Cervical posterior rhizotomy for reducing spasticity in cerebral palsy

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Cervical posterior rhizotomy was carried out in 15 patients with cerebral palsy. Spasticity of the neck, spine, arms, and legs decreased in 13 of the 15. The improvement was not dramatic in any, but permitted improved voluntary function in five, and more effective rehabilitation in the remainder. Abnormal involuntary movement was decreased and progressive scoliosis arrested. Specific surgical problems and suggestions are discussed.

KEY WORDS: cerebral palsy · spasticity · involuntary movements · scoliosis · posterior cervical rhizotomy

S PASTICITY, one of the most common and disabling neurological disorders, is alleviated very little by available treatment. Drugs, occupational and physical therapy, and muscle lengthening or transfer have only a limited benefit. Operations on the nervous system have not been widely used because it is difficult to relax muscles without paralyzing them. A variety of stereotaxic surgical techniques for alleviating spasticity have been tried.

In 1970, Kottke reported decreased spasticity in six patients with cerebral palsy following bilateral cervical posterior rhizotomy of C-1 through C-3. He postulated that the abolition of tonic neck reflexes was responsible. We are reporting our experience with 15 patients treated by this method since 1970.

Clinical Material and Surgical Technique

Selection of Patients

The patients selected for cervical posterior rhizotomy ranged in age from 3 to 55 years. The initial patients had almost no voluntary neck control. The muscle spasms that kept their necks turned forcibly to one side were accompanied by increased tone in the muscles of the opposite arm and leg. As we gained experience with the effects of the procedure, the indications suggested by Kottke were expanded to include some patients with chorea and athetosis. All patients in the series had been classified in the Cerebral Palsy Clinic as “tension athetoids” or “mixed cerebral spastics.” Since a wide range of abnormalities are represented, an attempt has been made to separate the patients into more specific categories for this report.

The term “spastic cerebral palsy” has been reserved for those who have increased muscle tone in the entire musculoskeletal system, with very little voluntary movement possible. Patients in this group have no involuntary movements except for the increased muscle tone precipitated by at-
tempts to move joints or change body positions. They have decreased muscle tone as infants; increasing spasticity or tension appear as they become older, accompanied by contractures in extremities, hip dislocations, scoliosis, and "cow horn" deformities of the rib cage.

Those classified as patients with choreoathetoid quadriplegic cerebral palsy (abbreviated to athetoid) have involuntary movements, including facial grimacing, abnormal neck movements, chorea of the proximal muscles of the arms, athetosis of the hands and fingers, and extensor spasticity of the paravertebral muscles and legs. The involuntary movements of the arms occur spontaneously while those of the legs come about only during changes of body position or attempts at active or passive movement of the legs. These patients also tend to develop increasing scoliosis during periods of rapid growth.

Posterior cervical rhizotomy has not been carried out on patients with infantile spastic hemiplegia or cerebral diplegia.

Patients were selected for surgery because of rapid increase in spasticity, scoliosis, or difficulty in maintaining a sitting posture. Many, but not all, had constant spasm of the neck muscles accompanied by tonic neck reflexes (Table 1).

**Operative Technique**

Operations were done under general endotracheal anesthesia; the first four patients were prone, the last 11 in the sitting position. In the first 10 operations, the spinous processes of C-1 through C-3 were removed with the laminae of C-1 and C-2 plus the superior portion of C-3. This permitted exposure and sectioning of the posterior roots of C-1 (when present), C-2, and C-3. In two cases the rim of the foramen magnum was removed; this did not provide any better access to the C-1 posterior roots, and has not been done subsequently. Initially the rootlets were severed between silver clips. More recently it has been found easier to separate the visible vessels from the rootlets with a nerve hook, and then section the fascicles by running the blade of a blunt pair of scissors inferiorly to superiorly along the denticulate ligament, thus severing most of the rootlets in a single cut. A nerve hook is then passed superiorly to inferiorly to pick up rootlets that may have been missed.

In the last five cases, the entire lamina of C-3 was removed in addition to those of C-1 and C-2. This permitted sectioning of the upper fascicles of C-4 posterior roots bilaterally in addition to those of C-1, C-2, and C-3, and provided better relaxation of muscle tone with a barely detectable increase in the area of sensory loss. A watertight closure of the dura mater was made with silk sutures.

**Associated Abnormalities**

Abnormalities of the upper cervical spinal column were common. In practically all cases, the paraspinal muscles seemed unusually adherent to the spinous processes and lamina. The laminae frequently overlapped in an unusual way, such as C-1 within the foramen magnum and C-3 under the lamina of C-2. The dura mater was usually thickened and adherent to the epidural tissue, which was often difficult to separate from the laminae. The arachnoid was also thickened and unusually adherent to the dura mater and spinal cord. These findings are reminiscent of the suggestion made years ago by Dr. W. M. Phelps of Johns Hopkins, that upper cervical damage occurring at birth may be the cause of some instances of cerebral palsy.

In most patients, there was no posterior root of C-1; when present it was a large single fascicle. Occasionally it was difficult to differentiate the posterior from anterior roots at the C-1 level. Manipulation of the C-1 anterior root usually produced contraction of the neck and shoulder muscles. It could also be identified by its firm connection with the spinal accessory nerve. The presence

**Table 1**

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Spastic</th>
<th>Athetoid</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 10</td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>11 - 20</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>21 - 30</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>31 - 40</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>41 - 60</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>total</td>
<td>8</td>
<td>7</td>
<td>15</td>
</tr>
</tbody>
</table>

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or absence of the C-1 root was not always symmetrical.

Complications

Complications have been relatively few. In one case, a cerebrospinal fluid (CSF) fistula occurred probably because the thickness of the dura mater had been reduced as it was separated from the adherent ligamentum flavum in the space between C-1 and the foramen magnum. Secondary closure was unsuccessful in stopping the leak until continuous CSF drainage was instituted. Another child developed bowel and urinary retention. Both of these children required relatively prolonged hospitalization. Pneumonia delayed release in only three patients, which is surprising in view of the poor coughing reflex and difficulty in swallowing that is characteristic of these patients. The average hospital stay was 11.7 days, with a maximum of 45 and a minimum of 4. Three of the older patients have developed neck pain several months postoperatively. This has been controlled by heat and massage and the use of cervical collars for a few weeks.

Drug Therapy

Muscle-relaxing drugs were continued postoperatively in the same dose each patient had received preoperatively. Recovery was speeded if muscle relaxant dosage (usually Valium) was increased for 48 to 72 hours postoperatively, as spasticity was usually increased during this period.

Results

Some encouraging improvements have been achieved (Table 2). These are hard to measure by casual observations, or even careful manual muscle testing or neurological examination, but they seemed quite real to the people responsible for the day-to-day care of these patients.

The most apparent improvement occurred in a 17-year-old girl who had experienced some relaxation of her hands and arms after bilateral dentateotomies in 1964 and 1965; however, her hands never relaxed enough to permit coordinated function. With growth and increasing weight, she developed a slumped posture and her arms and hands became less useful. Following cervical posterior rhizotomy in 1971, her arms and hands relaxed enough to permit effective use of a special spoon with her left hand. Now, for the first time in her life, she can push her wheelchair with hands and feet well enough to move both backward and forward. She had had much fruitless physical therapy prior to rhizotomy; postoperatively it has been possible to reduce contractures at the knees sufficiently so that long leg braces may be applied for brief periods of standing.

Improvement in other patients has not been as demonstrable, but has made daily care less difficult. Involuntary neck movement, torticollis, and lack of strength have improved in all but two. It is now possible for most of these patients to hold the neck and trunk more erect and provide a more solid base for arm movements. One spastic and one athetoid patient were not improved, but were no worse. Voluntary arm and hand movements improved significantly in the one case described; only three have developed new purposeful hand movements since surgery. However, 10 of the 15 patients have had noticeable relaxation of spasticity in the arms. Chronic neck pain was completely relieved in a 43-year-old man who was the only patient that had it. One child who could raise his head when lying prone prior to surgery has not regained that ability during the 3 months following it.

One of the criteria for posterior rhizotomy was rapidly increasing scoliosis. Seven of the 15 have had significant relaxation of spinal muscles postoperatively. Some have been able to sleep supine or prone, positions that were never comfortable preoperatively. The rapid progress of scoliosis has stabilized at the preoperative level in 14 patients; in one it continued to increase.

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TABLE 2

<table>
<thead>
<tr>
<th>Condition (No. of Cases)</th>
<th>Improved</th>
<th>No Change or Worse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Neck</td>
<td>Arms</td>
</tr>
<tr>
<td>spastic (8)</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>athetoid (7)</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>total (15)</td>
<td>13</td>
<td>10</td>
</tr>
</tbody>
</table>
Cervical posterior rhizotomy for cerebral palsy

Not much relaxation of spasticity was initially expected in the legs. However, the five most severely spastic patients have had considerable decrease in extension and adduction spasticity of their legs. This makes lifting and caring for them considerably easier. One 24-year-old athetoid patient has been able to put his right foot flat on the floor instead of walking with it in equinus as he did for many years prior to surgery.

Since most of these patients cannot communicate well verbally, sensory loss was difficult to assess. There has been complete anesthesia in the appropriate dermatomes immediately postoperatively and no indication, as measured by completeness of sensory loss, that any significant rootlets have been missed. However, sensation appears to return with time. The loss of sensation has not been a problem or even a source of comment by any of the patients.

Six months after posterior cervical rhizotomy one severely spastic 9-year-old girl appears to be unchanged by the surgery. Although the 55-year-old man is decidedly worse, this cannot be entirely blamed on the surgery; his mother, who had provided total care for 54 years, died and he has had to go through the emotional experience of being moved to a nursing home.

Discussion

Cervical posterior rhizotomy provides another method for reducing spasticity in cerebral palsy. Like the other known methods, the results are not dramatic nor are they effective in every patient. However, it does appear to offer severe spastic patients the best relief known; it is apparently more effective than stereotaxic dentateotomy or thalamotomy in these patients. It will be interesting to compare the results of cervical posterior rhizotomy with stereotaxic lesions in the pulvinar. The improvement seen in athetoid cerebral palsy following cervical posterior rhizotomy is more easily demonstrated than in the spastic patients. Although rhizotomy reduces the involuntary movements of athetoid cerebral palsy, it has not been tried on patients with severe involuntary movements of the extremities.

It has long been conjectured that maximal improvement in muscle control in cerebral palsy is most likely to be achieved through multiple surgical procedures. The bilateral stereotaxic dentateotomies performed on one of our patients may have prepared the ground for the unexpectedly good result following cervical posterior rhizotomy. As in all surgical procedures for relieving dyskinesias, postoperative rehabilitation is vitally important. The two patients with the greatest improvement had the most intense rehabilitative care.

Cutting the upper fascicles of the posterior root of C-4 in addition to bilateral sectioning of C-2 and C-3 appears to add considerably to relaxation of the spasticity.

Our experiences with posterior cervical rhizotomy and with stereotaxic operations suggest that the benefit depends almost entirely on eliminating some of the inappropriate impulses coming from the periphery into the central nervous system. These impulses can be exteroceptive, as illustrated by the increase in spasticity that often results from noise, discomfort, or emotional stress, or they can be proprioceptive, as shown by the increased muscle tone resulting from passive manipulation. Cervical posterior rhizotomy apparently decreases the number of abnormal proprioceptive impulses entering the upper spinal cord and brain stem. Kottke seems to have discovered an area where there is a high density of proprioceptive impulses. Decrease in the volume of stimuli passing through this internuncial pool appears to have more than a local effect; it also relaxes the arms and legs in many patients. It is fortunate that this high density of normal or abnormal proprioceptive impulses is brought to the central nervous system through nerve roots that are not particularly important to body function, so no serious loss results when they are sectioned.

Summary

Cervical posterior rhizotomy was carried out in 15 cerebral palsied patients ranging in age from 3 to 55 years. Spasticity of the neck, spine, arms, and legs decreased in 13 of the 15. The improvement was not dramatic in any of them. It has permitted improved voluntary function in five, and easier
handling in the remainder. A 9-year-old girl is no better or no worse. A 55-year-old man is worse 14 months postoperatively than he was preoperatively.

It is probable that improvement in these patients arises from a decrease in the number of abnormal proprioceptive impulses adding to the total tone of the internuncial pool of the spinal cord and brain stem.

References


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