RESECTION OF THE GREATER SUPERFICIAL PETROSAL NERVE IN THE TREATMENT OF UNILATERAL HEADACHE*

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H. G. WOLFF,24 whose opinions regarding headache certainly command respect, has stated that from the data available six basic mechanisms of headache from intracranial sources may be formulated:

Headache may result from (1) traction on the veins that pass to the venous sinuses from the surface of the brain and displacement of the great venous sinuses; (2) traction on the middle meningeal arteries; (3) traction on the large arteries at the base of the brain and their main branches; (4) distention and dilatation of intracranial arteries; (5) inflammation in or about any of the pain-sensitive structures of the head; and (6) direct pressure by tumors on the cranial and cervical nerves containing many pain afferent fibers from the head.

Of these six mechanisms, only one can conceivably be responsible for any significant proportion of cases of chronic recurring headache. That mechanism is distention and dilatation of intracranial arteries, which is the theme of this paper.

In the latter part of November 1940, 3 patients with a strikingly similar clinical picture were observed simultaneously. These patients were subject to attacks of excruciating unilateral head pain recurring once to several times a day, lasting from 30 minutes to a few hours, and frequently awakening them from sleep. The pain was deep and boring, limited to the peri-orbital and retro-orbital areas. It caused the patient to pace the floor, and nothing appeared to give relief. The attacks were accompanied by profuse lacrimation, nasal discharge, and nasal obstruction, all limited to the side of the headache. To the neurophysiologist these objective signs indicate excitation of the greater superficial petrosal nerve, which is the parasympathetic portion of the facial nerve. Therefore, it was presumed that the unilateral head pain accompanying these phenomena was also due to abnormal parasympathetic discharges coming over this same nerve. In other words, these patients were presumed to have a “neuralgia” of the greater superficial petrosal nerve.

In 1939 Horton, MacLean, and Craig12 described this syndrome and suggested the term “erythromelalgia of the head.”

Horton11 in 1941 redescribed the condition and because of its response to histamine therapy suggested the name “histaminic cephalgia.”

In searching for a physiologic explanation as to how an excitation of the

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greater superficial petrosal nerve could cause unilateral head pain, it was found that in 1932 Cobb and Finesinger\(^3\) collaborated with Chorobski and Penfield\(^4\) in a series of physiologic and anatomic studies on this nerve. From a review of the literature these authors showed that the greater superficial petrosal nerve carried secretory fibers for the lacrimal gland and secretory and vasodilator fibers for the mucous membrane of the nasal cavity. As a result of their own investigations they showed that this nerve carries somatic afferent fibers from the dura mater, internal carotid artery, and sphenopalatine ganglion to the ganglion cells in the geniculate ganglion. Of greatest significance in the present consideration, however, was their demonstration that the greater superficial petrosal nerve carries vasodilator fibers to the ipsilateral cerebral hemisphere (Fig. 1). In 1940 when Schumacher, Ray, and Wolff\(^7\) showed that cerebral vasodilatation causes headache, the chain of evidence was complete.

To recapitulate, in view of the above evidence it appears that periodic discharges of parasympathetic impulses over the greater superficial petrosal branch of the 7th nerve should cause unilateral lacrimation, unilateral swell-
ing and secretion of the nasal mucosa, and unilateral head pain. Since these were the outstanding symptoms in the 3 cases described above, a diagnosis of "greater superficial petrosal neuralgia" appeared justified. It remained, however, to be shown that interruption of the nerve would relieve the attacks. One of these 3 patients was operated upon.

CASE REPORTS

Case 1. A man, aged 48, was first seen on Nov. 28, 1940, complaining of headaches of 6 weeks' duration. The attacks occurred daily, lasted from 2 to 6 hours, and frequently awakened him from sleep. They consisted of intense pain at the outer end of the right eyebrow, radiating into the cheek, accompanied by profuse lacrimation and congestion of the right eye, and obstruction and discharge from the right nostril.

There were no significant physical or neurologic findings. The blood pressure was 140/80, the blood count was normal, and the blood Wassermann reaction was negative. X-rays of the skull and sinuses were negative. The patient stated that his pain was intolerable, and he begged for relief. Resection of the greater superficial petrosal nerve on the floor of the middle fossa of the skull was recommended.

The operation was performed on Dec. 5, 1940, under pentothal anesthesia. Employing the usual approach to the gasserian ganglion, the dura was elevated from the floor of the middle fossa, and with a dental applicator a bit of cotton was forced into the foramen spinosum, after which the middle meningeal vessels were divided. The dura was elevated further medially until the hiatus fallopii and groove of the greater superficial petrosal nerve were exposed. The nerve could be seen leaving the hiatus and traversing the groove until it disappeared beneath the lower portion of the gasserian ganglion. The nerve was picked up on a nerve hook, divided, and a portion of it removed.

Following operation the pain was completely relieved. Tear function was markedly diminished in the right eye, as measured by the Schirmer test.

Following his discharge from the hospital on the 6th postoperative day the patient developed a mild superficial keratitis in the right eye. This healed promptly following the application of a watch crystal shield. When last heard from 2 years after operation he reported that he had not experienced another attack and that lacrimation was still diminished in the right eye.

In searching for the manner by which this operation could relieve head pain, three possible mechanisms are disclosed. The first and most attractive is that the operation interrupts abnormal parasympathetic discharges which are causing dilatation of the cerebral, meningeal, and nasal mucosal blood vessels, the resulting pain of this dilatation being transmitted over the filaments of the 5th cranial nerve.

A second possible explanation is that the operation interrupts painful impulses coming over the geniculate somatic afferent fibers (described by Chorobiski and Penfield1) from the dura, internal carotid artery, and vidian nerve.

Third, the relief might be due to the incidental interruption of the superficial temporal artery, the middle meningeal artery, or the lesser superficial petrosal nerve, or perhaps to psychic factors incidental to hospitalization and operation.

A great deal has been written on the subject of headache and the mechanism of intracranial pain, but the possible role of the greater superficial petrosal nerve has been overlooked. Under the title of sphenopalatine ganglion
neuralgia, Sluder\textsuperscript{19,20,21} undoubtedly encountered cases similar to that described above. In fact, the anatomic and physiologic findings of Chorobski and Penfield\textsuperscript{1} suggest that irritation of the sphenopalatine ganglion could, by an axon reflex, be responsible for an ipsilateral cerebral vasodilatation with accompanying intracranial pain. The fact that so few cases of unilateral head pain can be relieved by cocainization of this ganglion indicates that this mechanism is not often operative. In Vail’s conception of vidian neuralgia\textsuperscript{22,23} the causative lesion is sphenoiditis, but again this theory can account for a very small percentage of cases of head pain.

In his cases of “geniculate neuralgia,” Ramsey Hunt\textsuperscript{13} described pain deep in the ear and deep in the face. The presence of unilateral head pain was not stressed in this syndrome. He did not take into account the work of Cobb and Finesinger\textsuperscript{8} and Chorobski and Penfield\textsuperscript{1} on the anatomy and physiology of the greater superficial petrosal nerve, most of whose fibers lie in close proximity to but actually by-pass the geniculate ganglion.

Fay\textsuperscript{7} described the syndrome of atypical facial neuralgia and his operative procedures in 19 cases in an attempt to relieve it. The neuralgia which he was treating consisted of chronic attacks of deep, dull, aching pain in the eye, malar region, about the ear, and down the neck, worse at night, throb-bing in character, and associated with tenderness to deep pressure over the arterial branches of the neck and head. He believed that this type of pain probably finds its port of entry to the brain and consciousness through branches given off by the vagus nerve which associate themselves with the large cranial vessels and travel with the sympathetic nerves.

The work of Chorobski and Penfield had not appeared at the time of Fay’s writing.

Broadly considered, there are seven methods by which attempts have been made to relieve neuralgias of the head: (1) the use of drugs during the attack in order to raise the pain threshold or to alter the tonus of smooth muscle; (2) the correction of an underlying constitutional factor by an altered regimen or desensitization procedure; (3) the treatment of extracranial factors such as ocular muscle imbalance and cervical arthritis; (4) the removal of lesions causing pressure on cranial or upper cervical nerves; (5) the surgical interruption of pain impulses en route to the seat of consciousness; (6) the ligation of branches of the external carotid artery; and (7) the surgical interruption of efferent sympathetic impulses to smooth muscle. So far as we have been able to discover there has been no previous attempt to relieve headache by surgical interruption of parasympathetic impulses.*

In treating neuralgias other than typical trigeminal or glossopharyngeal neuralgia, the resection of somatic afferent nerves has seldom proved successful. This is, no doubt, due to overlapping in distribution of the sensory filaments of the 5th, 7th, 9th, and 10th cranial and 2nd and 3rd cervical nerves. This failure has led the surgeon to attempt to correct a presumed abnormal

* Clark,\textsuperscript{2} however, reported a case of tic douloureux of the geniculate ganglion relieved by division of its sensory root.
physiologic state by interrupting the sympathetic nerve supply to the head.\textsuperscript{4,5,6,10,14} Sympathectomy, however, has also usually failed. The cause of this failure is obvious in the light of the work of Schumacher, Ray, and Wolff\textsuperscript{17} showing that cerebral vasodilatation and not vasoconstriction causes headache.

In reviewing our cases we found that since 1938 the greater superficial petrosal nerve has been divided 31 times in 26 patients for the relief of unilateral head pain. The types of cases could be separated into three groups: "petrosal neuralgia," migraine, and miscellaneous. We continued to use the term "petrosal neuralgia" even after Horton's further description of the syndrome\textsuperscript{11} in 1941 for the following reasons. In our cases we seldom observed signs that could not be due to impulses coming over the greater superficial petrosal nerve. That is, the unilateral engorgement of cutaneous vessels and unilateral sweating described by Horton were seldom found. Secondly, in only the occasional case could a typical attack be precipitated by histamine or could the attacks be relieved by histamine desensitization. Thirdly, the term "greater superficial petrosal neuralgia" or simply "petrosal neuralgia" appeared to be more descriptive. The continued use of this term, however, may well be questioned, since all patients with this syndrome are not helped by dividing the nerve.

THE SYNDROME DESCRIBED BY HORTON

(Petrosal Neuralgia)

In this group there were 13 cases including Case 1 reported above, and the greater superficial petrosal nerve was divided 17 times. Of the 13 patients, 3 had attacks on both sides. These cases satisfied most of the criteria laid down by Horton for "histaminic cephalgia," except that typical attacks were not induced by histamine injection and, as stated above, the attacks were not usually accompanied by obvious unilateral cutaneous vasodilatation or sweating. The ages varied between 23 and 52, the average being 34 years. There were 10 men and 3 women. They had their attacks for an average of 4 years, the attacks recurring in series lasting perhaps 2 to 3 months with free intervals of 2 to 12 months. The individual attacks lasted from $\frac{1}{2}$ to 6 hours and occurred from 8 times a day to once in 2 days. Alcohol was recognized as a precipitating factor in 2 cases. In none was there a history of familial headache.

Two of these patients had bilateral operations, and in 1 case in which the pain recurred the nerve was divided a second and a third time. Since these cases are so similar clinically, we shall describe only the results of the operation.

\textit{Case 1.} described above. There was immediate and complete relief of pain when the patient was last heard from 2 years after operation.

\textit{Case 2.} The attacks continued into the 2nd postoperative day, then ceased for 4 months. Since this time efforts to trace the patient have failed.
Case 3. The pain was immediately and completely relieved for 2 years, recurred mildly for 2 years, and then resumed its former severity. This patient's longest free interval in 7 years preceding operation was 2 months.

Case 4. A previous ligation of the middle meningeal artery gave no relief. Resection of the greater superficial petrosal nerve was followed by mild attacks for 3 weeks, then complete relief for 3 years, followed by recurrence.

Case 5. The operation was followed by no change in the attacks except that they were no longer accompanied by lacrimation.

Case 6. The attacks were immediately relieved. This patient noticed a return of normal tear function 4 months after operation, and 18 months after operation her attacks recurred. A 2nd operation disclosed some tissue resembling a regenerated nerve in the groove leading from the hiatus fallopii. This was divided, and the peripheral stump was treated with the cautery. The eye was again dry and the headaches were relieved. There was some return of tear function 17 months after the 2nd operation, and 2 months after this the attacks recurred. The nerve was divided again with immediate relief of the attacks.

Case 7. The attacks, though otherwise typical, were not accompanied by lacrimation. At the 1st operation merely the middle meningeal artery was divided. This resulted in complete relief for 3 months, when the attacks recurred. Six months later the greater superficial petrosal nerve was divided. This was followed by diminishing attacks which ceased after 6 weeks and had not recurred 17 months later.

Case 8. The patient had only slight improvement in his left-sided headaches following operation. For 4 months after operation the attacks were not accompanied by tearing. Eight months after operation he reported a change in the character of the headaches. They seldom occurred any longer at night and usually appeared during meals. At this time he reported that severe lacrimation from the affected eye began a few minutes after he started to eat and that this lacrimation was frequently followed in a few minutes by left frontotemporal pain.

Case 9. The operation was followed by relief from the original attacks, although 6 months after operation the patient was complaining of some pain below the eye where she had not had it before.

Case 10. The attacks of pain were limited to either eyeball and were not accompanied by lacrimation. Resection of the left petrosal nerve gave immediate relief of the left-sided attacks, so 2 months later the right nerve was divided. This was followed by no relief of the right-sided attacks and by a recurrence of the left-sided attacks 2 months later.

Case 11. The attacks also occurred on both sides but were otherwise quite typical. Resection of the left petrosal nerve abolished lacrimation on the left side, and the attacks were less severe, but there was scarcely enough benefit to justify operating upon the other side.

Case 12. The operation was followed by "90 per cent relief" when the patient reported 9 months later. He thought that his remaining pain was "due to something else."

Case 13. The attacks occurred on both sides. Four days after dividing the left petrosal nerve the patient was free of pain on that side and wished to have the other nerve divided. This was done and was followed by milder attacks for 1 week and then complete relief when the patient was last heard from 7 months after operation.

In trying to express the value of the operation, from the above survey it seems fair to say that the results were excellent in 25 per cent, fair to good in 50 per cent, and failures in 25 per cent of the cases. In the failures it is obvious that neither the efferent nor afferent impulses responsible for the attacks were interrupted. This means that the attacks of headache in these cases were not due to vasodilator impulses originating in the 7th nerve system central to the point at which the nerve was divided. Since this operation constitutes a preganglionic neurectomy it would not be expected to relieve head pain due to discharges of vasodilator impulses if they originated in the system peripheral to the point of surgical interruption.
TREATMENT OF UNILATERAL HEADACHE

In this group, with one or two exceptions, there was no recognizable difference in the clinical picture of the patients who obtained good results and those who did not.

MIGRAINE

Of the 26 patients who had a resection of the greater superficial petrosal nerve for the relief of unilateral head pain, 9 were fairly typical cases of migraine. Of these, 7 were women and 2 were men. The youngest patient was 27 and the oldest 62. The average age was 41, and the average duration of the headaches was 13 years. The headache was always unilateral at the onset, though more diffuse than in the preceding group. The attacks were preceded by an aura in 6 cases, accompanied by nausea and vomiting in 7, and there was a history of familial headache in 5. The average duration of the attacks was 48 hours; the average interval 7 days. Four of these patients had obtained some relief with ergotamine tartrate. The results of operation in these cases were as follows.

Case 14. The patient had immediate and complete relief when last heard from 19 months after operation.
Case 15. There was immediate and complete relief for 17 months when last seen.
Case 16. There was relief for 3 months, but 8 months after operation the patient reported that he was having some headache though probably not the same kind.
Case 17. There was relief for 7 months, when the attacks recurred following a head injury in an automobile accident.
Case 18. The patient was relieved for 6 months, and then the attacks recurred.
Case 19. The patient reported 4 attacks in 10 months, as compared with 5 or 6 per month before operation.
Case 20. The patient reported no attacks 13 months after operation.
Case 21. The attacks were only slightly less frequent and severe than they had been before operation.
Case 22. The patient had attacks on both sides. Operation on the left side relieved the left-sided attacks for 11 months. Four months after this operation the patient returned to have the right nerve cut, after which the right-sided attacks were greatly reduced in frequency and severity but not entirely controlled.

The above results suggest that resection of the greater superficial petrosal nerve is more apt to relieve classical migraine than the syndrome described by Horton. In view of Schumacher and Wolff's demonstration that the pain of migraine is due to extracranial vasodilatation, one cannot deny that the incidental ligation of the superficial temporal arteries may have been a factor in the relief in these cases. This aspect of the problem must be investigated further.

MISCELLANEOUS

The results of the operation in the 4 remaining cases were as follows.

Case 23. This was the first case in which the greater superficial petrosal nerve was intentionally resected. The patient was a woman of 38 with a constant, severe, dull, throbbing pain in the left eye and ear of 11 years' duration, associated with a chronic left mastoiditis. The petrous apex was explored with negative findings on Sept. 8, 1938, after which the greater superficial petrosal nerve was divided. The patient had a dry eye but no relief of pain following the operation.
Case 24. The patient was a man of 64 with postherpetic neuralgia of the ophthalmic division of the 5th nerve. The operation gave him no relief.

Case 25. A man of 36 with early malignant hypertension had almost continuous pain in the left temple which could not be relieved by compression of the temporal or carotid arteries. Resection of the nerve was followed by relief of pain for 4 months, after which it returned.

Case 26. This was a patient of 32 with post-traumatic unilateral headache of 12 years' duration. It was not benefited by spinal air insufflation nor by ligation of the middle meningeal artery. Resection of the greater superficial petrosal nerve was followed by definite improvement but not complete relief when last seen 11 months after operation.

COMPLICATIONS AND SEQUELLAE

The patients were usually aware of diminution of tears on the denervated side, though they seldom complained of it. On crying, tears would flow only from one eye. Irritating vapors introduced into the nostril on the denervated side produced no lacrimation. The Schirmer test (a filter-paper wick in the conjunctival sac) in each case showed less moisture on the operated side. The patients occasionally stated that the nostril felt drier. In some cases there was demonstrated a diminution of pain and tactile sensation of the nasal mucosa on the operated side. There was no noticeable difference in caliber of the conjunctival vessels. In 6 instances the tear function returned within 2 to 4 months (Cases 4, 6, 8, 17, 18, 25), but in most cases it remained decreased throughout the period of observation, in 1 case for 4 years. In 1 case the operation was followed by Horner's syndrome, due probably to injury to the carotid plexus. Following the 31 operations a facial paralysis developed in 7 instances. It appeared most commonly on the 4th postoperative day and with one exception cleared completely 4 to 8 weeks later. In one case, a facial paralysis, which developed within 24 hours after operation, did not begin to clear up for 3 months, and recovery was not complete for 5 months. The incidence of facial paralysis was higher in the early operations, when it was the surgeon's practice to elevate the greater superficial petrosal nerve on a nerve hook, thus making traction upon it before dividing it. This practice was later discontinued, and the nerve was divided in its groove by a curved scalpel. With this precaution the incidence of facial palsy has been reduced. Placing a silver clip on the peripheral stump of the nerve appears to retard regeneration, as indicated by rate of return of tear function. Two patients developed a postoperative keratitis which was indistinguishable from that following resection of the sensory root of the 5th nerve except that since the cornea retained its sensitivity, the condition was painful. The keratitis, which was merely the result of drying of the cornea, cleared promptly when evaporation of tears was retarded by sealing the eye behind a watch crystal.

Stimulation of the exposed greater superficial petrosal nerve was performed a few times, but the results were partly obscured by the anesthesia and also by the proximity of other nerves, particularly the carotid plexus and the lesser superficial petrosal nerve.

The return of tear function 4 months after operation in Case 6 and its
subsequent elimination by a second resection of the nerve offers convincing proof that preganglionic parasympathetic fibers can regenerate. In Case 8 the late development of unilateral lacrimation and head pain while eating suggests that the fibers of the central stump of the divided lesser superficial petrosal nerve became misdirected and grew into the peripheral stump of the greater. Thus, secretory impulses originating in the 9th nerve and destined for the parotid gland reached the lacrimal gland, while vasodilator impulses from the same source and destined for the parotid gland reached the internal carotid artery. This is the only recorded case of crocodile tears resulting from injury to the 7th nerve distal to the geniculate ganglion. It lends further proof to Ford’s theory of misdirection of regenerating nerve fibers\(^8,9\) in the explanation of this syndrome.

The occurrence of temporary facial paralysis and keratitis in these cases indicates that when these complications occur after resection of the sensory root of the 5th nerve they are due to incidental trauma to the greater superficial petrosal nerve, as maintained by Rowbotham.\(^15,16\)

**SUMMARY**

Acting on the hypothesis that some varieties of unilateral headache may be due to vasodilator discharges over the parasympathetic portion of the 7th nerve, the authors divided the greater superficial petrosal nerve 31 times in 26 patients. Most of these patients were benefited, some were not. The complications and sequellae of the operation are described. The operation provides a useful tool in the study and treatment of headache.

**REFERENCES**

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