Keen (W. W.)

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W. W. KEEN, M.D., LL.D.,

PROFESSOR OF THE PRINCIPLES OF SURGERY AND OF CLINICAL SURGERY, JEFFERSON MEDICAL COLLEGE OF PHILADELPHIA.

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WILLIAM G. SPILLER, M.D.,

PROFESSOR OF DISEASES OF THE NERVOUS SYSTEM IN THE PHILADELPHIA POLYCLINIC.

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REMARKS ON RESECTION OF THE GASSERIAN GANGLION.[1]

By W. W. Keen, M.D., LL.D.,
PROFESSOR OF THE PRINCIPLES OF SURGERY AND OF CLINICAL SURGERY, JEFFERSON MEDICAL COLLEGE, PHILADELPHIA.

WITH A PATHOLOGICAL REPORT ON SEVEN GANGLIA REMOVED BY PROFESSOR KEEN.

By William G. Spiller, M.D.,
PROFESSOR OF DISEASES OF THE NERVOUS SYSTEM IN THE PHILADELPHIA POLYCLINIC.

Up to the present time I have done eleven operations for the removal of the Gasserian ganglion. The first of these cases was reported in the *Transactions* of the Philadelphia County Medical Society for 1894 and in the *Medical and Surgical Reporter* for March, 1894, in conjunction with Dr. John K. Mitchell. It was the fourteenth operation done on the patient. From the date of that operation, October 18, 1893, the patient has been well. Although his condition of mental anxiety lest the pain should return, and his mental instability as a result of his long-continued use of opium, are very marked, yet practically he is well of his neuralgia. He still has pain, but not the old tic.

In The American Journal of the Medical Sciences for January, 1896, I reported five additional cases. The later history of these cases is as follows:

Case II.—The operation was done June 18, 1894. No ganglionic cells or nerve-fibres were found in the tissue supposed to have been removed from the site of the ganglion. The pain returned in six months, though not so badly as before. It still continues (September, 1897).

Case III.—Died in a week from septic infection.

Case IV.—The operation was done May 2, 1895, and at present, September 29, 1897, she is entirely well.

Of Cases V. and VI. I append a brief summary, since the examination of the specimens from these two cases is an important part of the pathological report which follows.

[1] Read at the twenty-fourth annual meeting of the American Neurological Association, held in New York, May 26, 27, and 28, 1898.

This paper was written for the volumes published in celebration of Prof. Durante's completion of twenty-five years' surgical teaching in the University of Rome.

Of the remaining five cases (VII. to XI., inclusive), which have never been reported, I give only a brief *résumé* of each, sufficient to compare with the pathological report. I shall publish them more fully hereafter.

In conjunction with my own remarks on the removal of the ganglion, and as a very important addition to our knowledge of the pathology of tic douloureux, I have been so fortunate as to secure the co-operation of my friend, Dr. William G. Spiller, who has examined with great care the seven specimens which I had removed and which were as yet unexamined. In all of these ganglionic tissue was found. These specimens cover the cases V. and VI. of my second paper and all the five additional cases (VII. to XI., inclusive) here briefly reported. I consider myself most fortunate in being able to enlist the services of so accomplished a neuro-pathologist as Dr. Spiller, and the value of his contribution will be seen not only in the text, but in the beautiful illustrations, for which we are indebted to the skill of Miss A. G. Newbold.

It will be observed that of the eleven, ten were secondary operations, multiple peripheral operations having been done in all the cases before the ganglion itself was attacked, with the exception of one case (Case VIII.). In this case, all of the branches being involved, I removed the ganglion at once. All of the operations were done by the Hartley-Krause method. Of the eleven three died, one from direct and avoidable infection (Case III.), the other two of shock.

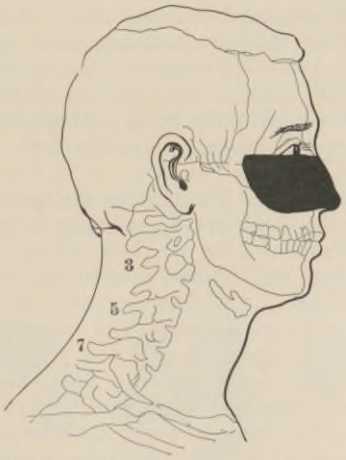
In six cases (VI. to XI.) an attempt was made to remove the entire ganglion, and the illustrations from photographs show that I was perfectly successful in Cases VI. and XI. in removing the entire ganglion with its roots, and reasonably successful in removing at least the ganglion itself in all the others. In Case VI., in which the entire ganglion, including its second and third divisions, and its sensory and motor roots were removed, Dr. Spiller was able to obtain sections which showed the microscopical condition of the ganglion as well as its physical relations with its sensory root and peripheral branches all in a single slide. As the motor root joins the third branch on the distal side of the ganglion, it could not, of course, be cut in the same plane as the other portion of the ganglion. In Case VIII. we were fortunate also to have a ganglion from a case in which no peripheral operation whatever had been done.

One disadvantage Dr. Spiller has labored under is that I was not aware at the time of my operations of the technical value of Nissl's method, or I should not have preserved the entire specimens in Müller's fluid, which prevents their examination by that method. The cellular changes, therefore, could not be studied in all their details, but the advantages of the selected method of hardening for an examination of

the alterations in the intra-ganglionic nerve fibres are very great. The next specimen I have Dr. Spiller shall have perfectly fresh, and be able to examine it by the Nissl method.

Case I. *Breaking up of the Gasserian ganglion after thirteen prior operations; done in two stages, on account of packing to arrest the hemorrhage; recovery; cure for four and a half years.*—Dr. K., aged forty-one years. He had suffered from neuralgia for thirteen years, and had had thirteen operations done, including removal of a large part of the upper jaw, as well as various branches of the nerves. Date of operation, October 18, 1893. The anterior branch of the middle meningeal passed through a canal and was, of course, torn in turning down the flap. In chiselling the posterior portion of the flap the posterior branch was also divided and the dura wounded. Both vessels were secured after much

Fig. 1.



The dark portion indicates the area of imperfect sensation.

trouble. The hemorrhage, on lifting the middle lobe, was so great that the cavity was packed, and the operation completed in a second stage after three days, the ganglion being broken up. The piece of gauze was found to measure thirty-seven by six inches, or two hundred and twenty-two square inches. This remained in the skull for three days, during which time his temperature had risen to 100.8°, and the respiration had gone down to from six to ten in a minute, with a slight aphasia. Immediate recovery followed the completion of the operation. He has suffered from temporary twinges of the pain, but except these he has been free from pain. His general health has never been very good. This patient was examined in September, 1897, by Dr. Spiller, whose notes are appended.

"Dr. K. states that he has real pain at times below the right eye and on the side of the nose, but has no paroxysms.

"Sensation is imperfect in the area indicated (Fig. 1), but evidently not entirely lost. He perceives pressure on the right side of the tongue,

but no pain from the stick of a pin. Sensation on the inside of the right cheek is much impaired, but not destroyed. Tactile sensation is preserved on the back of the right side of the tongue and on the soft palate.

"He cannot taste salt, vinegar, or quinine on the right side of the tongue, even at the tip.

"The right masseter muscle contracts well, and the lower jaw is moved from side to side (pterygoid muscles).

"On account of the continuance of some form of pain, the absence of total anæsthesia, the preservation of the motor root of the fifth nerve, as indicated by the contraction of the muscles of mastication, and the probably intact or nearly intact condition of the first and third branches, it is evident that only a small portion of the ganglion was destroyed."

CASE II. *Breaking up of the Gasserian ganglion; done in two stages, on account of hemorrhage, after eight prior operations; recovery; recurrence of attacks.*—C. H. B., aged about thirty-five years. Neuralgia began in April, 1886, apparently from the filling of a tooth. From 1889 to 1890 subcutaneous neurotomy was twice done, the antrum drilled, the right infra-orbital resected three times, and the right carotid was tied. The last five operations were done by Dr. John B. Roberts. In March, 1890, the sight of his right eye began to fail, and in February, 1891, another surgeon removed the crystalline lens. When first seen in June, 1894, the right eyeball was utterly useless, the face was shrunken over the antrum, and for three years he had never been free from pain.

Operation, June 18, 1894. The middle meningeal ran in a groove and was torn in turning down the flap; secured by ligature. On lifting the temporo-sphenoidal lobe, the hemorrhage was so profuse that the wound was packed with gauze, measuring sixteen by six inches (ninety-six square inches). Cultures at the first operation and when the gauze was removed were sterile. The second and third divisions were torn loose from the ganglion, and the ganglion itself broken up. Dr. Burr reported that neither nerve fibres nor nerve cells were found in the supposed tissue of the ganglion. In September, 1897, the patient wrote that he had frequent sharp attacks of pain.

CASE III. *Breaking up of the Gasserian ganglion after two prior operations; rupture of middle meningeal at the foramen spinosum; infection after operation; death from septic meningitis.*—Mrs. E. E. H., aged sixty-three years. Neuralgia began in 1883. In 1889 inferior dental removed by Dr. Thomas G. Morton. On February 23, 1892, I removed the inferior dental nerve, which had been reproduced, and the lingual nerve by trephining the vertical ramus of the jaw. Recurrence of pain in November, 1893. At no point was there complete anæsthesia on the left side of the face; but, on the contrary, a large part of the skin was hyperæsthetic.

Operation, February 20, 1895. The anterior branch of the middle meningeal ran in a canal and was ruptured. While lifting the temporo-sphenoidal lobe the middle meningeal ruptured at the foramen spinosum; arrested hemorrhage by packing with gauze. During the operation a gentleman, not one of my regular assistants, without my knowledge, infected an instrument which was used in the wound. She died at the end of a week. Pyogenic cocci were found by culture.

CASE IV. *Breaking up of the Gasserian ganglion after five prior operations; done in two stages, on account of hemorrhage; recovery; cure*

for three years ; necrosis of bone in the flap.—Mrs. S. R., aged sixty years. Neuralgia in the second and third divisions of the right fifth, for which five operations had been done, the last being a division of both of the branches at the foramina rotundum et ovale.

Operation, May 23, 1895. Rupture of anterior branch of middle meningeal, which ran in a long canal in the bone. On lifting the temporo-sphenoidal lobe, the hemorrhage was so severe and continuous that I packed a piece of gauze, afterward found to be twenty-three by fourteen inches (three hundred and twenty-two square inches), into the wound. Three days later packing removed and ganglion broken up. Dr. Kyle reported undoubted ganglion cells in the tissue removed. The central portion of the section showed slight, if any, variation from the normal, but the outer portion showed some inflammatory infiltration. Sections of the nerves showed a thickened neurilemma (inflammatory), with infiltration of round and spindle cells. No apparent change in the axis cylinders or white substance.

At the present time (May, 1898) she is still free from pain and her general condition good. Some of the bone in the flap necrosed.

Case V. *Curetting of the ganglion after two prior operations; rupture of the middle meningeal at the foramen spinosum; post-operative corneal ulcer; recovery; cure for two years and a half.*—Mrs. F., aged fifty-four years, was first seen July 15, 1891. Neuralgia, at first confined to the right inferior dental, had existed for twelve years following an abscess at the root of a tooth. In 1886 a half inch of the right inferior dental was removed, with relief of pain for eighteen months. It then returned in the superior maxillary division.

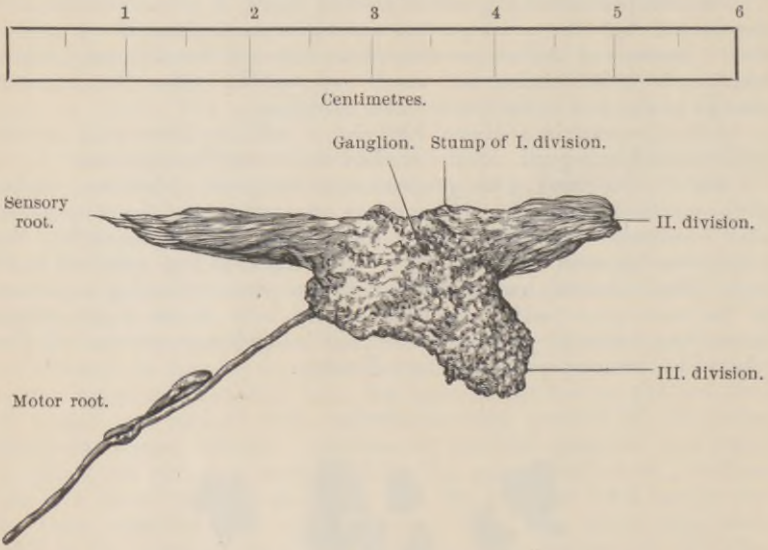
Fig. 2.

Gasserian ganglion (*a*) and second and third divisions (*b* and *c* respectively) from Case V.

July 17, 1891, I operated both on the inferior dental and the superior maxillary. The inferior dental was found reproduced and as large as the median nerve. This gave relief for over eighteen months. October 6, 1895, I operated on the ganglion. (Fig. 2.) In lifting the temporo-sphenoidal lobe the middle meningeal tore directly at the foramen spinosum. It was controlled by the Allis dissector, for which was substituted, first, the left forefinger, and then a small piece of iodoform gauze, which was packed into the canal. This iodoform gauze was removed on the third day. In a week the wound was entirely well. On the third day after the operation a corneal ulcer developed. She went home November 27, 1895. The ulcer, which had been most skilfully treated by Dr. de Schweinitz, was then healing, and after very many vicissitudes, in the course of a year under the care of her physician, Dr. Moore, of Spartanburg, S. C., she recovered entirely. When last heard from, early in 1898, she was entirely well.

Case VI. *Removal of entire Gasserian ganglion, with its second and third divisions and both its sensory and motor roots back to the pons in a piece four centimetres long, after four prior operations; recovery; complete cessation of pain for two years and a half; post-operative corneal ulcer.*—C. W. E., aged thirty-three years, was first seen November 16, 1895. Neuralgia began five years before, after an attack of diphtheria. In March, 1895, the right upper teeth and the right alveolar process were removed. Since then three other operations have been done, including the removal of the infra-orbital nerve and opening of the antrum.

Fig. 3.



Gasserian ganglion, with the II. and III. divisions and the sensory and motor roots removed from Case VI. The nerve bundles are well shown. The motor root is elongated by the accidental reversal of one of its bundles. (From a photograph which unintentionally was enlarged about one-third, but the scale of centimetres which was photographed with the specimen will serve for comparison.)

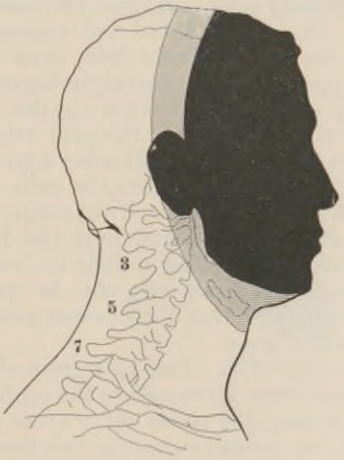
Operation, November 22, 1895. The eyelids were first stitched together. On lifting the temporo-sphenoidal lobe the middle meningeal tore just above the foramen spinosum. It was secured with a ligature. The ganglion was twisted out complete, as is seen in the drawing. (Fig. 3.) A profuse hemorrhage occurred as the ganglion was removed, which I judged to be from the cavernous sinus. It was arrested by packing a strip of gauze, ten by one and one-half inches. After an uncomfortable night, the next day he had severe frontal headache, and his temperature had risen to 104°. Though the gauze had only been in for twenty-four hours, I deemed it necessary to remove it, and no hemorrhage followed. The wound was entirely healed on the eighth day. Four days after the operation the stitches were taken out of the lids, but within twenty-four hours signs of corneal ulceration began. The lids were then stitched together again. After a great deal of difficulty

Dr. de Schweinitz, who cared for his eye, was able to save it, but with only partial vision.

This patient was examined by Dr. Spiller, October 5, 1897, and his notes are appended.

"C. W. E. states that he has not had the slightest pain since the ganglion was removed; he has not even once had any indication of a return of the suffering. With the exception of a 'drawing sensation,' he has had no paræsthesia in the affected area. He has had no trouble with fish-bones and cherry-stones remaining in his mouth. When he masticates he uses only the muscles of mastication on the left side. The hair grows as well on the top of the head, in the eyelashes, moustache, and beard on the right side as on the left, and he has to shave the beard on the right side as often as on the left. The skin also is normal. These are interesting statements in view of the supposed trophic functions of the fifth nerve.

FIG. 4.



The dark shading indicates the area of complete anæsthesia for all forms of sensation; the light shading indicates the area of hypæsthesia.

"*Sensation.* Complete anæsthesia exists on the right side of the face in the area indicated in the drawing. This area shades off into the region of normal sensation, as is also indicated in the drawing. (Fig. 4.) The total anæsthesia extends to the median line of the face, but the hypæsthesia extends a slight distance beyond the median line into the left side of the face. The right nostril is completely anæsthetic. The inside of the mouth and the right side of the tongue, including the point, are anæsthetic on the right side. The back of the tongue and the soft palate, as well as the left side of the tongue, are sensitive. The right cornea, conjunctiva, and auditory canal are anæsthetic.

"The sensation of the face was tested for heat, cold, pain, and touch. On the left side of the face sensation is normal.

"*Taste.* He has no sense of taste for vinegar, sugar, or salt on the right side of the tongue, even at the point, but all these substances are

tasted at the back of the right side of the tongue and still better on the left side of the tongue.

"*Motion.* There is no contraction whatever in the masseter and temporal muscles of the right side of the face, while on the left side the contractions seem to be unusually vigorous. The muscles of mastication on the right side are entirely atrophied. Saliva at times drops from the right side of the mouth.

"*Ocular condition.* He has some sight in the right eye; he can count the fingers held before him, and says he sees them sharply, but that most objects have a hazy outline. He cannot read with the right eye. The left eye is good. The conjunctiva of the right eye is much injected, and the cornea is slightly hazy as compared with the left. The eyelashes of the right lower lid grow inward and irritate the eyeball, and he has had most of them pulled."

Case VII. *Removal of the Gasserian ganglion after two prior operations, with portions of its roots; recovery; cure for two years and five months, and no return as yet of the severe pain, but some paræsthesia.*—Mr. J. McM., aged seventy-six years, was first seen with Dr. Charles A. Currie, December 28, 1895. A tall and vigorous man, apparently much younger than his age; arteries free from atheroma. Twenty years ago, without apparent cause, neuralgia began in the second division of the right fifth nerve. Nine years ago the late Dr. Agnew resected the infra-orbital nerve, and, as the pain returned shortly afterward, three years ago Dr. Thomas G. Morton again resected the same nerve. Soon after the second operation the pain again returned, and has extended to all the branches of the fifth, coming in paroxysms only a minute or two apart and extending over the forehead, cheek, and jaw, the point of severest pain being a little in front of and below the ear and in the tongue. He is scarcely able to speak. Meat is only eaten when finely cut up, and even then causes severe pain. The anterior wall of the antrum is gone.

Operation, December 31, 1895. One-half grain of morphine and one-twentieth of strychnine were given before the operation, and the latter was repeated twice during the operation. As in all the other operations, ether was used, the operation lasting two hours. An osteoplastic flap was turned down and the anterior branch of the middle meningeal, which was torn in doing so, secured. When I had turned down the flap I found that the dura was so firmly adherent to the bone that the outer layer of the dura had adhered to the bone over a considerable extent and left the brain covered only by the thin inner layer. At one point the dura was ossified over an area of one-half inch. Other small areas of ossification were also found under the temporo-sphenoidal lobe. The third division was at least one-half inch away from the middle meningeal, and was quite small, less in cross section than the second. In isolating the third division considerable hemorrhage took place, though no vessel was seen; it was arrested by pressure. The ganglion was then seized and, after dividing the second and third divisions, was twisted out, the roots being imperfectly removed. The third division tore and had to be removed separately. I particularly noted whether avulsion of the ganglion caused any shock. Dr. Spencer, one of my assistants, held his finger on the pulse at the moment, and no perceptible effect was produced either upon the pulse or in any other way that could be noticed. The eyelids had been stitched together before

the operation. In ten days he went home, his highest temperature having been 100°. Since then he has remained entirely free from pain.

For the histological examination of the specimens, see Dr. Spiller's notes of Case VII. Dr. Spiller's notes of the patient's condition are added.

"At the present time, May, 1898, his general health is excellent, he has gained twenty-five pounds, has no return of the tic douloureux, but has some obscure "creeping" feeling in his right face. His eye waters somewhat, but otherwise there is no trouble.

"Mr. McM. stated that when he ate cherries or fish the stones or bones, as the case might be, collected on the right side between the teeth and cheek, and were not noticed until two or three hours later, when they were moved to some more sensitive area of the mouth.

"He has never had a return of the old severe pain, but has had 'three or four different kinds of pain' on the right side of the face. At times he has a sense of itching, which begins at the right ala nasi, and is followed by a sensation as of worms creeping over the anæsthetic area. This seems to be in reality a form of paræsthesia and not of pain.

FIG. 5.

The dark shading indicates the area of total anæsthesia.

"The area of total anæsthesia is indicated by Fig. 5, and, by comparison with Fig. 490 (*Gray's Anatomy*, p. 731, edition of 1887, edited by Keen), is found to correspond quite closely to the distribution of the second branch of the fifth nerve, leaving the distribution of the first branch intact and impinging slightly on that of the third. Along the border of the anæsthetic area a pin-point is felt as dull pressure. Within the area the anæsthesia is complete, except that pressure causes a displacement of the parts pressed upon, and affects the surrounding sensitive tissues, and is perceived in this way.

"No sensation is felt on the inside of the right cheek, and the right side of the tongue is almost anæsthetic, but not entirely so. Sensation at the back of the mouth on the right side is impaired.

"According to his statements, the saliva escapes at times from the

right corner of the mouth, and at night the lower jaw hangs somewhat. He can open his mouth only to about the width of one and a half inches, and is obliged to cut his food into small pieces in order to get it into his mouth. In opening his mouth the lower jaw goes somewhat to the right, and this is probably due to more vigorous action of the external pterygoid muscle of the left side. No contraction of the right masseter is felt, and none of the right temporal muscle.

"Salt and acid are tasted a little on the right side of the tongue and quite well at the point on the right side.

"No loss of vision has occurred, but he complains of impairment of sight, which, most probably, is a result of old age. No trophic lesions of the eye are noticed. As the first branch is probably not destroyed, judging from the distribution of the anæsthesia, trophic lesions of the eye could hardly be expected."

Case VIII. *Removal of the Gasserian ganglion as a primary operation; possible tear of the cavernous sinus, controlled by packing; uneventful recovery; cure for one year and eight months.*—Mrs. A. W. S., aged sixty-nine years, first consulted me January 11, 1895. Her present trouble began eighteen years ago, with pain in the left face. In a few years all her teeth were removed. The pain is chiefly felt in the second and third divisions, but is also felt in the area supplied by the first division. Free purgation by sulphate of magnesium and later by castor oil was tried for ten days without result.

Fig. 6.

Gasserian ganglion, from Case VIII.

Operation, January 24, 1896. The usual Hartley-Krause flap was turned down. The anterior branch of the middle meningeal ran in a complete canal, the posterior in excessively deep grooves practically equivalent to canals. All of these branches were torn, therefore, in turning down the flap, but were rapidly secured. The ganglion was seized, the second and third divisions severed, and the ganglion twisted out. (Fig. 6.) In doing so the second division tore loose from the ganglion, and was lost in the rush of blood which followed its avulsion. The hemorrhage was so severe that I was inclined to think that the cavernous sinus was torn, though this was uncertain. Packing by gauze controlled it readily. The highest temperature, on the third day, was 100.6° F. The gauze was removed on this day without hemorrhage. For three days the eyelids were closed by a bit of sterilized cotton and a bandage and by the Buller shield afterward. I kept her under observation for three weeks, lest trouble should ensue with the cornea, but when she went home the cornea was perfectly normal. She has had no return of pain for a year and eight months. For report on specimen, see Case VIII. of Dr. Spiller's notes.

Case IX. *Removal of the Gasserian ganglion after one prior operation; wound of cerebral vessels while making flap; rupture of the cavern-*

ous sinus, packing with gauze; coma and hemorrhage, followed by death in three days.—Mr. G. K., aged forty-nine years; father and mother died of old age. In his personal history the only thing of importance is that he had smallpox at sixteen years of age. Seventeen years ago the pain began in the right upper jaw near the canine tooth, gradually extending over the cheek. A number of his teeth were extracted, without relief. Seven years ago, at the Jefferson Hospital, the infra-orbital nerve was removed, giving relief for two and a half years on the cheek, but the pain in the forehead still remained. His pain has become entirely unbearable. It extends over the right forehead and sweeps down to the cheek. The lower jaw is not involved. When he is quiet a touch on the cheek does not cause pain, but the slightest touch on the forehead is followed by intense pain. For the last six or eight weeks the pain has been increasing greatly in severity.

Operation, April 21, 1896. The Hartley-Krause osteoplastic flap was made by means of Dr. Cryer's drill. In making the first small trephine opening, in spite of the utmost care, the trephine slipped inside the skull. This was followed by copious hemorrhage, showing that a large vessel had been divided. The flap was then quickly turned down. As soon as the dura was exposed an extensive clot was found

FIG. 7.

Gasserian ganglion, Case IX.

under it, having resulted from the mishap in the first small trephine opening. About an ounce of clot was removed; the source of the bleeding was a branch of the middle cerebral. The dura was then closed. The anterior branch of the middle meningeal ran through a canal and had been torn. This was ligated. The temporo-sphenoidal lobe was then lifted, the second and third divisions readily found, and the middle meningeal avoided. The ganglion was seized with a pair of hæmostatic forceps, the second and third divisions were separated, and I then attempted to twist out the ganglion. (Fig. 7.) In this I found two difficulties: one that the forceps did not grasp the ganglion with sufficient tightness to twist it, and the other that the third division had been only partly divided. The third division was then completely divided, and I removed the major part of the ganglion. A portion of the ganglion still escaped the jaws of the forceps. They were reapplied so as to get a good hold on the ganglion, but the moment that I began to twist it out a copious gush of venous blood convinced me that I had probably pushed the forceps too far inward and torn a rent in the cavernous sinus. The wound was packed with iodoform gauze immediately and the wound closed, leaving the packing in place. He reacted well; at the end of an hour his temperature was 97.4° F., but he was not yet conscious, and his puffing respiration made me suspect that the pressure of the gauze had produced what I hoped to be a temporary hemiplegia. He remained, however, hemiplegic and unconscious till his death, at 1.20 A.M., on April 24th, almost three days after the operation. The temperature rose very little till about forty-eight hours

after the operation, when it fluctuated between 103° and 104° F. The gauze (two hundred and sixty-seven square inches) was removed after forty-eight hours, without hemorrhage.

Post-mortem examination was refused. For the histological examination of the specimen, see Dr. Spiller's report of Case IX.

Case X. *Removal of the Gasserian ganglion; death from shock in ten hours.*—Mrs. M. S., aged sixty-three years, first consulted me about the middle of October, 1896. She had suffered with neuralgia for over thirty years. A few years ago Dr. W. J. Hearn removed the second and third divisions, with relief for a considerable time. The pain has now returned not only in these two divisions, but also in the first. Unfortunately, the notes of the earlier history were lost by one of my assistants, and these are the only facts which I can give. (Fig. 8.)

Fig. 8.

Gasserian ganglion (A) and second and third divisions (B and C) respectively, from Case X.

Operation, October 31, 1896. The ordinary osteoplastic flap was turned down. The anterior branch of the middle meningeal divided into three large branches, all running in very deep grooves in the bones, and all were lacerated in turning down the flap. After some little trouble they were secured. The second and third divisions were readily found and traced back to the ganglion. In uncovering the ganglion I met with such profuse hemorrhage that I divided the second and third divisions and endeavored to remove the ganglion by traction instead of seizing the ganglion itself. I decided upon this procedure not so much because of the amount of blood lost, which constantly recurred upon the slightest manipulation in the effort to uncover the ganglion, as because of the amount of time lost. Avulsion of the third division brought a considerable quantity of the ganglion with it. When the second was avulsed no ganglion tissue could be recognized. The ganglion was broken up and wiped away by the small sponges which we used to check the hemorrhage. The operation lasted an hour and a half; the patient's pulse kept up very well, but the respiration was very poor. During the operation three doses of one-twentieth of a grain of strychnine and one one-hundredth of a grain of atropine were administered. In one hour after the operation she seemed to be reacting very nicely. Soon after that, however, she began to fail, and died ten hours after the operation. No post-mortem examination could be obtained. For a full report of the specimen in this case, see Dr. Spiller's notes of Case X.

Case XI. *Removal of the Gasserian ganglion after six prior operations; recovery; cure for sixteen months; eyesight lost from secondary corneal ulcer caused by his neglect.*—F. W. P., aged fifty-six years. Neuralgia began six years ago in the right lower jaw. At different times he has had six peripheral operations by Dr. Parmenter, of Buffalo. He has operated on the inferior dental both in the dental canal and finally at the foramen ovale. On November 8, 1895, Dr. Parmenter operated on the Gasserian ganglion, but the pain returned within a month. When I first saw him the conjunctiva and cornea had normal sensibility, as also the skin of the entire face and the tongue.

Operation, January 22, 1897. Owing to the former Hartley-Krause operation, great difficulty was found in turning down the flap on account of adhesions to the dura mater. The anterior branch of the middle meningeal was ligated, as it had been torn during the removal of the flap. Temporary packing and heat were applied, which checked the hemorrhage very readily. The third and, later, the second divisions

Fig. 9.

Gasserian ganglion and second and third divisions, from Case XI. The ganglion is the mass to the right; the left portion is the second division, and the detached mass is the third division.

were then readily found, and later the ganglion laid bare. (Fig. 9.) It was seized with a pair of hæmostatic forceps, and the second and third divisions of the nerve severed at their foramina. The foramen ovale, instead of being oval, was distinctly triangular, and the nerve only partly filled it. The foramen was much larger than I had ever seen it before. The second division tore loose from the ganglion. Removal of the ganglion was followed by moderate hemorrhage. The operation was unusually long, two and a quarter hours, on account of the adhesions to the bone and also the difficulty of determining when I had reached the dura. The eyelids were stitched together at the close of the operation. Thirteen days after the operation he went home, his highest temperature having been 100° F. The stitches were removed on the third day and the eye covered by a Buller shield. When he went home the eye was in good condition and he was beginning to dispense with the shield. Later, through his negligence in covering the eye with a handkerchief without the shield, friction on the cornea produced a corneal ulcer, from which I learned later that he ultimately lost his eyesight. He has been now entirely free from pain for sixteen months. His general health is excellent. For a fuller report of the specimen in this case, see Dr. Spiller's notes of Case XI.

To sum up the results of Dr. Spiller's researches, we may say that in a general way the pathological changes which he has found are:

1. That the medullary substance of the nerve fibres within the ganglion and its branches is much swollen, atrophied, or entirely gone, depending on the intensity of the disease.

2. That the axis cylinders similarly are markedly degenerated or entirely destroyed.

3. That the cells of the ganglion itself, in at least one case, are so degenerated or atrophied that there would be even doubts whether we were dealing with ganglionic tissue in certain parts of the field, were it not for the occasional nerve cells seen.

4. That the vessels are very distinctly sclerotic. In some instances the lumen is even entirely obliterated.

5. There is, in at least one case, a decided amount of increase in the connective tissue of the ganglion, which is enough to call the alteration a distinct sclerosis.

I propose now to consider four points:

1. Should the Gasserian ganglion be removed?

2. The answer being in the affirmative, to what extent shall it be removed—*i. e.*, shall we remove the entire ganglion, or only its outer two-thirds? or shall we be satisfied with simply "breaking it up" by blunt instruments or a curette?

3. Should the ganglion be removed as a primary operation, or should its removal be reserved till the very last operation for tic douloureux?

4. A few points in the technique.

1. The removal of the Gasserian ganglion is in some respects rather peculiarly American. The first deliberate proposal to remove the Gasserian ganglion was made by Dr. J. Ewing Mears, of Philadelphia (*Transactions American Medical Association*, 1884, vol. ii. p. 469). Andrews, of Chicago (*Chicago Medical Record*, 1891, vol. i. p. 322), had been at work for eighteen months devising practically the same operation as Rose, but the latter preceded him both in publication and performance (*Lancet*, 1890, vol. ii. p. 914). Similarly, Hartley, of New York, and Krause, of Altoona, almost at the same time devised the method of operating which has been most used and is, on the whole, perhaps the best method.

Of the 108 cases of intracranial operations on the fifth nerve, collected by Tiffany (*Transactions American Surgical Association*, 1896, vol. xiv. p. 1, and *Annals of Surgery*, 1896, vol. xxiv. p. 575), seventy-nine were done by American surgeons and twenty-nine by European surgeons.

Whether we ought still to resect the ganglion depends, in my opinion, on three conditions: (*a*) The mortality of the operation; (*b*) its efficiency as a means of permanent cure; and (*c*) whether its disadvantages,

especially the possibility of the loss of the eye on the operated side, can be avoided.

(*a*) The mortality of the operation may be taken as that shown by Tiffany's table (108 cases, twenty-four deaths), a mortality of 22.2 per cent. For an operation done by modern antiseptic or aseptic methods, a mortality of over one-fifth is very large. I have no doubt it will be diminished in the future, as we learn by experience to deal with the vicissitudes and emergencies. In fact, surgically speaking, we *must* master and overcome so large a mortality. No one who has ever resected a Gasserian ganglion will speak lightly of the operation. Even now, after having operated on eleven, I always approach the operation with a certain amount of hesitation. The mortality alone would cause me to answer the third question positively in favor of the resection being reserved for the last of the series of operations instead of the first.

(*b*) What has been the history of the cases as to cure? So far as I know, there have been four cases in which the pain has returned; one of Rose's, one reported by Dana, and two by myself. But I especially desire to call attention to the fact that my own two cases of recurring pain were my *first two operations;* that in Case I. no microscopical examination of the fragment removed was made, and in Case II. the examination revealed no ganglionic cells or nerve fibres. As I now look at it, Case I. was imperfectly done, and Case II. still more so. Therefore the recurrence of pain in these two cases cannot be used as an argument against the removal of the ganglion. The facts as to recurrence of pain in these two cases have been given earlier in this paper.

In addition to this, Krause has reported one case in which the sensory root was found diseased, and the pain returned on the other side of the face. We can conclude, therefore, in general, as a result of experience in over one hundred cases of intracranial operation on the fifth nerve that, practically, the pain will return in not over 1 or 2 per cent. with any such severity as to liken it to the original disease, and that it will return to any degree in not more than 4 or 5 per cent. Perhaps, if we consider the uncertainty of total excision of the ganglion in the reported cases in which pain did return, this percentage is too high. As Dr. Spiller has shown, there are only two cases known to him in which the sensory root has been examined (although it may be that Krause examined the sensory root in some of his other cases); one of these was by Krause and one by himself. In Krause's case the root was diseased, and the pain returned upon the opposite side. In my own case (Case VI.), though the lesions of the ganglion were very intense, and the disease had existed for five years, yet Dr. Spiller found the sensory root entirely free in longitudinal as well as transverse sections. We must expect, as a result of both the

clinical history and the pathological examination of Krause's case, that the disease may not only reach, but may pass beyond, the ganglion to the sensory root, and that, therefore, even the removal of the ganglion will not always absolutely prevent a return.

(*c*) Apart from the mortality the chief danger is the loss of vision, if not of the eyeball. This, I think, I now know how to master. I shall consider it under the question of technique. All other disadvantages, such as the possible necrosis of a piece of the bone, the sinking in of the flap, or the possible uselessness in a certain number of cases of the muscles of deglutition, are very slight as compared with the immense relief from the horrible pain. My conclusion, therefore, is that the removal of the Gasserian ganglion should still be done, but that we should especially strive to lessen the mortality of the operation.

2. To what extent shall the ganglion be removed? Tiffany has expressed the opinion (1) that the motor root can be saved, and (2) that it ought to be saved. In some of my cases, though I have made no attempt to save the motor root, the muscles of mastication on the operated side were not wholly paralzyed. In Case VI., in which the motor root was certainly removed, the muscles of mastication on the operated side are atrophied and useless, but the patient can readily masticate meats, the lower jaw being easily moved by the muscles of the opposite side. I do not, however, believe that the motor root can be preserved. In the first place, I do not think that, from an operative point of view, it is possible to do so, and, secondly, the very careful dissection of the ganglion made by Jouvara (Chipault's *Travaux Neurol. Chir.*, 1897, vol. ii. p. 205) makes me sure that this is even anatomically quite impossible. He says (pp. 209-210), "the masticatory nerve [by which I take it he means the motor root] and its branches are very adherent to the trunk of the inferior maxillary division and are contained in the same sheath of connective tissue; the separation of these two nerves is difficult even by the most careful dissection, and to avulse the inferior maxillary without at the same time avulsing the masticatory nerve is veritably impossible." If this cannot be done on the dead body by the most careful dissection, it cannot be done on the living during the exigencies of an operation.

In the microscopical examination of Case VI. the motor root was found to form an intimate part of the third branch so near the ganglion that it would have been very difficult or even impossible to separate it from the ganglion at the time of operation. Another point is worthy of mention; the peripheral sensory branches must degenerate after resection of the ganglion, and it may be that in the sclerosis which follows the destruction of the sensory fibres in the third branch the motor fibres would be at least partly affected even if they had not been cut. The only possible absolute necessity for preserving the nerve

would be the need for preserving it in case of a bilateral resection of the Gasserian ganglion. This has never yet been necessary, and will surely be extremely rare. If, after destruction of the ganglion, the muscles of mastication on the sound side are sufficient for the purposes of mastication, I see no reason to trouble ourselves to preserve the motor root.

A much more important question as to the extent of the removal of the ganglion is whether the entire ganglion shall be avulsed, such, for example, as is seen in Fig. 3 from Case VI. of my own series and in several of Krause's photographs (*Neuralgie des Trigeminus*), or whether we should follow the recommendation of Tiffany, that only the outer two-thirds of the ganglion, together with the second and third divisions, should be removed and the inner third left. The only object in leaving the inner third is the conservation of vision. But, as shown below, I believe that our methods of dealing with the eye are so improved that we can positively now remove the ganglion and yet conserve the eye.

In addition to this we must remember that the ganglion is not divided into thirds physically or physiologically. It is not true that the inner third of the ganglion is connected exclusively with the first division and supplies the eye, the middle third with the second division, and the outer third with the third division; but the cells of the ganglion in every part are more or less connected, so far as we know, with any or all of the three divisions.

An arbitrary line, therefore, removing the outer two-thirds and leaving the inner third will leave undoubtedly diseased ganglionic cells if the ganglion is affected. If these cells are diseased, any stimulus from the first division will excite sensation in them, and thus may bring about a return of the pain.

As the only objection to removing the whole ganglion—the effect upon the eye—can now, I think, be overcome, we ought, I believe, distinctly to aim at the removal of the entire ganglion.

3. Shall the ganglion be removed as a primary operation—the very first after the disease has set in—or shall it be left till the last operation?—that is to say, shall we perform as many peripheral operations as can be done first, and only remove the ganglion when we are driven to it?

I believe that this last is the proper position to take.

While Dr. Spiller, from his investigations of the pathology, is not able to say positively whether the ganglion becomes diseased primarily or secondarily, yet, as he points out, the clinical evidence would lead us to believe that the ganglion is the last of all to suffer. Of course, after any peripheral operation, just as after an amputation of an arm, atrophic changes will set in which will go direct to the Gasserian ganglion, and may, so far as we know, reach to the pons, or even possibly the cortex, just as after an amputation of an arm atrophic changes

can be traced into the central nervous system, yet these are very different from anything like an ascending neuritis which would involve the ganglion in inflammatory troubles as a result of the preceding disease of the nerve branches.

The effect on the ganglion, even after eighteen years of suffering, in Case VIII., was very slight. This, so far as I know, is the only examination of a ganglion in which no peripheral operation had been done, and in which the examination is, therefore, free from any suspicions of alteration in the ganglion other than that due to a possible ascending neuritis. It must be stated, however, that the entire ganglion could not be examined microscopically. If the ganglion is not diseased, therefore, primarily I believe that we ought to attack the disease where we know it exists—namely, in the peripheral branches. If the ganglion is primarily diseased, we cannot understand how it is that relief is afforded for one, two, three, or more years by a peripheral operation. The simple shock of the operation would not keep a diseased ganglion quiescent for months or years. My own conviction, based on examinations so far made, is that the disease, in many cases at least, is primarily peripheral and that the ganglion is involved by extension upward. In those cases in which some local growth is found on the branches of the fifth nerve the cause of the pain must, of course, be peripheral, and we have no means of detecting the presence of such a lesion previous to operation. I would, therefore, urge not only that the removal of the Gasserian ganglion should be the *last operation*, but I would specially urge that peripheral operations be done *early*. Most operations for tic douloureux are made two, three, five, ten, or even twenty years after the disease began and after vain attempts have been made to cure by drugs. My own view decidedly is that, if the disease has positively existed for so long a period as three or four months, and if during this time, while drugs may have relieved, they have not *cured* it, I would *wait no longer, but instantly do the peripheral operation in the hope of arresting the peripheral disease and preventing its upward course, which in time will result in its involving the ganglion.*

When we remember the fact that all the peripheral operations are virtually without danger to life, and that they relieve for a considerable time, and that we are in a position now to state that the mortality of Gasserian operations is over 20 per cent., and that in a small percentage of cases even the removal of the Gasserian ganglion *may* not surely and permanently cure, I think we are in a position to say that the removal of the ganglion should not be done till we have exhausted our resources in peripheral operations, or till a larger surgical experience shows that the removal of the entire ganglion will cure permanently and a better surgical technique greatly lessens the present mortality.

4. A few points in technique:

(*a*) *Access to the cranial cavity.* There is no question in my mind that either the Hartley-Krause operation, or the operation of Doyen (which I have never yet attempted), or an operation somewhat analogous to it, described by Poirier in Chipault's *Travaux de Neurologie Chirurgicale*, 1897, vol. ii. p. 213, is the preferable one. All of these approach the ganglion from the side and by lifting the temporo-sphenoidal lobe. By no possibility can one work with the same advantage either as to light or facility of manipulation by Rose's method. Whether the flap shall be raised by chisel or drill or saw I think is a matter largely of preference of each individual operator.

(*b*) *Hemorrhage.* In three instances I have done the operation in two stages on account of hemorrhage, packing iodoform gauze into the skull in these cases. The amount of gauze which I have used has surprised me very much. In one case it was 37 by 6 inches, or 222 square inches of gauze; in a second, 23 by 14 inches, or 322 square inches; in a third, 267 square inches; and in a fourth a piece 16 by 6, or 96 square inches. I mention this to show what an amount of pressure the brain will stand, but I also mention it to condemn the procedure if it is possible to avoid it. The danger of infection is always considerable in any case in which the skull cavity has to be reopened. Moreover, I think we ought always to avoid testing the power of the brain to stand pressure, if we can. I join, therefore, heartily with Krause in urging that the operation shall be completed in a single sitting, if possible.

Hemorrhage from the middle meningeal has almost invariably taken place in all of my operations, either by unavoidable tearing of the vessel in turning down the flap, or, as happened three times, by the tearing of the vessel at the foramen spinosum. In the latter case the simple use of the Allis blunt dissector, to block up the vessel for a moment by the curved end, and later the substitution first of the left forefinger and then of a small bit of iodoform gauze, will overcome the difficulty, if the vessel cannot be ligated. On no account, in my opinion, should the external carotid be ligated as a preliminary measure. In one case in this city (Philadelphia) in which it was done, necrosis of the temporal flap took place, and the patient's death from sepsis followed as a result.

(*c*) *The removal of the ganglion itself* is best done by Krause's method —namely, uncovering the ganglion and then seizing it and twisting it out after dividing the second and third divisions at their foramina. This method of removal should be employed instead of the uncertain method of "breaking up" the ganglion when we act blindly and unscientifically.

(*d*) *The preservation of the eye.* The method which experience has taught me now definitely to adopt is as follows: Either immediately

before or at the close of the operation I disinfect the eye and sew the two lids together by two or three stitches, near the margins, drawing together only the middle of the lids. This leaves the two ends open sufficiently, first, for washing the space between the lids and the eye-ball with a warm boric-acid solution, to wash away any mucus, and also leaves enough space for us to observe the cornea when the patient looks strongly to one side. This occlusion of the lids should last for not less than four or five days. The stitches may then be cut and the eye immediately covered by a Buller shield—*i. e.*, a watch-glass held in place by means of either a circular fenestrated disk of rubber plaster or by four separate pieces of plaster. I prefer the circular plaster.

The reason for the corneal ulceration and loss of vision or loss of the eye is undoubtedly, first, the drying of the cornea, due to the want of appreciation of its drying and, therefore, to want of winking, by which the cornea is kept moist; and, secondly, as another result of the want of sensitiveness of the cornea, either foreign bodies get into the eye, or, as in one of my cases, a bandage over the eye may rub the cornea and thus produce ulceration and the destruction of the cornea. The use of the Buller shield is so thoroughly satisfactory both in protecting the eye and in keeping it moist that I think any one who has tried it will be unwilling to dispense with it afterward. Its use should be continued for from ten to thirty days after the operation.

Pathological Report, by Dr. Spiller.

(From the Wistar Institute of Anatomy and Biology.)

Little attention has been paid to the microscopical examination of the Gasserian ganglia removed from patients suffering from tic douloureux; indeed, with the exception of a few cases, we have had almost no information furnished us on the pathological condition of these structures in the disease. It was, therefore, with a feeling of deepest interest that I undertook the examination of the ganglia removed by Dr. Keen from seven cases of prosopalgia.

This report is based on a study of several hundred sections. The stains employed have been carmine, hæmatoxylin (Delafield's and Weigert's), osmic acid (methods of Azoulay and of Marchi), thionin, acid fuchsin, and eosin. The method of Rosin has given most satisfactory results for a study of the nerve fibres, and in some cases, in which the material did not stain readily with carmine, Delafield's hæmatoxylin, with an after-stain of acid fuchsin, presented beautifully colored specimens. Unfortunately, the method of Nissl could not be employed, as all the ganglia had been placed in Müller's fluid. The method of Azoulay proved to be of great service, for in some cases in

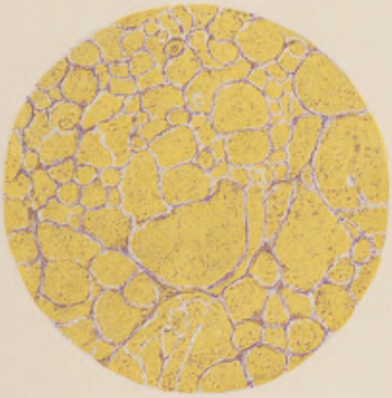


FIG. 11.

FIG. 10.

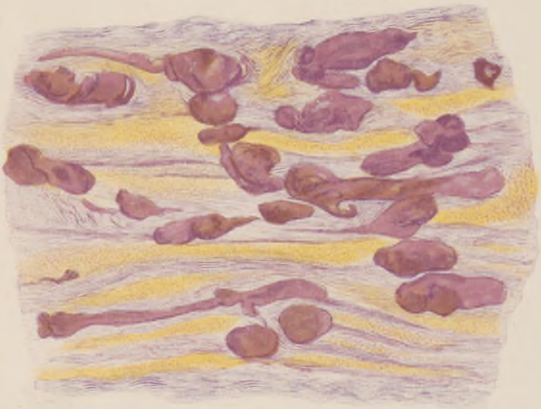


FIG. 12.

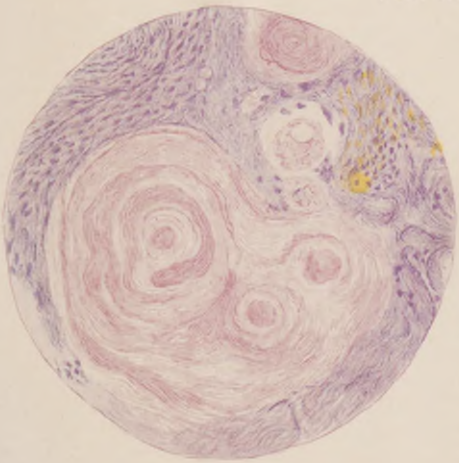


FIG. 13.

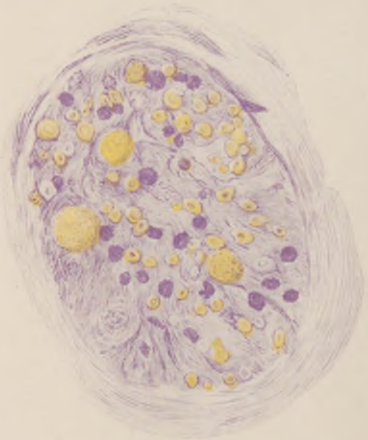


FIG. 14.

which the method of Weigert did not give thoroughly satisfactory results, the former yielded sections well stained.

Case V.—The nerve fibres are greatly altered ; in many the medullary sheaths are much swollen, and no traces of axis cylinders can be seen ; in others the latter are represented by irregular and separate masses of a hyaline-like red substance, which have little resemblance to normal axis cylinders. Many nerve sheaths are entirely empty. The vessels are sclerotic, and some of the smaller ones are entirely closed. The ganglion cells are in different stages of degeneration ; some are faintly stained and have very indistinct outlines, and there are numerous spaces in which the cells have entirely disappeared. Some of the nerve cells are very small and without nuclei and nucleoli, though possibly this may be due to the fact that superficial portions of these cells were obtained in the sections, and the connective tissue between them is increased in amount. The pericellular spaces seem to be somewhat larger than in normal ganglia, and appear as if the cells had shrunken away from their capsules. No very great difference can be noticed in the condition of the second and third branches of the nerve, for they seem to be nearly equally diseased.

Case VI.—The ganglion removed from Case VI. presents, on microscopical examination, most distinct evidences of degeneration. The medullary sheaths of many of the intraganglionic fibres are greatly swollen, and the fibres have an irregular, beaded appearance in longitudinal sections. (Fig. 10.) Some bundles, cut transversely, contain masses of medullary substance varying greatly in size and of most irregular form, and without a trace of axis cylinders. Stained by the method of Azoulay or Weigert, these masses of medullary substance stand out prominently, and it is noticed that frequently they are not continuous with one another, but that they are connected by empty and contracted nerve sheaths. There is no great increase in the number of the nuclei of the sheaths of Schwann. Normal bundles of fibres are found lying close to fibres very greatly degenerated. It is impossible to find any greater alteration of the fibres belonging to the second than of those belonging to the third branch of the trifacial nerve.

Description of Plates.

Fig. 10. Portion of the Gasserian ganglion at the entrance of the third branch of the trifacial nerve, from Case VI. The medullary sheaths are most irregularly swollen, and at the right of the field empty nerve sheaths are seen (method of Azoulay).

Fig. 11. Portion of the second branch of the trigeminal nerve near the Gasserian ganglion, from Case VI. The axis cylinders have entirely disappeared, and the medullary sheaths are greatly swollen. In many places the medullary substance of two or more nerve fibres has united into irregularly shaped masses.

Fig. 12. One of the nerve bundles within the Gasserian ganglion, from Case VI. Numerous swollen and irregularly formed axis cylinders may be seen. In most portions of the field these appear as drops of a red, hyaline-like substance, but in one portion an axis cylinder of considerable length may be seen.

Fig. 13. Bloodvessels from the Gasserian ganglion in Case IX. The walls are greatly thickened, and the lumen of the large vessel has been almost entirely obliterated. In one place the innermost layers of the vessel have contracted from the outer during the process of hardening. Smaller vessels in the upper part of the field are entirely closed.

Fig. 14. A nerve bundle of the trigeminus close to the Gasserian ganglion, from Case X. Only a few nerve fibres are present, and everywhere an abundance of connective tissue is seen. Three much swollen medullary sheaths are in the field.

The sensory and motor roots are normal; the nerve fibres in these roots present medullary sheaths which stain well and have normal outlines. Longitudinal and transverse sections of the motor and sensory roots, and of the second and third branches of the nerve, have been obtained; the first branch had been broken off close to the ganglion at the time of the operation.

Transverse sections of the motor and sensory roots present the usual number of nerve fibres, each with an axis cylinder surrounded by a medullary sheath and separated from the other by a moderate amount of connective tissue. The contrast afforded by the transverse sections of the second and third branches with those of the sensory and motor roots is most striking. In the second branch, especially, the irregular and large masses of medullary substance are very distinct (Fig. 11), and in many bundles it is impossible to detect axis cylinders. Atrophied fibres seem to predominate in the transverse sections of the third branch, though in longitudinal sections a little nearer the ganglion the swollen medullary sheaths are as visible as in the second branch. The ganglion was cut longitudinally in such a manner that its relation to the second and third branches and the sensory root are shown in a single section. In some intraganglionic nerve bundles axis cylinders may be found greatly swollen and occurring in irregular masses of a pinkish hue when the carmine is employed as stain, but these masses are more numerous in certain bundles. (Fig. 12.) The process has evidently reached a stage in which the swollen axis cylinders have in large part been removed. The connective tissue about and between the bundles of nerve fibres is not very excessive, but is increased to some extent between the individual fibres.

The ganglion cells are somewhat more irregular in outline, the smaller cells are more numerous, and the pericellular spaces are larger than in normal ganglia. Many cells contain vacuoles, but the nuclei are not eccentric and the nucleolus can usually be seen. The pigmentation of the cells is not excessive, and the capsules of the cells do not appear to be much thickened, nor are their nuclei unusually numerous. The intercellular tissue is not notably increased. In some places the cells are very small and faintly stained, though a few appear unusually large and swollen, but these are comparatively rare. The most striking alteration of the cells is the atrophy with the enlargement of the pericellular spaces, of which the latter may be due to changes which have occurred after removal of the ganglion.

The small vessels in many parts of the ganglion are greatly altered; some are completely closed by the proliferation of the tissue in the walls of the vessels, while others show only a slight alteration.

Case VII.—The ganglion cells are most irregular in shape, and appear to be somewhat more separated than normally from one another by overgrowth of the intercellular connective tissue. Some of the cells are not sharply defined from the surrounding tissue, and some do not contain distinct nuclei or nucleoli. In some places the ganglion cells have been destroyed and removed; in others the cells contain much pigment and some vacuoles. The cellular changes are greater than in the preceding case, in which they are not especially striking. The medullary sheaths of the nerve fibres in many places are greatly swollen. Many nerve bundles contain very small nerve fibres; many are entirely deprived of nerve fibres and contain merely connective tissue; and

many contain swollen medullary sheaths without axis cylinders. The small vessels have thickened walls, and some are entirely closed by proliferated tissue.

Case VIII.—Some of the vessels are sclerotic, but there is little change in the nerve fibres. The smaller ganglion cells are abnormally abundant. In some places the medullary sheaths are somewhat swollen.

Case IX.—The findings in this case consist of swollen medullary sheaths, diseased axis cylinders, proliferated connective tissue in the nerve bundles, with destruction of nerve fibres, and altered ganglion cells. Only a portion of the ganglion has been obtained, but it is sufficient for the purposes of microscopical study. The cells and their capsules in certain parts can be distinguished with difficulty from the surrounding tissue; in other parts they are much more distinct; it is frequently impossible to detect nuclei or nucleoli, and one might well doubt whether he were examining ganglionic tissue were it not for the fact that here and there a nerve cell is detected. The intercellular tissue has replaced the ganglion cells.

The bloodvessels are much altered, as may be seen in Fig. 13. In the vessel represented here the media and intima are much thickened, and the latter has almost entirely filled the lumen of the vessel, leaving several smaller passages for the current of blood. In the process of hardening the inner coats at one portion have contracted and withdrawn from the outer, leaving an open space.

Case X.—The medullary sheaths in certain parts of the sections are greatly swollen, and the axis cylinders have been almost entirely destroyed (Fig. 14) and removed, leaving small lumps of pinkish hyaline substance here and there. Many nerve sheaths may be found in which the medullary substance and axis cylinders have entirely disappeared. The vessels seem to be less affected than in the other cases in which evidences of intense degeneration have been noted. The ganglion cells have indistinct outlines, and some stain very faintly. The intercellular tissue is increased in amount, and throughout the sections in which the ganglion cells are found numerous granular corpuscles are noticed.

Case XI.—The ganglion cells are vacuolated, but do not appear to be greatly altered, nor are the cell capsules notably thickened. In one portion of certain sections nerve bundles are found in a high degree of degeneration; the medullary sheaths have almost entirely disappeared, leaving only granular masses here and there; the axis cylinders are swollen, and the connective tissue and empty nerve sheaths occupy a large portion of the fields. The vessels are somewhat altered.

In six of the cases just described the lesions are of an intense degree and unquestionable. In a seventh case (Case VIII.) they are much less distinct.

The lesions in the Gasserian ganglion in the more advanced cases of tic douloureux consist of much-swollen medullary sheaths, swollen axis cylinders, atrophied fibres, empty nerve sheaths, nerve bundles in which the nerve elements have been destroyed and only connective tissue is left, atrophied ganglion cells, cells faintly stained, and sclerosed blood-

vessels, in some cases even without a lumen. In all the specimens examined numerous red blood-corpuscles are observed, which doubtless owe their position within the tissues to the surgical interference.

The pathology of tic douloureux has not been well known. Some have held that it is a neurosis; others that it is a neuralgia, though this distinction is not very clear; and still others that it is a neuritis. Some have believed that the disease is a peripheral one, and others that the primary lesion is within the ganglion. There is always a possibility that in some cases the lesion may be a central one.

Putnam[1] says that, as a rule, neuritis is present in trifacial neuralgia, and probably exists far oftener than we think. This seems to me exceedingly probable, for the dividing line between neuralgia and neuritis cannot be sharply drawn. One, we are told, is a functional, the other an organic process; but "functional" is a very comprehensive term. Putnam states that of late years physicians have been more favorable to the view that, in chronic forms of neuralgia, at least, the pain is simply the expression of the inflammation of a nerve.

Dana[2] placed much more value on the condition of the bloodvessels than on inflammatory changes in the nerve fibres.

In a recent communication to the writer he expresses the opinion that trifacial neuralgia is due to degenerative neuritis of the peripheral sensory neurons of the fifth nerve, depending on or associated with obliterating arteritis.

The investigations by Thoma[3] of the bloodvessels from the painful area in supra-orbital neuralgia, and his explanation for their sclerotic condition, are most interesting.

Rose[4] also has remarked on the size of the vessels and the thickness of their walls in some of the cases on which he operated. He found great alteration of the peripheral nerves in trifacial neuralgia. The appearances were those of chronic neuritis, and were often more marked at the peripheral than at the central end of the nerves.

Microscopical alterations of the peripheral branches of the fifth nerve in cases of tic douloureux have also been noticed by Tuffier,[5] De Schweinitz,[6] Horsley,[7] Tripier,[8] Putnam,[9] Krause,[10] Spiller,[11] and

[1] Putnam: Boston Medical and Surgical Journal, 1891, vol. ii. pp. 157, 186.
[2] Dana: Medical News, May 16, 1891.
[3] Thoma: Deutsches Archiv für klinische Medicin, 1888, vol. lxiii. p. 409.
[4] Rose: Transactions of the Medical Society of London, 1892, vol. xv. p. 157.
[5] Tuffier: La France médicale, 1881, vol. i. p. 672.
[6] De Schweinitz: In paper by Mears, Transactions of the American Surgical Association, 1885, vol. ii. p. 469.
[7] Horsley. Transactions Odontological Society, 1887, vol. xix. p. 270. Cited by Rose.
[8] Tripier: Revue de Chirurgie, 1889, vol ix. p. 453.
[9] Putnam: Boston Medical and Surgical Journal, 1892, vol. ii. pp 157, 186.
[10] Krause: Die Neuralgie des Trigeminus Leipzig, 1896.
[11] Spiller: Journal of Nervous and Mental Disease, June, 1898, p. 400. (In a paper by J. K. Mitchell.)

others, and macroscopical changes have been detected by Tuffier,[1] Mears,[2] Tripier,[3] Keen,[4] and others.

Krause's[5] book is the most thorough which has as yet appeared on trifacial neuralgia. Though he found alterations in branches of the fifth nerve which had been slowly twisted out, he was unable to detect changes in the vessels. Krause observed marked lesions in the Gasserian ganglion in cases of tic douloureux, but only in one case could he demonstrate changes in the sensory fifth root, and in this case after the pain had disappeared on one side of the face, as a result of excision of the ganglion, it recurred on the other.

Krause could not find the sclerosis of the ganglion which other writers describe, and which certainly exists in one of Dr. Keen's cases (Case IX.).

In six of Krause's seven cases resection of the nerves had preceded by some years the excision of the ganglion, and he justly compares his findings with those seen after amputation, but he regards them as too intense to be merely secondary. He thinks the question cannot be positively settled until a ganglion is examined the peripheral nerves of which have never been resected. This examination has been made in Case VIII. of this paper. In none of Krause's cases did the neuralgia return after excision of the ganglion, even within three and a half years after the operation, and as the peripheral operations did not give permanent relief, and extirpation of the ganglion did do so, he thinks it is allowable to conclude that the cause is to be sought in the Gasserian ganglion.

It seems to me quite possible that the trouble may first be peripheral, and as resection gives only temporary relief, the recurrence of the pain may be due to extension of the morbid process to the ganglion.

Krause is disposed to regard the changes in the ganglion partly as primary and partly as secondary from the resection.

The fact that nerve degeneration may extend beyond the spinal ganglia and affect the posterior roots must make us prepared for the possibility of an extension of a similar process after extirpation of the Gasserian ganglion.

Other investigators who have found lesions of the Gasserian ganglion are Wedl, Rose, Podrazky and Lavéran, Horsley, Putnam, and Antonino d'Antona (all cited by Krause).

The possibility of the changes in the ganglion being secondary, as Krause suggests, is not to be lightly passed over. Lugaro[6] has shown

[1] Tuffier: La France médicale, 1881, vol. i. p. 672.
[2] Mears: Transactions of the American Surgical Association, 1885, vol. ii. p. 469.
[3] Tripier. Revue de Chirurgie, 1889, vol. ix. p. 453.
[4] Keen: The American Journal of the Medical Sciences, 1896, vol. i.
[5] Krause: Die Neuralgie des Trigeminus. Leipzig, 1896.
[6] Lugaro: Rivista di Patologia nervosa e mentale, 1896. Cited by Schaffer in Monatsschrift für Psychiatrie und Neurologie, July, 1897.

that the nerve cells of the spinal ganglia undergo marked alteration after lesions of the peripheral fibres, and the spinal ganglia are so similar to the Gasserian that the results of these experiments may be applied to the latter.

Fleming has noticed that the cells of the ganglia on the posterior nerve roots in rabbits and dogs undergo definite changes as the result of nerve section or of ligature, and do so at a much earlier period than do the multipolar cells in the cord, beginning probably as early as the fourth day, and certainly by the seventh day. The nucleus, and sometimes the nucleolus also, become small, and the nucleus may be excentric and even bulge the cell wall. The chromophilic granules are altered, the cells atrophy, and the pericellular lymph spaces become enlarged. Just here we may mention, however, that Lanhossék's[1] recent studies on fresh spinal ganglia, obtained from an executed man, have taught us that when the ganglia are properly hardened such pericellular lymph spaces do not exist. Fleming[2] also says that large vacuoles are found in some cells. He thinks it is quite comprehensible that the cells of the ganglia should suffer before the cells of the anterior horns, inasmuch as nerve impulses pass normally to them from the site of the lesion.

Kowalewsky[3] cut the sciatic nerve in animals, and injected a few drops of a 5 per cent. chromic acid solution into the central end. The animals were killed two to four days later, and the chromophilic bodies of the cells of the spinal ganglia were found much altered.

If, therefore, such alterations of the ganglion cells occur within a few days after resection of the nerve we may expect greater changes when the time which has elapsed since the operation is reckoned by years instead of days. And yet it is probable that some of the lesions of the ganglion cells which have been described are only of a temporary character.

Neuritis may ascend; it seems that the possibility of this, though often disputed, must be acknowledged. Mlle. de Majewska[4] has recently written a thesis on the subject. She states that the lesions of ascending neuritis are the same as those of ordinary peripheral neuritis; viz., fragmentation of the myelin, multiplication of the nuclei, and alteration of the axis cylinders. There is no reason why this neuritis should not extend to the cells of the Gasserian ganglion.

It is well, of course, to examine an entire Gasserian ganglion in a case in which resection had never been performed, but the examination of the motor root in a case in which the third branch of the fifth nerve

[1] Lanhossék: Archiv für Psychiatrie, vol. xxix. No. 2.
[2] Fleming: Brain, parts lxxvii. and lxxviii.
[3] Kowalewsky: Abstract in Monatsschrift für Psychiatrie und Neurologie, vol. ii. No. 2, p. 147.
[4] Mlle. de Majewska: Abstract in Revue Neurologique, 1897, No. 15.

had been resected in the portion which contains this root, would also be of value, if done some years after the operation. Should no degeneration of the motor root be found there would be some evidence that the ascending degeneration had not been important, for this ascending degeneration is not limited to sensory fibres.

Krause could demonstrate changes in the sensory fifth root only in one case. In Case VI., which I have examined, the sensory root is perfectly normal. The cells of the Gasserian ganglion have each a single axis cylinder, which, at a short distance from the cell body, divides, and one branch passes centrally and the other peripherally. If, therefore, the lesion is primarily within the ganglion cells, we cannot understand why only the peripheral branches of the axis cylinders are diseased, while the central branches remain normal. The same objection has been raised against the ganglionic theory for the commencement of tabes in the spinal ganglia, only in the latter case the central branches of the axis cylinders are diseased and the peripheral, as a rule, are intact.

The great and durable improvement occurring in many cases of trifacial neuralgia after removal of the Gasserian ganglion would seem to indicate that the cause of the suffering is to be sought, at least in many cases, in the Gasserian ganglion; but it by no means follows that we may expect to find lesions of the ganglion in every case, any more than we may hope to find lesions of the spinal ganglia in every case of tabes in which there has been pain, unless the employment of the method of Nissl changes our views, which Schaffer's[1] recent studies make improbable.

We know that a lesion within the cerebrum may produce intense pain, as Edinger,[2] Biernacki,[3] and Kirchhoff[4] have shown, and Gowers[5] states that in a case known to him irritation of the sensory nucleus of the fifth nerve in the pons seemed to be the cause of the suffering in the face. Indeed, Gowers says distinctly that we know nothing of the sensory function of the posterior ganglia, and are justified in looking to the nerve cells within the cerebro-spinal axis as the seat of the morbid process.

In a case of trifacial neuralgia, therefore, attention should be directed not only to the condition of the Gasserian ganglion, but also, if possible, to that of the sensory nucleus of the fifth nerve, and to the spinal root of this nerve—*i. e.*, the descending branch.

We must acknowledge, it seems to me, that pain is not the usual manifestation of a lesion confined to the brain or cord, and, indeed, the

[1] Schaffer: Neurologisches Centralblatt, 1898.
[2] Edinger: Deutsche Zeitschrift für Nervenheilkunde, 1891, vol. i.
[3] Biernacki: Deutsche med. Wochenschrift, 1893, No. 52, p. 1372.
[4] Kirchhoff: Archiv für Psychiatrie, vol. xxix. No. 3.
[5] Gowers: A Manual of Diseases of the Nervous System, vol. ii. p. 803. English edition.

presence of pain in cases of suspected hæmatomyelia leads one to diagnosticate hæmatorrhachis. We do not, as a rule, find pain in chronic degenerative processes of the cord which respect the posterior roots and meninges, as, for instance, in syringomyelia, but we find it as an early symptom of tabes, which is also a chronic process, but one which affects the posterior roots.

As Gowers states, vascular dilatation attends functional activity, and it is probably also true that vascular dilatation, if not excessive and too prolonged, causes functional activity. Excessive functional activity of sensory cells may be manifested as pain, but it is possibly equally true that diminution or imperfect quality of the blood-supply may be a cause of pain. How can we better explain the frequent headache of anæmia? If, therefore, we find alteration of the bloodvessels within the ganglia, we may with reasonable suspicion look upon the condition, in part at least, as the cause of the pain, and may believe that peripheral irritation which under normal conditions would not be perceived would be sufficient to produce painful sensation.

As yet, as far as I am able to judge from my researches in the literature, the Gasserian ganglion excised from a case of trifacial neuralgia has never been examined by the method of Nissl.

This method is so important for a study of degenerative changes in nerve cells that no one can say that such changes are absent until he has used the method. Nissl[1] teaches that the employment of the older methods of technique, especially the hardening of the tissue in the chromic salts and the staining with carmine, are not only unsuitable, but likely to be most misleading, a view which most neuropathologists accept.

I am unable, therefore, from a study of these seven cases and from an examination of the literature, to state whether the lesions of the ganglia are primary or secondary, and, if secondary, whether of the nature of ascending neuritis or not. The possibility of the secondary nature of the process within the ganglia in some cases, it seems to me, should not be overlooked. I base the opinion of a possible peripheral involvement, in certain cases, chiefly on the clinical evidence afforded by the relief of pain during two or more years in some patients by nerve resection, though, unfortunately, such cases are in the minority; on the normal condition of the sensory root in Case VI., and on the examination of Case VIII. of this paper, in which the lesions are very slight in comparison with those in the other cases, though the pain had existed for eighteen years. It is true that only a part of the ganglion was obtained in this case, and it is possible that this portion was the least diseased, but it is remarkable that in all the other cases intense

[1] Nissl: Allgemeine Zeitschrift für Psychiatrie, vol. liv. Nos. 1 and 2, pp. 26–27.

alteration was found, and in some of these the parts of the ganglia obtained were not larger than in Case VIII.

Case VIII. is the only one of the seven in which a primary resection of the peripheral branches was not done. The pain involved all three branches of the fifth nerve, and Professor Keen therefore attacked the ganglion at once. The possibility of an ascending neuritis in this case, due to nerve resection, is excluded, inasmuch as no operation on the peripheral branches had been performed.

The clinical evidence is of importance, for an absence of pain for two or three years seems to indicate that during the respite the ganglion cannot be greatly diseased. No branch of the fifth nerve is sharply limited to any one portion of the Gasserian ganglion, and were the ganglion primarily diseased the resection of one branch would not remove the peripheral irritation transmitted by the other branches to the hypersensitive cells.

There can be no doubt that intense alteration of a chronic inflammatory character may be found in the Gasserian ganglion in certain cases of tic douloureux, and also that the sensory root may be intact. This, it seems to me, is a satisfactory explanation for the relief of pain experienced by many patients in whom the ganglia have been excised.

The removal of the diseased cells within the Gasserian ganglion, which are capable of responding abnormally to every peripheral irritation, may well be attended with the relief of pain. Excision of the ganglion destroys at once the paths of painful sensation from a large area.

The integrity of the sensory root, in the case in which the whole ganglion was removed by Professor Keen, is a fact of considerable importance. It teaches that though the ganglion may be greatly diseased, the process may be arrested at this point. In the other case in which the sensory root was examined—the only other case (Krause) with such an examination which seems to have been reported, though possibly Krause examined the sensory roots of some of the other ganglia, and if so, he probably found them normal—the fibres were found diseased, and the process extended to the other side of the face. This report, and the four cases (one reported by Rose, two by Keen, and one by Dana) in which the pain returned after removal of the ganglion, though we are not sure that all portions of the ganglia were excised in these cases, must make us prepared for the possibility of a renewal of the suffering in some instances, even after the excision of the Gasserian ganglion.

I feel more than ever inclined to believe, from a study of these cases, that neuralgia cannot be sharply distinguished from neuritis, and in some cases of so-called chronic neuralgia, such as obstinate sciatica, I believe we may frequently be able by the microscope to detect evidences of chronic inflammation. At the same time we should not forget that neuritis may assume different clinical forms.

If it could be shown that the sensory root of the Gasserian ganglion does not unite after its fibres are divided, we should have a fact of great importance. Division of this root would probably be a less serious operation than the removal of the entire ganglion, and might have the same effect in the relief of pain, but the surgical difficulties might be insurmountable. Experiments on animals to determine whether or not the sensory root of the Gasserian ganglion unites after section of its fibres might result in a lessening of the great mortality now existing in operations on the ganglion.

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