Rapid advances in understanding glaucoma occurred following the invention of the ophthalmoscope in the mid-19th century. To our knowledge, attempts by neurosurgeon Harvey Cushing, MD, to cure the condition during his years at Johns Hopkins Hospital have never been previously reported. The Johns Hopkins Hospital surgical records from 1896 through 1912 were reviewed. A case in which Cushing attempted a surgical cure for a patient diagnosed as having glaucoma was selected for review. In 1905, Cushing performed extirpation of the superior cervical ganglion of a patient believed to have chronic glaucoma experiencing an acute episode who had previously undergone bilateral iridectomies. The patient reported stabilization of vision and decreased pain after the procedure. Respected neurosurgeon Cushing undertook surgical treatment of glaucoma at the turn of the 20th century. His approach provides insight into contemporary glaucoma therapies and pathophysiology.


A newly discovered surgical case file from 1905 reveals that Harvey Cushing, MD, the man widely regarded as the father of modern neurosurgery, attempted a surgical cure of glaucoma during his time at Johns Hopkins Hospital. He received encouragement in undertaking his chosen operation from an ophthalmology colleague. At that time, Cushing was still in the early years of his surgical career. His contributions to the medical field would ultimately include the use of a cuff for blood pressure monitoring during surgery, the invention of hemostatic techniques including silver clips and electrocautery, and the definition of the constellation of symptoms now known as Cushing disease and Cushing syndrome.1

The history of glaucoma is rich and celebrated; descriptions of the condition can be found dating back to the writings of Hippocrates.3,4 In fact, the term glaucoma came from the early Greek glaukos, meaning shining or gleaming, and it evolved to describe a sea-green color in affected eyes.5-7

Thorugh histories such as that written by Gordon have given credit to many individuals who contributed to the understanding of glaucoma over centuries; these individuals include Bourdelot, the blind physician of King Louis XIV whose donated eyes postmortem led to the conclusion that glaucoma was not due to abnormalities of the lens, and von Graefe, the proponent of iridectomy in the 1850s.4,8,9

Despite these vivid clinical descriptions, the pathophysiology of glaucoma remained elusive during much of ophthalmological history; the condition was nearly indistinguishable from cataract and inflammatory conditions of the eye prior to the 17th century.5,6 The invention of the ophthalmoscope and improvements in measuring intraocular pressure (IOP) in the mid 19th century provided tools for better understanding of the disease’s key features distinct from other ophthalmologic conditions.7,8 Dramatic advances were made—in the mid 1800s, Donders discovered that high IOP caused blindness.9,10 Von Graefe and Jaeger asserted...
that the cupping they viewed in the eyes of patients through the ophthalmoscope was due to swelling of the optic disc.\textsuperscript{1,2,13} This phenomenon and the symptoms of glaucoma were suspected to be due to elevated aqueous pressure.\textsuperscript{12-14} Although their hypothesis was slow to take hold, by the end of the century, it became an established theory, albeit with competition and some skeptics.\textsuperscript{13} The work of Leber revealed the ciliary body as a source of aqueous humor secretion,\textsuperscript{16,17} and scientific articles published in 1905 demonstrated an understanding of fluid dynamics within the eye.\textsuperscript{18}

Along with enhanced pathophysiologic understanding, pharmacologic and surgical treatment strategies for glaucoma rapidly began to evolve. In 1876, Laqueur introduced the anticholinergic agent physostigmine as a medical treatment of glaucoma.\textsuperscript{14,16,19} Contemporaneously, von Graefe experimented with the ordeal bean, a natural physostigmine source,\textsuperscript{20} and Weber introduced pilocarpine.\textsuperscript{14,16,21} During the 1800s and into the 20th century, induced pupillary miosis was presumed to be the mechanism of relief provided by the drugs. The effects on the anterior chamber depth, morphology of the angle, and prevention of pupillary block would not be discovered and synthesized into theory until after 1906 and into the mid-1900s.\textsuperscript{14} The emphasis on pupil diameter in the late 1800s was enforced by observations that mydriatics such as atropine could cause acute glaucoma.\textsuperscript{12,21}

Several individuals pioneered surgical advances: Desnare and subsequently Mackenzie proposed corneal puncture as early as 1848.\textsuperscript{12,22} von Graefe introduced the iridectomy in 1856,\textsuperscript{6,23} and de Vincentiis developed a form of goniotomy in 1892\textsuperscript{24} although this technique would not gain popularity until 1936.\textsuperscript{14} The anterior and posterior sclerotomy were also introduced.\textsuperscript{25} Surgical procedures targeting the sympathetic nervous system emerged in the late 1800s as part of an ongoing trend into sympathetic surgery.\textsuperscript{26}

Cushing's glaucoma file provides insight into the ophthalmologic understanding during that era and serves as a reminder of a lesser-known therapeutic intervention for glaucoma targeting the sympathetic nervous system, which experienced brief popularity in the early 1900s.

\section*{METHODS}

Following institutional review board approval and through the courtesy of the Alan Mason Chesney Archives, the Johns Hopkins Hospital surgical records from 1896 to 1912 were reviewed. A case in which Cushing attempted a surgical cure for a patient who was diagnosed as having glaucoma was selected for further review.

\section*{RESULTS}

On August 28, 1905, a 56-year-old driver from West Virginia with loss of vision was admitted to Johns Hopkins Hospital under Cushing's care. The patient's history was remarkable for bilateral eye pain that had begun "years ago" and was accompanied by changes in vision. He sought treatment from a doctor who gave him a substance called caistres, the composition of which was unclear, that ultimately failed to relieve his symptoms. After an unknown period, the patient presented to another physician with an episode of "acute glaucoma" and bilateral iridectomies were performed. This provided great relief for about 3 years and allowed the patient to have "good vision for distances." However, 3 weeks prior to presenting at Johns Hopkins Hospital, the patient began to experience intermittent pain and impairment of vision in his right eye, the extent of which was not documented. His physical examination was unremarkable. A note from the eye clinic reads:

\textit{Dear Doctor [Cushing],}

He has, as you are aware, a chronic glaucoma, with an acute inflammatory attack. The tension is only slightly + now, but likely increases at night. He has two huge iridectomies already so I do not see why this operation you've suggested should not be tried.

James J. Mills

While observed in hospital, it was noted on September 9 that the patient was in a great deal of pain "in and about right eye ball" requiring large doses of "morphia" to enable the man to sleep. Cushing noted in the patient's medical record that he had "chronic glaucoma with an acute exacerbation of right eye." A corneal ulcer of his right eye also was noted. On September 13, Cushing performed an extirpation of the right superior cervical ganglion in an attempt to treat this condition. His operative note recorded:

According to Jenosko's [sic] rule, an incision was made through the sterno cleido mastoid muscle in line with the fibres and nearer the posterior anterior border. Largely by blunt dissection the incision was then carried about 3 years and allowed the patient to have "good vision for distances." However, 3 weeks prior to presenting at Johns Hopkins Hospital, the patient began to experience intermittent pain and impairment of vision in his right eye, the extent of which was not documented. His physical examination was unremarkable. A note from the eye clinic reads:

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According to Jenosko’s [sic] rule, an incision was made through the sterno cleido mastoid muscle in line with the fibres and nearer the posterior anterior border. Largely by blunt dissection the incision was then carried down to the space back of the large vessels and vagus nerve. The sympathetic was readily disclosed and the superior ganglion freed as high up as the base of the skull. With a small pair of curved scissors the nerve was then cut away apparently above the uppermost cells of the ganglion. The wound was closed without drainage (Figure).
Following the operation, the patient reported relief of pain for 1 week; however, his pain returned prior to being discharged from the hospital. While one note recorded that the patient had no change in sight, another note reported that the patient described things being "brighter than before." Ultimately, he was discharged on October 2 after 36 days in the hospital. The reported discharge condition was "unimproved," a selection made from among the choices of "improved" or "dead." A follow-up letter from the patient dated February 1906 noted improvement in pain and some stabilization of vision:

I don't suffer vary much more with the pain was in my right eye.

I can see vary well and also in the evening I can tell white from black. I think the meadson is doing me some good and I think that I will continue taking it for a while. The reason I rote you and asked you about the meadson I thought you wanted me to stop taking it but I will contert take it for I think it is doing me good. I so thankful that I can see a little I wood of rote sumer but the Dr tote to always rite the first of the month and that is the reason I didon rite the reason I asked about the meadson I thought you was going to give me some other cind.

I will close hoping an early reply

Yours recp.

[Patient signature]

**COMMENT**

Cushing’s exirpation of the superior cervical ganglion highlights the focus on the sympathetic nervous system as an area of interest and debate in glaucoma treatment in the early 1900s.

Manipulation of the sympathetic nervous system to treat a multitude of conditions was an area of burgeoning interest at the turn of the 20th century. Although the anatomy of the sympathetic nervous system had been fairly well defined nearly a century prior, cervical sympathectomy was first introduced by Alexander in 1889.29,30 Initially proposed as a treatment for epilepsy, Jennesco and Abadie expanded the indications for the procedure to include exophthalmic goiter by 1896.28,30 Relevant to the field of ophthalmology, Jennesco and Abadie performed the procedure in the late 1890s to treat glaucoma, and Ball, another ophthalmologist performing the procedure, extended its application to optic nerve atrophy around the turn of the century.27,30,31

Jennesco’s 1896 series became a particularly well-known reference for sympathetic work.32 He reported the results of 61 operations in which he removed the superior cervical ganglion. For 7 patients in his series who were diagnosed as having glaucoma, Jennesco noted that ocular tension was permanently reduced and that the pupil had become markedly and permanently contracted.33 Following Jennesco’s publication, several other case series were reported in which extirpation of the cervical ganglion was performed with variable results; iridectomy and sclerotomy were still considered by many as “the most reliable operations” for glaucoma. In the Section of Ophthalmology of the British Medical Journal in 1900, Cross remarked that extirpation was most applicable in “quiet, chronic” cases of glaucoma, where the results of iridectomy were doubtful.34 He skeptically followed that “even though the patient willingly submits to such a heroic measure . . . the surgeon could not undertake it without great anxiety as to the wide ultimate effect on the control of the sympathetic nerve that might be likely to result.”33

Cushing was particularly interested in trigeminal neuralgia early in his career; thus, he arguably first became aware of sympathetic surgery when cervical sympathectomy was proposed as a treatment for trigeminal neuralgia by Pappaldo in 1902. In addition to learning that the operation had been applied to glaucoma, Cushing would have been aware of pharmacological glaucoma therapies such as pilocarpine, which produced miosis and were believed to work through this effect.14,16,18,22,23 Anatomically, pupil diameter was associated with the cervical sympathetic chain. As surgeon Macawen stated in 1887: “When the cervical sympathetic . . . is divided or paralyzed, the pupil contracts.”34 Presumably, Cushing felt that removing the superior cervical ganglion would cause constriction of the pupil and offer more permanent relief than contemporary pharmacological therapy. Perhaps aiming for a permanent effect, he removed the ganglion in its entirety rather than perform a simple transection, a practice he also used in treating trigeminal neuralgia.35

The procedure provides insight into understanding glaucoma and options for refractory cases during this time. Cushing chose to operate on an individual who had undergone 2 iridectomies without lasting improvement. Iridectomies had skeptics since they were not uniformly effective, although iridectomies did prevent blindness in some individuals and the mechanism of action (ie, prevention of pupillary block) was not understood.36

The case is also noteworthy because it documents Cushing’s process for using a relatively new treatment strategy for a disorder with which he had relatively little prior experience. Cushing did not perform the treatment without first consulting Mills, an instructor of ophthalmology at Johns Hopkins who clearly expressed approval. Cushing also attempted to maintain follow-up by instructing the patient to write about his progress. Presumably, the fact that the patient did not report significant improvement at discharge (although he did report improvement in pain and stabilization of vision in subsequent correspondence) led to reluctance on the part of Cushing to publish his results and continue extirpation for patients with glaucoma. As the patient likely had chronic glaucomatous damage and resultant optic atrophy, the results may be less indicative of the efficacy of the operation than the fact that the patient’s condition was irreversible. Nevertheless, we are limited by our inability to know what the patient’s true diagnosis would be by present-day standards. The actual findings from his ophthalmologic exam were not recorded. However, an ophthalmoscope was presumably used because this tool had been developed nearly 50 years prior and had reached general acceptance by that time.37 Furthermore, fundoscopic examination findings were recorded in the Johns Hopkins surgical records for many of Cushing’s other patients. According to Mills’ note, IOP was also mea-
sured; however, the method used and thereby its accuracy are uncertain. Digital measurements of IOP using the index finger against a closed eye were the oldest, simplest, least expensive, and least accurate method in use at the time. 14,16,38 In 1862, von Graefe had developed a transpalpebral tonometer. 38 In the 1880s, following the emergence of local anesthetic in the form of cocaine, application tonometers were developed by von Graefe’s student Maklakoff and Fick. 38,39 The Schiotz tonometer, which would become widely used in the field, was invented in 1905. 34,36,38,39 Nevertheless, the crucial fact remains that the extirpation of the superior cervical ganglion was performed on a patient understood to have glaucoma.

Although Cushing did not repeat the operative technique during his time at Johns Hopkins, following this case, the surgical trend in targeting the sympathetic nervous system would continue. Interestingly, additional indications for the procedure that emerged in the early 1900s including the angina pectoris and vasospastic disorders continue to exist as limited applications. Additionally, in the 1920s, the therapy was applied to hyperhidrosis and blushing, 2 areas that still benefit from the procedure, albeit through less-invasive approaches. 28 However, interest in sympathetic surgery for its original targets of epilepsy, goiter, and glaucoma waned. In the case of glaucoma, this was owing to the emergence of further treatments and enhanced understanding. 65 Around 1914, Smith remarked, “The operative treatment of glaucoma has undergone more improvement during the last five years than during the previous fifty.” 65 In 1916, Curran from Kansas University made the observation that pil- lars of iris rest heavily on the lens of patients with acute glaucoma, essentially defining an anatomical basis for hindered fluid drainage and resultant pressure increase in this population. 37 By 1924, Mitchell commented that despite a burst of interest into the sympathetic nervous system as a point of attack for glaucoma, “The operation does not seem to have remained popular.” 41 Now, Cushing’s operative note provides an historical reminder of the early understanding and lesser-known advances made in the quest to treat this blinding group of diseases.

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Correspondence: Alfredo Quinones-Hinojosa, MD, Department of Neurosurgery and Oncology, Johns Hop- kins School of Medicine, Brain Tumor Stem Cell Laboratory, Cancer Research Building II, 1550 Or- leans St, Room 253, Baltimore, MD 21231 (aquinn20@jhmi.edu).

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