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“Fulfilling the chief of his duties as a physician”: Harvey Cushing, selective dorsal rhizotomy and elective spine surgery for quality of life:

Historical vignette

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Abstract

At the beginning of the 20th century, the development of safer anesthesia, antiseptic techniques, and meticulous surgical dissection led to a substantial decrease in operative risk. In turn, the scope of surgery expanded to include elective procedures performed with the intention of improving the quality of life of patients. Between 1908 and 1912, Harvey Cushing performed 3 dorsal rhizotomies to improve the quality of life of 3 patients with debilitating neuralgia: a 54-year-old man with “lightning” radicular pain from tabes dorsalis, a 12-year-old boy cutaneous hyperesthesia and spasticity in his hemiplegic arm, and a 61-year-old man with postamputation neuropathic pain. Symptomatic improvement was seen postoperatively in the first 2 cases, although the third patient continued to have severe pain. Cushing also removed a prominent spinous process from each of 2 patients with debilitating headaches; both patients, however, experienced only minimal postoperative improvement. These cases, which have not been previously published, highlight Cushing's views on the role of surgery and illustrate the broader movement that occurred in surgery at the time, whereby elective procedures for quality of life became performed and accepted.

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Keywords

Harvey Cushing; history of neurosurgery; quality of life; rhizotomy

At the beginning of the 20th century, the development of safer anesthesia, Lister's principles of antisepsis, and meticulous surgical technique converged and led to a substantial decrease in operative risk.^{3,43,57} As a result, the scope of surgery expanded. Although surgery had originally been performed exclusively for life-threatening conditions, during this time period some surgeons began to perform elective operations—including procedures that were performed solely to improve the patients' quality of life.

Also at the turn of the last century, Harvey Cushing was beginning his career at the Johns Hopkins Hospital, where he was a resident and later a faculty member from 1896 through 1912. Although Cushing is well known for his work on intracranial pressure and brain tumors,^{12,14,38,51,53} cerebrovascular surgery,¹³ radiology,⁵⁰ anesthesia,⁴⁴ and endocrinology,⁴⁰ few know that he was a spine surgeon.^{15,18,19,21,47}

Cushing was one of the surgeons during this time period who performed elective surgery to improve his patients' quality of life. For example, Cushing developed the operative route to the Gasserian ganglion for patients with trigeminal neuralgia;^{23,41} likewise, he pioneered the subtemporal decompression to prevent debilitating symptoms from elevated intracranial pressure in patients with inoperable brain tumors.^{17,20,22} In his paper “The Special Field of Neurological Surgery,” Cushing emphasized quality of life: “in affording a measure of relief to these distressing cases, one may fulfill the chief of his [or her] duties as a physician—to prolong life and at the same time alleviate suffering.”²⁴

In the same paper, Cushing discussed the potential for spine surgery to improve quality of life. He suggested that a cordotomy is merited in patients with spinal disease, excruciating pain and a poor prognosis: “had I appreciated the intensity of suffering which this patient was destined to undergo, purely as a palliative measure I would deliberately have divided the cord at a point a segment or two above the growth.”²⁴

Toward the end of his tenure at Johns Hopkins, Cushing performed elective spine surgeries, including early dorsal rhizotomies, with the goal of improving the quality of life of his patients. However, Cushing never published these cases. These cases are noteworthy as they highlight the broader transition surgery underwent at this time, whereby the performance of elective operations, including those for quality of life, became accepted. Moreover, this paper is also the first time that Cushing's spinal cases while he was at Johns Hopkins have been described, and in doing so, points to the breadth of Cushing's operative experiences.

Methods

The records at the Chesney Medical Archives of the Johns Hopkins Hospital were reviewed from 1896 through 1912. The files of cases in which Cushing was listed in the operative notes were analyzed. Cushing's original files have been destroyed, and all of the records obtained, including the images in this paper, were from microfilm copies.

Results and Illustrative Cases

Between 1908 and 1910, Cushing performed dorsal rhizotomies in 3 patients (Table 1). An artist in his own right,^{45,56} Cushing made sketches depicting his intraoperative exposure in his operative notes for his patients with spasticity (Fig. 1) and postamputation neuralgia (Fig. 2). Cushing removed a prominent cervical spinous process in 2 different patients with chronic debilitating headaches (Table 2).

Case 1: Division of Posterior Roots for Tabes Dorsalis

History and Presentation—This 54-year-old man with a history of syphilis presented in November 1908 with shooting pains radiating into his chest and abdomen. The patient underwent antisyphilitic treatment for both primary and secondary syphilis at the age of 17, with little improvement. Two years later, he began to experience shooting pain in his leg that he compared with lightning. After 20 years, this leg pain subsided; however, he simultaneously developed similar pain in his right chest and abdomen, and this pain had subsequently increased substantially in severity.

Physical examination was remarkable for pupils that did not react to light but did react to accommodation, an area with lack of sensation extending posteriorly between the spinous process of T-5 and the sacrum and anteriorly from the nipples to the groin, and hyporeflexia. The patient had a positive Romberg sign but his gait was unaffected.

First Operation—Attributing the neuropathic pain to tabes dorsalis, Cushing planned on dividing several of the patient's thoracic posterior roots 3 days later. However, Cushing faced unexpected intraoperative difficulty achieving hemostasis, and the life-threatening hemorrhage forced him to abort the procedure:

A long incision was made in the midline ... the tissue was evidently scar tissue and resembled very much cut pork.... It was extremely difficult to find the [spinous processes] of the vertebrae and considerably more bleeding than usual was encountered. ... The [spinous processes] of about nine vertebrae were freed, beginning from about the fourth [thoracic] and extending downward ... During the latter part of the operation there was a constant fall in blood pressure ... only about 80 mm Hg. Due to this fact and also that the patient had lost more blood than customary in this operation ... the operator decided to back out at this stage and complete the operation at a second sitting.

Second Operation—One week later, Cushing attempted to complete the operation that he had aborted. However, rather than performing an extensive rhizotomy, which was his original intention, he limited the extent of his operation:

The laminectomy proved to be a most difficult procedure. The [spinous processes] and laminae were removed partly by the usual laminectomy forceps and partly by the Horsley rongeur—a slow, tedious performance ... [the dura] was finally exposed and incised throughout its length. ...

The cord itself was small and evidently had not been by any possibility injured by the forceps as it lay at great depth within the exposed meninges. Although a long incision at the time of the first operation had been made with the purpose of exposing at least eight roots...it was impossible to bring into view more than four posterior roots. After dividing the tough arachnoid, the posterior roots were hooked up on a small blunt nerve hook and successively divided...

The dura was resutured by fine black interrupted silk, the muscle likewise brought together by a number of heavy silver mattress sutures and the 'porky' layer, fully an inch in thickness, was held as well as possible by a second layer of mattress sutures. In addition to these deeper layers, the subcutaneous fascia was drawn together by interrupted fine silk sutures and the skin closed with a running subcuticular silver wire.

Postoperative Course—Initially, the patient had severe pain, which was treated with morphine every 2–3 hours. Four days after the second operation, he had a fever of 104.6°F and urinary retention requiring catheterization. Ultimately, the patient did well and he was comfortable upon discharge.

Follow-Up—Cushing received an unsigned note months later: "I am glad to say that he has again regained all his strength and [is] able to do the same things as he used to do...I take him to town every am at 9:30 and call for him again at 4:30 pm. He goes to his clubs...we go out to the theatre and so on and manage to pass the time pleasantly."

Case 2: Division of Posterior Roots for Spastic Hemiplegia

Presentation and Examination—This boy with right hemiplegia was admitted in November 1910 at the age of 12 years. When he was 8 months old, he had an attack of "meningitis," which left him with substantial developmental delay. At age 4, he was kicked on the left side of his head by a horse, leading to right hemiplegia as well as excruciating right arm pain and hyperesthesia. Physical examination revealed an extremely spastic right upper extremity that was held in flexion, strongly contracted, with practically no movement; his right lower extremity was spastic and atrophic. Hyperreflexia with clonus was seen on the right side, with an extensor response to plantar stimulation.

Operation—One week later, Cushing performed a C3–7 laminectomy with division of the right cervical posterior roots (Fig. 1):

No great difficulty in exposing spines in median line. ...A black suture was placed ... opposite the lamina of the V cervical thus serving as an important landmark. The laminae of the II to the VII cervical inclusive were then removed together with the [spinous processes]. ... The dural membrane was then drawn up and incised without injuring the arachnoid. ...

It was possible without much difficulty to identify the roots, the fourth root emerging just over the lamina of the fifth vertebra which was indicated by the suture as described. There were about five bundles in this root and the upper four of these were divided leaving the lower bundle with the artery intact. This root was

then divided in turn it being possible to split the artery from the lower bundle of fibres without great difficulty. The same is true of the VII. The VIII was a little bit less but nevertheless the two or possibly three upper bundles were divided.

Postoperative Course—By postoperative Day 4, the patient reported less pain in his right arm. Upon discharge, the boy's motor function was also improved: “when asked, pt can extend rt. arm almost completely, in ... contrast to the condition seen on admission.” There is no further follow-up on this case.

Case 3: Division of Posterior Roots for Neuralgia

Presentation and Examination—This man presented in December 1910 at the age of 61 years. Two years earlier, he had been injured in an occupational accident when falling timber crushed his left calf and foot. Osteomyelitis and subsequent gangrene necessitated two below-the-knee amputations of his left leg. He later developed debilitating neuralgias in his stump as well as referred (phantom) pain to his amputated calf and foot.

Operation—Cushing performed a T10–L3 laminectomy with a selective dorsal rhizotomy of the nerve roots of T10–L2 (Fig. 2). No intraoperative complications were reported.

Postoperative Course—Postoperatively, the patient's pain was “as severe as ever.” He continued to report pain both in his stump and a feeling that “his foot and the stump were being smashed.” Moreover, the patient reported new hyperesthesia in his stump. There is no further follow-up on this case.

Case 5: Removal of the Spinous Process of the Axis for Headache

History and Presentation—This woman presented with debilitating headaches in January 1912 at the age of 30 years. Her pain was described as a “heavy feeling” that started in her right suboccipital area and radiated through the right side of her head, occasionally lasting for days to weeks. The patient had tried many therapies, including electricity, counter-irritation, and narcotics. She usually used a combination of ice bags and large doses of aspirin, consuming up to 60 grains (almost 4 g) daily. Physical examination revealed that the spinous process of the axis was “unusually prominent and broad, not very tender, but prolonged palpation causes pain.” Any discussion between Cushing and the patient at this point was not recorded, but she was discharged without an operation.

Operation and Hospital Course—In May of that same year the patient returned, and the next day Cushing removed the C-2 spinous process, although he did not note any abnormalities. On postoperative Day 10, the patient had yet another severe headache. Her pain did not subside with phenacetin, aspirin, codeine, or nitroglycerin: she refused to “respond to questions, wanted to be left alone, wanted to die, was found on [the] floor, crying and moaning. This persisted for 5–6 days when [it] gradually passed off.” She was then discharged, and there is no further follow-up.

Discussion

During the 19th century, “the dread of the operating room, which many doctors share with their patients”²⁵ was pervasive. However, as surgery became safer due to innovations in anesthesia and antisepsis, the scope of surgery expanded to include elective operations that were performed to improve quality of life. Dorsal rhizotomy was one such operation, the historical importance of which has not been fully recognized: this procedure highlights a major shift that occurred in surgery, including spine surgery, at the turn of the century. This shift— from considering surgery only in life-threatening cases to including it among the options for improving a patient's quality of life—launched the discipline into a new epoch.

In 1888, Abbe in New York^{1,2,37} and Bennett in London^{7,8} independently performed the first dorsal rhizotomy in patients with ascending neuritis and sciatica, respectively. Otfrid Foerster, who published his results first in German in 1909²⁸ and then in English in 1913,²⁷ is most commonly credited today with being the first to perform a selective dorsal rhizotomy.⁴⁹ This is historically inaccurate. However, Foerster popularized the usage of rhizotomies for neuralgia.

Syphilis was one of the most important diseases of the time, and the preferred treatment was mercury injections and oral potassium iodide.^{9–11,55} The fact that these treatments did not prevent late manifestations of syphilis, including tabes dorsalis, was well known.^{16,35} Treatment for tabes dorsalis included chloroform sprinkled on lint and then oiled on the skin, subcutaneous injections of cocaine, aluminum chloride, and some of the newly developed analgesics, phenacetin, antipyrin, and antifebrin.^{32,48}

Foerster was the first to publish the performance of a posterior rhizotomy for both spasticity and for the “violent neuralgic pains, which defy other methods of relief” of tabes dorsalis.²⁷ Harvey Cushing performed his posterior rhizotomy for the relief of the lightning pains of tabes dorsalis in 1908, before Foerster's work was first published in German in 1909.²⁸ However, Cushing never published his case and thus his operation did not directly impact the field of spine surgery.

The efficacy of dorsal rhizotomy for neuralgia eventually was questioned because many patients, such as the patient in Case 3, did not experience postoperative pain relief. In 1918, Charles Frazier published a review showing that only 19% of patients had sustained pain relief from this procedure.²⁹ Dorsal rhizotomy was only intermittently used for intractable pain after this publication,⁴² and by 1964 Wilkins wrote that this operation had “lost most of its original importance, but it still has historical significance as a major step in the development of modern techniques for the relief of pain.”⁵⁸

Posterior rhizotomy was also used by Foerster as a treatment for spasticity.^{27,28} The rationale was that “spasticity is believed ... [to] be a reflex process, originating in sensory impulses...transmitted by the sensory nerves ... under normal conditions [tone] is present only to a moderate degree because of the restraining influence of the cortex ... [when] this inhibitory action is interrupted by a lesion of the motor tract, there follows the inordinate and excessive joint fixation and muscular resistance.”³⁰ Harvey Cushing's case of posterior rhizotomy for spastic hemiplegia was successful, as the patient had some improvement in

his spasticity and motor function postoperatively; similar results were reported by other surgeons.^{34,54} However, other interventions were also described for spasticity, including muscle group isolation and the injection of alcohol directly into involved nerves.^{4,52} These operations came to be preferred.³¹

The management of spasticity continues to be challenging. Some have returned to the time of Cushing and Foerster: since the 1980s, selective dorsal rhizotomy has been increasingly used again, as it has been shown to reduce spasticity and improve functional outcome in children with cerebral palsy,^{26,36} persisting with long-term follow-up.³⁹

Migraine and tension headaches were poorly understood at the beginning of the 20th century. While some attributed headache to a hypersensitive state of the sympathetic nervous system,⁵ others argued that headaches represented paroxysmal elevations in intracranial pressure.³³ The fact that analgesics such as opiates and chemical pharmaceuticals such as phenacetin and antipyrin could provide at least partial relief of headaches was attributed to their negative inotropic and cardiac depressant effects, which was believed to lower blood pressure.³³ This may have been why the patient in Case 5 received nitroglycerin for her severe headache as an inpatient.

Cushing's notes are sparse with respect to why he decided to remove the spinous process of cervical vertebrae in these 2 patients who presented with intractable headaches. At the time, exostoses were first being described as sources of pain, but the benefit of operative interventions was debated.^{6,46} In the patient in Case 4, Cushing (and the patient, who was also a physician) both believed that he had a cervical exostosis, but no pathology was found intraoperatively. Cushing may have thought that the "prominent, broad" axis of the patient in Case 2 also represented an exostosis. Nevertheless, neither of these 2 patients improved substantially postoperatively. Such disappointing results may have discouraged him from doing further cervical operations for patients with headache.

As a surgical pioneer, however, Cushing faced substantial limitations. Operative techniques for adequate hemostasis were only being developed: thus, intraoperative blood loss had the potential to be severe and occasionally necessitated aborting the operation, as in Case 1. Moreover, precise surgical indications were unknown at the time. Thus, it is perhaps not surprising that only 2 of the 5 patients reported on here experienced significant improvement postoperatively. Cushing's rationale for removing a spinous process from the cervical vertebrae of 2 patients is not clear. It is unlikely that this operation had long-term benefits for either patient.

Today, many elective spinal operations are performed with the goal of improving patients' quality of life. Degenerative conditions of the spine can cause debilitating pain and weakness interfering with the ability to perform daily tasks, as well as bowel and bladder dysfunction. Quality of life for these patients can be severely impaired and can be improved with surgical treatment. Moreover, surgery is still performed—including selective dorsal rhizotomy—for children suffering from spasticity. Surgeons who perform these procedures are, in fact, following in the footsteps of the early pioneers of surgery, including Harvey

Cushing, and in doing so, are fulfilling one of their “chief duties as a physician”—the alleviation of suffering.

Conclusions

At the beginning of the 20th century, the substantial decrease in operative risk allowed for the scope of surgery to expand to include elective procedures performed with the goal of improving the quality of life of patients. During this time period, Harvey Cushing performed some early spine surgeries for quality of life. These cases were never published and thus did not directly impact the field. Nonetheless, they are noteworthy in that they highlight Cushing's views on the role of surgery and illustrate the broader movement in surgery that occurred during this time period, whereby the performance of elective surgeries for quality of life became acceptable.

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Fig. 1.

Case 2. This 12-year-old boy with right spastic hemiplegia presented with intense hyperesthesia in his spastic and contracted right arm. Cushing performed a C3–7 laminectomy with division of 4 posterior roots. His drawings depict the intraoperative approach after exposure (**left**), with the spinous processes of C-2 to T-1 labeled, as well as after the laminectomy (**right**), with the spinous processes remaining on C-2 and T-1, but having been removed from the other cervical vertebrae. Courtesy of the Alan Chesney Medical Archives of the Johns Hopkins Hospital.

Fig. 2.

Case 3. This 61-year-old man who had previously undergone a below-the-knee amputation presented with severe neuralgia in his stump. Cushing performed a T10–L2 laminectomy with resection of the posterior nerve roots. His postoperative sketch shows his exposure (**right**) as well as the spinal cord after he had resected some of the posterior roots (**left**), with a clear demarcation by an X of where he has drawn a severed root. Courtesy of the Alan Chesney Medical Archives of the Johns Hopkins Hospital.

Table 1
Harvey Cushing's cases of dorsal rhizotomy*

Characteristic	Case 1	Case 2	Case 3
age in yrs, sex	54, M	12, M	61, M
admission date	November, 1908	November, 1910	December, 1910
medical history	primary & secondary syphilis, tabes dorsalis: shooting pains in legs	meningitis at 8 mos, at 4 yrs kicked on the head by a horse, rt hemiplegia	lt leg crushed in 1908 by falling lumber, amputated, postamputation neuralgias
presenting symptoms	shooting lightning pains in rt abdomen & chest, numbness in chest bilaterally	rt hemiplegia, rt arm hyperesthesia, spasticity & contractures	debilitating neuralgia in left (amputated) leg
findings on physical exam	numbness & anesthesia btwn nipples & groin, Argyll Robertson pupil, Romberg sign	rt hemiplegia, rt hyperreflexia w/ clonus, spastic gait	prior BTK amputation, hyperesthesia in lt L1–3 region
location & no. of nerve roots divided	thoracic, division of 4 posterior roots	cervical, division of 4 posterior roots	thoracolumbar, division of posterior roots of T10 –l2
outcome	substantially improved, months later writes of going to clubs & the theater	significantly improved, less spasticity & hyperesthesia, no FU	pain was “as severe as ever”

* BTK = below-the-knee; exam = examination; FU = follow-up.

Table 2
Harvey Cushing's spinal operations for headache, 1909–1912

Characteristic	Case 4	Case 5
age in yrs, sex	39, M	30, F
admission date(s)	November, 1909	January, 1912; May, 1912
type of headache	35 yrs of neck pain, radiates to occipital & temporal areas, bilateral, w/ nausea & vomiting	21 yrs of “heavy feeling” in rt suboccipital region, radiates to rt side, no nausea or vomiting
prior therapy	none recorded	electricity, counter-irritation, large doses of narcotics, ice packs, up to 4 g aspirin/day
findings on physical exam	exostosis of C-3, which is easily palpable, “gritting noise and audible click when patient turns head”	“the spine of the axis is unusually prominent and broad, not very tender but prolonged palpation causes pain”
operation	removal of large bifid spinous process of C-4	removal of posterior spinous process of axis
outcome	improved, no FU	continued headaches, no FU