RAPID TRACTION FOR REDUCTION OF CERVICAL SPINE DISLOCATIONS

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There is still some controversy about the reduction of unilateral and bilateral facet dislocations in the cervical spine. We have reviewed the notes and radiographs of 210 such patients; reduction was attempted by manipulation under anaesthesia (MUA) in 91, and by rapid traction under sedation in 119, using weights up to 150 lb (68 kg).

Our results suggest that early reduction in patients with neurological deficit gives the best chance of neurological recovery, that rapid traction is more often successful than MUA, and that traction is safer than MUA. We found that the use of heavy weights with close monitoring was safe and brought about reduction in an average time of 21 minutes. We recommend this technique for the reduction of all cervical facet dislocations.

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The reduction of dislocated facets in the cervical spine requires a method that is effective and avoids further damage to the spinal cord or nerve roots. It is still uncertain whether such dislocations should be reduced urgently in the hope of aiding neurological recovery, or whether the discs should be scanned by MRI or myelography before reduction is attempted. Opinions also differ on the best method: traction on a conscious patient and manipulation under anaesthesia have both been advised. If traction is used there is no agreement as to whether it should be slow or rapid, or on the maximum weight which should be used.

Before 1987 we attempted to reduce all such dislocations as emergencies by manipulation under anaes-

thesia (MUA). If this failed and the patient was fit for it, we proceeded to open reduction and posterior cervical fusion. Since 1987, we have used rapid reduction by traction of up to 150 lb (68 kg) in the conscious patient. We have compared the results of these two methods in terms of success, neurological outcome, and early mortality.

PATIENTS AND METHODS

From 1981 to 1986, 91 patients (73 men, 18 women) with dislocated cervical facets had attempted reduction by MUA. From 1988 to 1993, 119 patients (95 men, 24 women) with similar injuries had attempted reduction by rapid traction. The average age of the patients at presentation was 32 years (18 to 65) in the MUA group and 33 years (16 to 68) in the traction group. The mean delay before attempted reduction was 58 hours (4 hours to 4 weeks) for MUA, and 78 hours (4 hours to 17 days) for traction. The average follow-up was for ten months from injury (six months to four years).

Table I. Mechanism of injury in the two groups

	MUA* (n = 91)	Traction (n = 119)
Motor accident	59	64
Assault	12	12
Fall	11	27
Diving	6	7
Rugby	3	9

* manipulation under anaesthesia

The groups were similar in terms of mechanism of injury (Table I), level of injury (Table II), and neurological damage at presentation (Table III).

On admission to the spinal unit each patient was fully examined and resuscitated. Neurological assessment included both the Frankel grading system (Frankel et al 1969) and the ASIA motor scoring system (Donovan et al 1990). An attempt at reduction was made as soon as possible after admission.

Manipulation under anaesthesia. Under full operating-theatre conditions, the patient was given relaxant anaes-

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Table II. Level of injury in the cervical spine

	MUA* (n = 91)	Traction (n = 119)
C3/4	3	4
C4/5	28	30
C5/6	29	44
C6/7	27	38
C7/T1	4	3

* manipulation under anaesthesia

Table III. Neurological status at presentation in the two groups

Frankel grade	MUA* (n = 91)	Traction (n = 119)
A	64	77
B, C, D	27	37
E	0	5

* manipulation under anaesthesia

thetia of pentothal and scoline. Two assistants provided counter traction on the arms; the surgeon applied traction by one hand under the chin and the other under the occiput. Image-intensifier screening was used throughout the reduction. For unilateral dislocations, lateral flexion was applied away from the side of the dislocation when the facets were seen to be perching, and reduction was completed by rotation towards the side of the dislocation. For bilateral dislocations, traction was in mild flexion until the facets had disengaged; the neck was then extended. If bilateral cases could be distracted only as far as the perching position, we used either gentle forward pressure on the more caudal spinous processes or attempted reduction of the facets one at a time by lateral flexion and rotation. Reduction was often accompanied by a palpable and audible click. The neck was then extended and 5 lb (2.3 kg) of traction applied through Cone callipers.

Traction reduction. Cone callipers were applied under local anaesthesia, and heavy straps from the bottom of the bed over the patient's shoulders provided counter traction. Titrated doses of morphine and diazepam were given intravenously. Traction was in slight flexion since marked flexion reduces the sagittal diameter of the spinal canal (Cotler et al 1987). Traction was started at 5 lb (2.3 kg) and was increased in 5 lb increments at one to two minute intervals, as observations were made, up to 20 lb (9 kg) and thereafter in 10 lb (4.5 kg) increments. The patient was asked to report any change in neurological symptoms. After each weight had been added, the neurological examination was repeated, with special emphasis on assessment of the lowest functioning motor root and the sixth cranial nerve. Changes in pulse rate, blood pressure, and oxygen saturation were also recorded.

The cervical spine was screened after each increase in weight, to avoid overdistraction. When the facets were no longer overlapping, the patient's head was placed in a neutral position and the neck extended. If the facets could not be distracted beyond the perching position, a gentle manipulation was performed by the technique described for MUA. The neck was then extended and the weight reduced to 5 lb (2.3 kg).

After reduction the patients were treated either by traction for six weeks followed by a brace for a further six weeks, or by posterior cervical fusion followed by traction for two weeks and a brace for ten weeks. This choice was made according to the patients' general medical condition. A more aggressive policy was adopted in later years. In the MUA group, 37 had conservative treatment and 54 had posterior cervical fusion. In the traction group, 17 patients were managed conservatively and 102 had operations.

Review. At follow-up examination we recorded Frankel grading, the ASIA motor score, and any evidence of root sparing at the nerve roots between the dislocated vertebrae, for example the C6 root after a C5/C6 dislocation. Root sparing was diagnosed when the motor unit scored 4 or 5 on the MRC grading system.

RESULTS

Reduction. Of the MUA group, 66 of 91 had a successful reduction (73%). Of the traction group 105 of 119 were satisfactorily reduced (88%). The success rates at different spinal levels are shown in Table IV.

Table IV. Rate of successful reduction at each spinal level for the two groups, given as number and *percentage*

	MUA*		Traction	
C3/4	3/3	100	4/4	100
C4/5	22/28	79	28/30	93
C5/6	25/29	86	38/44	86
C6/7	15/27	56	32/38	84
C7/T1	1/4	25	3/3	100
Total	66/91	73	105/119	88

* manipulation under anaesthesia

Failures. Of the 14 failures in the traction group, eight had associated fractures of the pedicles, facets or laminae, and two had presented 17 days after injury. In the other four, the tongs had pulled out at traction weights of 120 lb (54.5 kg) in two and 130 lb (59 kg) in two. Of the 25 failures of MUA, none had associated fractures and none had presented later than 48 hours after injury.

Weights used. The average weight used to achieve reduction was 57 lb (26 kg; 10 to 150 lb) for unilateral dislocations and 81 lb (37 kg; 10 to 150 lb) for bilateral

cases. We found no relation between the spinal level involved and the weight needed for reduction (Table V). *Time taken.* The mean time taken to achieve reduction after the first weight had been added was 21 minutes (5 to 65).

Neurological outcome

Frankel grading. The changes in neurological deficit between admission and follow-up in each group are shown in Table VI. No patient in either group lost a Frankel grade. In the MUA group, 29 patients (32%) improved by at least one Frankel grade. In the traction group, 40 of the 114 patients (35%) with a neurological deficit showed improvement.

ASIA scoring. Patients with a complete neurological lesion (Frankel A) in the MUA group started with an average ASIA motor score of 9 and at follow-up averaged 22, a mean increase of 13 or 144%. Similar patients in the traction group started with a score of 8 and finished with 19, an increase of 11 or 138%.

Patients with an incomplete neurological deficit (Frankel B, C and D) in the MUA group presented with an average ASIA score of 33 and at follow-up averaged 65, an increase of 32 or 97%. Such patients in the traction group improved from 34 to 68 at follow-up, an increase of 34 or 100%. Six patients in the MUA group had a lower ASIA motor score at follow-up than on admission, and one of the traction group deteriorated.

Root sparing. In the MUA group there was bilateral root sparing in 48 patients, unilateral sparing in 8 and none in 19. In the traction group, there was bilateral root sparing in 71 patients, unilateral sparing in 15, and none in 24.

Delay in presentation. Neither group as a whole showed a statistically significant correlation between neurological recovery and delay in reduction. In the MUA group, those who improved by two or more Frankel grades had presented at an average of 38 hours after injury as against 58 hours for the whole group. In the traction group, those who improved by two or more Frankel grades presented at a mean of 25 hours after injury as against 77 hours for the whole group.

Sixteen patients in the MUA group were seen within 12 hours, and of these three (19%) improved by two or more Frankel grades as against 20% of those presenting after 12 hours. Twenty-three patients from the traction group presented within 12 hours, and of these six (25%) improved by two or more Frankel grades, compared with 8% of those presenting after 12 hours.

Deaths. Sixteen patients in the MUA group and nine of the traction group died within three months of injury. In the latter group four deaths (44%) were due to respiratory failure, two secondary to a gastro-intestinal (GI) bleed, one to acute renal failure, and one to multisystem organ failure after a spontaneous abortion in a pregnant woman. One patient had septicaemia secondary to a chest infection. In the MUA group 12 deaths (75%) were due to respiratory failure, two to GI bleeds, and two to septicaemia.

Three of those dying from respiratory failure had a

Table V. Average weight (lb, kg) used for reduction at each spinal level in unilateral and bilateral dislocations

	Unilateral	Bilateral
C3/4	50 (22.7)	150 (68) (1 case)
C4/5	64 (29)	67 (30.4)
C5/6	53 (24)	58 (26.3)
C6/7	54 (24.5)	114 (51.8)
C7/T1	None	57 (25.9)

Table VI. Neurological progression by Frankel grade (A, B, C, D, E) from admission to follow-up in the two groups

Admission	Follow-up									
	After MUA*					After traction				
	A	B	C	D	E	A	B	C	D	E
A	38	2	4	5	1	52	10	2	3	1
B	0	4	2	1	1	0	8	3	5	1
C	0	0	1		5/6	0	0	3		7/2
D	0	0	0		3/2	0	0	0	2	6
E	0	0	0	0	0	0	0	0	0	5

* manipulation under anaesthesia

deteriorating neurological level after MUA. We believe that this is one cause of the increased mortality after MUA compared with traction, although it is uncertain whether the neurological deterioration was due to the MUA itself or to the general anaesthesia.

DISCUSSION

There is still some controversy on the best method of reducing facet dislocations in the cervical spine. MUA is favoured by some (Evans 1961; Burke and Berryman 1971; Shrosbree 1979; Kleyn 1984; Osti, Fraser and Griffiths 1989), but traction reduction in an awake patient is advocated by others (Crutchfield 1933; Maiman, Barolat and Larson 1986; Cotler et al 1987; Sabiston et al 1988). There is also no agreement on whether neurological recovery is enhanced by emergency or early reduction. Urgent reduction of both unilateral and bilateral facet dislocations is favoured by some (Evans 1961; Burke and Berryman 1971; Kleyn 1984; Sabiston et al 1988) but Maiman et al (1986) believe that neurological recovery is not possible after reduction of bilateral dislocations and that urgent reduction is therefore not justified.

The probable mechanism by which reduction may facilitate recovery and prevent deterioration is decompression of the blood supply of the spinal cord and minimising of ischaemic and hypoxic damage (Tator and Fehlings 1991). Early decompression may prevent further cord damage and may also promote recovery of neurones on the brink of cell death.

Our MUA group showed no difference in recovery between those reduced within 12 hours of injury and those reduced after 12 hours, but in our traction group 26% of those reduced within 12 hours improved by two or more Frankel grades, as against 8% of those reduced after 12 hours. We therefore conclude that the best chance of neurological recovery lies in early traction reduction. We do not agree with Durbin (1957) that a complete lesion present for more than 48 hours never recovers: one MUA case reduced at 96 hours improved from Frankel A to Frankel D, and one traction case, also reduced at 96 hours, went from Frankel A to Frankel C.

The risk that a retropulsed fragment of disc will cause further damage to the cord during reduction has prompted some authors to recommend MRI or CT myelography before reduction of all patients with a neurological deficit (Eismont, Arena and Green 1991; Mahale and Silver 1992; Robertson and Ryan 1992). These authors advocate anterior decompression and fusion if imaging shows such an extruded disc. Rizzolo et al (1991) found herniated discs in 80% of bilateral facet dislocations, but neurological deterioration after reduction occurs in less than 1% of cases (Mahale and Silver 1992) and not all herniated discs therefore cause problems during reduction.

Eismont et al (1991) emphasised the danger from an extruded disc lying behind the body of the upper dislocated vertebra: this may be pushed back into the cord during reduction. Six of Eismont's 68 patients (9%) were shown to have a herniated disc with marked protrusion into the spinal canal. If this figure is generally accurate for both unilateral and bilateral dislocations, closed reduction in these will cause neurological deterioration, and we should have seen such worsening in 9% of our patients with neurologically incomplete lesions. None of the latter, however, deteriorated. It is possible that open reduction by a posterior approach in the presence of a disc extrusion, as in one of Eismont's patients who deteriorated, is dangerous because this method of reduction levers the facets over each other without distraction. In both MUA and traction reduction the initial distraction may partially reduce the disc extrusion.

Osti et al (1989) reported that patients with complete neurological lesions have a high mortality after acute anterior surgery, and those with incomplete lesions have impaired neurological recovery. We consider that the risks of anterior surgery should be contrasted with the minimal neurological deterioration after reduction in our series. It seems that imaging of the disc is not necessary before reduction; the consequent delay may well be detrimental to neurological recovery. Neurologically intact patients, however, do not appear to have an increased mortality from early surgery; in these cases reduction is less urgent, and imaging of the disc may be useful.

Varying success rates have been reported for MUA: Evans (1961) reported success in 85%, Burke and

Berryman (1971) in 90%, Shrosbree (1979) in 68% of unilateral and 64% of bilateral cases, Kleyn (1984) in 82%, and Osti et al (1989) in 91%. Slow traction has also given variable success rates: O'Brien, Schweigel and Thompson (1982) reported 55%, Maiman et al (1986) 55%, Cotler et al (1987) 71%, and Sabiston et al (1988) 90%. Our success rates of 73% for MUA and 88% for traction would seem to confirm that traction is the most reliable method. Although there was no overall correlation between fracture and failure of reduction, we believe that bilateral pedicle fractures in particular decrease the chances of successful reduction.

General anaesthesia during the acute phase of spinal injury is thought to be detrimental to the blood supply of the cord (Verbiest 1969; Burke and Berryman 1971; Osti et al 1989) and this may be one reason why our MUA group had a higher mortality and a higher rate of neurological deterioration. We feel that general anaesthesia should be avoided during spinal shock if this is possible.

Animal experiments have shown that a neurological deficit produced by rapid traction may recover when traction is released, but that sustained traction resulted in a permanent injury (Cusick et al 1982). The traction technique described by Crutchfield in 1933 lasted for several days. Cotler et al (1987) speeded this by adding a weight every 30 minutes, allowing this time for 'creep' of the soft tissues. This rate is still time-consuming: it would take over eight hours to reach 150 lb (68 kg), and if a neurological deficit develops in the absence of the surgeon the patient may suffer the sustained traction injury described by Cusick et al (1982). Our technique of rapid traction takes a maximum of one hour, and starts with small weights so that gross ligamentous damage is obvious before heavier weights are used.

Our use of heavy weights has also been controversial since it was introduced by Cotler et al (1987). Crutchfield (1933) used 10 lb for the head and 5 lb for each level to a maximum of 40 lb (18 kg) and Bohlman (1979) advised a maximum of 50 lb (22.7 kg). Sabiston et al (1988) used up to 70% of body-weight. These upper limits would have reduced only 22%, 45% and 76% of our cases respectively, while we succeeded in 88%. We believe that rapid reduction is important and that general anaesthesia is detrimental. We therefore recommend the technique that produces the greatest success rate without anaesthesia and have shown that it rarely causes an increase in neurological deficit. Our MUA group had 16 deaths and six patients with neurological deterioration compared with nine deaths and one case of neurological deterioration in the traction group.

Conclusions. Early reduction of unilateral and bilateral facet dislocations of the cervical spine offers the best chance of neurological recovery. Reduction is an emergency procedure in a neurologically injured patient and should not be delayed for imaging of the intervertebral disc by MRI or myelography. Our traction method is

quicker, more effective, and safer than MUA, and both rapid traction and the use of weights up to 150 lb (68 kg) are safe provided that neurology, vital signs, and radiographs are closely monitored. We recommend the use of this method for all patients with a neurological deficit due to unilateral or bilateral facet dislocation.

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