Age related shift in the primary sites of involvement in cervical spondylotic myelopathy from lower to upper levels

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Cervical spondylotic myelopathy ranks first among non-traumatic disorders of the spinal cord in Japan. Analogous to the short incremental stimulation used to localise a peripheral nerve lesion,12 multisegmental recording of ascending spinal evoked potentials can identify precisely the site of abnormalities in cervical spondylotic myelopathy.13 This is achieved by placing pickup electrodes in the structures adjacent to the spinal cord; an abrupt reduction in the size of the negative wave over a short segment is taken as strong evidence of a focal conduction block.23 Electrophysiological documentation of this often treatable condition plays an important role in surgical intervention, particularly in elderly patients who tend to have clinically silent cord compression at multiple levels on magnetic resonance imaging (MRI).4 In a previous report in which we showed a higher incidence of conduction block at C3–4 or C4–5 in older patients with cervical spondylotic myelopathy,4 we postulated that there might be a shift in the primary sites of involvement from lower to upper cervical levels with aging. To test this hypothesis, we have now analysed a series of 129 patients representing all age groups.

METHODS

From July 1991 to July 2001, 136 patients with cervical spondylotic myelopathy and with moderate to severe spastic limb paresis underwent intraoperative electrophysiological studies. We excluded patients with myelopathy from other causes such as ossified posterior longitudinal ligament, rheumatoid arthritis of the cervical spine, or trauma causing cord damage immediately after injury.

We analysed the recordings from 129 patients (74 men and 55 women) ranging in age from 24 to 88 years (mean 65 years). All had unequivocal evidence of focal conduction block, with a reduction in area of the negative peak to 60% or less compared with the immediately caudal level.

Based on Nurick’s functional grading system,6 six patients walked normally despite signs of spinal cord compromise (grade 1), 56 had some difficulty but were able to walk unaided (grade 2), 37 required walking aids (grades 3 and 4), and 30 were chairbound or bedridden (grade 5). All but five patients had loss of fine finger movement in doing up buttons and opening and closing the fists. All but 12 showed sensory impairment for light touch, pin prick, or vibration in the upper limb, and all but 13 in the lower limb. Of the 82 patients with bladder symptoms, 42 had hesitancy and urgency and 40 had retention and incontinence. Stretch reflexes were generally hyperactive although responses were diminished for the biceps in 18 patients, in the triceps in four, in the quadriceps in one, and in the gastrocnemius in 15. Extensor plantar responses were elicited in 50 patients.

A pair of stimulating electrodes (UKG-100-2PM, Unique Medical Corporation, Tokyo, Japan), with two platinum tips at the end of an 18 gauge polyethylene tube, was introduced into the dorsal epidural space at the lumbar or lower thoracic level through a Tuohy needle.78 Electrical stimulation consisted of a square wave, 0.1 ms in duration and 20–40 mA in intensity, delivered at a rate of 3–20 impulses a second. In 105 patients in whom an anterior approach was used at operation, a series of recording needle electrodes (G1) (Dantec 13R23, Dantec Medical, Skovlunde, Denmark) was inserted into the intervertebral discs in the midline after exposure of the anterior aspect of the vertebral bodies.49 The electrodes were advanced posteriorly to cover the disc diameter. In the remaining 24 patients,
who required a posterior approach, the needle electrodes (G1) were inserted into the ligamentum flavum in the midline in serial intervertebral spaces after exposure of the posterior aspect of the vertebrae.\textsuperscript{1,3,4}

A series of needle electrodes (Dantec 13R21) served as the reference (G2), inserted at the same level as G1 into the longus colli muscles for anterior recordings and into the erector spinae muscles for posterior recordings.

An eight channel averager (Dantec Evomatic 8000) allowed simultaneous recording of evoked potentials from all sets of electrodes for measurements of amplitudes from the baseline to the positive and the subsequent negative peaks, and areas under the initial positive and the negative phases.

Statistics
Statistical analyses comprised the two tailed Wilcoxon signed rank test for paired data, the Mann-Whitney U test for unpaired data, and Spearman rank correlation coefficients for interrelation analysis. Values are given as mean (SD) and were considered significant at a probability (p) value of < 0.05.

RESULTS
Incremental electrophysiological studies uncovered a single site of focal conduction block characterised by an abrupt reduction in size of the negative peak and a concomitant augmentation of the initial positive peak in 129 patients: two at C1–2, one at C2–3, 51 at C3–4, 39 at C4–5, 30 at C5–6, and six at C6–7 (fig 1). A rare high cervical involvement of cervical spondylotic myelopathy resulted from cord compression by the ligamentum flavum with mild atlantoaxial instability at C1–2, or a distinct disc herniation at C2–3.

At the site of conduction block, the negative component declined to 34 (18)% in amplitude (mean (SD); range 0% to 65%); and to 26 (17)% in area (range 0% to 58%) compared with the level immediately caudal to this (both p < 0.0001; fig 2). In contrast, the initial positivity increased to 162 (84)% in amplitude (range 2% to 463%) and to 340 (318)% in area (range 22% to 2463%) (both p < 0.0001).

The lesion sites shifted more rostrally with advancing age (p = 0.466, p < 0.0001); C6–7 at 49 (11) years; C5–6 at 52 (12) years; C4–5 at 68 (14) years; C3–4 at 72 (10) years; C2–3 at 74 years (one patient); and C1–2 at 81 (6) years (fig 1). Statistical analysis showed a significant age difference between patients with a conduction block at C3–4 or C4–5 and those with a block at C5–6 or C6–7 (p < 0.005). In particular, 92% of the 60 patients aged over 70 years had focal involvement at C3–4 or C4–5, while 68% of 40 patients aged under 60 years had a lesion at C5–6 or C6–7.

Based on the Nurick functional grading, the patients had increasing clinical incapacity with advancing age (p = 0.457, p < 0.0001). The electrophysiological studies also confirmed this tendency, showing a significant age difference (p = 0.0003) between 51 patients with a complete conduction block (71 (12) years; fig 2, right) and 78 patients with a partial block (61 (15) years; fig 2, left). Outcome analyses in 116 patients, followed for a minimum period of one year, showed that poor surgical results correlated with advancing age (p < 0.0001) but not with a more rostral level of compression (p > 0.1).

DISCUSSION
We reported previously that incremental electrophysiological studies can identify the site of conduction block by showing an abrupt reduction in size of the negative peak accompanied by an enlargement of the initial positive peak.\textsuperscript{1,3,4} At this site, a blocked fibre contributes a normal positivity followed by a substantially reduced negativity, as the impulse approaches without reaching the recording site.\textsuperscript{10} This reduction in negativity not only decreases the negative peak of the evoked potential but also increases its positive peak resulting from loss of physiological phase cancellation.\textsuperscript{11,12} Rostral to a conduction block, a blocked fibre gives rise to a killed end effect with a volume conducted positive wave. Thus monophasic positive evoked potentials rostrally are characteristic of complete focal conduction block.

In the present study, we have applied this principle to test the notion that the site of involvement in cervical spondylotic myelopathy is more rostral in elderly patients than in middle aged patients, even though both groups commonly show radiological abnormalities at C5–6 and C6–7.\textsuperscript{13} Our data in an older cohort of patients, of average age 65 years, confirm a higher incidence of focal lesions more rostrally at C3–4 or C4–5, despite morphological abnormalities at C5–6 and C6–7. Our data indicate that with advancing age the primary site of the lesions shifts from lower to upper cord segments.

Because of the inherent limitation of our technique—that it identifies only the most caudal conduction block—our data...
may have overlooked additional sites of involvement further rostrally. Assessments of both descending and ascending evoked potentials would circumvent this problem, possibly uncovering conduction block at two separate levels. An additional electrophysiological exploration, however, would have modified the present results only partly, because clinically silent cord compression shown by MRI in asymptomatic subjects mostly occurs at lower cervical levels.\(^5\)

Our conclusion that the upper cervical segments are affected preferentially in those who develop the disease later is somewhat counterintuitive in the face of documented incidences of lower cervical involvement as identified by computed tomography and MRI. We postulate that in elderly patients the lower cervical segments show less mobility than the upper segments, reflecting an advanced degree of bony degeneration. This tendency may paradoxically protect the lower segment,\(^1\)\(^5\)\(^6\) accounting for the lack of conduction block in the face of apparent compression. In contrast, an excessive compensatory movement imposed on the higher segments may cause instability, leading to functional compromise.\(^2\)\(^3\)\(^4\)\(^5\)\(^6\)\(^7\) In these cases, incremental electrophysiological studies can detect the precise level of dysfunction, directing surgical intervention to the actual site of involvement.

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Received 6 February 2002

In revised form 8 May 2002

Accepted 16 May 2002

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J Neurol Neurosurg Psychiatry 2002 73: 316-318
doi: 10.1136/jnnp.73.3.316