the lesion in these circumstances depended in great measure on the existence of mitral incompetence due to dilatation of the ventricle from aortic regurgitation, as well as on the presence of some sclerosis of the mitral segments; in two cases, indeed, the mitral cusps were healthy.

Such are some of the causes which predispose to infective endocarditis.

I will begin my next lecture with a brief discussion of the manner in which the infecting micro-organisms enter the circulation.

An Address

ENTITLED

A FRAGMENTARY CONTRIBUTION TO THE OPERATIVE TREATMENT OF CHRONIC SUPPURATION WITHIN THE TEMPORAL BONE.

*Delivered before the Burnley Medical Society on
Dec. 4th, 1902,*

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(With Plate.)

MR. PRESIDENT AND GENTLEMEN,—When I received your secretary's courteous invitation to read at a meeting of your society a paper on Chronic Suppurative Disease of the Temporal Bone I gladly accepted the invitation. The subject includes so many questions—such as meningitis, inflammation of the brain, and general systemic infection—of such great interest to all branches of the profession that it was a little difficult to decide on the exact title of my paper. However, as I understand that it is your desire that I should address you on the operative treatment of chronic otorrhœa I invite your attention to this fragment of the subject.

Some of you will remember that in January, 1900, I read a paper before the Royal Medical and Chirurgical Society on the Operative Treatment of Chronic Otorrhœa which gave rise to some discussion. The great attraction of surgery is that it is ever an advancing science and I can honestly say that never, since the reading of that paper, have I performed the operation exactly as it is there described. I therefore welcome this opportunity of bringing to your notice the modifications and (as I consider) improvements which appear to me to be useful and trustworthy. An improvement of a great operation, even in some small detail, is as beautiful and fascinating to the spirit of surgery as is the "trembling of the ocean waves under the first pure gleam of morning"¹ to the eye of the artist.

The objects which I have had in view have been: (1) to simplify the operative procedure; (2) to avoid any external deformity; (3) to conserve the hearing power; and (4) to hasten the healing process. In 1889, Küster, in the course of a discussion on the treatment of chronic suppuration in rigid walled cavities, stated that "the simple opening of the antrum could have but a limited influence on chronic middle-ear suppuration, and for the reason that the communication between the antrum and tympanum is small and, in such cases, apt to be still further narrowed by granulations and swollen mucous membrane." "The rational treatment of chronic otorrhœa, therefore, must be based on the surgical principle that a diseased bony cavity should be opened up extensively, all diseased tissue removed, and the source of the suppuration clearly brought to the light. Only when this is done are the surgical requirements fulfilled."²

In the same year Stacke wrote: "Otology is an offshoot of surgery and only in close adherence to it and in the true and conscientious observance of its principles is success to be sought for and to be found. The most important

principle is the care for free, unhindered, spontaneous drainage. Incomplete drainage and, as a consequence, further and deeper bone disease, is the cause of the difficulty in healing middle-ear suppurations."³ It is to the recognition of these truths that successful practice in recent years in abating and curing chronic purulent otorrhœa has been due. As Körner so clearly indicates by the very title of one of his works⁴ chronic purulent otorrhœa is in effect suppuration in a cavity in the temporal bone. In the recesses of the temporal bone suppuration follows the same course as does suppuration in a cavity in any other bone, or indeed in any situation where the walls of the abscess cavity are incapable of contraction or approximation. What this course is all surgeons know.

When a simple empyema is opened early, before the lung has become bound down by adhesion, the expansion of the lung soon obliterates even a large abscess cavity and healing is not long delayed; but if the empyema be not opened until late, after the lung has become so firmly fixed as to render its expansion impossible, a very different result follows. The acute symptoms may, indeed, be relieved, but instead of the wound readily cicatrising suppuration persists and will go on indefinitely unless surgical measures are taken for the obliteration of the cavity. In the large irregular cavity which is left in such a case we have a picture on a large scale of the essential condition underlying the difficulty of curing middle-ear suppuration. In the one case the complete Estlander, and in the other the complete mastoid, operation must be done. In the temporal bone the suppurating cavity is, as regards its mere size, insignificant, and the amount of pus discharged therefrom is not often of itself important, but the environment of the disease is such as to render it at once difficult to eradicate and dangerous to leave untreated.

Until recent years surgeons cannot be said to have been keen on the operation for the cure of chronic purulent disease within the temporal bone, for—

"We all, that are engaged to this loss,
Knew, that we ventured on such dangerous seas,
That, if we wrought out life, 'twas ten to one."⁵

And few dared to embark, in the true spirit of surgery, upon such an undertaking:—

"And yet we ventured: for the gain proposed
Choked the respect of likely peril fear'd."⁶

Now, however, the anatomical and pathological labours of many workers have done much to remove the difficulties that beset the path of the surgeon in conducting the operation. Just as well-surveyed waters, even though narrow and tortuous, may be calmly and confidently, though never heedlessly navigated, so now the surgeon, well acquainted with, and relying on, the chart of knowledge which is so freely available to all may safely traverse "the perilous narrow ocean"⁷ of the complete mastoid operation and attain in almost every case his object—namely, the complete ablation of the disease from which his patient is suffering.

The surgery of the temporal bone is, as Greig Smith so well said of another department of surgery, "no longer a field for legitimate and versatile experiment; certain fixed and useful laws and customs have been laid down by the dearly bought experience of great men: the surgeon ought to begin fully equipped with such knowledge as has been gathered for him."⁸ Alas, it is not always so, and even now some timid soul, "getting into a sea far beyond his sounding,"⁹ turns back before the voyage so essential to the life of his patient is completed, while perhaps another,

"Most ignorant of what he's most assured,"¹⁰

founders his patient upon a charted rock. The vessel is posted at Lloyds as "missing" but the pilot, a practised swimmer, rarely suffers the same fate.

I am convinced that the operation should be undertaken whenever the ear suppuration *persists* in spite of careful antiseptic treatment carried out through the meatus. For not only is extension of the disease to the temporal bone, with all its dangers, then almost a certainty, but it must not be forgotten that neglected chronic suppuration in all

³ Berliner Klinische Wochenschrift, April 22nd, 1889.

⁴ Die Eiterigen Erkrankungen des Schläfenbeins.

⁵ King Henry IV., Part 2, Act i., Scene 1.

⁶ Ibid.

⁷ King Henry V., Prologue.

⁸ Abdominal Surgery, fifth edition, vol. i., p. 133.

⁹ Carlyle: The Hero as Man of Letters.

¹⁰ Measure for Measure, Act ii., Scene 2.

¹ Carlyle: The Hero as Poet.

² Berliner Klinische Wochenschrift, 1889. Quoted from Allen: "The Mastoid Operation."

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

TO ILLUSTRATE MR. BALLANCE'S ARTICLE.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

TO ILLUSTRATE MR. BALLANCE'S ARTICLE.

parts of the body, including the tympanum, may become secondarily infected and give rise to a fatal form of blood infection without any infection of bone.

"And danger, like an ague, subtly taints,
Even then when we sit idly in the sun."¹¹

Such measures as curetting away granulations, removal of ossicles, polypi, &c., are, I consider, except in quite exceptional cases, not only inefficient but dangerous. By the complete operation alone, is it true to say

"Out of this nettle, danger, we pluck this flower, safety."¹²

The persistence of the disease is therefore the indication for operation, for

"If we suffer

this contagious sickness,
Farewell all physic: and what follows then?
Commotions, uproars, with a general taint
Of the whole state."¹³

Operation should not be deferred until intracranial complications are present or are immediately threatened. It is true that many patients with chronic otorrhoea pass through even a long life without experiencing any grave inconvenience therefrom, but it is also evident that anyone suffering from chronic ear suppuration is always in danger of a grave, or even fatal, illness which

"Only stays but to behold the face
Of that occasion that shall bring it on."¹⁴

No surgeon would advise that operative treatment for the cure of caries of the sternum should be deferred until the pericardium had become infected or the patient had commenced to develop the symptoms of general infection. Nor would any surgeon postpone the operative measures necessary to heal a cavity in the head of the tibia until the abscess had made its way into the knee-joint. The operation here dealt with is that required for the cure of chronic disease. The same operation is not called for in acute cases. In these a local operation limited to the mastoid usually suffices to effect a cure and the tympanum and meatus should be left undisturbed. The posterior wall of the meatus should not, in these acute cases, be interfered with except in that small group of patients in whom the mastoid is involved by infection, voyaging through the posterior wall of the osseous meatus. The surgeon here operates with the same object as in acute suppuration in a joint—namely, to arrest the inflammatory process by free drainage and antiseptic flushing. In the case of the tympanum another reason exists for the operation—namely, the prevention of the destruction of the delicate structures in the middle ear and the conservation of the function of the organ of hearing.

It must be remembered, however, that in many cases of acute disease simple opening of the antrum is inefficient; pus is frequently found in cells at the extreme apex and as far back as the posterior edge of the bony groove for the lateral sinus. The whole mastoid then requires ablation so that even when performed for acute disease the operation becomes a very extensive one. Nevertheless, in these cases also the tympanum should be preserved. The operation for the cure of chronic otorrhoea is always an extensive one; complete removal of the disease is the first essential to complete success. It cannot be too explicitly affirmed or too clearly comprehended that imperfect performance of the primary or bone operation is the chief reason of failure of the subsequent treatment, whether this is carried out with grafting or without.

The attempt to cure cases of chronic otorrhoea without removing the bridge which overhangs the communication between the antrum behind and the attico-tympanic cavities in front is to act in opposition to this fundamental principle of surgery. It is my desire again specially to accentuate this cardinal fact, because it has happened to me even recently to have to perform the complete mastoid operation months and years after operation had been done, leaving the bridge unremoved. On the inner side of the bridge I have observed infective granulations, caries, small encapsuled abscesses, and an open Fallopian canal. There is no part of all the operation which requires more care and thoroughness in the extirpation of disease than here.

"This fester'd joint cut off, the rest rests sound;
This, let alone, will all the rest confound."¹⁵

¹¹ Troilus and Cressida, Act iii., Scene 3.

¹² King Henry IV., Part 1, Act ii., Scene 3.

¹³ King Henry VIII., Act v., Scene 2.

¹⁴ King Henry IV., Part i., Act i., Scene 3.

¹⁵ King Richard II., Act v., Scene 3.

The outer wall of the attic is formed by the bone of the roof of the osseous meatus. The thickness of the bone here varies greatly, but it contains cells which communicate with those of the mastoid process and with the attic. The removal of the outer wall of the attic, therefore, not only enables disease of this cavity to be extirpated, but it provides for the extirpation of infective granulations and pus which are likely to have extended from the attic into the cells of the roof of the meatus. Unless this plan of operation is systematically and carefully carried out diseased tissue will escape the curette and remaining unmolested by the operator will be a potent influence antagonising the successful issue of the operation. Indeed, the greatest care and circumspection are required in every step of the operative procedure on the bone for, to quote once again from Greig Smith, "Not only must no part of the work be hurried over or scamped, but every detail must be finished and rounded off with a thoroughness as minute and genuine as if that detail were the turning point of success. And, practically, it is a fact that imperfect attention to almost any detail may result in a catastrophe."¹⁶ The tendency of modern surgery is against the performance of type or formal operations: for example, we do not perform formal excision of the knee-joint; we endeavour to remove all disease. So, also, in the complete mastoid operation we perform no formal operation, but we follow and eradicate the disease to its utmost limits.

The first, or bone operation, is not completed till the tympanic end of the Eustachian tube has been curetted. The ulceration may extend into the tube and collections of inspissated pus may be found in it. Not only is it most necessary to remove any disease which may here be harboured, but the subsequent healthy granulations which spring up will close the tube and the surgical occlusion of the tube thus attained cuts off the mastoid operation cavity from any infection from the throat. It is to be remembered, too, that the function of the Eustachian tube, as the channel for the aeration of the tympanic cavity, is now no longer required.

Jansen¹⁷ makes every endeavour, in performing the complete mastoid operation for chronic otorrhoea, to conserve healthy ossicles, and in from 5 to 10 per cent. of his cases he does so. His advice is, when there is good hearing leave the ossicles, for dislocation of the malleus and incus will disturb the labyrinth and cause loss of hearing, but if there is much deafness, remove the ossicles and hearing will improve; and further, if there is deafness in the opposite ear while the hearing in the ear about to be operated on is fairly good, leave the ossicles whenever it is possible to do so. The conservation of the ossicles in some of these chronic cases is made possible by the fact that, although the disease has originated in the tympanum, it is, in its later stages, more advanced in the antral region so that the tympanum may, in these later stages, be merely a passage for the exit of pus. On the other hand, it may well be asked of what possible use can the ossicles be when they must become bound together by adhesions as cicatrisation takes place. Politzer, Schwartze, and other great authorities always remove the malleus and incus. My own practice is to remove the malleus and incus and, when possible, to leave the stapes. At the grafting operation it has been my custom to make a hole in the graft through which the stapes projects.

Whether the hearing will be better or worse after the radical mastoid operation cannot be pre-determined. In some cases there is a great improvement in hearing. Yet this question, about which all patients are naturally anxious, cannot be answered by the truth-loving surgeon. He is bound to confess his ignorance, for post-suppurative deafness frequently depends upon the filling of the niche or recess on the inner tympanic wall, in which the base of the stapes is fixed, with new connective tissue which bars the entrance of auditory vibrations and the presence of which can only be determined by making a microscopical section through the oval window. The same scar-tissue obstruction may also form over and block the round window.

The successful conduct of the treatment for the cure of chronic otorrhoea requires the fulfilment of two conditions: first, the removal of all disease by operation. We may say at once and deliberately that, in the great majority of the cases, all the disease can be removed. Secondly, the healing of the large bone wound from the bottom. Greater difficulty

¹⁶ Greig Smith: Op. cit., p. 132.

¹⁷ Personal communication.

has been experienced in the fulfilment of this second condition. Systematic tamponning, usually through the unsutured mastoid wound, has been employed for this purpose. All who have carried it out are aware how painful it is to many patients and how tedious it becomes for both the surgeon and the patient. Politzer¹⁸ says: "The duration of the after-treatment varies from six weeks up to nine months and over. The mean duration varies between three and four months." Grunert¹⁹ says: "In exceptional cases cicatrization proceeds so smoothly that the entire cavity is healed in from four to six weeks; on an average, cicatrization is complete in three to four months. There are, however, specially unfavourable cases in which, either as a result of constitutional peculiarities or of particularly unfavourable local conditions, this period of time becomes considerably extended."

Passow,²⁰ in a thoughtful paper on the Retro-auricular Opening after the Radical Operation for Chronic Middle-ear Suppuration, gives statistics from various clinics showing that the average duration of treatment by the tamponning method varied from four to ten weeks in the most favourable instance up to 36 weeks and over. Respecting the most favourable figures quoted he, however, says: "Though Hartmann, in the most recent edition of his text-book, when referring to the radical operation, remarks laconically that the healing takes from four to ten weeks; this can really only be taken *cum grano salis*." Most striking, however, are the figures which he gives respecting the cases operated on in his own clinic at Heidelberg. Of 44 recovered cases, 18 were operated on by different methods but all without Thiersch grafting. In these the average duration of the after-treatment was 20 weeks. The other 26 cases were operated on by a method described in the paper of which Thiersch grafting forms a part. In these the average duration of treatment was 11 weeks. One healed in three and a half weeks, but the majority took over three months to heal. A visit which I recently paid to several continental clinics in which I saw hundreds of cases in various stages of treatment by the tamponning method gave me the impression that the above-quoted statements took rather a too favourable view of the results of that treatment. I should say that in the majority of cases treatment was continued for six or seven months. I am therefore confirmed more than ever in the opinion that the method which I described before the Royal Medical and Chirurgical Society presents great advantages over tamponning alone and over the methods of grafting hitherto practised by myself and others,²¹ and that it indicates the direction in which further advance may yet be anticipated. The surgeon who does not use the method of grafting in these cases seems to me like one

"Who half through
Gives o'er and leaves his part created cost
A naked subject to the weeping clouds." ²² 23

In general surgery skin grafting is carried out in order to hasten the cicatrization of a wound having a large superficial area. It cannot be too strongly emphasised that the sole object of the grafting operation is to expedite the healing of the wound—an object which is the desire of the patient and should be the chief aim of the surgeon. The wound left after the complete mastoid operation is not only of large superficial extent, but its floor is in great part raw bone, a tissue which heals much more slowly than does soft tissue and is, moreover, much more susceptible of re-infection during the process of healing. The surface of the wound is not flat, but is so shaped that granulations which are allowed to become exuberant may cross the cavity and so shut off spaces which are unhealed and which become a fertile cause of persistent discharge and so of failure of the operation. Jansen in doing the complete mastoid operation applies immediately several small grafts, completely sutures the mastoid flap, and treats the case by tamponning through the enlarged meatus. He objects to grafting the tympanum on account of its numerous recesses, which he considers make the proper application of a graft impossible, and also because the graft may throw a veil over the two windows

and so produce a loss of hearing. This is probably true of some cases, but it is not true of the method of grafting which I now strongly urge as a marked improvement on the old method which left a graft of variable thickness to be absorbed and replaced by an equally thick sheet of scar tissue. The ideal plan of treatment would involve carrying out in one operation all the following details: (1) the complete removal of the disease; (2) the fashioning of a flap from the membranous meatus without causing deformity of the concha; (3) the epithelial grafting of the inner and outer surfaces of the operation cavity; and (4) the complete suture of the mastoid wound—the subsequent after-treatment being carried out by dry gauze tamponning through the meatus.

This ideal method of procedure is in my judgment not feasible except in certain quite exceptional cases. The wisdom of completing the operation at one sitting cannot be justified when it is remembered that in many cases the wound is foul and that the epithelial grafting is best done and is most likely to succeed when a surgically clean surface has been prepared. The administration of anæsthetics has now been brought to such a high standard of perfection that in skilled hands it involves no more risk than a short railway journey.

"Things done well,
And with a care, exempt themselves from fear."

It is far better for the patient that the anæsthetic should be administered a second or even a third time than that there should be any approach to hurry and want of thoroughness in carrying out those measures which make for perfection in the treatment of a disease which may, and still too often does, end fatally. Moreover, I believe that there is much more danger in the undue prolongation of anæsthesia than in the repeated administration of an anæsthetic. The repetition of the anæsthetic is not a new procedure recommended for the first time by me, but has been a necessary part of the treatment of chronic otorrhoea in the past. Even now a great many operators leave the mastoid wound open and after several months administer an anæsthetic to close the retro-auricular opening. The ultimate and complete success of the operation should never be jeopardised merely for the sake of the brilliancy of completing all that is required in one sitting. Therefore, although the second or grafting operation may in a few instances follow immediately as a direct continuation of the first I have usually allowed an interval of a week or longer to intervene between the operation for the removal of the disease and the grafting operation. In some cases, such as those of brain abscess or of lateral sinus pyæmia, I have postponed the grafting operation for a month or more. These are specially foul cases or cases in which the graver intracranial disease must first be mastered. After any interval the surface must be prepared anew for the reception of the graft by the removal of every visible trace of granulation tissue. In such instances we are indeed obliged to

"Heal the inveterate canker of one wound
By making many." ²⁵

In many other operations the prospect of complete success is much increased by operating in stages. As an illustration of this point I may mention that I have found great advantage in performing the operation of excision of the knee in weakly children in two or even three stages. The operation for tumour of the brain is invariably conducted in two stages and Professor Jalaguier, with whom I agree, speaking of the cases of acute obstruction in which excision of a portion of bowel is called for, says: "The operation is performed in two stages; it is less brilliant than complete operation at one sitting, but it is infinitely less dangerous."²⁶ The same principle should, as a rule, be carried out in operating for strangulated hernia. The acute condition threatening life should first be dealt with and later an operation for radical cure can be performed.

The attempt to do too much at one time is to be deprecated not only in the practice of surgery but in the undertakings of other professions. Victory, in the great operations whether of surgery or of war, is to be gathered laboriously step by step, stage by stage. In support of this theme I may appeal from my own humble experience to the voice of Britain's most illustrious sailor. Nelson ordered two of his frigates (the *Phæbe* and the *Amazon*) to cruise together.

²⁴ King Henry VIII., Act i., Scene 2.

²⁵ King John, Act v., Scene 2.

²⁶ *Traité de Chirurgie*, Duplay-Reclus, vol. vi., p. 47.

¹⁸ Politzer: *Lehrbuch der Ohrenheilkunde*, fourth edition, p. 470.

¹⁹ *Encyklopädie der Ohrenheilkunde* (Blau), p. 234.

²⁰ *Zeitschrift für Ohrenheilkunde*, Band xxxii., pp. 215, 216, and 223.

²¹ Siebemann: *Berliner Klinische Wochenschrift*, 1893, No. 1 and No. 33. Reinhardt: *Versammlung Deutscher Naturforscher und Aerzte in Düsseldorf*, 1898. Jansen: *Verhandlungen der Deutschen Otologischen Gesellschaft*, 1898.

²² Weeping granulations.

²³ King Henry IV., Part 2, Act i., Scene 3.

Previously to their going away he gave to Captain Capel and Captain Parker several injunctions in case they should get an opportunity of attacking two of the enemy's frigates. The principal one was that they should not each single out and attack an opponent but that they should endeavour together to take one frigate; if successful to chase the other; "but if you do not take the second, still you have won a victory and your country will gain a frigate." Then, half laughing and half snappishly, he said kindly to them as he wished them good-bye: "I dare say you consider yourselves a couple of fine fellows, and when you get away from me will do nothing of the sort but think yourselves wiser than I am."²⁷

I claim that in our art, and in particular at the present moment in the mastoid operation, Nelson's illuminating principle of executing a great task by doing each stage thoroughly before proceeding to another is the sure guide to success. On the other hand, it may be that in the future the operation we are now considering may be replaced by a simpler and more perfect method which will enable the operator in almost all cases to complete all that is necessary at one sitting. We are now able to complete at one sitting some operations, such as gastrotomy, colotomy, and the removal of hydatid of the liver, which until recently were always performed in stages. For the present, however, the safeguards and advantages afforded by operating for temporal bone disease in stages are "like temporary props of an edifice; they must not be removed until we have built a firm wall in their stead."²⁸

The plan of treatment which I now practise is carried out in three distinct stages; of these the first two are those which are described in my former paper, but with certain alterations in the details, and the third is an additional step which I believe to be of great importance. The modifications introduced are:—I. *In the first stage of the operation*: 1. The use of both burr and gouge for the bone operation. 2. In dealing with the membranous meatus; (a) the flap is fashioned out of the meatus alone so that no deformity of the concha is produced; (b) the cartilage is removed from the flap; and (c) the flap is sutured to the raw surface of the mastoid flap with gossamer silkworm gut which can be removed at the second operation or with fine catgut which soon becomes absorbed.

I formerly advised the use of the electrically driven burr almost to the exclusion of the gouge, but in the varying conditions of the operation I like to feel free to use burr, gouge, or chisel as may seem best adapted for the immediate purpose in hand. Whenever the motor is available the burr should be used off and on during the course of the operation and at its close it is valuable for neatly smoothing down the bone surface so as

"To leave no rubs nor botches in the work."²⁹

Further, there can be no doubt that when the burr is used the patients are far less prone to sickness than they are after operations carried out entirely with gouge or chisel. The cut in the concha which was recommended in my previous paper had not in the cases on which I operated produced an unsightly deformity. My attention was called to the point by seeing patients who had been operated on by others and who asked "for something to be done to close Ballance's hole." One such case presented a "fearful hollow"³⁰ of a meatal aperture in which two fingers could be placed. Such results were facetiously described by an eminent surgical friend as "a new form of flowerpot constructed on the side of the head." I found it quite easy to diminish such openings by simply throwing forward the mastoid flap and then shifting the conchal flap from the inner surface of the mastoid flap back to its original position.

The way in which I now deal with the membranous meatus is as follows. The floor of the membranous meatus is divided from within outwards right out to the concha. The pinna is then pulled backwards and the tragus forwards and the knife is carried, not as was formerly advised through the concha, but through the posterior half of the extreme outer end of the meatus, just at its line of junction with the concha. The flap thus fashioned is turned upwards and the cartilage is removed from it. It is then fixed with stitches to the raw surface of the mastoid flap. The inner corner of

the flap has always to be cut off as it gets in the way of the free removal of the outer wall of the attic. A triangular piece of cartilage is next removed from the floor of the meatus and the skin which was over it, and which is now loose, is stitched to the raw tissues in the neighbourhood in the same manner as was adopted for the main meatal flap. When healing is complete, though there is a real enlargement of the conchal opening of the meatus, yet there is no visible sign of the enlargement and no deformity. The cut edge of cartilage should be protected by suturing as far as possible the skin over it. This is important in view of the always tedious healing of an exposed cut edge of cartilage, and especially is it needful in foul cases, as infective perichondritis (which though very uncommon in this country is not infrequently met with in some foreign clinics) may occur and give rise to much trouble and deformity.

II. *In the second stage of the operation*:—1. A crescentic portion of skin is removed from the mastoid flap of a width sufficient to adjust the pinna to its proper position on the side of the head. 2. An ordinary razor moistened with sterile normal saline solution is used instead of a special instrument moistened with a special fluid. 3. The main mastoid cavity is not now grafted. The graft is only allowed to cover the inner wall of the tympano-attic-antral cavity. An additional graft is placed on the corresponding part of the inner surface of the mastoid flap. 4. The graft is maintained in position by means of tiny mops of sterilised wool covered with gauze. These mops are dusted with a non-irritating and drying sterilised antiseptic powder. Gold leaf is no longer used. If previously to doing the second operation the pinna is pushed upwards a crease will be produced in the mastoid flap. This generally affords a sure guide to the exact amount of skin, crescentic in shape, of the mastoid flap which should be removed in order to adjust the pinna to a symmetrical position on the side of the head. The removal of the crescentic portion of skin has a further advantage in that it brings the scar close to the attachment of the pinna to the side of the head. This, and careful stitching of the mastoid flap with gossamer silkworm gut, combine to place the scar under cover of the pinna and to attain that "almost traceless cicatrization of the retro-auricular wound"³¹ which should be the aim of the surgeon, especially when his patient is a woman. The operation cavity is cleansed and bleeding is arrested by peroxide of hydrogen and warm sterile saline solution.

The graft is cut with an ordinary hollow-ground razor of suitable size, moistened with sterile normal saline solution only, without admixture of alcohol or glycerine, which, though facilitating the cutting, has seemed to me to cause thickening of the graft. The graft is applied to the inner wall of the tympanum, attic, and antrum, and should slightly overlap the vertical boundaries of these cavities. I never allow it to extend below the lower margin of the antrum, for otherwise a needlessly large permanent cavity would be formed. Moreover, this part will rapidly enough heal by the approximation of the raw inner surface of the mastoid flap to the granulating bone surface. The graft is held in place against the bone by the application of small, dry, sterile cotton-wool mops dusted with a non-irritating antiseptic powder. The first of the little plugs is placed in the lower part of the tympanum and often extends into the upper part of the Eustachian tube. The next is placed against the upper part of the inner wall of the tympanum and attic, and the next against the inner boundary of the aditus and antrum. About seven plugs are usually employed. A piece of sterilised gauze is then placed over all to prevent displacement. Another graft is now placed on the outer boundary of the operation cavity—namely, the inner surface of the mastoid flap, corresponding in extent to the tympano-attic-antral cavity. It is also a good plan to apply another small graft and to arrange it so as to cover the raw edge of the posterior margin of the meatus, for here the cartilage is exposed without a complete skin covering.

Until some nine months ago the plugs covered with powder were left *in situ* for about two weeks and then dry gauze tamponing was carried out for a further period of three or four weeks—i.e., until the wound had healed. Now, however, I carry out:—

III. *The new third stage of the operation* which consists in the deliberate removal of the dead portion of the graft. This can be done through the meatus, but it is best and most accurately performed under an anæsthetic. In some

²⁷ The Influence of Sea Power upon the French Revolution and Empire, Mahan, vol. ii., p. 45.

²⁸ Wilhelm Meister's Lehrjahre, Book v., Chapter 4. Carlyle's translation.

²⁹ Macbeth, Act iii., Scene 1.

³⁰ Romeo and Juliet, Act iii., Scene 5.

³¹ Politzer, op. cit., p. 465.

cases after the operation had been previously performed and had failed I have kept the mastoid wound open; in these cases the third stage of the operation is completed and the wound is immediately sutured.

The third stage of the operation consists, as already said, of the removal of the *main portion of the graft which is dead*. After washing with warm sterilised normal saline solution the dead part of the graft comes away as a distinct membrane. The cavity is then gently dried with sterilised wool and on careful inspection can be seen to have a surface of pearly smoothness which is in fact a surface of epithelium. Anyone not familiar with this separation of the dead part of the graft might think that the graft had failed. The separation of dead from living tissue is, as we all know, by aseptic molecular necrosis or by suppuration. In epithelial grafting operations in such a cavity as this which can hardly remain aseptic it is not surprising that when the graft is thick the separation occurs by suppuration. I therefore think that the removal of the dead part of the graft as a deliberate measure, either by opening up the flap again or by irrigation through the meatus, is a distinct gain in treatment. All dead tissue is removed, the thinnest conceivable layer of epithelium covers the fenestra, and the final healing is markedly hastened. Though, of course, a thin graft is to be desired yet with this improved method an extreme degree of tenuity of the graft becomes of less importance. The thicker the graft the more necessary is it to remove the slough and the greater the benefit that is thereby gained. After the cavity has been dried the small plugs covered with powder are again inserted. This tamponing cannot be perfectly effected unless the mastoid flap has been thrown forwards, and especially is this true of the lower part of the tympanic cavity which often lies far below the level of the osseous meatus. At the end of a week these plugs are easily removed through the meatus by means of speculum and forceps. This is accomplished without pain as the bone surface is healed. The further treatment consists in dry gauze tamponing until the gauze returns unstained. The last place to heal is a cartilage granulation which usually presents just inside and behind the lower margin of the meatus. Last year I saw Herr Geheimrath Professor Trautmann employ acetate of aluminium gauze for tamponing and in order to check exuberance of granulations the surface was painted with trichloroacetic acid (10 per cent.) two or three times a week. This plan or the employment in the same way of solution of chloride of zinc (40 grains to the ounce) I have found to be admirable.

To sum up, the scheme which I now adopt for dealing with chronic suppuration in the temporal bone, stated briefly, is: (1) The removal of the disease and the fashioning of the meatal flap; (2) one week later the epithelial grafting operation; (3) a few days (from the sixth to the ninth day) after this, and the earlier the better after the graft has taken, the removal of the dead portion of the graft as a deliberate measure; and (4) dry gauze tamponing through the meatus until the gauze comes away unstained. In three weeks the inner bony boundary is dry and any moisture which appears on the plugs later is from the inner surface of the mastoid flap. The critical part of the healing process is thus early completed. What happens afterwards is of less moment. In from five to six weeks from the first operation, in the majority of cases, the operation cavity is soundly healed. I know of no other method which can be relied upon to give such results.

The operation for the cure of chronic suppuration in the temporal bone is practised abroad almost exclusively by highly skilled operators who have devoted special attention to the subject. In this country it would appear to be considered within the competence of all. In skilled and careful hands it is attended by no more risk than other great operations, but to quote a remark from a French book on Surgery about another operation, if it is undertaken by "the rash, the ill-informed, and the ill-equipped,"³² there is grave risk of disaster or injury to the patient, or perhaps still greater risk of failure to cure the disease, from the operation being ill-conducted and incomplete.

Again, great operations are not brought to a successful issue by those who, like Bunyan's "Mistrust" and "Timorous," turn back when confronted with the "Hill Difficulty," saying one to another: "The further we go the more danger we meet with; wherefore we turned and are

going back again."³³ Nor are the over-confident in much better case for

"When men think they most in safety stand
Their greatest peril often is at hand."³⁴

The operation for the removal of chronic suppuration from within the temporal bone should therefore only be undertaken when the operator has carefully and specially prepared himself for its performance. I have known it to be more difficult to complete *perfectly* and to require a more sustained mental effort than the operation of resection of a portion of intestine, of removal of a gall-stone from the common duct, or of removal of a tumour of the brain.

"Much more in this great work,
(Which is almost to pluck a kingdom down
And set another up) should we survey
The plot of situation and the model;
Consent upon a sure foundation;
Question surveyors; know our own estate,
How able such a work to undergo."³⁵

It must not be supposed that in my view every case calls for the formal execution of every detail with rigid uniformity. Far from it. Every case must be treated upon true surgical principles, but the details necessarily vary with the exact requirements of each particular case. Before actual personal experience is acquired the experience of others will be given perhaps more than its due weight; as personal experience increases, so will the operator perceive how best he may vary the plan that has been imparted to him. Only a part of the art of surgery can be taught, the surgeon needs it all.³⁶ "Imitation is born with us, what should be imitated is not easy to discover."³⁷

The observations contained in this paper are only offered as a small personal contribution to the progress of a great and pressing subject in surgery and by no means as a final settlement of the matter.

"Assumptions hasty, crude, and vain
Full oft to use will Science deign.
The corks the novice plies to-day
The swimmer soon shall cast away."³⁸

DESCRIPTIONS OF FIGURES ILLUSTRATING THE COMPLETE MASTOID OPERATION. (TWO-THIRDS NATURAL SIZE.)

First Stage.

Fig. 1.—The dark continuous line shows the incision recommended. Whatever incision is chosen it is essential that the area of operation should be freely exposed. The portion of skin between the dotted and the continuous lines is removed at the final operation. This varies in width and the objects attained are (1) the replacement of the pinna, which tends to drop downwards and forwards, and (2) the final line of cicatrization lies more under cover of the pinna and nearer its attachment.

Fig. 2 shows the antrum opened and the posterior surface of the membranous meatus exposed. The fashioning of the flap of the membranous meatus is done at this stage of the operation so as freely to uncover the bone forming the outer boundary of the attic.

Fig. 3.—The meatal flap. The posterior half of the inner extremity of the meatus is displaced outwards. The floor of the meatus is seen being divided by the knife right out to the concha.

Fig. 4.—The meatal flap. The dotted line shows the line of incision at the junction of the posterior half of the outer extremity of the membranous meatus with the concha. The outer extremity of the meatus is enlarged but there is no visible deformity.

Fig. 5.—The meatal flap. The knife is shown making the cut described under Fig. 4.

Fig. 6.—The meatal flap. The incisions in the membranous meatus completed.

Fig. 7.—The meatal flap. The flaps above and below freed from cartilage are shown stitched to the raw surface of the mastoid flap. The dotted line shows the inner angle of the upper flap which must be cut off in order to expose the outer wall of the attic and which if left gets in the way of the burr or gouge.

Fig. 8 shows the first stage of the operation completed.

Second Stage.

Fig. 9 shows the graft on a lifter placed over the bone cavity. It will be noticed that the sutures of the meatal flaps have been removed.

Fig. 10 shows the graft lying over the bone cavity, the lifter having been taken away. The air is now about to be sucked by means of a pipette from underneath the graft.

Fig. 11 shows the graft lying against the inner walls of the tympano-attico-antral cavities and slightly overlapping their vertical boundaries. Note that the graft is not allowed to pass below the lower margin of the antrum. On the outer boundary (inner surface of the mastoid flap) two smaller grafts have been applied. Note that a portion of each graft has been coaxed round the edges of the external meatus—the posterior half of which is a raw cut edge.

Fig. 12 shows the portions of the two grafts on the inner surface of the mastoid flap appearing on the external aspect of the meatus. They

³³ The Pilgrim's Progress.

³⁴ Drayton: The Barons' Wars, Canto vi., v. 44.

³⁵ King Henry IV., Part 2, Act i., Scene 3.

³⁶ "It is but a part of Art that can be taught; the Artist needs it all." Wilhelm Meister's Lehrjahre, Book vii., Chapter 9. Carlyle's translation.

³⁷ Ibid.

³⁸ A. H. Clough: The Higher Courage.

³² "Téméraires, ignorants, et mal outillés," Traité de Chirurgie; Duplay-Reclus, tome viii., p. 51.

are thus caused to cover the raw cut edge which forms the posterior half of the new meatus.

Third Stage.

Fig. 13 shows the graft sloughs removed on the seventh day. The large one is from the bone cavity. They were washed in salt solution and then sketched. The edges are grey and gangrenous.

Fig. 14 shows the graft sloughs removed on the sixth day. They were drawn immediately after being removed. Their edges are black and gangrenous. The large slough is from the bone cavity and shows a cast of the tympano-attic cavity.

NERVE SUTURE AND NERVE REGENERATION.

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THE question about the changes that take place in a nerve when it is interrupted has for more than half a century been the topic of numerous investigations. Reading through the literature, however, one gets the impression that there has been accumulated a fund of observations—gained partly by new and excellent methods of investigation, partly by researches in the clinical material—that has made the question more acute. In this place it will only be possible to mention shortly the different views.

Waller showed that when a nerve is cut degenerative changes will take place in the whole of the peripheral part of it. Views have been divergent as to the pathological significance of these changes and which parts are essentially touched by them. Waller and Bruch suppose that the nerve is totally ruined, while Schiff and Philipeaux and Vulpian think that the degeneration only touches the myeline sheath while the axis cylinder is left. Neumann and Eichhorst suppose that the myeline sheath and axis cylinder are altered by chemical change to a homogeneous mass out of which by differentiation new nerve fibres are formed. Most observers have found that the sheath of Schwann is not ruined, while the myeline sheath and axis cylinder in the whole peripheral and part of the central segment are broken into smaller and smaller pieces that disappear by re-absorption or phagocytosis. At the same time the nuclei of the sheath of Schwann become elongated and arrange themselves parallel with the nerve fibre; they become surrounded by protoplasm that takes the place of the myeline sheath and the axis cylinder, and as a result there will be protoplasmic bands with nuclei. According to the view of Waller a nerve is totally ruined when severed from its trophic centre. He therefore presumed that the regeneration only can occur by the growing out from the central part of the new fibres. Ranvier contends that the axis cylinders of the central end grow into the old sheaths of Schwann in the peripheral part which only formed a conductor for the new fibres. With this view Vanlair, Howell and Huber, Stroebe, Kolster, Gurwitsch, and others agree. On the other side it has been asserted that new fibres are formed in the peripheral part, either by the transformation and fusion together of cells or by the differentiation of the protoplasm that surrounds the nuclei of the sheath of Schwann. The new-formed fibres grow secondarily together with the fibres from the central end. Philipeaux and Vulpian found that regeneration might occur in the peripheral part even if there were no communication with the central end. By this it seemed that the question of the regeneration of the nerve was finally settled. Vulpian, however, afterwards came to the conclusion that the regeneration was due to connexion with the central organ by anastomotic fibres. Lately, however, Kennedy, Bethe, and Ballance and Stewart reasserted that nerve fibres can be formed without connexion with the central organ. It soon proved difficult to bring Waller's interpretation about the dependence of the nerve on its connexion with the trophic centre to correspond with clinical experience. Paget has reported two cases where sensibility was observed ten and 14 days respectively after the nerves had been cut and he therefore concludes that the nerves had been united without degeneration having taken place, as there was no evidence that nerve fibres could be formed so rapidly. Numerous other instances of early restoration of function as examples of healing by first intention of different nerves have been published. Schiff and Bruch supposed that degeneration was not necessary; but almost all later observers have come to the conclusion that it always

takes place after severing the nerve. Gluck by experiments on animals found that the nerves could conduct impulses after 70 hours. By microscopical examination he found only granulating tissue at the place of union, and therefore he concluded that this might be conducting, supposing that the granulations might contain "specific nerve granulations." In this scarcely anyone has agreed with him so far as can be seen. On the contrary, attempts have been made to explain the early return of sensation by the conduction of the impressions through other nerve courses, through nerve nets or nerve anastomoses or recurrent sensory fibres. Or the explanation has been supposed to be that the same area can be innervated from different nerves.

These involved circumstances have been thoroughly discussed by Leegaard, who insists that the symptoms caused by the interruption of a nerve are contingent on the pathological conditions of the interruption and that no assistance from other nerves takes place. To illustrate the conditions that are taking place after injury to the peripheral nerves a series of cases will be related. Two of the cases were treated at the Rigshospitalet, Christiania; the third case was kindly given to me by Dr. Jakob Roll. The electrical examination has been done at the ward for nervous diseases.

CASE 1.—A girl, 15 years of age, was received into the hospital on Nov. 13th, 1899. While at work she came too near a knife-machine and received a wound 12 centimetres in length over the middle of the forearm. Most of the flexor muscles were cut through and on the radial side the wound went into the bone. The radial and ulnar arteries, the superficial branch of the radial nerve, and the ulnar nerve were cut through. The nerves were sutured with thin silk. On the 16th the patient could feel pricking with a needle in the area both of the radial and of the ulnar nerve. On account of the bandage it could only be tested on the fingers. On Dec. 5th she could bend and stretch the fingers, though incompletely and slowly. She could feel pricking with a needle over the ulnar area as pressure and over the radial area as pain.

CASE 2.—A man, 26 years of age, was seen on August 27th, 1899. He was cut with a knife over the left forearm. The tendons of the palmaris longus, the flexor digitorum sublimis, and the flexor carpi ulnaris, and the ulnar nerve and artery were cut. The patient had no sensation in the area of the ulnar nerve. The central and the peripheral parts of the nerve were isolated and sutured with three silk sutures. The wound healed by first intention. On Sept. 16th the patient was still anæsthetic in the little finger but had good sensation in the rest of the ulnar area.

CASE 3.—A boy, four and a half years of age, was seen on June 18th, 1902. The left peroneal nerve had been cut just below the knee. It was immediately sutured. On the next day the patient asserted that he could feel a touch on the upper part of the foot with the finger. On the 20th he could feel when the upper part of the foot was touched with a pad of cotton wool. On the 26th he could feel when the extensor side of the toes and a little of the upper part of the foot were touched gently. The centre of the upper part of the foot felt pricking with a needle, but less than the corresponding part of the other foot. The foot and toes were flexed and he could not extend them. The sensation was asserted to have been better on the 19th than it was on this day.

CASE 4.—A male patient was admitted into the hospital on Dec. 7th, 1901. 14 weeks previously he had had a complicated fracture of the middle of the upper arm. After some time had elapsed it was noticed that he could not stretch the wrist and could scarcely stretch the arm at the elbow. He also seemed to have less sensation on the dorsal side of the right forearm and hand than on the left. Sensation had improved a little during the previous weeks. On admission the hand could be stretched 25° in the wrist when the fingers were kept flexed. The fingers could be stretched in the distal and in the middle phalangeal joints but not in the metacarpo-phalangeal joint. He could supinate and flex the arm at the elbow but with little power. The extensor muscles were atrophied. The radial¹ (musculo-spiral) nerve gave no reaction to the galvanic or the faradic current. There was slight anæsthesia over the upper two-thirds of the extensor side of the forearm. (Plate I., Fig. 1.) The operation was performed on Dec. 13th, 1901. The radial (musculo-spiral) nerve was laid bare on the middle

¹ It will be seen that Dr. Henriksen uses the term "radial nerve" to express both the musculo-spiral nerve (nervus radialis) and its continuation, the radial nerve of English nomenclature. We have therefore added the words "musculo-spiral" in those places where Dr. Henriksen refers to that nerve under the term "radial."—Ed. L.