. The assessment of the spinal cord injury is made according to the three degree of classification of incomplete

Table III Degree of spinal cord lesion

Mechanism of injury		Spinal cord lesion on admission				without neurological deficit	Total
		complete	1	2	3		
Flexion	fracture	96	29	29	57	47	258
	dislocation	268	43	79	106	63	559
Compression	fracture	27	50	54	63	43	237
	crushing	149	21	14	10	1	195
Extension		111	63	116	90	58	438
Total		651	206	292	326	212	1687

injuries (Haftek *et al.*, 1968; Kiwerski, 1989), similar to Frankel's classification (1969):

1. Four limb paralysis with at least traceable deep sensation preserved in the feet.
2. Massive motor-sensory involvement.
3. Pareses of lesser intensity (the strength of paretic muscle groups greater than 3° by Lovett's scale).

The commonest injuries in our material are complete lesions of the spinal cord (39%). There are, however, noticeable differences in the degree of the spinal cord damage associated with particular mechanisms of injury. Flexion injuries often cause complete spinal cord lesions, referring particularly to vertebral dislocation. Forty eight per cent of patients had complete spinal cord lesions and only 11% had no relevant neurological deficits. In flexion fractures complete spinal cord lesions were noted in 37%, and absence of neurological deficits in 18% of patients. Injuries from a compression mechanism show a different distribution. In typical fractures complete lesions of the cord were seen in only 11%, whilst 18% had no neurological deficit. In crush fractures the occurrence of complete lesions was high, 76%, and only one patient had no neurological deficit.

In extension injuries the distribution of cord lesions is more uniform. Twenty five per cent of such patients sustained a complete spinal cord lesion, similar numbers refer to groups 2 and 3 with an incomplete injury, while 13% showed no evidence of a cord lesion.

Results of treatment

The results of treatment are set out in Table IV. The assessment involved only patients who had a neurological deficit on admission. The assessment of neurological recovery was based on the improvement of the neurological state observed during hospital treatment. Marked improvement denoted complete subsidence of neurological disorder, or neurological recovery by at least two degrees of our scale, e.g. from group 1 of incomplete injuries/tetraplegia with partially preserved deep sensation to group 3/pareses of lesser intensity/. The improvement was defined as fair if the patient recovered by one degree of the scale. No improvement means either no or very slight change in the neurological state.

Neurological recovery occurred in 51% of the patients, no recovery was noted in 31%, and the mortality was 18% of the analysed patients. The best results of treat-

Table IV Neurological improvement

Mechanism of injury		Neurological improvement			Dead	Total
		significant	satisfactory	No improvement		
Flexion	fracture	70	32	81	28	211
	dislocation	126	84	171	115	496
Compression	fracture	94	64	26	10	194
	crushing	33	21	104	36	194
Extension		124	105	73	78	380
Total		447	306	455	267	1475

ment was recorded in patients with a typical compression fracture, which is undoubtedly related to the less extensive spinal cord damage. In this group of patients neurological improvement was noted in 81%, being marked in 48%, and with the lowest mortality rate of 5%.

The results were poorest in the other type of compression injuries, i.e. crush fractures, where improvement was obtained in only 28% (17% with marked improvement), and in 54% no improvement was noted.

There are significant differences in the results of treatment in injuries from flexion mechanism. The results were slightly better in those with dislocations to fractures dislocations. A marked neurological improvement (33 and 25% in respective groups), and lower mortality (13 and 23% in fractures and dislocations, respectively). It should be remembered, however that dislocations were more often associated with a complete spinal cord lesion, and involved mainly patients over the age of 50 to 60 years. Relatively good results of treatment were obtained in patients with injuries resulting from an extension mechanism, neurological improvement was noted in 61% of patients, no recovery in only 19%. Mortality, however, was high (21%) and in our opinion was related to the older age of the majority of the patients.

Conclusions

1. Spinal injuries from a flexion mechanism prevailed in the analysed clinical material (48%). The incidence of injuries from a compression and extension mechanism was the same (26% of each).
2. The radiological changes are only to a certain extent related to the age of the injured person. Crush injuries occur almost exclusively in young individuals (average age of 27.7 years). Flexion fractures and typical compression fractures occur more frequently in young people (average age 31.8 and 34.6 years, respectively). Dislocations are commoner in older persons (average age 48.2 years), and extension injuries usually occur in elderly people (average age 53.1).
3. The mechanism of the injury affects the degree of the spinal cord lesion. The most serious sequela is observed in crush fractures of the vertebrae, which resulted in a complete spinal cord lesion in 76% of patients. The second most severe neurological sequela is observed in injuries from a flexion mechanism. In dislocations, a complete spinal cord lesion was found in 48% of patients: in flexion fractures in 37%. The incidence of severe neurological deficits was least common in patients with compression fractures (complete spinal cord lesion in 11%, no neurological deficit in 18%).
4. The best results of treatment occurred in those with a typical compression fracture (improvement in 81%, mortality below 5%). The poorest results were recorded in those with a crush fracture (improvement in 28% of cases, mortality 18%).

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