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“Can't Walk Nor Raise Arms to Head”:

Harvey Cushing's Surgical Treatment of Poliomyelitis

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Abstract

Study Design—This study was a retrospective chart review for patients undergoing operative treatment by Dr. Harvey Cushing at the Johns Hopkins Hospital between 1896 and 1912.

Objective—To illustrate the early use of peripheral nerve anastomoses for the treatment of postpoliomyelitis paralysis.

Summary of Background Data—At the turn of the 20th century, poliomyelitis was recognized as a disease of neurons; neurological surgeons sought to find a surgical cure for the paralysis occurring after the disease onset. Peripheral nerve anastomoses were an attractive option employed during this time.

Methods—Following IRB approval, and through the courtesy of the Alan Mason Chesney Archives, the surgical records of the Johns Hopkins Hospital from 1896 to 1912 were reviewed. A single case of peripheral nerve anastomosis for the treatment of postpoliomyelitis paralysis was selected for further analysis.

Results—Cushing performed a multiple peripheral nerve anastomoses in a 3-year-old girl. Although the patient experienced no postoperative complications, there was no improvement in her function at the time of discharge from the hospital, and no long-term follow-up was available.

Conclusion—While unsuccessful, Cushing's use of peripheral nerve anastomoses to restore motor function in the pediatric patient described here demonstrates his commitment to pushing the boundaries of neurological surgery at the turn of the 20th century.

Keywords

Harvey Cushing; peripheral nerve; poliomyelitis

Prior to the advent of poliomyelitis vaccinations, with Salk's inactivated virus vaccine announced in 1955,¹ and Sabin's live virus vaccine licensed in 1962,² the disease was the bane of medical practices worldwide. Poliomyelitis was first recognized as a distinct disease

entity in 1840 by Jakob Heine³; however, it was not until 1908 that a virus was recognized as the causative factor by Landsteiner and Levaditi.⁴ At the turn of the 20th century, it was recognized that poliomyelitis, or anterior poliomyelitis, was caused by “inflammation of the gray matter of the anterior horns of the spinal cord.”⁵ Recognized as a disease of neurons, neurological surgeons sought to restore motor function by performing nerve anastomoses.^{5–8}

Although literature from the time contains some reports of nerve anastomoses, the procedure was considered radical and was not widely practiced. Here we report a case of multiple nerve anastomoses in a single patient, conducted by Harvey Cushing at the Johns Hopkins Hospital during his career as a young attending in neurosurgery. The case presented here illustrates Cushing's desire to explore all facets of the field he helped develop in American surgical practice.

MATERIALS AND METHODS

After IRB approval, and through the courtesy of the Alan Mason Chesney Archives, we reviewed the surgical records of the Johns Hopkins Hospital from 1896 to 1912. Approximately 26,000 surgical interventions were reviewed; a single case of a child with paralysis after poliomyelitis, who underwent surgical treatment by Dr. Harvey Cushing, was selected.

RESULTS

On October 9, 1904, a 3-year-old girl presented to the Johns Hopkins Hospital with a chief complaint of “can’t walk nor raise arms to head.” The child had a history of anterior poliomyelitis, described in the history as the onset of severe fever at the age of 15 months; the fever lasted for 2 weeks and was followed by weakness of the limbs.

The physical examination was documented:

“Pt lies flat in bed with arms by side and legs extended. Electrical examination very unsatisfactory owing to struggling of patient. Muscles about shoulders seem normal except the deltoids, which are both atrophied and useless. The biceps are both atrophied and weak but there is still some power. Other arm muscles seem normal. Legs seem paralyzed from knee down. There is a marked drop foot on both sides. Patient does not seem able to move feet or legs. Patient can flex and extend the hip but extensors are weak [...] internal and external rotators of both legs seem very weak.”

Cushing brought the child to the operating room on October 27, 1904, for “nerve anastomoses for paralysis.” Cushing's operative note documents the procedure:

“(1) the left brachial plexus was exposed in its supraclavicular portion by the usual incision for glands of the neck in breast cases. The flap was turned back, the structures of the neck exposed, the spinal accessory nerve brought into view, as well as the upper portion of the plexus, and especially the fifth cervical division of the plexus. On faradizing these nerves, the spinal accessory nerve responded with prompt, vigorous contractions of the trapezius; the fifth cervical root responded by

slight movements of the elbow and shoulder, and on carrying the incision along over the shoulder so as to bring into view some of the pale and atrophied fibres of the deltoid, even in these fibres some contraction seemed to occur. The spinal accessory was divided at its point of entry into the trapezius and was transplanted into a nick made in the upper cord of the brachial plexus.

(2) An incision was made over the left popliteal space and the sciatic, the external and internal popliteal nerves were readily exposed. There was on macroscopic appearance a great difference between these two nerves. The external popliteal was flabby and soft, whereas the internal popliteal had the usual firm feel of a normal nerve. Stimulation, furthermore, of the two nerves gave absolutely no response from the muscles supplied by the external popliteal and a quick sharp response from the muscles of the internal popliteal. Occasionally when using a very strong current, either faradic or galvanic, upon the external popliteal bundle the current would be carried either backward or through the tissues to the internal popliteal and would cause contraction of this group of muscles. The external popliteal was divided and the central end of the peripheral stump was inserted into a nick made in the outer half of the normal internal popliteal.”

Postoperatively, the child had no complications. Cushing's handwritten notes document postoperative examination:

“The left arm selected as the worst at time of operation. Now certainly strongest and most used. Some visible [illegible] seen in deltoid fibres. Left shoulder elevated less well than right (Spinal acc y paral [accessory paralysis]). Elbow movements fairly good—biceps palpable.

Right leg. Plantar flexion of toes [...] Slight flexion of ankle also. Appears nothing at knee. Leg [...] rotated inward by Rectus fem (attach to supr spine) [...] No adductor tone whatever (Figure 1).

Must put N. fem into sciatic. Must put psoas nerves into obturator.”

Cushing brought the child back to the operating room on December 15, 1904, for “nerve anastomosis for paralysis of right leg.”

“The accompanying [sic] diagram shows sufficiently well what procedures were carried out, the line of incision and exposure (Figure 2). The rectus femoris muscle and the adductors, the psoas, iliacus, pectineus, and so on were exposed and stimulated. The first mentioned muscle was the only one that had anything like the normal muscle color. The others were all very pale and flabby. The reactions that were obtained from the rectus femoris were prompt both from the nerve and muscle itself, and although reactions were obtained in the adductors by direct stimulation—and possibly some slight movement was seen on stimulation through the nerve with the galvanic current—the contrast between the good muscle and the flabby ones was most striking. No reaction was obtained in the psoas or iliacus either by stimulating the nerves or by direct stimulation of the muscles themselves.

The N. femoralis nerve was exposed both on the outer and inner sides of the psoas without any difficulty whatever. The nerve was split, as shown in the diagram (Figure 3) and after

the splitting each half was stimulated before the inner half, as shown, was cut away from its peripheral connection. The reaction from stimulating each half was exactly the same, namely a fairly sharp opening and closing contraction of the rectus muscle. The obturator nerve gave no apparent response in the adductor group of muscles when it was stimulated, even with a strong galvanic current. The obturator was anastomosed after division into the trunk of the N. femoralis near its point of emergence from the foramina of exit (Figure 4). The sciatic nerve was not stimulated for the muscles were not bared by an operation, and it would merely have prolonged the procedure to have uncovered the child's leg and foot. A nick was made in the upper group and the inner half of the split femoral nerve was transplanted into this notch.

The opening into the abdominal cavity was made in the line of the usual hernia incision. The internal oblique fibres, however, were cut, as were also those of the transversalis, directly across the line of fibre. The wound was subsequently closed in layers with interrupted fine silk sutures [...] The sutures were made with a single knot of delicate split silk fibre, which served merely to bring the raw edges of the nerve into near proximity with one another.”

Postoperatively, the patient had no complications. As expected, there was no improvement in her motor function, and no documentation of neurological worsening. She was discharged on May 6, 1905. No further follow-up was available.

DISCUSSION

Although Cushing did not publish on his early work with the surgical treatment of poliomyelitis, the disease held a fascination for him throughout his career. Cushing theorized that poliomyelitis was caused by a streptococcal infection; as late as 1913, Cushing persuaded Edward Towne, a resident at the Peter Bent Brigham Hospital, to work with E.C. Rose-now at the Mayo Clinic, to elucidate the bacteriologic cause of polio.⁹⁻¹¹

Management of poliomyelitis at the start of the 20th century aimed to provide comfort care and consisted of warm water baths at bedtime for affected limbs, electrotherapy, and massage. Because of the limited effectiveness of nonoperative therapy, surgeons sought to develop a surgical cure. As early as 1902, Charles Frazier began performing peripheral nerve anastomoses to relieve paralysis in children affected by polio-myelitis, with his published report of the surgery following in 1905.⁵ During the first decade of the 20th century, several other surgeons published reports of using nerve anastomoses for the treatment of poliomyelitis. Concurrent with the work of neurological surgeons, orthopedic surgeons and general surgeons sought to cure the paralysis of poliomyelitis with tendon transfers,^{7,12,13} effectively substituting functional muscle groups for those disturbed by the disease.

Although nerve anastomoses for treatment of poliomyelitis paralysis appears to have been performed by Cushing in only 1 patient during his time at the Johns Hopkins Hospital, the performance of nerve anastomoses for improvement of motor function was familiar to Cushing. He published on his early success with spinal accessory-facial nerve anastomoses for facial reanimation.¹⁴ The final documentation for the patient described here is only 7

months after the first surgery (5 months after the second surgery); improvements in motor function at this point would be unlikely given the rate of nerve regeneration (approximately 1 mm/day) and distance from repair site to target muscle. The final result from the surgery is unknown.

The discovery and implementation of the poliovirus vaccine has virtually eradicated the disease worldwide; however, to date there is no cure for poliomyelitis. Contemporary management of the rare case of poliomyelitis closely resembles that used at the start of the 20th century and consists of the use of antibiotics to prevent infections and physical therapy and rehabilitation to maximize preserved motor function. Likewise, surgical interventions for poliomyelitis and other polio-like infectious paralyses consist of the use of nerve, muscle, and tendon transfers with varying results.^{15–17}

The operative techniques described by Cushing at the start of the 20th century—specifically, the use of intraoperative electrical stimulation to identify functioning nerves and the use of meticulous surgical technique to dissect and suture nerves—remain essential to peripheral nerve surgery in the current microsurgical era. The use of the spinal accessory nerve as a donor nerve, as described by Cushing, remains one of the most common procedures for restoring function in the paralyzed upper extremity.¹⁸ Likewise, Cushing recognized the need to restore ankle dorsiflexion and attempted to do so by end-to-side coaptation of the external popliteal (peroneal) nerve to the internal popliteal (tibial) nerve. The end-to-side technique was rediscovered by Viterbo et al¹⁹ and has become a popular nerve repair technique. Nerve transfers to restore lower limb function have only recently become standard practice.²⁰

Here, we report a case of attempted cure of postpolio paralysis using peripheral nerve anastomoses to restore motor function. Although this surgical intervention was unsuccessful, it demonstrates Cushing's commitment to exploring the breadth of neurosurgical technique available at the turn of the 20th century.

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Must put N. fem. into Sciatic
" " psos nerves into obturator

Figure 1.

Cushing's handwritten note documenting his plan for nerve anastomosis in the patient.

Reads: "Must put N. fem. into Sciatic. [Must put] psos nerves into obturator."

Figure 2.

Cushing's illustration documenting the lines of incision in the second operation; the patient's upper legs are seen at the right of the image, with her torso to the left.

Figure 3.

Cushing's illustration documenting the exposure of muscles and nerves during the second operation. Labels on left (top to bottom): Psoas, Ant. Supr Spine. Label at bottom: Rect fem. Labels at right (top to bottom): Bowels, N. Femoris, Int oblique, Ext Iliac [illegible], N. obturator, N. trunk—first incision, Int oblique.

Figure 4.
Cushing's illustration of the nerve anastomoses between the obturator nerve and nerve femoralis. Label to right reads "Anastomoses made as per Figure 2."