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HANGMAN'S FRACTURE

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The first and second cervical vertebrae differ, anatomically and functionally, from the remainder of the cervical spine. Half the rotation in the cervical spine takes place in the atlanto-axial joint, and a large part of the movement in the sagittal and frontal plane in the joints between the occipital bone, atlas, and axis (Werne 1957, Hohl 1964, Fielding 1964). At the same time the weight of the head is transmitted through the mobile cervical spine to the stable thoracic spine. Traumas cause several characteristic injuries to the atlas and axis, including bilateral fracture through the neural arch of the axis. According to Wood-Jones (1913) hanging by the use of a submental knot and drop invariably entailed a dislocation fracture through the arch of the axis (Figure 1) with severing of the spinal cord and instantaneous death. The mechanism of the trauma in this ideal hanging injury was vigorous hyperextension combined with traction in the longitudinal direction of the spine. The same injury to the cervical spine may arise in accidents, especially in traffic accidents, and is often called "hangman's fracture" (Schneider et al. 1965).

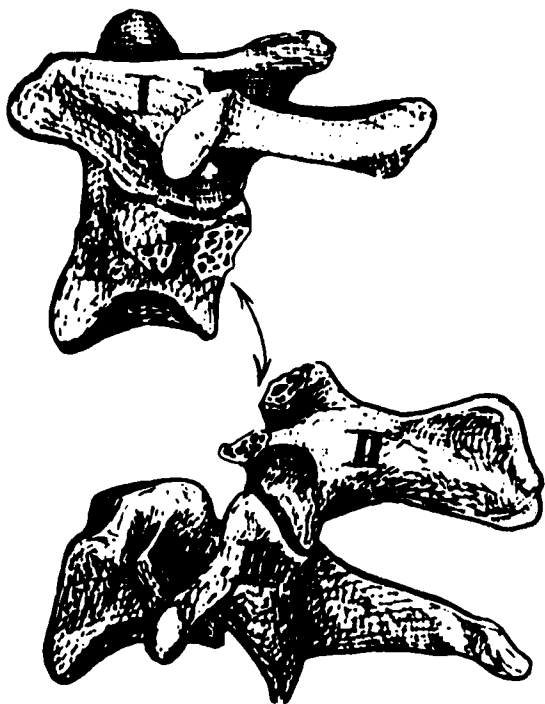
MATERIAL

The present material comprises 19 patients with bilateral fracture through the arch of the axis treated in the Odense Hospital, Neurosurgical Department U and Orthopaedic Surgical Department O during the period 1962-1972. The sex ratio and age distribution are given in Figure 2. Ten were females and nine males. The youngest patient was 15 and the oldest 75 years of age.

Traffic accidents are the most common cause. Twelve of the patients were motor car drivers and one a cyclist. The remaining six were injured by falling upon the head, including one by diving into shallow water.

Radiologically a fracture through the arch is often best visualized on a lateral film (Figures 3 a and 4 a), possibly supplemented by lateral tomography, whereas it is seldom seen in the anteroposterior view. All the patients had bilateral fracture

Figure 1. Hangman's fracture after hanging using submental knot (Wood-Jones 1913).



through the arch of the axis, most often through the weak spot of the arch at the sulcus of the spinal nerve. In a few the fracture was anteriorly, through the superior articular surface, in others more posteriorly through the inferior articular surface or the laminae, sometimes asymmetrical. Fifteen patients had anterior subluxation of the body of the axis on the third cervical vertebra. Two had co-existing fracture of the posterior arch of the atlas (Figure 4 a), and one had bilateral fracture through the arch of the sixth cervical vertebra. One had an avulsion fracture of the inferior anterior corner of the second cervical vertebra and one of the superior anterior corner of the third and fourth cervical vertebrae.

Among associated injuries, those affecting the head and cervical spine were by far the most common (Table 1). The site of the soft-tissue injuries on the head afforded some information about the mechanism of the trauma (*vide infra*). Six patients had concussion and three cerebral contusion. Two of the patients with cerebral contusion lay unconscious for 3-4 weeks with brain-stem attacks; both had incomplete tetraplegia but survived. The third patient was lax, areflexic, with multiple injuries and succumbed on the sixth day after the accident without having regained consciousness. Another two patients had mild signs of neurological deficits (dysaesthesia on the thumb, hypaesthesia on the neck), but in the remaining 14 patients the neurological findings were normal. In 7 patients the hangman's fracture was the only injury of importance. All patients who were awake were complaining of pain at the back of the neck on admission.

By means of the history and objective findings the mechanism of the trauma

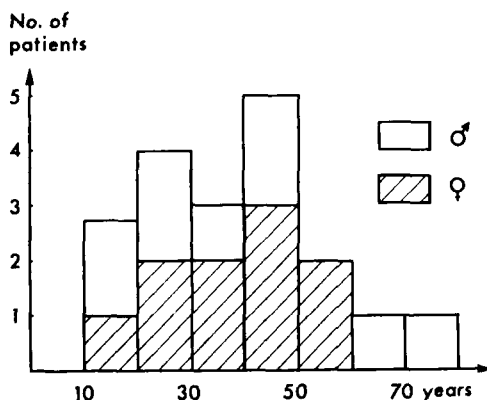


Figure 2. Sex ratio and age distribution (19 patients).

could usually be clarified with a fair degree of accuracy. Three car drivers sustained an extension trauma when run into from the rear. Three patients remembered extension trauma in connection with diving and falling accidents, and after yet another fall the same mechanism was divulged by fracture through the arch of the sixth cervical vertebra. Six patients had soft-tissue injuries of the face, forehead, and temporal region, suggesting extension trauma. Thus, a total of 13 patients had presumably been exposed to extension trauma.—On the other hand, there were four patients with presumed flexion traumas, viz. one who remembered the trauma and who had a soft-tissue injury in the occipital region compatible with such a flexion trauma, and three patients with soft-tissue injuries on the occiput and neck. One of these patients also had an avulsion fracture of the upper anterior corner of the third and fourth cervical vertebrae, an injury stated to arise as a result of hyperflexion (Norton 1962).—Six patients were hurt by falling on the head and must have been exposed not only to extension or flexion trauma, but also to vertical compression of the cervical spine. Similar forces are presumably often active in traffic accidents in which the victim is flung forward, injuring the head on parts of the vehicle.

In two patients the mechanism of the trauma could not be elucidated in any detail.

Table 1. Associated injuries (19 patients).

Soft-tissue injuries to the head	12
Fracture of the skull	1
Concussion/cerebral contusion	9
Other cervical fracture	4
Extremity fractures	4
Multiple injuries	1

Table 2. Treatment (19 patients).

Posterior spinal fusion	2
Bed rest	10
Plaster cast	5
Collar	1
No treatment (died)	1

METHODS

Table 2 lists the methods of treatment. In the early part of the period skeletal traction was felt to be needed, until stability had been attained in the fracture site. Three of the patients who were treated by bed rest and one of those who was operated had been kept in bed with skeletal traction for from 53 to 82 days. Later, the practice has been changed to positioning the patients, immediately after admission, with extended head upon a special double mattress depicted in Figure 5, a method which affords rapid and gentle reduction (Figure 3 b) and guards against secondary displacement. After the primary positioning, the treatment consisted in 7 cases in bed rest with extended head for about eight weeks, whereas 5 patients were treated in a Minerva jacket (Figure 6) after the fracture had been reduced during a few days' positioning in extension. The importance of extension during the application of the plaster cast is illustrated by one patient whose arch fracture did not heal until the Minerva jacket was re-applied during increased extension of the cervical spine. This patient was in plaster for 157 days, the others from 54 to 95 days. Two patients were treated by operation. In one the arch fracture had united on conservative treatment, but in the course of the subsequent mobilization a rupture of the posterior ligament complex was disclosed by increasing forward dislocation of the second cervical vertebra on the third. Posterior spinal fusion of the second, third, and fourth cervical vertebrae was performed. The other patient had a typical hangman's fracture and was treated, a few days after the accident, by posterior spinal fusion of the first, second, and third cervical vertebrae. In most cases the treatment was concluded by Camp's collar worn for up to about 6 months after the accident. However, one patient was treated exclusively by Camp's collar, and one patient died before any treatment could be instituted.

No type of treatment caused any complications.

RESULTS

The 18 surviving patients were followed up from 7 months to 9½ years after the accident. One is disabled by the sequelae to cerebral contusion. The other patient with brain damage has been socially and occupationally rehabilitated, although she exhibits some mental impairment and mild paresis of the limbs. The other 16 patients had no neurological sequelae, but three complained of pain in the back of the neck and

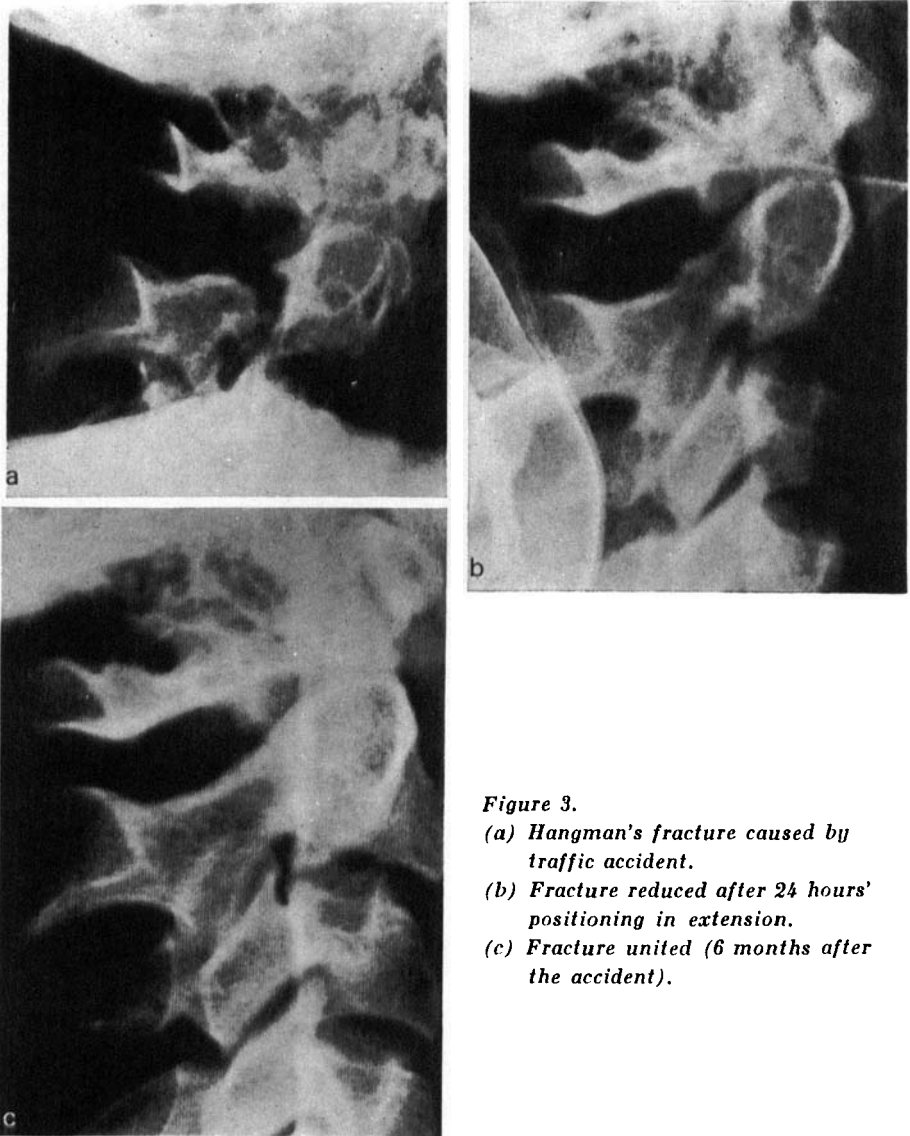


Figure 3.

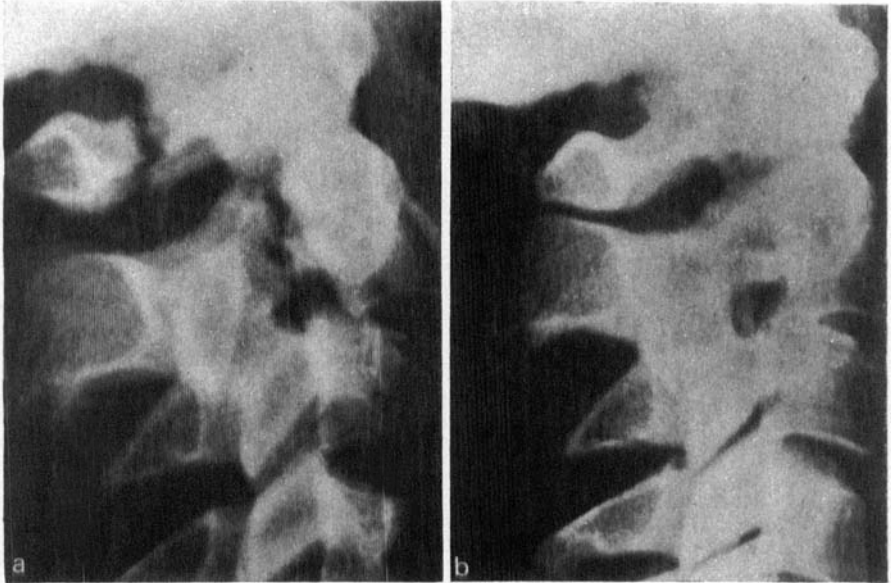
(a) Hangman's fracture caused by traffic accident.

(b) Fracture reduced after 24 hours' positioning in extension.

(c) Fracture united (6 months after the accident).

three of fatigue at the back of the neck and in the shoulders. Seven had subjective limitation of movement in extension and rotation, but only three had major complaints on this account. Nine were symptom free.

At follow-up the total range of movement in the cervical spine was measured using a goniometer (Table 3). The lower limits of normal



*Figure 4. (a) Hangman's fracture combined with fracture of the posterior arch of the atlas, due to diving into shallow water.
(b) Fractures united, synostosis between the second and third cervical vertebrae (4½ years after the accident).*



Figure 5. Positioning in extension on a double mattress.

Figure 6. Minerva jacket with the cervical spine about 30° extended



were taken to be: flexion and extension 50°, rotation 80°, lateral bending 40°. In assessing the range of mobility no regard was paid to age variations. Out of the examined patients, five had normal mobility in all directions. Flexion was reduced in only three, including both patients who had been treated by posterior spinal fusion. Extension was reduced in six patients. Other movements were reduced in about half the patients, but only reduced rotation and extension gave rise to complaints. The poorest mobility was found in a 30-year-old man who had been subjected to posterior spinal fusion.

The radiological end results are listed in Table 4. All the fractures united, but in half the cases with a slight forward dislocation of the second cervical vertebra on the third. However, the persisting subluxation was less marked than at admission. There was a distinct ten-

gency to spontaneous synostosis between the bodies of the second and third cervical vertebrae, especially after a long follow-up period (Figure 4 b). Both spinal fusions had healed.

Table 3. Follow-up. Total range of mobility in cervical spine (18 patients).

		$\geq 50^\circ$	$49^\circ-30^\circ$	$\leq 29^\circ$
Flexion		15	3	0
Extension		12	4	2
		$\geq 80^\circ$	$79^\circ-45^\circ$	$\leq 44^\circ$
Rotation	R	7	9	2
	L	7	8	3
		$\geq 40^\circ$	$39^\circ-25^\circ$	$\leq 24^\circ$
Lateral bending	R	8	8	2
	L	9	6	3

Table 4. Radiological end results (18 patients).

Union	18
Subluxation	9
Calcification in the ant. long. ligament	2
Spontaneous synostosis (CII/CIII)	5
Spinal fusion	2

The cervical injury had occupational consequences in only three cases. One patient is disabled, and two have given up their previous occupation because of occipital pain. Thirteen have gone back to their former work, two have retired, but are fully restored. The period off work averaged 6 months (3-12 months).

There was no difference in therapeutic results between the 7 patients treated by extension positioning on a double mattress and the five patients treated in a plaster cast.

DISCUSSION

Before Schneider et al.'s description of "hangman's fracture" the literature on the subject was sparse. Garber (1964) briefly reported his experience of eight cases, but otherwise the injury was reported only

as single cases in major clinical series of cervical fractures (Grogono 1954, Rogers 1957, Durbin 1957, Norton 1962). The largest published series (40 patients) of "axis pedicle fractures" was reported in summary form by DeLorme (1967). In the same year Pedersen et al. (1967) published nine cases. Cornish (1968) found 14 patients with "traumatic spondylolisthesis of the axis" among 77 cases of cervical injuries. Loisel (1971) discussed the subject in detail on the basis of four cases of his own.

The majority of these injuries arise in traffic accidents, the remainder are due to falls. Neurological complications are few, as the spinal canal is proximally fairly wide in relation to the spinal cord and the trauma causes further decompression (Schneider et al. 1965). The mechanism of the trauma is usually pronounced hyperextension (Schneider et al. 1965, Pedersen et al. 1967), often combined with vertical compression (Cornish 1968, Loisel 1971). More rarely the injury is due to a flexion trauma (DeLorme 1967). Hangman's fracture combined with compression fracture anteriorly in the third cervical vertebra (Rogers 1957) must be due to a flexion-compression trauma.

According to Holdsworth (1963) an extension trauma to the spine may entail rupture of the anterior ligament complex (anterior and posterior longitudinal ligaments and intervertebral disc), whereas the posterior ligament complex (flaval ligaments, interspinal and supraspinal ligaments) will hold. Post-mortem studies after hanging using a submental knot have confirmed that the anterior ligament complex is ruptured (cit. Schneider et al. 1965), and the same ligamentous injuries have been found in patients with hangman's fracture (Cornish 1968). Avulsion fracture at the inferior anterior corner of the vertebral body or a fracture of the posterior arch of the atlas, spinous process or arch of other cervical vertebrae indicate extension trauma, possibly combined with compression. Holdsworth (1963) stated that extension injury with preserved posterior ligament complex is stable in flexion. According to the present author's experience hangman's fracture forms an exception, flexion increasing the forward dislocation of the anterior loose fragment, whereas positioning in extension will reduce and stabilize it. Simultaneous injury to the posterior ligament complex, caused according to Roaf (1960) and Holdsworth (1963) by a flexion-rotation trauma, entails great instability.

Cautious flexion-extension of the cervical spine on the waking patient under fluoroscopy affords information about the degree of instability, especially of the anterior fragment. The condition of the

posterior ligament complex cannot be assessed until the arch fracture has united. In uncomplicated cases the present author has found that in a few days the fracture may be reduced by positioning the patient with backward bent head on a double mattress. Thereafter, a Minerva jacket can be applied, fixing the head in extension. If other injuries or other factors render it necessary, the positioning in extension on a double mattress has to be maintained for about eight weeks. Posterior spinal fusion is indicated, if union of the arch fracture is followed by secondary dislocation of the axis due to rupture of the posterior ligament complex. Anterior spinal fusion, used mainly by Cornish (1968), is rational, as it fixes the loose fragment, but conservative treatment is preferable, as it is harmless and according to our experience equally effective.

All patients are advised to use a neck collar for up to six months after the accident or for 3-4 months after radiological union.

CONCLUSION

Bilateral fracture of the arch of the axis occurs in traffic accidents and falls due to an extension trauma, more rarely due to a flexion trauma. Both may be combined with vertical compression. Neurological complications are rare. Rupture of ligaments and discs is an important link in the injury. Treatment is by positioning in extension which leads to reduction; followed by bandaging with extended head for about eight weeks. The healing tendency is good. Posterior spinal fusion is rarely indicated. There are few permanent complaints which consist especially in pain and fatigue at the back of the neck and in the shoulders as well as a moderate limitation of movement. Spontaneous synostosis between the second and third cervical vertebrae is common after a lengthy follow-up period. The great majority of patients are fully restored, also occupationally.

SUMMARY

From a 10-year period 19 cases of bilateral fracture of the arch of the axis, the so-called hangman's fracture, are described. In 13 cases it was caused by extension trauma, in four by a flexion trauma. In two cases the mechanism of the trauma was unknown. The significance of co-existing ligament and disc injury is emphasized. Treatment was generally conservative, and according to recent experience it should consist

in most cases in reduction during a few days' positioning in extension on a special double mattress, followed by bandaging in a Minerva jacket for approx. eight weeks with the cervical spine about 30° extended. Eighteen patients who survived the injury were examined at follow-up from 7 months to 9½ years after the accident. There were but few permanent complaints.

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