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CERVICAL INJURIES:  
FREQUENCY, ETIOLOGY, AND SEVERITY

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16. Abstract A review of a portion of the literature on the subject of cervical spine injury has been made. The findings and opinions of researchers relative to frequency, etiology, and severity of various types of injuries are summarized.					
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## CERVICAL INJURIES: FREQUENCY, ETIOLOGY, AND SEVERITY

### INTRODUCTION

A review of a portion of the literature (approximately 125 papers) on the subject of cervical injury has been made. The direct result of this is a table (appended) which identifies the types of injuries which occur to the cervical structure. Distinction is not generally made between cases resulting from automobile accidents and any other type of accident. The table summarizes the findings and opinions of the authors represented. As there was generally good agreement among the authors on the frequency, etiology, and severity of the various types of injuries, it is possible to capsule the contents of the table. That is done here. Also presented is a subjective analysis -- based on the content of the papers -- of the relative importance of the different elements of the neck as components of a structural model.

### CERVICAL INJURIES: A SUMMARY

According to one author (10), approximately 17% of auto-accident cervical injuries are fatal. Virtually all of the deaths result from lesions of the spinal cord. Many other types of injuries occur, involving discs, vertebrae, ligaments, nerves, and muscles. Most of these injuries are painful, and many severely disable the victim for months, but only when they cause immediate or eventual trauma to the cord do they threaten life.

Mortality in cases involving cervical cord injury is over 60%. Functional transection of the cord results in permanent tetraplegia and is nearly always fatal, death occurring within a few days. Incomplete lesions have an associated mortality of over 30%, and paraplegia usually occurs when death does not. Cord injury can result from hyperflexion violence or hyperextension violence. If ligaments between vertebrae rupture, then vertebral dislocation can occur, resulting in a local narrowing of the spinal canal. The cord may then be pinched, and the effects will be severe whether a discontinuity of cord tissue occurs or only contusion and edema. It is common for cord damage to occur in the absence of roentgenographic evidence of vertebral fracture or dislocation. The commonly accepted mechanism for this is pinching between the discs (anterior to the spinal canal) and the ligamenta flava, which bulge inward in hyperextension. Another common cause of cord damage is a bursting fracture of a vertebral body with backward displacement of the postero-inferior margin of the body into the spinal canal.

Vertebral dislocation and ligamentous rupture are best considered together. First, dislocations do not generally occur unless ligaments have ruptured. In addition, where dislocations have not caused cord damage at the time of the accident, instability of the spinal column due to ligamentous rupture still leaves the cord particularly vulnerable during clinical management. Ligaments will heal, but only slowly and never completely. It is generally agreed that ligaments

in the cervical structure can rupture as a result of either hyperflexion or hyperextension, but that at least a small component of rotation is necessary in addition. Anterior dislocations and rupture of the ligamenta flava or the longitudinal posterior ligaments are associated with hyperflexion violence while posterior dislocations and rupture of the anterior longitudinal ligaments result from hyperextension (with rotation).

Except for minor ligament strain and neurological effects, vertebral fracture is the most common cervical injury. While it may occur unaccompanied by other injuries, some sort of fracture is nearly always present if the violence was severe enough to cause rupture of ligaments or discs. By various mechanisms, any part of a vertebra may be fractured. Compression fractures of a vertebral body (usually at C5 or C6) are common. These are of two types, both of which result from hyperflexion: a) "wedge" fracture, in which the anterior portion of the body is crushed; and b) "burst" fracture, in which the body is shattered. Wedge fractures are usually not serious, but a very high incidence of cord damage accompanies burst fractures. Fracture of the laminae, facets, and pedicles are less common, and transverse and spinous process fracture or avulsion is least common, occurring as perhaps 5% of cervical fractures. By level, C5 and C6 have greatest involvement, accounting for perhaps as much as 60% of cervical fractures. Atlas and axis (including the odontoid process, or dens) involvement is possibly in excess of 20%. Atlas/axis fractures are seldom

severe since the cord is rarely damaged. Hyperextension violence probably causes about 50% of cervical fractures, with hyperflexion causing perhaps 40%.

Damage to intervertebral discs is not common. Incidence in "whiplash" injury cases is reported to be less than 1%. In general, ligament rupture will occur and the vertebral body will break before the normal disc gives way. When it occurs, however, disc rupture results from extreme hyperflexion. The involvement of the C6-C7 disc is very high, 70%, while the C5-C6 disc accounts for almost 25% of the ruptures. Neurologic symptoms often result in the neck and shoulder.

Neurological effects other than cord lesion are seen in about 50% of patients with cervical injuries. Nerve root irritation and brachial and cervico-occipital neuralgia are most common. The etiology for this type of injury is not as clear as for others. Certainly, it occurs with all types of violence to the cervical region. It may be characterized in general as resulting from nerve root compression of the cervical nerves from mechanical misalignments of intervertebral canals, ligaments and fascia. Edema and hemorrhage occurring with ligament and musculature damage also have a role.

Muscle damage in the cervical region is seldom serious. Neck muscles rarely rupture completely, although in severe cases hemorrhagical infiltration may evidence rupture of some muscle fibers. The muscles most commonly involved

are the cervical capital flexors and the trapezius.

Injuries to the head and neck, far more often than to other parts of the body, induce mental disturbances, even in mentally healthy, well-adjusted individuals. Differences in terminology and diagnostic criteria make it difficult to estimate a frequency of such psychiatric complications, but it may be as high as 50 to 75 percent of all cases. In one study, psychoneurotic tendencies were judged to be present after one month in 20% of the cases. It is generally agreed that emotional aspects of the cervical syndrome must be dealt with for satisfactory recovery.

The appended table was compiled from 24 papers (and other publications) on the subject of cervical injury selected from 125 which were reviewed. In the table, numbers in parentheses indicate sample sizes if not underlined. Reference numbers for the list of references which accompanies the table are underlined.

#### THE CERVICAL STRUCTURE: A SUBJECTIVE ANALYSIS

The most severe injuries involve lesions of the spinal cord, but it is not a structural component and should not be considered necessary in any structural model of the neck. Neck muscles, on the other hand, rarely experience traumatic damage, but there is considerable evidence that they play a significant role in lessening the probability and severity of injury to more vulnerable components of the neck structure. The musculature must therefore be represented in any structural



model of the neck which is to be used in assessment of cervical injury potential. The most serious cervical injuries almost always involve rupture of ligaments. Their most important function is in maintaining stability. The ligaments should therefore be considered of primary importance in the structure even though ligamental damage in itself is not of consequence. The intervertebral discs are the structural components most resistant to injury. As deforming elements, they are important in a structural model. The vertebrae have a clear role in a structural model. With the intervertebral discs, they constitute the spinal column itself, and they provide attachment points for both muscles and ligaments. The vertebrae are the weakest part of the structure; in absence of rotation, vertebral fracture will always occur before failure of the ligaments.

Listed below are the specific muscles and ligaments thought to be of primary importance as elements of a structural model.

Muscles -- Levator scapulae, longissimus capitis, scalenus anterior, scalenus medius, scalenus posterior, semispinalis capitis, semispinalis cervicis, spinalis capitis, spinalis cervicis, splenius capitis, splenius cervicis, sternocleidomastoideus, trapezius.

Ligaments -- Ligamenta alaria, l. apicis dentis axis, l. cruciforme atlantis, l. flavum, l. longitudinale anterius, l. longitudinale posterius, l. transversum atlantis.

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## CERVICAL INJURIES

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APPENDIX

CERVICAL INJURY TABLE

GENERAL INJURY TYPE	SPECIFIC INJURY TYPE	FREQUENCY	ETIOLOGY	SEVERITY/ PROGNOSIS	COMMENTS
Cervical Injuries (general)		<p>1% of all hospital admissions (<u>23</u>)</p> <p>75 to 90% of all patients with cervical sprain injuries have been in automobile accidents (<u>23</u>)</p>		<p>1.1% of all neck injuries are fatal (<u>23</u>)</p> <p>16.7% of all motor-vehicle cervical injuries are fatal (<u>114</u>) (<u>10</u>)</p> <p>75% of cases have cervical injury confined to soft tissue (<u>24</u>)</p> <p>6.8% of persons injured in auto accidents have cervical injury (<u>1678</u>) (<u>10</u>)</p>	

\*\* CERVICAL INJURIES \*\*

GENERAL INJURY TYPE	SPECIFIC INJURY TYPE	FREQUENCY	ETIOLOGY	SEVERITY/ PROGNOSIS	COMMENTS
Spinal Cord		33% of cervical injuries (2) 42% of patients with fractures and dislocations (161)(10) 40% of patients with fractures (95) (20) 62% of patients with neurological symptoms (8)	Anterior dislocation caused the greatest number of deaths (10)	Mortality 28% (68)	Cord injury is often spread over several segments (2)  There is greater incidence of spinal cord involvement in the later years of life and prognosis is worse. (20)
	Functional transection	21% of cervical injuries (1) 16% of cervical injuries (2) 50% of cord injuries (2) 58% of cord injuries (8) Hyperflexion: 29% of the cord injuries (38); Hyperextension: 13% of the cord injuries (38) (20)	(See Incomplete Lesion, Etiology) Hyperextension with posterior dislocation (5)	Mortality 81%, lesions below C3-C4 (16); mortality 100% lesions above C3-C4 (20)  Nearly always fatal, death occurring within a few days (8)	"Functional transection of the cervical cord results in complete and permanent tetraplegia.
	Incomplete lesion	42% of cord injuries (8)	Contusion of cord caused by buckling of ligamentum flavum in hyperextension (11)	Mortality 32% (22) (20)	"Incomplete lesion" of the cervical cord results in paraplegia.

\*\* CERVICAL INJURIES \*\*

GENERAL INJURY TYPE	SPECIFIC INJURY TYPE	FREQUENCY	ETIOLOGY	SEVERITY/ PROGNOSIS	COMMENTS
	<p>Incomplete lesion (continued)</p>		<p>In the absence of vertebral fracture or dislocation, hyperflexion cannot result in cord damage unless the articular processes dislocate and lock. In hyperextension the cord is subject to pinching between the discs and the ligamenta flava. (19)</p> <p>In hyperextension, anterior compression by disc and posterior compression by ligamentum flavum. (5)</p> <p>In hyperextension, pinching of cord by inferoposterior border of dislocating vertebral body and sometimes inward bulging of ligamentum flavum. (21)</p> <p>Rotation-caused subluxation with spontaneous reduction may cause cord lesion. (16)</p> <p>Hyperextension posterior dislocation with spontaneous reduction (no roentgenographic evidence) (9)</p> <p>"Burst" fracture of a vertebral body often results in cord damage. (13)</p> <p>A common result of burst fractures and anterior dislocations. (3)</p>		<p>Cord damage is usually at C5 to C7. (19)</p> <p>Fatal cord lesions occur mostly in the upper cervical region but are less common than lower cervical cord lesions, which produce paraplegia or tetraplegia. (22)</p>



\*\* CERVICAL INJURIES \*\*

GENERAL INJURY TYPE	SPECIFIC INJURY TYPE	FREQUENCY	ETIOLOGY	SEVERITY/ PROGNOSIS	COMMENTS
Discs	<p>Rupture of annulus fibrosus, herniation of nucleus pulposus</p>	<p>0% incidence in 50 cases of cervical injury (6)</p> <p>Less than 1% incidence in cases of cervical injury (23)</p> <p>Ruptures by level (500+):            C4-C5 2%            C5-C6 24%            C6-C7 70%            C7-T1 4%            (18)</p>	<p>Rotation and hyperflexion with bilateral dislocation of the articular facets (2)</p> <p>Hyperflexion (4)</p>		<p>A disc with a dehydrated nucleus pulposus is much more susceptible to damage. (16)</p> <p>Neurologic symptoms often result in neck or shoulder, most commonly from defects at C6-C7. (10)</p> <p>The vertebral body will always break before the normal disc gives way. (16)</p>
	Displacement	Anterior displacement is rare (23)	May result from rupture of anterior or posterior longitudinal ligament (23)	May ultimately cause disc degeneration, with reduction of neck flexibility (23)	
	Tears			Usually occurs only in fatal cases. (22)	May vary in severity from a mild cleft to a complete tearing of the disc from its normal moorings. (22)

\*\* CERVICAL INJURIES \*\*

GENERAL INJURY TYPE	SPECIFIC INJURY TYPE	FREQUENCY	ETIOLOGY	SEVERITY/ PROGNOSIS	COMMENTS
Dislocations	Anterior dislocation	A component of rotation and/or shear is always necessary to cause dislocation. Pure hyperflexion or hyperextension is not sufficient. (16)	Dislocations do not generally occur unless ligaments have ruptured (13)		The most commonly observed anatomical displacement is anterior fracture-dislocation caused by hyperflexion. (19)
	Anterior subluxation	14% of cases having fractures (10)	Hyperflexion (15)		75% incidence of cord damage if facet dislocation is bilateral (20) and 26% if unilateral (23). (3)
	Posterior dislocation	Uncommon (5)	Hyperextension (2)	Severe if dislocation is complete (5)	Stable in flexion since posterior ligament complex is intact (13)
	Posterior subluxation	Hyperextension, with rupture of the anterior longitudinal ligament (13)	Hyperflexion with rotation (2)		Posterior ligament complex always ruptures; disc rupture and serious cord injury are likely if dislocation is bilateral (2)
	Articular facet dislocation	Anterior dislocation caused by compression and hyperextension in combination (2)			Seldom occurs without ligamentous ruptures; dislocation is always anterior (8)
	Fracture-dislocation				

\*\* CERVICAL INJURIES \*\*

GENERAL INJURY TYPE	SPECIFIC INJURY TYPE	FREQUENCY	ETIOLOGY	SEVERITY/ PROGNOSIS	COMMENTS
Fractures		<p>Fractures by level (152):</p> <p>C1 9%</p> <p>C2 9%</p> <p>C3 6%</p> <p>C4 12%</p> <p>C5 34%</p> <p>C6 26%</p> <p>C7 5% (10)</p> <p>30% at C5/C6 (335) (1)</p> <p>Fractures present in 5.5% of cases with cervical sprain (1907) (23)</p> <p>Fractures present in 25% of cases with cervical sprain (24)</p> <p>% deaths with fracture at site (50):</p> <p>C1/C2--24%</p> <p>Atlas burst fracture--4%</p> <p>Odontoid--8%</p> <p>C3-C7--10%</p> <p>C3-C7 fracture dislocations --4% (22)</p>	<p>27% extension-tension loading</p> <p>24% extension-compression loading</p> <p>40% flexion-compression loading (55) (15)</p>	<p>Over-all mortality rate for fractures and dislocations: 4.2% (335) (1)</p>	

\*\* CERVICAL INJURIES \*\*

GENERAL INJURY TYPE	SPECIFIC INJURY TYPE	FREQUENCY	ETIOLOGY	SEVERITY/ PROGNOSIS	COMMENTS
	<p>Axis and atlas</p> <p>Odontoid process</p>	<p>16% of cervical fractures (161) (<u>10</u>)</p> <p>31% of cervical injuries (55) (<u>15</u>)</p> <p>77% of cervical fractures in children under ten (13) (<u>1</u>)</p>	<p>Hyperextension (<u>5,10</u>)</p> <p>Atlas: hyperextension with compression</p> <p>Axis: hyperextension with tension (<u>15</u>)</p> <p>Shear force resulting from direct impact of face; bending moment resulting from direct impact of chin, causing acute flexion at C1/C2 and extension from C2 to C7 (<u>15</u>)</p> <p>Hyperflexion or hyperextension (<u>4</u>)</p> <p>Hyperflexion plus compression (<u>23</u>)</p>	<p>Prognosis is good, death rare (<u>10</u>)</p> <p>0% mortality in 17 cases (<u>15</u>)</p>	<p>Cord is rarely damaged (<u>10</u>)</p> <p>Pure atlantal injuries are unlikely to damage the spinal cord. (<u>22</u>)</p>

\*\* CERVICAL INJURIES \*\*

GENERAL INJURY TYPE	SPECIFIC INJURY TYPE	FREQUENCY	ETIOLOGY	SEVERITY/ PROGNOSIS	COMMENTS
	Compression "wedge" fracture	22% of cervical injuries (50) (6) 9% of cervical fractures (161) (10) Common (13)	Hyperflexion (4, 6, 10, 12, 15) Hyperflexion with compression (2)	Prognosis generally good; paraplegia may occur rarely (10) Usually not serious (2)	82% at C5 or C6 (6) Most common at C6 (10) Incomplete cord lesion sometimes results (2) In pure hyperflexion or hyperextension the vertebral body will always crush before ligaments or discs fail. (16)
	Compression "burst" fracture of vertebral body		Results from compression force transmitted directly along line of the vertebral bodies (13) Hyperflexion (15)		Ligaments remain intact (13) Fracture of C5-C7 most common (15) 85% incidence of cord damage (16) (3)
	Transverse and spinous processes	5% of cervical fractures (161) (10) 0% in 50 cases (6)	Hyperflexion or hyperextension (4, 10)	Rarely serious (10)	
	Laminae, facets and pedicles	Unilateral fracture occurs as 12% of cervical fractures (161) (10) Uncommon (13)	A blow from behind, usually with a rotational force added (10) Hyperextension (13) Hyperextension or hyperflexion (4)	Mortality 11% (19) (10)	

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GENERAL INJURY TYPE	SPECIFIC INJURY TYPE	FREQUENCY	ETIOLOGY	SEVERITY/ PROGNOSIS	COMMENTS
Ligamentous rupture (sprain), or strain, or avulsion at insertion	Ligamenta flava; Posterior longitudinal ligaments		Hyperflexion with rotation ( <u>2</u> )  Very vulnerable to rotation and horizontal shearing forces; not vulnerable to pure hyperflexion or hyperextension ( <u>16</u> )  Rotation or flexion-rotation ( <u>13</u> )  Very vulnerable to rotation and horizontal shearing forces, not to hyperflexion or hyperextension ( <u>16</u> )  Hyperextension ( <u>11</u> )  Forceful hyperflexion ( <u>24</u> )	All ligament injuries heal slowly and incompletely ( <u>23,24</u> )	Commonly injured ( <u>23</u> )  Particularly prone to rupture in the lower segments ( <u>22</u> )  Disc material protrusion may occur posteriorly and threaten cord ( <u>23</u> )  Particularly prone to rupture in the upper segments ( <u>22</u> )  Disc degeneration may result from anterior disc displacement ( <u>23</u> )  Rarely torn ( <u>22</u> )
Muscle tearing	Transverse ligament of axis  Cervical capital flexors  Trapezius  Longus colli and intertrans-			Cord compression often fatal ( <u>24</u> )	Even in fatal cases, the neck muscles, although hemorrhagically infiltrated, are rarely ruptured. ( <u>22</u> )  At C4, tearing of these muscles is as important as injury to ligaments. ( <u>12</u> )  Very susceptible to injury ( <u>23</u> )  May be torn from their attachments ( <u>24</u> )

