Surgery for cervical dystonia: the emergence of denervation and myotomy techniques and the contributions of early surgeons at The Johns Hopkins Hospital

Historical vignette

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Cervical dystonia is a psychologically and physically disabling disease that has intrigued clinicians since the early history of surgery. Because of its elusive etiology, its operative treatment has had an extended evolutionary voyage. Early surgical approaches involved resection of the sternocleidomastoid muscle. Later recognition of more diffuse involvement of the posterior neck muscles led to the introduction of new techniques with more effective results. A review of available surgical patient records at The Johns Hopkins Hospital from around the turn of the 20th century provided a glimpse of the early history of the operative treatment for torticollis through the work of some of the leaders of surgery, including Halsted, Cushing, and specifically Finney. Here, the authors present a segment of history on the surgical treatment of this disease as it relates to the introduction of myotomy and denervation techniques. (DOI: 10.3171/2009.9.SPINE09276)

**Key Words**
- cervical dystonia
- torticollis
- surgery
- denervation
- myectomy

As we have just seen, medical and other measures short of surgery offer so little, we are justified in taking even extreme measures, where less radical ones have proven unsatisfactory in providing relief from such a deforming and disabling condition.

**John M. Finney**

The evolution of the surgical treatment for cervical dystonia has been intriguing, as the primary cause of this disease remains elusive.[12] Because of doubts related to the authenticity of an organic cause of dystonia, new surgical methods have been carefully examined.[13] Recent treatments for cervical dystonia have been satisfying for both the patient and the surgeon. In this article, to further elucidate the foundation for currently available therapies, we reviewed the literature on the history of the early surgical treatment of cervical dystonia and, in particular, referred to preserved early patient records at The Johns Hopkins Hospital. In this historical review we focused on the contributions of William Halsted, John Finney, and Harvey Cushing during the late 1800s and the beginning of the 20th century.

**History of Early Surgical Techniques**

Isaac Minnus, a German army surgeon, has been recognized as the first person to surgically address cervical dystonia.[6] In 1641 Minnus sectioned the sternocleidomastoid muscle. Later, in 1737, G. F. Jaeger, a professor of surgery in Vienna, presented his thesis “Torticollis” and asserted the need for more effective surgical methods.[2] The French military surgeon Guillaume Dupuytren modified the approach in 1812 by performing the first closed tenotomy; however, complications associated with severing the jugular vein and subsequent morbidity prevented the procedure’s further popularity.[5]
Denervation techniques were also explored. Sectioning the spinal accessory nerve for torticollis is usually first credited to Campbell de Morgan of London, who performed such a procedure in 1866. Bujalski sectioned this nerve bilaterally for “bilateral spasms” of the sternocleidomastoid muscle in 1843. Modifications to de Morgan’s technique included nerve stretching and constricting with silver wire.

In 1891 W. W. Keen, a pioneer in neurology and surgery, presented a modified technique to the Philadelphia Neurological Society. This approach was developed at the request of Weir Mitchell, a neurologist, who suggested dividing or excising the nerves that supplied the contralateral posterior rotatory neck muscles. After dissecting cadavers to determine the feasibility of the procedure, Keen proposed a denervation method for the posterior neck muscle groups. He continued to recommend sectioning of the spinal accessory nerve. After performing a laminectomy, Keen unilaterally divided the first 3 posterior cervical nerves, the suboccipital nerve, the occipitalis major nerve, and an unnamed posterior division coming off of C-3.

The importance of myotomy or myomectomy versus neurectomy procedures for torticollis has remained a controversy since the introduction of these techniques. In 1895 a Polish surgeon, Jan Mikulicz-Radecki, described a myomectomy procedure in which the distal attachments of the sternocleidomastoid muscle were freed from their respective sternal and clavicular attachments. In 1896 a Swiss surgeon, Fritz de Quervain, reported on Emil Theodor Kocher’s multiple myotomies; myotomies of the respective sternal and clavicular attachments. In 1891 W. W. Keen, a pioneer in neurology and surgery, presented a modified technique to the Philadelphia Neurological Society. This approach was developed at the request of Weir Mitchell, a neurologist, who suggested dividing or excising the nerves that supplied the contralateral posterior rotatory neck muscles. After dissecting cadavers to determine the feasibility of the procedure, Keen proposed a denervation method for the posterior neck muscle groups. He continued to recommend sectioning of the spinal accessory nerve. After performing a laminectomy, Keen unilaterally divided the first 3 posterior cervical nerves, the suboccipital nerve, the occipitalis major nerve, and an unnamed posterior division coming off of C-3.

Further Development of Techniques by Halsted, Finney, and Cushing

William Halsted developed the first organized US surgical residency training program at Johns Hopkins, and his residents affected the development of surgical specialties and techniques throughout the world. Halsted and his residents, including Finney and Cushing, performed some of the early operations for cervical dystonia at the turn of the 20th century.

Cushing’s first exposure to the surgical treatment of torticollis most likely occurred while he was a medical student at Harvard and a surgical intern at the Massachusetts General Hospital, where surgeon Maurice Richardson and neurologist George Walton performed a study in 11 patients. They described resecting at least 2 inches of the spinal accessory nerve through an incision along the anterior edge of the sternocleidomastoid muscle.

A direct review of patient records available in the Johns Hopkins archives provides an unbiased view of these surgeons’ thought processes and techniques. After obtaining institutional review board approval, we examined all the original surgical records on microfilm from 1896 to 1901 and retrieved 9 operative records pertaining to patients with torticollis treated surgically. Although Finney performed most of these operations, Cushing often assisted him, gaining experience in the treatment of this disease (Table 1).

Finney and Hughson’s 1925 paper cataloged Finney’s later surgical experience with 32 patients whose treatment was based on 50 cadaveric dissections. That paper was a landmark summary of the history of surgical therapy for torticollis and the newly proposed technique for bilateral posterior extraspinal rhizotomy. Finney’s technique required a U-shaped incision (Fig. 1). The spinal accessory nerve was identified and resected. Finney also described removing the greater occipital nerve and the second and third posterior cervical nerves at the point of their emergence from the vertebral foramina. On the basis of that paper, we concluded that Finney did not believe myotomy was necessary.

Illustrative Cases

Here are 3 summaries of original patient records of Halsted, Finney, and Cushing, selected from the Johns Hopkins archives (1896–1901; Table 1).

Case 3

This 7-year-old girl was admitted to The Johns Hopkins Hospital on November 22, 1899, with a diagnosis of “congenital wry neck.” Her neck posture was noticed soon after she was born. This condition became more exaggerated by the time she was 2 years old. The detail in Cushing’s documentation of the neurological examination is exemplary and was unique at the time:

The head is rotated towards the left shoulder or . . . the face looks out at an angle between straight forward and over the shoulder. The head is also bent down over the right shoulder; thus the ear is drawn down a line toward the sternum; and to look forward the child must look up and out of the corner of the eyes. Rotation of the head toward the right is impossible. Rotation toward the left does not seem to be limited. Bending back of the head is somewhat limited. The face is asymmetrical. The right eye is lower than the left. Distance from the outer angle of the eye to middle of the mouth: right 6.7 cm, left 7.2 cm. The right corner of the mouth is drawn down a little. Movements of the face seem to be equally possible on both sides. The neck appears shortened. Upon examination of the anterior edge of the sternocleidomastoid muscle on the right side is seen as a tense thick cord, very much shortened, extending from the mastoid process to the sternum; the length is 5 cm. It feels as if it was made entirely of fibrous tissue, much too hard and dense for muscle. It has no inequalities in it. The rest of the muscle[s] of the neck look and feel normal. No glands are palpable. The neck is twisted and bent much a wry [sic]. It’s as if the neck were . . . held like a bow, with the greatest concavity in front of the anterior portion of the sternocleidomastoid and the greatest convexity behind just at the left of the spine. The left shoulder is distinctly lower than the right. The spinal column has a double lateral curvature in its upper third. The upper cervical vertebrae have followed the rotation of the head and so are sharply bent to the right. There is a secondary slighter curve to the left and there in sections of the right ribs are prominent. The chest in front is also asymmetrical. The left side is distinctly fuller than the right. In summary, this child has a very exaggerated degree of congenital torticollis. The sternocleidomastoid, which is apparently nothing more than a fibrous cord, measures 5 cm. The left measures 10 cm. The
child’s head tilts about 45 degrees. The right shoulder elevates several centimeters above the left. Right scapula elevated 5 cm above the left. Considerable rotated curve, chiefly limited to regions above the 7th cervical. Right nipple slightly above the left. Child has a very unusual degree of facial distortion. Right eye must be 1 cm above left. Nose and mouth and rest of head similarly distorted by growth. The sternocleidomastoid seems to be the cause of shortening.

Please note the illustrations by Cushing in Fig. 2. In his operative note, Cushing adds:

Incision carried to and just above right clavicle about one inch in length. Sternocleidomastoid very tense. Fascia was divided and sternocleidomastoid was exposed. This was on its internal surface almost converted into fibrous tissue, while on the external border there were muscle fibers remaining. Sternocleidomastoid was cut through about one inch above its clavicular attachment. A portion of sternothyroid muscle was also severed transversely. The secondary fascia was also cut. Great care being taken toward floor vessels and nerves. The head came around in very good fashion after severing the muscle. The wound was brought together with interrupted sutures. Head was put in an overcorrected position and put up in plaster.

The patient was placed in the Bradford brace after surgery (Fig. 3).

Follow-up notes from March 7, 1900, document Cushing’s findings: “Aside from the fixed asymmetry of the face and spinal cord, seems perfectly well. Can turn head beyond midline to right.”

Case 4

This 8-year-old boy was admitted on March 16, 1900, with a diagnosis of “wryneck.” Bending of the child’s neck was noticed when he was 1 year old. The condition worsened, with rotation of the head to the left. Halsted’s notes from the physical examination are as follows:

On physical exam, fairly well nourished boy with wryneck deformity to left side. No deformity of the body. No curves of the back. Neck drawn to the left side at an angle of 30°. Sternocleidomastoid on left tense especially when patient endeavors to hold head erect. Possible lateral motion of head to right only to 30 degrees. Face asymmetrical—left eye lower [than] right, and left side of face so well developed.

Halsted used ether for anesthesia in his operation:

Incision parallel to the clavicle on the left side over the attachment of the sternocleidomastoid. The muscle was stretched and divided near the clavicle. The fascia beneath and at the sides of the muscle was divided. The wound was closed with silver and the head fixed in forced overcorrection.

Follow-up notes on the chart document that when the patient returned to be fitted for a brace, his head was held in such good position that a brace was deemed unnecessary.

Case 9

Finney admitted this 12-year-old boy for progressive worsening of his “right-sided wryneck.”

All his life, his head had been drawn to the right side but the wry-neck has recently gotten worse. No pain and no spasm in the muscles of the neck. Experiences no inconvenience at all. General health has been fair. On physical exam, head is held in constrained position, tipped slightly to the right and

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Admit Date</th>
<th>Age (yrs), Sex</th>
<th>Procedure</th>
<th>Surgeon</th>
<th>Anesthesia</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>December 6, 1897</td>
<td>13, M</td>
<td>myotomy of SCM</td>
<td>Finney</td>
<td>ether</td>
<td>markedly improved</td>
</tr>
<tr>
<td>2</td>
<td>July 11, 1899</td>
<td>16, M</td>
<td>myotomy of SCM</td>
<td>Finney</td>
<td>local (cocaine)</td>
<td>slightly improved</td>
</tr>
<tr>
<td>3</td>
<td>November 22, 1899</td>
<td>7, F</td>
<td>myotomy of SCM</td>
<td>Cushing</td>
<td>ether</td>
<td>markedly improved</td>
</tr>
<tr>
<td>4</td>
<td>March 16, 1900</td>
<td>8, M</td>
<td>myotomy of SCM</td>
<td>Halstead</td>
<td>ether</td>
<td>markedly improved</td>
</tr>
<tr>
<td>5</td>
<td>March 21, 1900</td>
<td>7, F</td>
<td>bilat myotomy of SCM</td>
<td>Finney</td>
<td>ether</td>
<td>markedly improved</td>
</tr>
<tr>
<td>6</td>
<td>June 16, 1900</td>
<td>12, M</td>
<td>myotomy of SCM</td>
<td>Finney</td>
<td>ether</td>
<td>markedly improved</td>
</tr>
<tr>
<td>7</td>
<td>July 5, 1900</td>
<td>13, M</td>
<td>myotomy of SCM &amp; excision of spinal accessory nerve</td>
<td>Finney</td>
<td>ether</td>
<td>markedly improved</td>
</tr>
<tr>
<td>8</td>
<td>August 28, 1900</td>
<td>32, M</td>
<td>division of spinal accessory nerve &amp; myotomy of pst neck muscles</td>
<td>Finney</td>
<td>ether</td>
<td>unknown</td>
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<tr>
<td>9</td>
<td>July 11, 1900</td>
<td>12, M</td>
<td>myotomy of SCM &amp; pst neck muscles</td>
<td>Finney</td>
<td>ether</td>
<td>markedly improved</td>
</tr>
</tbody>
</table>

*pst = posterior; SCM = sternocleidomastoid muscle.
History of surgery for cervical dystonia

**Fig. 1.** Left: Finney’s technique required a U-shaped incision. The spinal accessory nerve was identified and resected. Right: Finney also described removing the greater occipital nerve and the second and third posterior cervical nerves at the point of their emergence from the vertebral foramina. a = spinal accessory nerve; b = lesser occipital nerve; c = greater occipital nerve; d = third cervical nerve; e = first occipital nerve; f = branch of venous plexus. Images reproduced from Finney JM, Hughson W: Spasmodic torticollis. *Ann Surg* 81:225–269, 1925.

**Fig. 2.** Case 3. Illustrations by Cushing. Reproduced courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.
forward. Left shoulder humped up slightly higher than right. All voluntary movements are possible except bending head toward left shoulder, which can only be partially done. Both sternocleidomastoids are rather prominent, the left being more so. Posteriorly on the left side there is a prominence caused by tonic musculature contracture running from the mastoid process nearly to the vertebral prominence. It’s impossible to move the head for any distance toward either shoulder without having the opposite shoulder raised by the tense muscles running from the head to it.

Finney’s operative notes detail a myotomy procedure involving the sternocleidomastoid and posterior neck muscles. This technique is different from the one he described in his paper mentioned above, in which he mainly described a denervation procedure.

An incision was made along the outer border of the sternomastoid muscle. The external jugular was tied and divided. The sternocleido-mastoid muscle was cut across entirely. The incision was then carried through the posterior cervical muscles on the right side to the vertebrae, everything being divided as met. There was some tenseness of the posterior muscles, especially the deep muscles near the vertebrae, and when cut they would immediately spring apart for a distance of 2 cm. the skin was then closed with subcutaneous silver; small iodoform, and protective drain left in wound and the head put up in plaster in the over-corrected position.

Discussion

The history of torticollis surgery begins with sternocleidomastoid myotomy as an inadequate procedure to paralyze all the rotators of the head and neck. Subsequent procedures included more extensive myotomy and denervation techniques for both the sternocleidomastoid and posterior neck muscle groups. Cushing, and mainly Finney, refined these early techniques at Johns Hopkins. The cases included in the present paper refer to records during and before 1900 when early myotomy techniques were being tested. Finney later refined denervation techniques for posterior neck muscle groups, further excluding muscles involved in the creation of the abnormal neck posture responsible for cervical dystonia.

Along with the further evolution of intradural surgical techniques, in 1915 Taylor introduced intradural denervation methods of dividing the upper 4 cervical sensory roots. In 1923 Cushing refined his method by performing an “intrameningeal division” of the spinal accessory nerve at the jugular foramen at the same time he divided the motor and sensory roots of the upper 3 cervical nerves. This intradural upper cervical rhizotomy procedure provides a less selective denervation approach with the associated risk of swallowing difficulty as a result of the denervation of some of the pharyngeal muscles.

Dandy used a modified technique in 1930 by dividing the upper 3 cervical motor and sensory roots intradurally and then turning the patient on his or her back to expose and divide the spinal accessory nerve through 2 small neck incisions. He reversed and sutured the nerve endings to prevent regeneration. Dandy’s technique may be commended for preserving the function of the trapezius muscle.

Cushing most likely inspired one of his residents, Kenneth McKenzie, to pursue a lifetime interest in treating cervical dystonia. McKenzie realized that the trapezius muscle was not involved in creating the abnormal dystonic neck posture. Similar to Dandy, he sectioned the spinal accessory nerve in the neck and left the trapezius muscle innervated, thus preserving its function. In addition to peripheral selective denervation of the sternocleidomastoid muscle, McKenzie later used the bilateral intradural rhizotomy recommended by Dandy.

While the above denervation procedures continued to be performed, other treatments aimed at the central etiology of torticollis were explored. The later introduced stereotactic thalamotomy procedures of the 1960s were associated with complications and were therefore abandoned. The recent development of selective peripheral denervation techniques, as described by Bertrand, and deep brain stimulation therapy have provided immense hope to patients suffering from this disabling and psychologically devastating disease.

Conclusions

Through a first-hand appraisal of their contents, preserved surgical records allow us to glimpse the evolution of neurosurgical techniques. The surgical treatment of cervical dystonia has progressed from inadequate rudimentary myotomies to selective and effective peripheral denervation and deep brain stimulation procedures.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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