FRACTURES OF THE RING OF THE AXIS

A CLASSIFICATION BASED ON THE ANALYSIS OF 131 CASES

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The retrospective analysis of 131 patients suffering from a fracture of the ring of the axis is reported. The injury was classified into three types according to radiological displacement and stability. Associated injuries and neurological deficit are discussed and a theory of pathogenesis presented. Guidelines for the management of each type of fracture are proposed.

Haughton, in 1866, was the first to describe fracture-dislocation of the axis in criminals who had been executed by hanging. Wood-Jones (1908, 1913) studying judicial hanging noted that a submental knot produced a consistent, fatal fracture-dislocation of the axis. Grogono (1954) published the first radiographs of a fracture of the posterior arch of the axis sustained in a motor vehicle accident, and noted that the appearance of the lesion was not unlike that reported by Wood-Jones following judicial hanging. Schneider *et al.* (1965) gave the lesion the colourful eponym "hangman's fracture" from the similarity of the radiological appearance of the traumatic lesion to that caused by hanging. The French were more accurate, when they called it "la fracture du pendu" (Roy-Camille, Saillant and Sagnet 1975). Most subsequent publications used the term "hangman's fracture" (Elliot, Rogers and Wissinger 1972; Termansen 1974; Wiley, personal communication), although radiographs showed a variable appearance. No classification of the lesion has been proposed (Brashear, Venters and Preston 1975), nor has there been recognition of the characteristics of different varieties of the injury (DeLorme 1967; Pedersen, Roy and Saliccioli 1967; Cornish 1968; Marar 1975).

MATERIAL AND METHODS

This paper is based on a review of 142 patients who had sustained fractures of the ring of the axis and had been treated by the authors and their colleagues in Canada and Australia. The case histories and 2620 radiographs were studied personally by two of the authors (BE, CAL). The main purpose was to develop a classification based on radiographic appearance and clinical course in the 131 patients for whom the complete case history and the original and final radiographs

were available, and who had been followed-up for at least four months (range four months to four years, mean 10 months).

Fracture of the ring of the axis may involve any part of the bony spinal canal including the laminae, the inferior articular facets, the pars interarticularis, the superior articular facets, the pedicles and the posterior wall of the vertebral body (Fig. 1). Involvement of the posterior wall of the body of the axis may not be obvious on lateral radiographs, and tomograms (Figs 2, 3 and 4) may be necessary to define the lines of the fractures. Fractures of the ring of the axis are almost always bilateral but are rarely symmetrical (Fig. 5), and do not necessarily heal at the same rate. This can be demonstrated by a CAT scan (Fig. 6). The fracture may cross the foramen transversarium on one side and not on the opposite side, and thus does not necessarily occur at the weakest part of the ring.

Displacement at the fracture site in 65 per cent of the patients was less than one millimetre, resulting in a hairline fracture with little, if any, displacement at the disc space between C2 and C3. All these lesions proved to be stable both clinically and on flexion and extension radiographs. If displacement of the body of the axis is obvious, stability will depend on associated soft-tissue damage, especially at the C2–3 disc space, which may show a position of flexion, of extension, or of forward listhesis. Unless displacement of the body of the axis is obvious, films in flexion and extension are necessary to assess the severity of soft-tissue damage. The clinical situation is similar to that in injuries of the ankle or the knee, plain radiographs are inadequate, since they are random views and give an incomplete picture; dynamic films are necessary to assess the stability of the lesion. Lateral radiographs may show the body of the axis to be in a normal position or displaced. An abnormal position of the body of the axis in flexion, extension or forward listhesis may change in flexion and extension views or during treatment. Thus a position of extension in the original radiographs may change to flexion when further radiographs are taken with a pillow under the head. It seems that any abnormality of the position of the body of the axis is indicative of potential instability. Gross tilting or listhesis indicates significant soft-tissue disruption, though mild deformities are not necessarily stable. Radiographs in flexion and in extension, with mild head traction, should be taken without anaesthesia, under the supervision of an experienced clinician,

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Fig. 1

Fig. 2

Fig. 3

Fig. 4

Figure 1—Axis vertebra. Fracture may involve any part of the ring of the axis including the facet joints (*a* and *c*), the pars interarticularis (*b*), the laminae (*d*) or part of the posterior wall of the C2 vertebral body (*e*). Figure 2—Plain lateral radiograph suggests that the fracture involves the pedicle of the axis bilaterally. Figures 3 and 4—Tomograms at different planes show that the fracture line involves the postero-inferior corner of the body of the axis on one side only.

Fig. 5

Fig. 6

Figure 5—Diagrams to show widening of the ring of the axis. The fracture lines are asymmetrical and occasionally involve the posterior wall of the body of the axis. The vertebral body of C2, which is anterior or cephalad to the fracture line, commonly moves forward, with widening of the spinal canal. Figure 6—CAT scan after conservative treatment to show the asymmetry of the lines of fracture, post-traumatic widening of the axis ring and different rates of fracture healing.

Fig. 7

Fig. 8

Figures 7 and 8—Classification and incidence of the various types of fractures of the ring of the axis.

includes the inferior articular facets of the axis which may be dislocated and locked. This complication has always been associated with forward displacement, and usually flexion, of the anterior fragment and with widening of the vertebral canal.

CLASSIFICATION

The degree and type of displacement of the anterior fragment (the body of the axis) and of the posterior fragment (the inferior facets of the axis) as expressed by

to supplement the information from static lateral views.

The variable radiographic appearance of the fracture depends on three factors: first, the site of the fracture of the ring; secondly the displacement of the fragment anterior to the fracture line; and thirdly and exceptionally, displacement of the posterior fragment which

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Type I lesions have minimal displacement and an intact C2-3 disc space. The fracture line may involve the posterior or middle segments of the ring (Figs 9 and 10) or may extend anteriorly on one side through the body of C2 (Figs 11 and 12). See also Figures 2, 3 and 4.

the state of the disc space and of the articular facets at C2-3 (Figs 7 and 8) allow the fractures to be classified into three types.

Type I: Isolated hairline fractures of the ring of the axis with minimal displacement of the body of C2 (Figs 9 and 10). The fracture may involve any part of the ring of the

axis and may extend anteriorly into the body of C2 (Figs 11 and 12). The fracture line is then oblique, involving usually one or rarely both postero-inferior corners of the body (Figs 2, 3 and 4). The disc space below the axis is normal and stable.

Type II: Displacement of the anterior fragment, with an abnormal disc below the axis. The body of the axis may be displaced in extension, flexion or obvious forward listhesis (Figs 13 to 18).

Type III: Displacement of the anterior fragment with the body of the axis in the flexed position; but in addition, the facet joints at C2-3 are dislocated and locked (Figs 19 and 20). A Type III lesion must be suspected when the body of the axis is in a position of flexion; it has not been seen when it is in a position of extension or of forward listhesis.

Fig. 13

Fig. 14

Fig. 15

Fig. 16

Fig. 17

Fig. 18

In Type II fractures the fragment of the axis which is anterior or cephalad to the fracture line is obviously displaced in extension (Figs 13 and 14), flexion (Figs 15 and 16) or anterior listhesis (Figs 17 and 18).

RESULTS

The incidence of various types of fractures in this series is reported in Table I and in Figure 8. Motor vehicle accidents were the predominant cause of this lesion (Table II). It is relevant that of 15 patients who had attempted suicide by hanging, none had sustained a fracture of the ring of the axis (Cappello and Langan 1979).

The age of the patients in this series ranged from 5 to 86 years with a mean of 31.2 years. No age group is spared and the youngest patient reported (Wiley, personal communication) was a five-month-old baby. Ninety-six of our patients (73 per cent) were male, probably because of their more frequent involvement in

Fig. 19

Fig. 20

Type III fractures are relatively rare. The facets at C2-3 are dislocated and locked, maintaining the body of C2 in a position of flexion, with the disc space at C2-3 open posteriorly.

motor vehicle accidents. There was no significant difference in distribution of type of lesion between men and women.

Associated injuries. As would be expected in patients involved in motor vehicle accidents, associated injuries were common. Severe facial lacerations, with or without facial fractures, were noted in 11 per cent of the series. These have been interpreted by DeLorme (1967) as evidence for a hyperextension mechanism of injury when the face is pushed violently backwards; we believe that such facial injuries may also be sustained after flexion when the face strikes a fixed object such as a steering wheel. Severe facial injury, such as a fractured jaw, makes skull traction preferable to halter traction.

Severe thoracic injuries were noted in 15 patients (11 per cent) all of whom had signs of pulmonary insufficiency. Two patients suffered rupture of the

trachea, one of whom also had a fracture of the cricoid cartilage. Haemothorax, a comminuted fracture of the sternum, and pneumothorax were each seen in one patient, and nine had severe fractures of the ribs. These serious respiratory lesions are important in that a radiograph of the cervical spine should, when possible, be taken before intubation despite the obvious therapeutic priority of an adequate airway. One unconscious patient was intubated in the emergency department and has a permanent neurological deficit which may be related to hyperextension of an unrecognised unstable fracture of the cervical spine.

Neurological signs. Twenty-nine patients (22 per cent) had cerebral concussion; the incidence was 20 per cent in Type I, 22 per cent in Type II and surprisingly high at 56 per cent in Type III patients. Three patients died as a result of their head injury. In the absence of distraction at the time of the accident, or during treatment, neurological signs were usually transient (Table III). The explanation for the apparent paradox in relation to the eponym of hangman's fracture is that fracture of the ring of the axis widens the spinal canal (Jefferson 1920): the anterior fragment moves forward, and distraction at the fracture site, as produced by hanging with a drop, is

Table I. Series classified by type of lesions

Type of lesion	Displacement of axis	Number of patients	Per cent
I	Nil	85	65
II	Flexion	7	5
	Extension	10	8
	Forward listhesis	20	15
III	Flexion	9	7
Total		131	100

Table II. Type of lesion related to cause

Type (and number) of lesions	Motor vehicle accident		Other causes	
	Number	Per cent	Number	Per cent
I (85)	61	72	24	28
II (37)	26	70	11	30
III (9)	7	78	2	22
Total (131)	94	72	37	28

Table III. Type of lesion and neurological deficit, excluding cerebral concussion

Type (and number) of lesions	Temporary deficit		Permanent deficit	
	Number	Per cent	Number	Per cent
I (85)	9	10.6	1*	1.2
II (37)	7	19	2†	5.4
III (9)	1	11	1	11
Total (131)	17	13	4	3

* Due to an associated fracture-dislocation at C3-4.

† One due to an associated fracture-dislocation at T12-L1.

Fig. 21

Vertebral angiogram to show vascular blockage at C7 level. An axis fracture is commonly associated with injury at other levels in the neck.

rare. When the fracture is sustained in a motor vehicle accident or a fall, axial loading is more common than distraction.

With the exception of occipital neuralgia, permanent neurological signs were rarely noted after Type I fractures. Nine patients (18 per cent) with Type I fractures had transient neurological signs for a few weeks, seven patients had paraesthesia involving the extremities, one patient had paresis of the sixth cranial nerve, and another had a transient hemiparesis related to a thrombosis of the vertebral artery which was confirmed by angiography (Fig. 21). One patient, with a

Fig. 22

Fig. 23

Fig. 24

Fig. 25

A fatal case with a Type III lesion and tetraplegia. Figure 22—Radiograph before treatment. Figure 23—Photograph of post-mortem specimen. Figures 24 and 25—Radiographs of the post-mortem specimen to illustrate the potential instability of Type III lesions.

Type I fracture, had permanent tetraplegia but this was due to an associated fracture dislocation at C3–4. Type I fracture is a stable lesion with minimal displacement and should never be considered to be responsible for a permanent neurological deficit. The persistence of a neurological deficit should lead to further radiography of the whole cervical spine including repeated dynamic studies allowing for antalgic spasm; vertebral angiography may be required when neurological deficits persist.

Seven patients (19 per cent) with Type II lesions had transient neurological signs. One had a hemiparesis, two had hemiplegia due to thrombosis of the vertebral

Associated lesions of the cervical spine. Associated lesions were seen in 19 patients (14 per cent). These included fractures of the posterior arch of the atlas in eight patients, and fracture of the odontoid process in two patients. The fractures of the odontoid were not displaced and only one was obvious on plain lateral radiographs, the other fracture being revealed by tomography which is a useful diagnostic aid in these fractures. Fractures of the C3 vertebra were sustained in four patients, of C4 in one, of C5 in one and of C6 in two. Two patients sustained subluxation of C5 on C6.

Mortality. Nine patients died but this was due to associated injuries in six. In three patients, death was

Table IV. Type of lesion related to mortality from all causes

Type (and number) of lesions	Cerebral concussion		Shock, chest injury or multiple injury		Injury to axis		Total deaths	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
I (85)	1	1	0	0	0	0	1	1
II (37)	1	3	3	8	1	3	5	14
III (9)	1	11	0	0	2	22	3	33
Total (131)	3	2.3	3	2.3	3	2.3	9	7

artery which was confirmed by angiography, one had paraesthesia in the arms, two had tetraparesis and one had paresis of the sixth cranial nerve. Two patients (five per cent) had permanent neurological deficits. One patient had transection of the conus medullaris secondary to an associated thoracolumbar fracture-dislocation, and the other patient had permanent tetraparesis secondary to the injury of the axis, which was eventually fatal.

Two patients with Type III fractures had tetraplegia, one was transient, the other was permanent and attributable to the injury of the axis (Figs 22 to 25).

attributed to the injury of the axis. Details are given in Table IV, and it will be seen that only one of the 85 patients with a Type I lesion died. There were five deaths from 37 Type II injuries of which one resulted from head injury, three from surgical shock due to multiple injuries and one from transection of the cord at the C2 level. The highest death rate (33 per cent) was from Type III injuries: one of these three patients died as a result of severe head injury while two patients sustained fatal lesions of the cervical cord attributable to the injury at C2 (Fig. 23). The overall death rate in the series was 6.8 per cent.

DISCUSSION

This paper is a retrospective analysis of patients treated before the elaboration of the classification which led to a better understanding of the injury. The management regime proposed is based on this series although many patients were not treated as is now suggested. It is necessary to stress that patients must be thoroughly examined clinically and neurologically before radiographic investigation is undertaken. Attention must be given to problems of the airway, but unless immediate intubation is essential to save life, lateral radiographs of the cervical spine should be taken before this is done. Intubation is a potentially dangerous manoeuvre in the presence of Type II or Type III injuries. The endotracheal tube may also give a false impression of stability

for these Type I lesions is rest in bed for a few days until the patient can confidently lift his head, followed by support in an orthopaedic brace for six weeks. The possibility of a Type II injury which has reduced spontaneously, must be excluded by radiographs in flexion and extension in all patients.

Type II lesions should be managed according to the extent of soft-tissue damage, as shown by both static and dynamic lateral radiographs. If the lesion proves to be stable, the patient may be treated in a halo-thoracic type of immobilisation. Skull traction is advisable if the lesion is unstable as shown by gross listhesis or angulation at the C2-3 interspace on lateral radiographs, or if there has been a change in position of the body of the axis during dynamic flexion and extension examination. If traction be used, it should never exceed four kilograms

Fig. 26

Fig. 27

Fig. 28

Radiographs to show iatrogenic distraction and the changing position of fragments. Figure 26—Anterior listhesis of the body of the axis before treatment. Figure 27—In excessive traction. Figure 28—Traction reduced and the body of the axis in flexion.

if it is in place during the taking of radiographs in flexion and extension.

Radiographic investigation should establish the stability of the injury to the cervical spine and include anteroposterior and the more important lateral views. Lateral radiographs in flexion and extension should be taken without anaesthesia, while an experienced clinician exerts mild manual traction on the head. Lateral tomography may be useful, especially if a Type III injury is suspected. CAT scans are rarely necessary but can supply useful information concerning the integrity of the spinal canal. The whole cervical spine must be seen because of the common association of injuries above or below the fracture of the ring of the axis.

Type I lesions are stable and require only simple splintage. The stability was evident from the fact that 10 per cent of patients with this lesion presented more than 24 hours after their accident. Some patients presented for the first time three weeks after injury, with symptoms which had not justified immediate consultation. Other patients had had radiographs on the day of the accident on which the fracture line had not been seen and had not been treated by immobilisation; they presented, two weeks later, with no increase in displacement. The fracture line could often be detected with hindsight on the original radiographs. The proposed regime of care

and should start with no more than two kilograms, the direction and amount being determined by repeated radiographs. Excessive traction will produce the potentially fatal widening of the C2-3 disc space which is characteristic of judicial hanging (Figs 26, 27 and 28). Traction, preferably in extension, is usually continued for three weeks and the patient is then allowed up with adequate splintage of the cervical spine. Traction is designed to achieve reduction of the fracture and to realign the bodies of the second and third cervical vertebrae; but it is not the ideal method of immobilisation and it may be replaced by a halo-thoracic splint earlier than three weeks if acceptable alignment is achieved and maintained.

After 12 weeks of immobilisation in a halo vest or in a halo spica, the stability of the lesion and its healing should be assessed on flexion and extension films (Figs 29 and 30). CAT scans do not assess stability but may be useful to assess callus formation (Fig. 6). If there is instability at 12 weeks, an anterior fusion of C2 and C3 would seem to be justified. There is no place for an immediate fusion of C2 and C3 or for posterior fusion from C1 to C3 which would unnecessarily sacrifice movement between the atlas and the axis.

Type III lesions show the fracture line to be cephalad to the subluxated facets and manipulation and skull

Fig. 29

Fig. 30

Flexion and extension radiographs taken three months after injury, revealing persisting instability in spite of some new bone formation at the C2-3 disc space. This may require treatment by an anterior C2-3 fusion.

traction is usually ineffective in reducing the dislocated and locked facets at C2-3. When manual traction at the initial examination is unsuccessful, an open reduction of the dislocated facets should be done when the patient is fit for operation (Figs 31 and 32). The capsules of the facet joints are inevitably torn in Type III lesions, and interspinous wiring may be required. Once the facets have been reduced the injury is equivalent to a Type II lesion, with management as outlined above, and the temptation to wire the posterior arches of the atlas to C2 and C3 after reduction of the dislocated facets should be resisted. The surgeon may feel that this would produce greater stability, but the patient will needlessly lose atlanto-axial movement.

Most patients in this series were over treated in relation to our current proposals (Table V). The relatively conservative methods which are now recommended are used routinely by one of the senior authors

Pathogenesis

Attempts to reproduce the fracture of the ring of the axis by forceful manual hyperextension of fresh cadaver and animal cervical spines were unsuccessful, possibly because the applied force was not strong enough or was not specifically directed to the ring of the axis. Fractures and dislocations at other cervical levels were produced. Violent cervical hyperextension, as in judicial hanging with a submental knot and as experimentally achieved with a submental rest by Marshall (1913) and by Good (1913), produces stronger forces directed at the ring of the axis and results in fracture of the ring. In judicial

Fig. 31

Fig. 32

Figure 31—Lateral radiographs to show dislocation of the posterior facets which could not be reduced by skull traction. Figure 32—The C2-3 facet dislocation has been reduced and stabilized by interspinous wiring. The fracture of the ring of the axis was then treated by cervicothoracic support.

Table V. Type of lesion related to treatment

Type (and number) of lesion	Death		Treatment					
			Brace		Anterior fusion		Posterior fusion	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
I (85)	1	1	62	73	5	6	17	20
II (37)	5	14	17	46	4	11	11	30
III (9)	3	33	1	11	1	11	4	45
Total (131)	9	7	80	61	10	8	32	24

(BC) at his spinal centre in Australia. The main reason for this line of management is the propensity for spontaneous healing at both the fracture line and at the C2-3 disc. In Type I lesions the fracture line is undisplaced and is usually healed in eight weeks. Type II and Type III fractures have consolidated within three months in spite of imperfect reduction. Stability may also be achieved by fibrous or bony bridging across the disc space between C2 and C3. There were no instances of non-union among our patients, possibly because many were unnecessarily treated by operation. The less aggressive programme outlined would probably have yielded comparable results, without iatrogenic loss of movement of the cervical spine.

hanging distraction forces, acting after the fracture has been produced, cause death by distraction of the unprotected cord. After vehicular accidents some patients recall a hyperextension mechanism of cervical spine injury, and in others a similar mechanism is substantiated by the history or clinical findings, such as those in a patient riding a motorcycle under a clothes line, or a wire, and sustaining tell-tale transverse abrasions across the neck. Very rarely, the injury was reported to have been primary hyperflexion of the neck followed by rebound extension. Lacerations of the vertex of the scalp suggest that there is often an associated vertical compression force, or axial loading. This may well occur in motor vehicle accidents but is

obviously not the force causing fracture in judicial or experimental hanging. Well localised axial loading does, however, occur in judicial hanging, but it is secondary to hyperextension of the cervical spine (Schneider *et al.* 1965).

Fig. 33

Diagram to show the cervico-cranium. This is the segment proximal to the fracture of the ring of the axis. A posterior C2-3 fusion would be inadequate treatment, while a posterior C1-3 fusion would be over treatment. An anterior C2-3 fusion will stabilise the cervico-cranium, but is rarely, if ever, indicated as a primary procedure.

We believe that the pathogenesis of the injury is related to the morphology of the axis as a transitional vertebra. The concept of the cervico-cranium (Fig. 33) is useful in explaining the causes and pathology of the injury. The cervico-cranium is the cephalad element, consisting of the skull, the atlas, the dens and the body of the axis; and a caudad element distal to the fracture line, consists of the arch of the axis, the third cervical vertebra and the remaining cervical spine. The weight of the skull is transmitted caudally to the superior facets of the atlas, then to the inferior facets of the atlas, and thus to the superior facets of the axis. The axis, unlike the atlas, has a vertebral body anteriorly and a disc space linking it to the third cervical vertebra below, which will receive most of the vertical load. At this segment of the cervical

spine most of the weight is therefore transmitted in an anterior direction, towards the disc space (Fig. 34). Force vectors, passing downwards, diverge at the level of the axis and part of this force, probably less than that directed anteriorly, is transmitted to the posterior articular facets.

These vertical compressive forces are mainly secondary to violent hyperextension of the cervical spine and act against the intact anterior stabilising structures; the force vectors therefore divide at the ring of the axis and account for the location of the fracture within the bony ring, and for the anterior displacement of the body of the axis.

Forceful hyperextension accentuates the divergence of these vectors of force. Both cervical hyperextension and axial loading, which may be due to a blow on the vertex or secondary to the hyperextension itself, are the causes of the fracture in Type I lesions. Once the ring fracture has occurred, the soft tissues of the disc between C2 and C3 are vulnerable. Further hyperextension will rupture the anterior longitudinal ligament and the anterior annulus of the disc space, tilting the body of the axis into extension. The disc space at C2-3 is opened anteriorly, producing an unstable Type II injury. Rebound flexion, following excessive cervical extension, may also produce a Type II lesion, but the body of the axis is then in a position of flexion or anterior listhesis. The initial radiological displacement of the body of the axis is likely to be due to the force which was most recently applied to the skull and spine. It is considered that fractures may occur in different sites in the ring of the axis because of varying positions of rotation at the time of the accident. Rarely, the fracture lines are symmetrical and they occur at the pedicles. More often, the fracture lines are asymmetrical, probably because of rotation as well as violent extension (Figs 35 and 36).

The rare Type III fracture is an exception to the above theory, and usually involves bilateral or unilateral anterior dislocation of the facets. This dislocation must necessarily precede the fracture of the ring of the axis

Fig. 34

Fig. 35

Fig. 36

Figure 34—The axis is a transitional vertebra and forces are transmitted from the atlas via its inferior articular facets and the superior articular facets of the axis to the C2-3 disc space anteriorly and to the articular facets of C2 and C3 posteriorly. Forces thus divide at the posterior arch of the axis and, when strong enough, will cause fracture. Figures 35 and 36—Hyperextension and axial loading produce forces which will cause the ring of the axis to fracture. The fractures are usually asymmetrical because of cervical rotation at the moment of impact.

and is caused by forceful flexion. Rebound extension and axial loading will then produce the fracture of the axis because of the diverging forces previously discussed. The fracture of the ring of the axis occurs after the facets become dislocated and locked; the body of the axis is then held in a position of flexion by the anterior locking of the dislocated inferior facet.

The distinction between simple dislocation of the C2-3 facets and a Type III fracture of the ring of the axis is that the former is caused by forceful flexion only, and the latter by forceful flexion followed by rebound extension and axial loading (Fig. 37).

CONCLUSIONS

Fractures of the ring of the axis are now most frequently seen after motor vehicle accidents, judicial hangings are rare, suicidal hangings usually cause death by strangulation, without fracture, and the "hangman" eponym should now be discarded.

Fracture of the ring of the axis is usually benign; nonetheless, an overall mortality rate of 6.8 per cent is reported, with a significant incidence of associated vertebral injuries, cerebral concussion, and severe chest injuries. Neurological deficits attributable to the fracture are relatively rare, and are usually transient. Severe neurological deficits were more commonly attributable to associated cervical spine injury or to vertebral artery insufficiency.

A simple classification of fractures of the ring of the axis has been proposed which provides guidelines for treatment. Most patients can be treated conservatively and can be up and about within two to four weeks. The rare Type III lesions may need emergency operation; only a few Type II and Type III fractures will require an anterior fusion for instability persisting after 12 weeks of immobilisation.

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Fig. 37

Diagram to illustrate pathogenesis. The degree and type of displacement of the C2 body will depend on the force which is applied to it after the ring of the axis has fractured. Type I and Type II lesions in extension are due to cervical hyperextension injuries. Secondary rebound flexion will cause Type II lesions in which the body of C2 is in flexion or in a position of anterior listhesis. In Type III lesions, posterior facet dislocation occurs first, due to primary hyperflexion. Rebound hyperextension may subsequently fracture the ring of the axis.

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