NEUROLOGICAL DETERIORATION AFTER POSTERIOR WIRING OF THE CERVICAL SPINE

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Posterior cervical wiring is commonly performed for patients with spinal instability, but has inherent risks. We report eight patients who had neurological deterioration after sublaminar or spinous process wiring of the cervical spine; four had complete injuries of the spinal cord, one had residual leg spasticity and three recovered after transient injuries.

We found no relation between the degree of spinal canal encroachment and the severity of the spinal-cord injury, but in all cases neurological worsening appeared to have been caused by either sublaminar wiring or spinous process wiring which had been placed too far anteriorly.

Sublaminar wiring has substantial risks and should be used only at atlantoaxial level, and then only after adequate reduction. Fluoroscopic guidance should be used when placing spinous process wires especially when the posterior spinal anatomy is abnormal.

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Wiring of an unstable cervical spine was first reported by Hadra¹ in 1891, and numerous methods have been described including sublaminar, spinous process, tension band, facet and triple wiring. Neurological complications have been reported but are considered to be rare.²⁻⁶ Some recent articles have reported the significant risk inherent in the use of sublaminar wires.^{3,7,8}

At our regional spinal injury rehabilitation centre, we see many patients with cervical spinal injuries and quadriplegia. Since 1984, we have treated eight patients who sustained neurological injury during posterior cervical fixation with wire at other hospitals. We report the details, potential

risks and causes of neurological deterioration, and make recommendations to reduce the risk.

PATIENTS AND METHODS

All eight patients had been referred to our institution for evaluation and rehabilitation. In a retrospective review, we studied their medical records and all available radiographs and MRI and CT scans to assess any compromise of the spinal canal by the wires or in any other way. We used the classification system of Geremia et al⁴ to evaluate the degree of canal compromise (Table I). For patients treated by sublaminar wiring, we measured encroachment of the wire into the spinal canal on the lateral radiograph. For those treated by spinous process wiring, we assessed the extent of encroachment on axial CT scans.

Five of the patients had had sublaminar wiring and three spinous process wiring. Their mean age was 37 years (13 to 68). Six had been treated for traumatic instability, one for instability due to a hypoplastic odontoid and one for a painful pseudarthrosis after the failure of an anterior cervical discectomy and fusion for degenerative disc disease.

RESULTS

Five of the patients were neurologically intact or had very minor signs before the original operation. One had complete quadriplegia at the C5 level and two had incomplete quadriplegia (Table II). After surgery, all eight patients had developed new neurological deficits. Four had complete quadriplegia at a more cephalad level; three of them needed ventilator support, and all four remained unchanged after rehabilitation, although one was eventually weaned from the ventilator. Three had nearly complete resolution of their neurological injury, and one continued to have residual

Table I. Classification of canal encroachment by posterior wires (Geremia et al⁴)

Grade	
I	Anterior bowing into the posterior 25% of the spinal canal
II	Anterior bowing into the posterior 26% to 50%
III	Bowing beyond the midline of the canal but not into the anterior 25%
IV	Bowing into the anterior 25%

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Table II. Neurological status of eight patients with deterioration after wiring

Case	Level	Pathology	Operation*	Neurology		
				Preop	Postop	Eventual
1	C5 to C6	Subluxation	SL	Intact	C6 ASIA A	C6 ASIA A
2	C5	Burst fracture	SL	C5 ASIA A	C3 ASIA A - ventilator	C3 ASIA A - ventilator
3	C2	Hypoplastic odontoid	SL	Intact	C3 ASIA A - ventilator	C3 ASIA A - ventilator
4	C1 to C2	Subluxation	SL	Intact	Right hemiparesis	Right leg spasticity
5	C4 to C5	Subluxation	SL	C4 ASIA D	C4 ASIA C	Intact
6	C6 to C7	Bilateral facet dislocation	SP	Intact	C6	Intact
7	C5 to C6	Subluxation	SP	C6 ASIA B	C4 ASIA A - ventilator	C5 ASIA A
8	C4 to C5	Failed ACDF†	SP	Intact	C5 ASIA D	Intact

* SL, sublaminar; SP, spinous process

† anterior cervical discectomy and fusion

spasticity of the right leg.

Three of the five patients treated by sublaminar wires had adequate postoperative radiographs and these showed grade-II encroachment into the canal. Two of the patients treated by spinous process wires had grade-I encroachment. We found no apparent correlation between the degree of encroachment and the neurological deficit. The cause of the encroachments and injuries varied. Two of the patients with sublaminar wires did not have adequate reduction of the cervical spine before surgery, and the other three may have been injured by anterior bowing of the wires. In all three patients with spinous process wiring, the wire had been placed anterior to the spinolaminar line and within the spinal canal, probably traumatising the spinal cord during its passage.

Sublaminar wires

Case 1. A 60-year-old man sustained C5 to C6 subluxation in a motor-vehicle accident, and had no neurological signs. He was treated in traction and after six days had a posterior cervical fusion with sublaminar wiring. After this, he developed complete sensory paraplegia at the T3 level. At operation the wires were removed, a laminectomy was performed and C5 to C6 spinous process wiring applied. After this operation he became completely quadriplegic at C6 and did not improve.

Case 2. A 15-year-old youth had a C5 burst fracture and C5 complete quadriplegia in a diving accident. After two days in traction he had sublaminar wiring and fusion from C4 to C7 (Fig. 1). In the recovery room he had developed C3 complete, ventilator-dependent quadriplegia and radiographs showed grade-II encroachment of 42% into the canal. No further surgery was performed, and there was no improvement.

Case 3. A 53-year-old woman, neurologically intact, had C1 to C2 sublaminar wiring and fusion for a hypoplastic odontoid and subluxation. The wires were passed without adequate reduction and could not be properly placed. No wires were left in situ, but when she woke, she was ventilator-dependent with complete C3 quadriplegia and did not improve.

Case 4. A 13-year-old boy with Down's syndrome sustained C1 to C2 subluxation with normal neurological status. Traction and C1 to C2 sublaminar wiring with

fusion were performed on the same day. He developed a right-sided hemiparesis; postoperative radiographs showed anterior bowing of the sublaminar wires with 28% encroachment. The wires were removed and fusion from the occiput to C3 performed. There was almost full neurological recovery but some residual spasticity of one leg.

Case 5. A 21-year-old man sustained a C4 to C5 subluxation in a fall at gymnastics. The original dense quadriplegia quickly improved to C4 ASIA (American Spinal Injury Association) D quadriplegia. Seven days after the injury, sublaminar wiring and fusion from C4 to C5 led to increased left-sided weakness but eventually recovered to nearly normal neurological function. Postoperative radiographs showed grade-II encroachment of 39% into the canal.

Spinous process wires

Case 6. A 68-year-old woman fell from a bed and sustained

Fig. 1

Lateral radiograph after sublaminar wiring. Multiple wires had been passed at several levels.

Fig. 2

Fig. 3

Fig. 4

Figure 2 – Lateral radiograph showing spinous process wiring. The wires in the upper vertebra are anterior to the spinolaminar line and therefore within the spinal canal. Figures 3 and 4 – Axial CT showing spinous process wires passing through the laminae and into the spinal canal.

bilateral facet dislocation of C6 on C7. She was initially assessed as neurologically intact except for a weak right triceps and decreased rectal tone. Traction and attempts at closed reduction were unsuccessful. Open reduction and wiring of the spinous processes of C6 to C7 and fusion resulted in incomplete quadriplegia requiring ventilator support. Conservative management gave gradual improvement to C6 ASIA D quadriplegia, and at discharge she had only mild numbness in her hands and legs. Postoperative radiographs and CT showed encroachment of the wire by 2 mm into the posterior canal (grade I).

Case 7. A 22-year-old man sustained a hyperextension injury at rugby football. He had C5 to C6 perched facets and C6 ASIA B quadriplegia. After traction for three days he had C5 to C6 spinous process wiring and fusion (Figs 2 to 4). He awoke with complete, ventilator-dependent C4 quadriplegia. Postoperative CT scans showed C5 and C6 wires penetrating by 4 mm and 3 mm (grade I). No further surgery was performed and he improved to a C5 complete quadriplegic, and was weaned from the ventilator.

Case 8. A 47-year-old man, neurologically intact, had persistent neck pain after failed anterior cervical discectomy and fusion for a degenerative disc at C4/C5. The pseudarthrosis was treated by C4 to C5 spinous process wiring and fusion. The patient developed C5 ASIA D quadriplegia and postoperative CT showed wire in the spinal canal at C4. The wires were immediately removed at operation, a laminectomy was performed and a posterior cerclage wire placed. There was gradual improvement, eventually leaving only minimal left-sided arm and leg weakness.

DISCUSSION

Most surgeons now advise against the use of sublaminar wires in the cervical spine. Bohlman⁹ cites the risks of

radiculopathy and cord compression, and considers that spinous process wiring is safer. Meyer⁵ abandoned the use of sublaminar wires after two patients had sustained neurological deterioration. Geremia et al⁴ reported neurological complications in three of 42 patients (7%) after sublaminar wiring, and Wilber et al¹⁰ found a 17% incidence of neurological symptoms associated with sublaminar wires, noting that even in asymptomatic patients, neurological changes could be recorded by spinal cord monitoring by somatosensory cortically evoked potentials. Schrader, Bethem and Scerbin¹¹ also expressed reservations about sublaminar wiring after studying the chronic, local effects of wires in dogs, and Coe et al⁷ found no biomechanical advantage of such wires as against other techniques.

Sublaminar wires are still used at the atlantoaxial level, although there are some concerns. Smith et al⁶ noted a high incidence of complications in a series of 47 patients with sublaminar wiring of the upper cervical spine. There are individual case reports of a broken sublaminar cable or wire penetrating the spinal cord in the upper cervical spine, and Fraser et al,³ despite the proven efficacy of sublaminar wires in the upper spine, advised other means of fixation. Goll et al¹² recommend the avoidance of the lateral passage of the wire and careful prebending before placement.

Several authors consider that there is an increased risk of neurological injury when wires are passed under more than one lamina at a time. Geremia et al⁴ noted the increased risk of anterior bowing of a wire, and both of Meyer's patients with neurological damage had wires passed under three laminae.⁵ Watts, Smith and Knoller¹³ reviewed 34 patients without neurological damage and considered that sublaminar wiring is safe if limited to one or two laminae. Our review has shown that sublaminar wiring can be dangerous even at one level.

We have abandoned the use of sublaminar cervical wir-

ing^{4,5} in the subaxial spine unless unusual circumstances preclude other options. We continue to use them at the atlantoaxial level, where there is more anatomical canal space¹⁴ and there are inadequate spinous processes. Below C2, we consider that there is too little margin for error.

Some recent articles have cited the advantages of stranded cables over solid wires for cervical stabilisation. Songer et al¹⁵ found that stainless-steel cables were strong and flexible with a greater tendency to conform to the lamina while Huhn et al⁸ confirmed their strength and flexibility.

Spinous process wiring, in contrast to sublaminar passage, is widely considered to be quite safe since no wires should be introduced into the spinal canal. We have found no previous reports of neurological injury from this procedure. Hadra, in his pioneering 1891 report,¹ described "the wiring of the sixth and seventh spinous process with silver wire, carrying it four to five times around in a figure of eight". Numerous variations and refinements of the technique have since appeared,^{9,16-19} and Rogers,¹⁶ seeking to eliminate the problem of wire slippage, introduced the method of placing a small transverse hole in the base of the spinous process of each vertebra through which the wire is placed before and after wrapping it around the process. The three patients whom we report had neurological injuries resulting from technical errors in Rogers-type wiring. Injuries appeared to have occurred when the holes were placed too far anteriorly, and the wires were unknowingly introduced into the spinal canal. It may be quite easy to make the hole through the posterior lamina instead of the spinous process in vertebrae with no obvious transition from the lamina to the spinous process. We now use lateral fluoroscopy when placing these holes: in an ideal lateral view the spinolaminar line clearly shows the posterior boundary of the canal, and care should be taken to stay posterior to this level.

Our cases highlight the important role of modern imaging techniques in the treatment of cervical trauma. Preoperative images help the surgeon to determine if techniques of posterior cervical wiring are appropriate, based on the stability of the posterior elements. Axial CT images show the morphology of the spinous processes. When neurological injury is diagnosed after posterior cervical wiring, MRI and contrast CT can now show with much greater precision whether wires are compressing the spinal cord. Neurologically-incomplete postoperative deficits, with a recognised neuropathy, should be fully investigated as soon as possible with the aim of relieving compression. In one reported case⁴ of incomplete quadriplegia after sublaminar wiring, removal of the wires, although delayed, resulted in an excellent recovery.

Conclusions

- 1) During cervical traction to reduce a deformity, the patient should be conscious so that neurological problems at that stage can be recognised.
- 2) During spinous process wiring, lateral imaging should

ensure that the holes and wires are posterior to the spinolaminar line.

3) Sublaminar wiring of the subaxial spine should be used only when there is no acceptable alternative. At the atlantoaxial level, reduction must be complete before wires are passed.

4) Neurological deterioration after posterior wiring requires immediate imaging studies to exclude any compressive lesion and to allow early surgical revision when this is indicated.

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