Results of adequate posterior decompression in the relief of spondylotic cervical myelopathy

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The author reports his experience with 35 cases of spondylotic myelopathy treated by extensive laminectomy and section of the dentate ligament. After a follow-up of 1 to 7 years, 24 patients have maintained distinct improvement; in nine the disability has not improved and in two it has become worse. The technique is described, and postoperative myelograms are used to demonstrate the improvement.

KEY WORDS: spondylotic cervical myelopathy · laminectomy · dentate ligament section

The advent of anterior approaches to the cervical spine and conflicting opinions on the value of conventional posterior operations for compressive cervical myelopathy have led to a general decline of interest in laminectomy as a means of relieving this condition.

We have discussed the development of myelopathy, emphasizing the role of vascular changes, the size of the cervical canal, and the thickness of yellow ligaments. Variations exist, particularly in the anteroposterior dimension of the cervical canal, and persons with narrow canals are more likely to develop myelopathy when spondylosis occurs.

Kahn showed an early interest in the role of the dentate ligaments as did Epstein and Davidoff, but the subject has remained controversial.

Haft and Shenkin, in reviewing all the results of posterior decompression published to 1963, found that only 42% of the patients had benefited from the operation, but Stoops and King found that 83% of their patients showed some improvement. Scoville's operation evolved from a simple laminectomy to a more extensive procedure including bilateral facetectomy at one or two levels. His results were gratifying as were those of Aboulker, et al., and Rogers who both have advocated extensive unroofing of the entire cervical spine.

Few surgeons have removed ventral ridges by a posterior operation. Mayfield described this procedure, which necessitated a wide laminectomy and foraminotomy at multiple levels. Epstein's operation now includes removal of osteophytes by an extradural procedure.

The introduction of anterior disc excision and interbody fusion led Crandall and Batzdorf to make a comparative study of patients with myelopathy treated by various
surgical procedures. They felt the best results were achieved by the anterior operation. Verbiest and Paz y Guese employed their anterolateral operation on patients primarily with single level involvement. In Galera and Tovi's series, results of anterior disc excision and fusion were poor. Although Mayfield adopted the anterior approach, he could not make a valid comparison with his previous cases.

The experiments of Brieg, et al., detailed the biomechanics affecting the spinal cord under normal and pathological conditions, demonstrating that the spinal cord is normally unable to move up and down but adapts itself by plastic deformation. Bone protrusions stretch the cord in ventral flexion so that the major effect in spondylosis is an increase in axial tension as a result of the lateral anchorage through the dentate ligaments.

It appeared from these studies that the matter of the dentate ligaments, long considered a dead issue, might well be revitalized. With this in mind, it seemed worthwhile to consider the value of a combination of extensive cervical laminectomy to effect adequate posterior decompression and section of all the cervical dentate attachments to provide a longitudinal release of the spinal cord.

Lahey Clinic Foundation Experience

Review of previous results of laminectomy and dentate section performed at our institution provided little to recommend the procedure, especially for patients with severe myelopathy. In many instances, however, laminectomy had included only two or three segments; moreover, myelography was not performed after operation to evaluate the status of the cervical canal.

Selection of Patients

From 1965 to 1971, 35 patients were chosen for a more extensive procedure. All had evidence of progressive myelopathy and roentgenologic findings of severe cervical spondylosis. In most patients spondylosis involved the lower cervical interspaces, but, in many, advanced changes extended upward to include the level of the fourth to fifth cervical vertebrae and in some the level of the third to fourth cervical vertebral interspace as well. In some patients the lateral cervical roentgenogram showed a narrow canal in addition to spondylosis. Spinal cord encroachment was confirmed by myelography. Questionable cases, such as patients with motor system or demyelinating disease who may have had unrelated cervical spondylosis, were not included.

Symptoms and Signs

Of the 35 patients, 33 had weakness and spasticity of the legs; several also had some weakness or sensory disturbance of the arms. Two patients had a so-called dissociated motor loss, similar to that described by Keegan, with weakness of the arms but no difficulty in walking; both of these patients showed corticospinal tract signs in the legs. Varying degrees of impaired spinal cord function were seen (Table 1) from the more severe transverse type of lesion including bilateral spinthalamic and posterior column signs as well as corticospinal tract involvement to those with corticospinal tract findings alone. A number of patients

TABLE 1
Classification of cases of spondylotic cervical myelopathy

<table>
<thead>
<tr>
<th>Clinical Type</th>
<th>Motor Loss</th>
<th>Sensory Loss</th>
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<tbody>
<tr>
<td>severe</td>
<td>spastic paraparesis in legs, unable to walk, some arm weakness</td>
<td>transverse sensory level</td>
</tr>
<tr>
<td>moderately severe</td>
<td>spastic weakness in legs</td>
<td>some long tract signs including posterior column involvement</td>
</tr>
<tr>
<td>mild</td>
<td>minimal spasticity in legs</td>
<td>minimal, Brown-Séquard syndrome</td>
</tr>
<tr>
<td>dissociated motor loss</td>
<td>weakness &amp; lower motor neuron signs in arms, no weakness in legs but some corticospinal tract signs</td>
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had posterolateral signs, and a few had Brown-Séquard's syndrome. Each of eight patients with severe weakness of the legs showed evidence of extensive sensory loss as well, with levels extending to the upper dorsal and lowest cervical segments.

None of this group had serious pain, probably because the series did not include any of the far more numerous patients with single nerve-root compression caused by lateral spur formation. It is significant, however, that in many of the patients in whom spondylosis was most noticeable at the fifth and sixth cervical segments, the biceps and radial reflexes were reduced or absent, and the triceps reflexes were hyperactive as were those of the legs, probably indicating beginning involvement of the corticospinal tract or upper motor neuron function just above the C-7 level. While these patients had little or no radicular pain in the shoulder or arm, many reported numbness and paresthesias in the hands.

The duration of symptoms from the time of onset varied from 6 months to 10 years. In the majority, symptoms had been present for 1 to 2 years. In every patient, however, the presenting symptoms had been unrelenting and progressive. No remission or improvement was noted at any time, even after treatment with neck immobilization, traction, and other measures. Three patients had previously undergone anterior interbody fusion at one level with no improvement and no arrest in the progression of leg weakness.

**Preoperative Myelography**

Myelography before operation disclosed three types of abnormalities related to spinal canal encroachment. Type 1 included a number of patients with the typical shelf-like defects caused by midline ventral ridges at two or three levels with a more or less symmetrical appearance of the pantopaque.

![Fig. 1. Myelograms. Left: Complete block to passage of Pantopaque at the level of C6-7 with neck in hyperextension. Right: Same patient with neck in semiflexion showing typical “shelf” or “ladder” type of defect.](image)
Posterior decompression for spondylotic cervical myelopathy

iophendylate (Pantopaque) column. In others, partial block to passage of Pantopaque was more pronounced with either a trickle of contrast medium on one side of the canal or a complete filling defect involving one or more segments.

The second type of abnormality was characterized by a complete block to the passage of Pantopaque with the neck in hyperextension, which converted to a partial block, as in Type 1, when the neck was flexed (Fig. 1).

In the third type, which included only four patients, a complete horizontal myelographic block was seen, sharply demarcated at the interspace.

While it was not always possible to correlate the severity of neurological involvement or the degree of myelopathy with these gradations of abnormality on myelograms, usually the more severe instances of myelopathy were associated with a greater degree of block. One notable exception was a 62-year-old man with a complete block at C6-7 but with minimal weakness and spasticity in the legs.

Myelography also proved helpful in evaluating some of the mechanical disorders in the disease. While it seemed clear that the greatest damage to the cervical cord was incurred during flexion, it was also apparent that in many patients, particularly those with a shallow spinal canal, hyperextension could produce further crowding of the spinal cord.

Surgical Technique

In each case, extensive cervical laminectomy was carried out with the patient in the sitting position under endotracheal anesthesia with the head in a neutral position. Laminectomy was begun at either the first dorsal or seventh cervical level, depending upon the configuration of the cervical canal and particularly the cervicodorsal junction. In some instances the arch of the atlas was included. In others from a mechanical standpoint, it did not appear that including the first cervical vertebra would add significantly to the decompression.

The first dorsal lamina was removed in about one half of the patients because it was believed this improved the longitudinal decompression and the course of the cervicodorsal cord. While the laminectomy may have included small portions of medial facets at one or two levels, it was not deemed necessary to carry out extensive facetectomy or foraminotomy as would be done for root compression, particularly because an extensive longitudinal decompression seemed the factor of greatest mechanical importance.

In each case the dura was opened throughout the full length of the exposure, and all of the dentate ligament attachments were divided on each side. This was done not only to provide as much cephalocaudal release of the cervical cord as possible but also to permit a careful exploration of the anterior cervical canal so that any soft midline disc extrusion would not be overlooked. The dura closed easily, and dural grafting was never necessary.

Because two patients were significantly and permanently worse following the operation, a technical modification was made to preclude any possible danger of trauma to the already compromised and weakened spinal cord. We felt that since so little room was available in the midline, it was quite possible that even with the most delicate technique, the cord could inadvertently be contused by the rongeur. A rongeur of the narrow jaw type (Leksell) was therefore used to cut a groove up the spinal canal on each side beginning well lateral and below the areas of severe encroachment. The procedure frees the cervical laminae, ligaments, and posterior elements completely so that they can then be dissected away from the posterior dura virtually in one piece (Fig. 2).

Complications

Despite the difficult early recovery period, complications have been few. Five patients had a transient increase in neurological deficit for 48 hours. One patient had a wound infection that involved the muscle and subcutaneous layers without meningitis, and although his hospital stay was prolonged to 3 weeks, the wound subsequently healed well and he experienced a good reversal of myelopathy. Much of the discomfort the patients experienced for 1 or
Fig. 2. Operative drawings. *Upper:* Posterior exposure of cervical spine with narrow rongeur introduced lateral to the spinal cord for removal of posterior elements intact. *Lower:* Incision of dentate attachments to provide release of cord.
### RESULTS

Table 2 summarizes the results of surgical treatment. One of the two patients who were worse after the operation was a 62-year-old man with spastic paraparesis, who developed hemiplegia postoperatively. The other, a diabetic woman who had moderately advanced myelopathy but was able to walk with difficulty, has been severely quadriparetic since operation.

All of the 35 patients have been followed for periods from 1 to 6 years after operation. Except for the two patients mentioned, there has not been a single patient in whom the myelopathy continued to progress. The condition of 24 patients is considered improved, and the disease in nine appears to have been arrested. What is more noteworthy, however, is the surprising improvement in five of the eight patients whose condition was the most severe (Table 2). Each of these patients needed the support of one or two persons for walking or was in a wheelchair. Five of them have had a dramatic reversal, although it is evident that some myelopathy still exists. One is a traveling salesman who, although he still has a moderately spastic gait, has resumed all of his work. Two others have been able to return to similarly active occupations. Another, an elderly spinster, now walks well without assistance. The fifth is able to enjoy retirement and play 18 holes of golf, his only residual symptom being hyperreflexia in the legs.

This dramatic reversal was not as evident in the group of patients whose conditions were considered moderately severe. These patients were all able to walk without assistance but with varying degrees of spasticity and involvement of the arms. The differing results are probably accounted for by the fact that in most of these patients there has been a long-standing spinal encroachment probably with a lesser degree of severity but more chronic changes in the spinal cord. In the patients with reversible symptoms, the preoperative course seemed to have been more acute.

**Postoperative Myelography**

To obtain some objective evidence of the improved volumetric status of the cervical canal, myelography has been performed on 13 patients after operation; a few have even consented to return for myelography as long as 3 and 4 years after surgery. The degree of improvement in the myelographic appearance of the cervical canal shown in Figs. 3 and 4 was characteristic of nine of the 13 patients; in the four others improvement was not as striking. In two patients who had complete block before operation, myelograms taken soon after operation were unsatisfactory for reproduction, although the block obviously had been relieved. Despite the extensive laminectomy, there has been no instance of postoperative subluxation.

It is conceivable that if any of these patients were to show progression of myelopathy with a return of myelographic deformity or block they might be considered suitable for anterior interbody fusion at one or two levels. Certainly such a procedure can now be performed more safely with all the posterior elements removed and the increased anteroposterior depth of the spinal canal. Thus far, at least, it has not seemed necessary to impose this additional operation.

**Discussion**

Clinical experience with this group of patients supports Brieg's analysis of spinal cord mechanics and lends justification to the argument that the dentate attachments act as a longitudinal tether of the spinal cord. It is also clear that the cord is more bound by the nerve roots extrudally than intradural-
Fig. 3. Myelograms. Left: Preoperative midcervical partial blocks from spondylosis. Patient unable to walk. Right: Same patient 2 years after operation; there is good refilling of cervical canal. Patient walking well.

Fig. 4. Myelograms. Left: Partial block and extensive filling defects before operation. Right: Same patient 4 months after operation; neurological status improved.
Posterior decompression for spondylotic cervical myelopathy

by; thus, the same decompressive effect can be achieved by extensive and wide laminectomy including foraminotomy at several segments. This, of course, tends to release the entire dural tube and its contents but does incur the risk of subluxation. On the other hand, a laminectomy adequate enough to section all of the cervical dentate attachments provides satisfactory decompression without sacrifice of the supporting facets, improves the overall environment of the spinal cord itself, and allows for easy closure of the dura.

The question naturally arises as to whether a long relatively narrower laminectomy of the type described would accomplish the same results if the dentate attachments were not sectioned. Without a comparable control group of patients subjected to the same extensive laminectomy one cannot really conclude that section of the denticles adds materially to the procedure. Yet, it is a simple and safe addition to the operation, and the logic of the biomechanics involved remains a compelling argument.

Regardless of the procedure used or whether the dura is opened or not, it is important to remember that the margin of operative safety is small and the spinal cord exceptionally fragile.

Conclusions

The progressive course of cervical spondylotic myelopathy can be reversed and arrested by extensive laminectomy that provides adequate posterior decompression and longitudinal release of the spinal cord. Section of all the cervical dentate attachments may also be an important factor in relaxing the cephalocaudad axis of the cord. Myelography after operation correlates well with clinical improvement and attests to the relief of spinal cord encroachment by this procedure.

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