Frequent gastric disturbances supervened, although as was said, the child was breastfed. After weaning, however, when the supply of thyroid extract he got from his mother's milk was cut off, the child immediately, without any intercurrent illness, infectious or referable to the thyroid, developed a typical sporadic cretin state.

After a number of years the appropriate treatment was instituted. Small, very gradually increased dosage was employed; the mother carefully instructed to watch the least symptom of overdosage. Frequent intermissions were ordered to prevent such occurrence. The child was several times presented to the classes at the Postgraduate, and the good effect of the thyroid gland extract emphasized. At this point the child was put into my care, inasmuch as the mother felt the trip to the city too irksome and embarrassing for herself and child, and she desired treatment at her own home. She had begun to let up on the administration of thyroid, alarmed by the child's progressive emaciation, although she had been informed that this tendency prevailed when thyroid was given. At that time, as I had charge of two other cases of a similar nature, one a typical cretin, in whose urine I had found an almost pure deposit of uric-acid crystals, in such numbers and such beautiful formation, as I had ever seen before, I obtained a specimen from this patient also to determine if the same condition prevailed here. The urine at that time was normal in every respect and contained no sugar. To continue the good accomplished, small doses of thyroid tablets (0.2 gm. pro die) were administered, with frequent but unnecessary intermissions, as at no time did any tachycardia, vomiting or other hyperthyroid symptom develop.

Now, because the supply had run out, the child received no thyroid for a period of four weeks, and at the end of that time is presented with a violent glycosuria. However, the interesting discovery is made that in contrast to the accepted pictures of both athyria and diabetes mellitus, the patient presented less hebetude, is brighter, more active, his growth was noticeable, and, in fact, the supervision of the one condition served to relieve the other. Whether or not we had a vicarious action of some other gland must, of course, be purely speculative; as *a priori* must also be the condition of the other glands. We might infer an increased adrenal activity from the fact of a very small loss of blood during extraction of carious teeth; certainly we know that both his testicles were atrophied a few months before death.

But it is not warranted to go so far as Lorand⁸ does and the broader statement of Pineles⁹ must still hold good, and besides, as Ewald⁶ and, I hope, I have shown, diabetes mellitus may follow myxedema, whether you ascribe it to thyroid feeding or not. Of course, the contention that without such feeding diabetes has not been seen after myxedema, must also be admitted, as I can find no such case in an exhaustive search of literature; while it is equally true that in the administration of thyroid extract in dermatologic and general practice in cases where no lesion of the gland was demonstrable, temporary glycosuria supervened.

115 Beech Street.

Administration of Digitalis.—There is no drug which requires a more intimate knowledge and appreciation of existing pathologic conditions for its successful administration than digitalis, writes William F. Clemsha. The more carefully and thoughtfully we give it, the more uniform and satisfactory will be our results.

THE SURGICAL ASPECTS OF MAJOR NEURALGIA OF THE TRIGEMINAL NERVE.

A REPORT OF TWENTY CASES OF OPERATION ON THE GASSERIAN GANGLION, WITH ANATOMIC AND PHYSIOLOGIC NOTES ON THE CONSEQUENCES OF ITS REMOVAL.*

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The contents of this paper may be divided as follows:

1. A consideration of the various operative methods of approaching and of dealing with the ganglion.
2. Further points referable to an operative procedure heretofore described.
3. Histories of twenty personal cases thus operated on.
4. A discussion of the surgical complications and sequelæ of these cases.
5. Notes on the distribution and function of the fifth nerve deduced from postoperative observations.
6. Afterword: pathology.

Neuralgia Quinti Major. (Tic douloureux. Epileptiform neuralgia.) This form of neuralgia has been placed in a group apart owing to the marked similarity that one case bears to another both in course and symptoms. In the earliest stages, each case appears to be one of simple neuralgia, and under this impression relief has been sought in removal of teeth or in other operative procedures. At last the full picture of this hideous disease unrolls, varying in unessential details from the classical type.

In a recent medical treatise¹ thus is introduced the section on that form of trigeminal neuralgia which, unlike the other varieties, the minor neuralgias of the fifth nerve, is an affliction demanding surgical intervention, and for the relief of which the removal of the semilunar ganglion (Gasser) must ultimately be contemplated. It is, perhaps, deserving of emphasis, therefore, at the start, that from this group of cases are excluded the comparatively simple neuralgias arising in the trigeminal territory; those which are incidental to some general state of bodily ill health; those reflexly occasioned by some local disease; those ordinarily confined to one or another of the peripheral branches of the trigeminal nerve, all of which are usually amenable to therapeutic measures² other than surgical or, at the outside, to minor operative procedures.

Barely thirteen years have elapsed since Horsley and Macewen,³ quite independently, and, so far as I am aware, for the first time, attempted through a high temporal opening to divide the trigeminal nerve in two cases of tic douloureux. Both resulted fatally, an

* Presented by invitation at a meeting of the Montreal Medical Society, 1904.

1. Head: Trigeminal Neuralgia. Allbutt's System of Medicine, 1899, vol. vi, p. 728.

2. At times very simple measures indeed, of which there is an interesting historical illustration. In one of the old numbers of the European Magazine are reprinted a series of urgent letters which John Locke, the philosopher-physician, wrote from Paris to Mapletoft and Sydenham asking for advice in the treatment of the distinguished patient, the Countess of Northumberland, whom he was attending at the French Court. Owing to "the inclemency of the weather," Locke had refrained from following his first inclination of opening her ladyship's bowels. With a moderation in the temperature and before Sydenham's reply could have been received a purge was administered and the patient's neuralgia disappeared. There is an amusing reference by Lord King in an early number of The Lancet to this correspondence, which comments not only on what must have been the inconveniences of Parisian life in the latter part of the seventeenth century, but also on Locke's clear statement of the case and his skillful treatment.

3. Victor Horsley: An address on the Surgical Treatment of Trigeminal Neuralgia, The Practitioner, 1900, vol. lxx, p. 251.

event commonly ascribed to the undue severity of the intradural method followed in each instance. A few years later, Professor Rose of Kings College boldly essayed to attack the ganglion in a major case of the same malady by primarily excising the superior maxilla, by trephining the base of the skull beneath the ganglion, and by destroying the structure, thus blindly exposed, with the curette. From its successful outcome this pioneer effort not only is of historical import, but will stand a lasting commentary on the fearful nature of the affliction which would justify such an extreme procedure undertaken for its relief. From that time to the present many modifications of the operation have been proposed and carried out, all of them having their advocates, all of them having for their objective point the trigeminal neurectomy or removal of the ganglion, so that, so far as the operation itself is concerned, they may all be considered as variations of Horsley's or of Rose's appalling procedure.

In all of these modifications there are two essential factors to be considered: First, the method of approaching the ganglion; second, the manner of performing the neurectomy or of dealing with the structure when it has been brought into view.

METHOD OF APPROACHING THE GANGLION.

The methods of approach may be conveniently classified into three groups: the low or pterygomaxillary route, of which Rose's original operation may be considered the extreme type; the high or temporal route, which is represented by the Horsley and Hartley-Krause operation; and lastly, the direct transzygomatic or sphenoïdal route—below, above or through the region bridged by the zygomatic arch.

The first of these methods, through the pterygoid fossa, although considerably altered and improved in details,⁴ has never received wide acceptance. The high temporal operation, on the other hand, has almost completely and very properly superseded it, and the larger number of successful cases, both in this country and abroad, have heretofore been carried out on the lines which Hartley and Krause almost simultaneously laid down twelve years ago. Experience with the operative difficulties of the approach, over which hemorrhage, in either of these methods, holds chief sway, the consideration also of the postoperative deformities consequent on either method has led to modifications, the general tendency of which has been to make the low operation higher and the high lower; a tendency in other words toward a more direct or transzygomatic route. Coehlo,⁵ in the report of his first operative case, called attention to a modification of the high operation which involved division of the zygoma. Lexer⁶ has so circumscribed and lowered the Hartley-Krause opening, with which in its typical form he began his successful series of 15 cases in von Bergmann's clinic, that the details of his method have come to differ but slightly, and chiefly in the management of the meningeal artery, from those which I outlined in 1900.⁷ The anatomic studies by Dollinger and Bartlett have shown that the meningeal artery, when this method is employed, in the great majority of cases need interfere in no way with

the exposure of the ganglion. Frazier⁸ has followed this direct infra-arterial approach in his successful cases of division of the sensory root and many others have been led to adopt procedures which correspondingly are on a more horizontal plane than the older method.

In like fashion, the low or pterygoid operation, has undergone modifications tending to make it more direct. Thus Jacob, Sapejko, Juvara, Quénu and Sébilleau, with others, chiefly of the French school, with considerable variation in the incision and in other details, have used a method of approach via the zygomatic region, which, though much more direct than the Rose-Andrews method, nevertheless retains many of the undesirable features of the low pterygoid route, in which the nerves are sought at their exit from the base of the skull, and thus serve as guides to the situation of the ganglion.⁹

MANNER OF PERFORMING THE NEURECTOMY.

There will be found almost as many variations in the manner of dealing with the ganglion when it has been brought into view as there are in the ways of approach. By the pterygoid route it is difficult to conceive of a clean, dry exposure, and the fact that its advocates describe ways of tearing out the ganglion with small hooks and that blind curettage of the supposed seat of the *Cavum Meckelii* has often been resorted to, shows how uncertain must be the actual completeness of the neurectomy. Even when the low approach has been modified to the extent which Juvara's procedure typifies, it is evident from the description, which implies that the ganglion is uprooted by dragging on the second and third branches, that the structure can not be entirely removed. We owe much to Dr. Tiffany for the emphasis which he has laid on "known" versus "attempted" extirpation, and to Dr. Keen for his frankness in acknowledging the failure to find any ganglionic elements in the tissue removed from his first two cases of supposed enucleation. Lexer, in his careful tabulation of the 200 cases which he has gathered from the literature has placed them in two groups—those in which extirpation was accomplished or attempted, and those in which the method rendered this impossible. The majority of the latter cases were operations performed through the pterygoid route.

8. Frazier: University of Pennsylvania Med. Bull., December, 1901.

9. Of all these methods that described by Juvara has, I think, most to commend it, and though evolved from the low method, does not differ greatly from that of Lexer or myself similarly evolved as improvements on the high method. His procedure, however, remains somewhat too low; the facial supply to the orbicularis would be sacrificed by his incision and lagophthalmos would almost necessarily result; a sequel which possibly had been overlooked or not taken into account, since at the time of his description Juvara had practiced the operation on the cadaver alone. The extracranial dissection also is carried unnecessarily far, as are those above mentioned, namely, to the second and third divisions at their emergence from the skull, the floor of the temporal fossa alone having been removed. Jacob's operation also was advanced after anatomic studies alone, and when reported had not been put to practical test. He goes so far as to remove the outer wall of the orbit in order to expose the superior maxillary nerve, which then serves as a guide to the ganglion. There are other approaches more difficult to classify, thus, Doyen using a sickle-shaped incision, turns back a large bone flap from the high temporal region, resects the zygoma and coronary process of the inferior maxilla, ligates the internal maxillary artery and rongeurs away the base of the temporal fossa as far as the ganglion. Although the operation is begun as a high temporal one, the ganglion is finally approached via the low pterygoid route, and so ends with all the difficulties and disadvantages of the latter procedure. He designates it, nevertheless, a "*procédé temporo-sphénoïdal*." I know of no followers of this method. Two out of his first three cases succumbed to the operation, and it is generally condemned. Poirier uses a similarly complicated approach.

4. Rose: "The Lettsonian Lectures," the Lancet, 1892, vol. 1, p. 295. Instead of the superior maxilla, in the modified operation a portion of the ramus of the inferior maxilla is removed; thus allowing of a low lateral instead of a low anterior approach. The latter procedure was first carried out by Prof. Novaro of Genoa.

5. Coehlo: Revue de Chirurgie, 1899.

6. E. Lexer: Archiv für klin. Chirurgie, 1902, vol. lxx, p. 843.

7. THE JOURNAL, April 28, 1900, p. 1035.

In the earlier years the originators and all others who used the high temporal, or typical Hartley-Krause method, as the communications state, or as the post-operative study of the resulting anesthesia has made clear, satisfied themselves with the partial removal of the lower portion of the ganglion or even with the intracranial division of the *N. maxillaris* and *N. mandibularia*, oftentimes operating at two sittings with a few days interval. Some especially experienced and expert operators, led by the example of Krause, Keen, and Horsley, have subsequently been successful in removing the ganglion *in toto* by this exposure. It can rarely be a simple matter, however. The partial removal of the lower portion of the ganglion, furthermore, although it doubtless may cure a certain number of cases, must be criticized for several reasons. Although in many instances, even of severe neuralgia, symptoms referable to the ophthalmic region may be comparatively slight, it nevertheless sooner or later becomes involved in the disease, and to leave it courts a certainty of discomfort and a probability of pain in the supraorbital region. In two of my cases I was unable to extirpate more than the lower two-thirds of the ganglion. Both of these cases, after some months, have had a partial return of sensation in the cutaneous distribution of the ophthalmic nerve, with more or less attendant discomfort which the total extirpation cases have never shown. Again, some cases are primarily supraorbital in origin, with secondary involvement of the second and third divisions (six of my cases were such), and in these the fractional extirpation would necessarily be insufficient so far as permanent and complete relief is concerned. A partial extirpation, indeed, has been known to aggravate, in the region of the remaining and more or less traumatized first division, symptoms which before were relatively insignificant, although there may have been evidence that the disease had extended to this portion of the ganglion.

Recently Dr. Abbe has advocated a procedure which has for its object the simple intracranial section of the maxillary and mandibular divisions, with the interposition of a piece of rubber protective between the ends of the rami thus severed. Leaving aside the probability that in all severe cases of tic douloureux the ganglion cells giving origin to the *N. ophthalmicus* are likewise involved, it is difficult to understand how this procedure is in any way superior, or promises any greater permanence of relief, than a simple extracranial section; and it is hardly to be considered a Gasserian ganglion operation. Indeed, it probably would make a subsequent operation on the ganglion or on the *N. trigeminus*, should one be demanded, more difficult, and would seem to have less in its favor except ease of performance, than other and extracranial sections of the peripheral trunks. It must be acknowledged, however, that many of the partial operations have an extraordinary effect in inhibiting the transmission of painful impulses, and it is perhaps unjust to criticize Dr. Abbe's proposal without knowledge of his late results. One is inclined, however, to agree fully with Lexer when he says: "*In anbetracht der Gefahren der Operation halte ich es für einen grossen Fehler, das Ganglion wegen Neuralgia in einem oder in zwei Aesten aufzusuchen, auch wenn es mit der Absicht geschieht, es nur unvollkommen herauszunehmen. Krause hat deutlich die richtige Forderung gestellt, dass das ganze Ganglion entfernt werden müsse, sobald überhaupt das intracranielle Vorgehen angezeigt sei.*"

The same criticism and the same acknowledgment must be made in regard to a further manner of treating the ganglion after its exposure. Ferrier, in 1890, during a discussion of Rose's operative procedure, suggested on physiologic grounds the possibility that a simple section of the sensory root might answer the same purpose as the destruction or removal of the ganglion itself. Sir Victor Horsley, in his first operation by an intradural method through the temporal route, essayed to carry out this proposal, unfortunately, with a lethal result. Dr. Spiller,¹⁰ in 1898, and two years later Dr. Barker,¹¹ in a report on the histology of some Gasserian ganglia, again proposed this as possibly the most rational operation. Since then Dr. Frazier, at Spiller's suggestion, has successfully carried out the procedure.¹²

It is possible, should there prove to be a permanent abolition of afferent impulses from the trigeminal area of their patients, that the clinical evidence thereby gained may, as is not infrequently the case, decide a question which experimental physiology has left unsolved, and it is a great satisfaction to know that by the combination of experimental and clinical evidence they have set themselves to determine this point. Conclusive proof as yet is lacking, however, as to whether there is any regeneration centralward after the division of the sensory fibers proximal to a dorsal-root ganglion. Experimental evidence is conflicting, the observations of some¹³ favoring such a central regeneration, and unless this view becomes completely overthrown extirpation of the ganglion with all of its cells, can be the only certain method of permanently interrupting the transmission of all sensory impulses.

It is to be borne in mind also that, in all complete extirpations, the trigeminal root is removed together with the ganglion, and that not infrequently, when it has been impossible, for me at least, to expose the root, as would be necessary for its division, it will be extracted *in toto* when the freed ganglion is rotated out. Cases of easy access to the root are usually those of comparatively easy ganglion extirpation.

There is one reason, however, which, so far as I am aware, has not been sufficiently emphasized, and which, rather than ease of performance, would serve to make division of the *N. trigeminus* central to the ganglion preferable to extirpation of the structure itself. This concerns the restoration of motor function. In the extirpation procedure it is an anatomic impossibility to separate from the lower surface of the ganglion the underlying, obliquely placed and closely adherent motor branch of the nerve. Hence, if the extirpation is total, this means the removal of from 2 to 3 cm. of the latter, rendering reunion most improbable. In two of my long-standing cases of extirpation I have found evidence of a return of voluntary motion in the masseter and pterygoids, not, however, in the temporal. This, however, must be very exceptional, as it does not seem to have been observed by others. In the operation for division of the trigeminal root, should this prove, as it is to be hoped, sufficient to permanently shut off afferent impulses by way of the sensory division (*portio major*),

10. Spiller: The Amer. Jour. of the Med. Sciences, 1898, p. 532.

11. Barker: Protocols of Microscopic Examination of Several Gasserian Ganglia, THE JOURNAL A. M. A., May 5, 1900, p. 1093.

12. Spiller and Frazier: The Division of the Sensory Root of the Trigeminal for the Relief of Tic Douloureux, etc., Univ. of Penn. Med. Bulletin, 1901, vol. xiv, p. 34.

13. Baer, Dawson and Marshall: Regeneration of the Dorsal Root Fibers of the Second Cervical Nerve Within the Spinal Cord, Jour. of Exper. Med., 1899, vol. iii, No. 1.

the same will not be true for efferent impulses by way of the motor root (*portio minor*), since regeneration here with reunion of the nerve in case of simple section will almost certainly take place. Spiller and Frazier have suggested the possibility and have emphasized the importance of avoiding the motor root in the operation, doubtless a very difficult procedure, and one which so far as ultimate results are concerned, should be unessential. Preservation of the motor supply to the muscles of mastication would be well worthy of consideration for two reasons: one a cosmetic reason,¹⁴ since the chief postoperative deformity is due to a somewhat obtrusive flattening of the face from the atrophy of the temporal and masseter muscles; the other, a remotely practical reason, since, if by any procedure whatever, power of movement may be retained in the masticatory muscles of the side operated on, it would be possible in those unfortunates in whom tic subsequently appears on the opposite side, to carry out, what is now impossible, a bilateral operation. Involvement of the opposite side, however, is a very rare sequence, and has occurred in only one or two instances; almost as rare, indeed, as the subsequent involvement of another posterior-root ganglion in a malady of a different sort—herpes zoster.

All this discussion, it must be remembered, hinges on the still unproved dictum that no central regeneration allowing of the transmission of sensory impulses will occur after the section of a sensory nerve root proximal to its dorsal root ganglion.¹⁵

Thus efforts to destroy the ganglion or to remove it piecemeal; simple section intracranially of the second and third divisions with or without removal of the adjoining portion of the ganglion; and section of the trigeminus proximal to the structure, are all either undesirable procedures, or ones which, for the present, at least, stand on debatable ground. Total extirpation alone remains free from criticism, or would, did the anatomic site of the ganglion enable one by any method of approach to remove it with ease. It may be said that, so far as we know to-day, the certainty of total and of permanent relief from pain stands in direct relation to the totality of the extirpation.

Whatever procedure be that of choice, there are two elements which must influence all; one is so far as possible to avoid hemorrhage, both in the method of approach and in that of dealing with the ganglion; the other is so far as possible to evade any postopera-

tive evidences of one's work, either subjective or objective.

In the spring of 1900 the College of Physicians of Philadelphia held a so-called symposium, at which the treatment of trifacial neuralgia was the subject of discussion. At that time was presented a method of approaching the ganglion by a direct, trans-zygomatic, and as it has been called, an infra-arterial method. Influenced by the experience chiefly of Krause and Keen, the endeavor was made from the beginning to remove in each case the entire ganglion. The procedure involved an incision much lower than the Hartley-Krause operation; excision or temporary resection of the zygoma (I was at that time not sure which was preferable); a small cranial opening through the lower part of the temporal fossa without the detail of an osteoplastic flap; and an exposure and extirpation of the ganglion *in toto*, without occasioning injury or necessitating ligation of the meningeal artery. My experience at the time of this report was limited to four clinical cases, although the operation had been practiced and studied out on numerous bodies at autopsy. Previous acquaintance with the ganglion operation, as an assistant or on-looker, always by the high temporal osteoplastic method, with the ligation of the meningeal, etc., had been rather a disheartening one. I had seen in various hospitals several very skillful operators conduct the operation on these lines, and on one occasion had seen a death, as was supposed from hemorrhage, on the table. Difficulties from bleeding even during the approach had characterized all these performances. The Johns Hopkins Hospital experience also had been far from encouraging, as the records showed that two out of four cases had not long survived the operation. Subsequent to the introduction here of the direct operation, a colleague, one of the most careful and expert operators I know, again performed a Hartley-Krause operation, choosing it in preference to the other through past experience with the method. The patient also died within a few hours, presumably from operative hemorrhage and incidental shock. On the other hand, only 1 out of 23 cases in our local experience has succumbed to the operation, which will again be briefly reviewed. I mention these facts merely as evidence that the high osteoplastic operation is in the long run more critical, and even in the hands of those who have had the widest experience with the method, is attended with a higher mortality.¹⁶ It must be remembered also that the majority of these cases only represent an attempted extirpation, and often an operation intentionally confined to the lower two-thirds of the structure. In our series

14. This would, of course, remove the force of my argument in favor of permanent resection of the zygoma in order to lessen these deformities.

15. Since writing the above paragraphs I have learned that Dr. Sherman of San Francisco has observed a return of sensation and pain in the trigeminal field after the performance of simple root division, an extirpation of the ganglion having subsequently been necessary. Some features of the case, however, such as the extraordinarily early return of sensation, make the observation somewhat inconclusive, and on physiologic grounds leave the completeness of the primary neurectomy open to doubt, although the operator felt reasonably certain of its successful accomplishment. I have learned also that a similar experience has occurred to Sir Victor Horsley. Neither of these cases, however, have been sufficient, in my mind, to overthrow the principles of "no central regeneration" on which Drs. Spiller and Frazier have been working. On no more conclusive grounds has ganglion extirpation itself been claimed to be inadequate, two cases having been recorded of post-operative continuance of pain. Of these cases, Garré's (*Archiv f. klin. Chirurgie*, vol. lxx, p. 379) was confessedly an incomplete extirpation, and in Friedrich's case (*Deutsche Zeitschrift für Chirurgie*, 1899, vol. lxx) pain is said to have returned in four months. Regeneration of the peripheral branches in each of these patients, a condition that could not have taken place without the preservation of some ganglion cells, was evidenced by the relief from pain which was given through subsequent peripheral operations.

16. The mortality figures may be roughly given as follows: In the first series of one hundred cases, as collected by Tiffany (*Annals of Surgery*, 1896, vol. xxiv, p. 575), many of which represented cases of the low pterygoid operation, the mortality rate was 22 per cent. In the second series of one hundred cases, collected by Carson (*Medical Review*, St. Louis, 1899, vol. xxxix, p. 199), the majority of them being high temporal operations by the Hartley-Krause method, the mortality had been 11 per cent. Murphy and Neff, in 1892, collected 42 additional cases with six deaths, 12.5 per cent. Of those having a sufficiently long personal series to deserve mention, Horsley has had two deaths in 21 cases (*Practitioner*, September, 1900); Krause, in his series of 27 (*Münchener med. Wochenschrift*, 1901) has lost 7. Two or three of them, to be sure, were cases of late complication, which hardly should be included in the mortality percentages. Dr. Keen's cases, reported in 1898 in the twenty-fifth anniversary volume for Prof. Durante of Rome, were 11 in number, with 3 deaths, 2 of them from operative shock. Dr. J. B. Murphy (*THE JOURNAL A. M. A.*, 1902) likewise records 11 cases with 3 deaths. By the more direct method which Lexer's and my operations typify, the mortality figures, comprising more than twenty unpublished cases, of which I have cognizance, making fifty in all, are below 5 per cent. Lexer and I have each lost one case in our series of 15 and 20 respectively.

in which invariably the effort has been made to totally extirpate the ganglion, an effort successful in sixteen instances, the mortality has been under 5 per cent. Out of my personal series of 20 cases one was lost on the operating table, as will be described.

It was stated in my earlier communication that the operation differed only in detail from others previously described, but that in observance of detail hung the success of delicate surgical procedures of this sort. Every surgeon has, of course, his more or less personal ways of attacking operative problems, and the familiarity with any given method, that comes from practice, may make easy in one man's hands a procedure which may be unsuited to the needs of another. This is especially true of performances such as that under discussion, for at the best, removal of the ganglion is troublesome, and that so many ways of overcoming its difficulties have been advocated need occasion no remark. Since presenting the method, which at that time and subsequently has proved serviceable for my personal requirements, I have seen at home and abroad several other surgeons operate in other ways, and though indebted to these opportunities for many useful suggestions, the impression has always been conveyed that especially in the method of approach these gentlemen have encountered more difficulties and have run more risks than are usual in the variation I have described.

POINTS REFERABLE TO THE INFRA-ARTERIAL PROCEDURE.

There are certain details of the operative steps as they were first given, which for a moment may be dwelt on; there is no necessity of reiterating their main features, as the salient points remain the same.

Formation of Muscle Flap and Exposure of Temporal Fossa.—The arch of the skin incision has been made considerably lower than indicated in my original drawings.¹⁷ The vertical legs of the inverted U are, however, carried down no farther. This is important in the case of the anterior leg, which should not extend below the external angular process of the frontal bone, else twigs of the *N. facialis* to the orbicularis may be injured. Such a result is almost certain to follow in the procedure, which Juvara has described. The posterior leg, however, may be conveniently carried down as far as the temporal end of the zygomatic arch. It is to be regretted that in this, as well as in any of the temporal operations, be they high or low, the facial supply to the occipito-frontalis (*pars frontalis*) is necessarily sacrificed. This, by planing out all the wrinkles from the forehead on the side of operation, leaves a visible asymmetry of the brow, especially in old people who may possess deep furrows, as these patients usually do. The attempt has been made on the cadaver to work out an approach entirely posterior to the hair margin in order to avoid this sequel, but it apparently only adds difficulties to the already difficult procedure. I have been unable to examine all of my patients a year or more after the operation, but in some of those whom I have seen the occipito-frontalis has, in large measure, regained its function.

The necessity or advisability of resecting the zygoma has been much debated. Whether demanded or not by the particular approach employed, its complete removal, flush with the anterior edge of the temporal fossa as well as with the temporal bone at its point of origin, is, for reasons other than operative ones, distinctly advisable. One of the consequences of removal of the ganglion

by any method whatever is a permanent (unless exception will have to be made to this statement in case of motor regeneration after division of the sensory root) unilateral paralysis and consequent atrophy of the muscles of mastication. The late (months) deformity resultant to the atrophy of the exposed temporal and masseter muscles, whose outlines normally round out the face, is greatly accentuated if the arch of the zygoma is left intact or has been replaced after a temporary resection. Its removal has been invariably practiced in all but my earliest cases, and in consequence of this step the deformity in most instances is relatively inconspicuous and only shows as a slight flattening of the face, which a casual observer would pass unnoticed. The zygoma should be shelled out of its periosteal covering and cleanly divided at each end by a heavy pair of bone forceps, exactly as a portion of rib is excised in a thoracotomy. A new and less prominent bony arch is formed, and instead of curving outward, as in its previous condition, lies flush with the somewhat flattened temporo-masseteric surfaces. The pad of fat underlying the temporal fascia, together with the incised fascia itself, should be carefully preserved. The lessening in obtrusiveness of this unavoidable postoperative atrophy has been especially well brought out in one of my cases (Case 7), in whom the temporal muscle had been paralyzed and become atrophied in consequence of a preceding operation on Meckel's ganglion. In this case the zygoma was removed at the time of the Gasserian operation, as a result of which the sunken temporal fossa was so much less apparent as to be commented on by both the patient and his friends. The cosmetic result, with and without removal of the zygoma, may be seen on comparing some of the photographs showing the late postoperative results.

Exposure and Elevation of Dura as Far as the Ganglionic Sheath.—Unless the high temporal route is chosen there is no reason for making an osteoplastic flap in the operation, although many adhere to this time-consuming detail.¹⁸ Only a comparatively small opening in the skull is needed; indeed, there are many advantages attached to the small opening, as will be described, and it subsequently is covered in by the temporal muscle and, more important still, by its firm fascia. If a high-bone flap is made, the line of the craniotomy almost always runs across the deep meningeal groove of the lower angle of the parietal bone and often causes annoying hemorrhage, and if the flap with its temporal muscle attached is turned down over the zygoma the bone is apt to be more or less stripped away from its vascularizing soft parts. Several cases of necrosis consequent to this accident have been reported by Krause and others. If the approach is low and made on a level with the zygomatic arch, the thick covering of muscle and retreating angle of the skull make the formation of the bone flap as difficult as it is needless. In any case, should drainage be advisable, an osteoplastic craniotomy complicates the placing of drains. In the last of his series of cases, although developed from the Hartley-Krause procedure, Lexer has come to regard as unnecessary the preservation of the bone. A mallet and gouge or a burr is for me a much quicker, easier and safer way to make the primary opening in the skull in this situation than by the trephine. The small opening is primarily enlarged by prying up the edges of the thin bone plate with an elevator, and the opening is then

17. This operative method was illustrated and described in detail in *THE JOURNAL A. M. A.*, April 28, 1900.

18. Sir Victor Horsley has from the first, although adopting the Hartley-Krause method in other details, regarded it as unnecessary to preserve the bone. (*Practitioner*, September, 1900.)

rongeured away well down toward the base, somewhat lower than in my original drawings, and, I wish to emphasize again, need never be made high enough to encounter the meningeal artery where it channels the parietal bone. A slight elevation of the dura brings into view the thin, transparent expansion of this membrane, which makes a sheath about the *N. maxillaris* and here, I think, the serious task of exposing the ganglion by splitting its envelope and bringing into view its upper surface should always begin.

Elevation of the Dura with Meningeal Artery and Exposure of the Upper Surface of the Ganglion.—This step illustrates the infra-arterial feature of the operation. Injuries to the meningeal artery heretofore have been among the complicating features of the approach to the ganglion. The vessel in its intracranial course has two fixed points, one at the Foramen spinosum, where it enters the skull, and a second at the Sulcus arteriosus, where it tunnels or deeply grooves the anterior angle of the parietal bone. Between these two points the vessel lies in the dura, with a curve presenting a considerable downward and forward convexity, corresponding to the concave surface of the middle cranial fossa. The distance on the curve of the skull between these two points measures on an average nearly 5 cm. In order to expose the ganglion, the dura underlying the temporal lobe must be gradually elevated during the process of separating from the ganglion the upper sheath of its inclosing dural envelope. The artery in its new position then runs across the dura from behind upward and forward, and as the temporal lobe is elevated and compressed the vessel assumes a concave downward in place of its normal convex position, and instead of hanging like a swing it now arches between its two fixed points, and under this arch all manipulations may be carried out. In 19 of my 20 cases it was thus possible to avoid all complications from meningeal bleeding. Only once did I tear the vessel at the Foramen spinosum owing to an awkward approach and resultant poor orientation which led me to mistake the third for the second division.

Most operators, I believe, prefer to ligate the artery at its point of entrance into the cranial cavity, and criticism has been passed on the infra-arterial method in that it does not allow of sufficient room between the artery and the third division of the ganglion (*N. mandibularis*) to safely attack the latter. This has not been found to be the case. It is very easy to insert the blunt dissector between these two structures, though they be only a few millimeters apart, and to pry the ganglion forward, using the edge of the trephine opening as a fulcrum; in this way no strain need be put on the vessel. For the carrying out of these manipulations a small opening in the skull possesses distinct advantages. I think it has been Krause's universal practice to ligate, and German operators, including Lexer and others, have followed his lead. Dollinger¹⁹ soon after my report, as the result of anatomic investigations, arrived quite independently at the conclusion that it was possible to free and to extract the third division without injuring the artery at the Foramen spinosum and consequently that ligation is unnecessary. His operation, however, does not avoid injury to the meningeal at its higher fixed point, so that only one-half of the possible advantages of the infra-arterial method is gained in his procedure. More recently Bartlett²⁰ has considerably

extended Dollinger's observations on the relative positions of the meningeal artery and the ganglion. He has shown that only in anomalous cases would it be impossible to carry out the infra-arterial procedure and has himself in two instances successfully followed it.²¹ The method which Lexer has described and carried out in the last of his fifteen personal cases differs from my own chiefly in this detail of meningeal ligation. He uses the same low incision, makes his opening with mallet, chisel and rongeur, so large (*dreimarkstück-grosse*), however, that he does not avoid injury to the artery as it channels the anterior inferior angle of the parietal bone, resects the zygoma (temporarily), and has come to regard the preservation of the small area of bone as unnecessary. He has not, however, appreciated the detail emphasized in my earlier paper, namely that the skull is entered between the two fixed points of the meningeal artery.²²

In the pterygoid operation its followers advocate, almost without exception, ligation of the internal maxil-

Fig. 1.—Sketch from a frozen coronal section of the head, schematizing the three chief methods of approach. *Oblique methods.* (1.) The high or temporal route. (Horsley and Hartley Krause.) (2.) The low or pterygo-maxillary (Rose, Andrews, etc.). *Horizontal or direct method.* Transzygomatic (Lexer, Cushing, etc.). The Doyen method demands the space included by all three.

lary artery, which is necessarily encountered in the low approach. Several American surgeons have, indeed, gone so far as to advise a preliminary ligation of the

21. Bartlett: Excision of the Intact Gasserian Ganglion, *Annals of Surgery*, 1901.

22. He says (*Archiv für klin. Chirurgie*, 1902, vol. lxx, p. 14): "Das bestreben von Dollinger und Cushing diese Unterbindung (that is of the meningeal artery at the foramen spinosum) zu umgehen und die Arterie zu erhalten, ist, wie auch Krause hervorhebt, zu verwerfen. Denn, wenn es auch den genannten Autoren gelungen ist, unter Erhaltung der Arterie das Ganglion zu entfernen, so kommt doch häufig eine Verletzung der Arterie schon beim Öffnen der Schädelhöhle vor, wenn das Gefäß in einem von Knochenspannen überückten Sulcus verläuft; ausserdem kann die Arterie zu leicht bei den Manipulationen in der Tiefe zur Freilegung des Ganglion zerrissen werden, besonders bei dem stets notwendigen mehrmaligen Tamponieren zur Stillung der venösen Blutung." The first of these criticisms may be answered by the statement in the context that the cranial opening need never, unless in anomalous cases, be made high enough to reach the "überbrückten sulcus" (Sulcus arteriosus parietalis, Anat. Nomen.) and the last by giving John Hunter's blunt advice to Jenner: "Injury to the meningeal has occurred only once in my twenty cases, and then by inexcusable awkwardness."

19. *Centralblatt für Chirurgie*, 1900, No. 44, p. 1089.

20. Bartlett: A Contribution to the Surgical Anatomy of the Middle Cranial Fossa, *Annals of Surgery*, 1902.

external carotid, which seems quite an unnecessary step if the meningeal can be avoided, and such a step can affect the operation in no other way than to shut off the meningeal artery, without, so far as my experience goes, influencing the venous bleeding in the slightest degree.

The upper surface of the ganglion should, if possible, be entirely exposed during this step of the operation, and the degree of compression of the temporal lobe necessary to bring the structure into view, as can be judged by the accompanying sketch (Fig. 1), is much less in the transzygomatic than in the suprazygomatic or high approach. The extreme degree of compression, unless one satisfies himself with an incomplete extirpation or with an operation limited to the second and third divisions, must always remain a serious drawback to the Hartley-Krause procedure. It is during this and the following stage that complications from pressure by the spatula may ensue. In five of Krause's fatal cases, autopsies showed a superficial brown softening of the cortex; once a hemiplegia occurred; three times, in left-sided cases, a transient aphasia resulted. Lexer emphasizes the importance of care in retracting the temporal lobe and the special danger of placing the elevator in the unaccustomed hands of an assistant. The retractor in my cases has always been held by the operator himself in the left hand, all the necessary manipulations of elevating dura, of freeing the ganglion and of packing being carried out with the blunt dissector held in the right. I have employed a retractor of much the same form as that of Lexer, although instead of having a square end the end has been rounded, and it is possible that this may, in a measure, account for the unusual number of pressure palsies of the ocular nerves which I have occasioned. It is in this and in the following stage also that the blood-pressure reaction of acute cerebral compression usually occurs, depending in its degree on the extent of elevation of the temporal lobe. The entire upper surface of the ganglion and in many cases the sensory root may be brought into view at this stage of the operation.

(To be continued.)

POINTS IN THE TECHNIC OF ASEPTIC OPERATING.*

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The principles of antiseptics are well understood by the profession, and the methods employed to avoid septic infection are fairly uniform, but, since infection not infrequently occurs as the result of an imperfection in our antiseptic detail, it is well for us occasionally to discuss the subject and to criticise our methods, that we may reject the bad and adopt the good.

The most important point in the prevention of operative infection, of course, is to keep our hands out of septic matter for a considerable period of time before operating, because it is a physical impossibility to remove all infective material from the deeper layers of the cuticle.

If by looking through a strong lens we magnify the skin of the hand to the extent that the epithelial scales assume the size of the ordinary fish scales, and magnify also the bristles of the nail brush in proportion, it will not seem unreasonable to compare the scrubbing of our

hands and fingers to the scrubbing of ten fishes with a brush whose bristles are much larger in diameter than the fish scales.

On the human skin, however, the scales grow in more layers than on the fish, and are situated on rugæ and papillæ and in folds and sulci. The human skin also has many hairs with their own scaly surfaces and individual follicles, and has also many sweat glands. When we reflect that these hair follicles and epithelial tissues are the natural habitat of the staphylococcus albus, we realize that the cleansing and sterilization of many fish skins is child's play compared with the sterilization of our hands. In fact, our hands can not be made clean and sterile except by removing the cuticle, a procedure which I am not yet prepared to advocate.

The only practical and safe procedure is to clean and to disinfect the surface as well as possible, and then to cover it with a coating that will prevent the deeper unremoved septic matter or germs from reaching the field of operation. This is why so many operators use rubber gloves. Gloves, however, do not constitute an ideal coating; they interfere with delicacy of manipulation, and they are dangerous because they excite perspiration, and thus bring germs from the deeper layers of the cuticle to the surface ready to infect the patient through possible tears and punctures of the gloves. It is quite common during an operation for a puncture to be made in the finger of a glove and to be overlooked; and even with the greatest care we can not be certain that some puncture or tear will not be overlooked. It is exceedingly annoying, as well as dangerous to the patient, to be obliged to change a glove two or three times during a difficult and prolonged operation.

Coating the hands with gutta-percha or with some other material of similar nature, is open to the objection that a scratch would liberate an accumulation of germ-laden sweat, which the impervious coating had caused to accumulate in the glands.

The old way of thoroughly preparing the skin and then applying a germicide that will harden the surface and check perspiration, and that can be renewed from time to time during a long operation, still seems to be very nearly the ideal method of treating a surface that can not be sterilized except in a most superficial manner.

In cleansing the hands, I always keep in mind the fish skin and the comparatively coarse brush that can not penetrate between the scales nor to the bottom of the folds and sulci; hence I believe that in addition to scrubbing the hands with soapy water, a certain amount of soaking is necessary to soften and to loosen up the dirt between the epithelial scales and at the bottom of the depressions. Twenty minutes, therefore, should be given to scrubbing and to soaking the hands in soapy water. I prefer water drawn into a basin, and frequently changed, to running water because a better and soapier soaking is possible.

Even after the most thorough cleansing with green soap some stain or hardened inorganic matter that may be insoluble in the alkali is apt to remain on the skin, and hence a short scrubbing in diluted acetic, citric or oxalic acid is desirable. This dissolves the remaining inorganic matter and more thoroughly exposes the underlying cuticle. Two or three minutes of such scrubbing will usually suffice.

In order to penetrate still deeper, and to harden the cuticle which has been swelled and loosened by the alkaline scrubbing and soaking, a scrubbing and soaking in 90 per cent. or 95 per cent. alcohol is desirable

* Read at the Seventeenth Annual Meeting of the Southern Surgical and Gynecological Association, 1904.