OTITIC MENINGITIS.*

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By the term meningitis is to be understood an inflammation of the meninges of the brain and the spinal cord produced by a micro-organism. If an inflammation of the meninges arises secondary to and due to septic disease of the ear, then it must be regarded as a septic meningitis, whether or not an organism has been found in the cerebro-spinal fluid. The purport of this thesis is not so much the academic consideration of individual features of otitic meningitis, as the desire to deal with conditions which tend to be progressive, and which may lead to the fatal disease that we all know.

Much work has been done recently by Kopetsky, Ballance, Eagleton, and others on the advanced stages of meningitis in which micro-organisms have been found in the cerebro-spinal fluid, obtained by lumbar puncture, and a good deal of attention has been given to the operative treatment of these stages; but the conclusion arrived at after careful study of these works is, that we must diagnose and treat the disease at a much earlier stage than that described, if surgical treatment is to have a reasonable chance of success. There are a few cases on record of recovery from septic meningitis even after micro-organisms have been found in the cerebro-spinal fluid, but these are only exceptions to a very general rule that meningitis, when it reaches this stage, is practically a fatal disease.

In these circumstances it remains for otologists to recognise and determine: (1) The septic affections of the ear that are prone to cause meningitis, so that the observer will be more prepared and more likely to diagnose this intracranial complication at an early stage. (2) The symptoms and signs that are associated with the early stages of meningitis, as well as those of the later stages of the disease. (3) The symptoms and signs that will indicate the region of greatest intensity of the inflammation, as well as the probable limits, if any, of the affected area.

Before attacking these problems it is necessary briefly to review other subjects that have a bearing on their elucidation.

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Otitic Meningitis

Pathology and Pathological Anatomy.

The study of otitic meningitis from the pathological standpoint resolves itself into the application of the principles of inflammation to the complicated meningeal system.

The causative factor is a colony of micro-organisms, situated either in the ear, or in some closely related structure infected from the ear, or in the meningeal system itself, but the progress, pathological and clinical, depends as much on the resistance of the individual to the organism and its toxins as on the nature of the actual organism.

The science of bacteriology has not been helpful to the otologist, except in so far as it affects the general principles of the surgical treatment of septic lesions. There does not seem to be any definite relation between the nature of the organism and the clinical progress. Apparently any of the pyogenic organisms may be causative either of a very acute or of a very chronic type of meningitis. The "strain" or type of a particular organism probably has a relation to the clinical progress, and an endeavour should be made to extend our knowledge in this direction, as possibly the time may come when such knowledge may be valuable in the treatment of meningitis.

It may be useful briefly to consider what is happening in the tissues about a slowly progressing small pyogenic infection in, say, the subcutaneous tissue. In the centre of this area there may be a collection of pus, then a zone of dead tissue in which will be found dead and dying polymorphonuclear leucocytes and some micro-organisms; beyond this is the advancing line of micro-organisms. The line may be so defined in some instances as to appear as such under the low power of the microscope; further beyond is an area, varying in extent, of altered connective tissue filled with polymorphonuclear leucocytes. Furthest from the point of maximum infection is an area in which will be found proliferating connective tissue cells, plasma cells, and lymphocytes. In addition, there are the "general effects" of a localised infection.

Meningitis of aural origin may, up to a point, be compared with such an abscess formation. In this instance the infection is extending from the ear, or some part infected from the ear, towards the meninges. In the early stages, the advancing line of infecting organisms will be outside the dura mater,

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but nevertheless the inflammatory changes within the dura, if present, must be regarded as being of a septic nature. These changes have a parallel in the two outer zones of the abscess described above. The line of organisms may reach the inner surface of the arachnoid mater, and the more advanced stage of septic meningitis be thus established and changes appear parallel to those of the inner zones of the abscess formation. There are, then, theoretically, two degrees of septic meningitis, one in which the organisms have not reached the internal surface of the arachnoid, and the other in which they have invaded the sub-arachnoid region. This is a theoretical classification, clinically recognisable only in extremely early and late stages, and of no practical value.

An extra-dural abscess is the simplest form of meningitis. In such a condition, only the outer surface of the dura may be affected. The dura mater is very resistant to the passage of infection, except, possibly, where vessels and nerves pass through the membrane, and at the cranial sutures. Weed has demonstrated the impermeability of the arachnoid mater to fluid injected into the subdural space, and it seems as if that membrane is also resistant to the passage of infection. Again, there is evidence that the pia mater is also very resistant to the passage of infection from without. A piece of the cerebellum with its meningeal coverings was removed post-mortem from a case of otitic meningitis (secondary to lateral sinus thrombosis), and examined microscopically. Polymorphonuclear leucocytes crowded the spaces of the sub-arachnoid tissue, but in the loose tissue of the pia, and in the sulci into which the sub-arachnoid space had not extended, there were only numerous plasma cells and a few lymphocytes. Although not demonstrable, there were probably organisms in the sub-arachnoid region; it is, however, unlikely that there were any in the meshwork of the pia mater in association with the plasma cells and lymphocytes. There is, then, a definite stage in which the sub-arachnoid space is certainly infected, and yet the pia mater and brain may be but slightly involved without any obvious destructive changes. In another specimen removed post-mortem from a case in which the changes appeared to be similar, on microscopic examination, there was to be seen a destruction of brain tissue, and a marked polymorphonuclear leucocytosis in the parts involved. It was not obvious that the invasion of the brain tissue was along the cerebral vessels.

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Obvious meningitis of the sub-arachnoid region may occur, secondary to ear disease, without any macroscopic evidence of disease of the dura mater, and so far I have not been able to demonstrate the track of micro-organisms microscopically.

The Cerebro-Spinal Fluid.—The study of the changes in the cerebro-spinal fluid in meningitis is of the utmost importance. These changes have been regarded as affording the most reliable information as to the nature and stage of the meningitis, but there is reason to believe that this source of information is often unreliable, and can only be of full value when considered together with the clinical features.

As the advancing front of micro-organisms approaches the arachnoid, the sub-arachnoid region with the cerebro-spinal fluid is doubtless undergoing changes corresponding to those described as occurring in the outer zones of inflammation.

As the process of inflammation continues to spread inwards, the sub-arachnoid region becomes correspondingly involved by the different inflammatory zones, until finally the organisms themselves have invaded the sub-arachnoid tissue, which now shows the destructive changes characteristic of the inner zones.

It is of the utmost importance, when estimating the value of the evidence obtained by examination of lumbar puncture fluid, to take into account the site of maximum infection. The character of the fluid at the region of maximum infection is not necessarily represented by the sample obtained on lumbar puncture, which has only a relative value.

It would be valuable to know where the various pathological elements originate. The cells, if formed only at the site of maximum infection, must be free, and must obviously be carried by some means for considerable distances from this point. This seems unlikely, and I would venture to suggest that the presence of a localised area of inflammation may produce effects extending over a much greater part of the cerebro-spinal fluid system, in consequence of which, cells may be formed at a spot considerably distant from the original area, and be found in the lumbar puncture fluid. Micro-organisms in an inflamed area may reach distant parts by direct extension, not by the mere mechanical action of the circulating fluid; one would not therefore expect to find them in the lumbar puncture fluid until the more advanced stages of the disease have been reached.

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When the inflammatory process directly involves a sub-arachnoid cistern, as, for example, in a patient suffering from labyrinthitis, the changes are very marked, and rapid in progress: on the other hand, when the meningitis is spreading in the sub-arachnoid space, without involving a cistern, as in a case of primary infection through the roof of the middle ear, then the changes are less marked and less rapid, and the lumbar puncture fluid, in these circumstances, is less likely to indicate the true condition at the site of maximum infection, than is the case in the former instance.

There are, then, two principal factors influencing the character of the changes observed in the lumbar puncture fluid: (1) The site of maximum infection. (2) The stage reached by the inflammatory process. My experience has led me to believe that differences in the character of the lumbar puncture fluid depend far more upon these two factors than upon the particular effect of any given bacterial toxin.

Infection of the Meninges of the Middle Fossa.—The path of infection has been through the roof of the middle ear in all the cases that have come under my personal observation. Mr Arthur Cheatle, at the International Congress of 1899, drew attention to the petro-squamosal suture in the roof of the middle ear, and showed that vessels pass through the suture between the petro-squamosal sinus and the veins of the sub-mucous tissue. He suggested that this intimate relation between middle fossa and middle ear, probably accounted for certain intracranial complications of middle-ear suppuration. The anatomy of the part is very suggestive, as is also the fact that middle fossa infection is less common in adults than in children in whom these anatomical features are more marked. It is difficult to find definite evidence that infection of the meninges of the middle fossa is secondary to septic thrombosis, either of the petro-squamosal sinus or of the veins from the middle ear to the sinus, but it is possible that this may sometimes be the case. In most of the cases amongst children under my personal observation, no obvious change could be found in the bone or in the dura mater of the roof of the middle-ear cavity. In adults, gross changes are more common. In some, there is an extra-dural abscess with necrosis of the bony roof of the middle ear, and, in others, abscess is found without any change in the bone.

The intra-dural complications usually met with when there

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are gross changes in the roof of the middle-ear tract are those of localised meningitis and meningeal or cerebral abscess, not those of general meningitis. When infection of the arachnoid and sub-arachnoid space has occurred, there is a tendency for it to spread in an upward and inward direction from the site of infection, rather than forwards or backwards. Very often, at death, no exudate is found at the anterior or posterior parts of the cerebrum. This distribution of the exudate rather suggests that infection produces the maximum effect in the part of the cerebro-spinal fluid system where stagnation has occurred owing to obstruction by the inflammatory exudate.

The changes in the cerebro-spinal fluid cannot be co-ordinated with the condition of the middle fossa, as the early state of the disease can very rarely be seen by post-mortem examination, but there seems no doubt that by careful consideration of the clinical progress of those cases which have been examined post-mortem, we may safely arrive at the conclusion that the changes in the cerebro-spinal fluid obtained by lumbar puncture, in the early and even in the late stages of infection of this spongy region of the sub-arachnoid space, may be comparatively slight. The gross changes in the cerebro-spinal fluid do not occur until infection of the cisternæ takes place.

Posterior Fossa Infection.—Infection of the meninges of the posterior fossa may occur by way of the labyrinth and through the posterior wall of the antrum, or they may be secondary to septic thrombosis of the lateral sinus. In those cases which I have personally studied microscopically, the infection has passed from the labyrinth to the meninges, along the elements of the auditory nerve, to the internal auditory meatus. In one case polymorphonuclear leucocytes in numbers were found in the aqueductus Fallopii as far as the internal auditory meatus, indicating a possibility of infection by this route. It is important to note that the infection reaching the meninges by the labyrinth involves the cisterna pontis direct, whereas all other infections are primary infections of the spongy sub-arachnoid space, the involvement of the cisternæ being secondary. Post-mortem examination—necessarily of the late stages—shows the presence of exudate on the surfaces of the pons, medulla, and cerebellum in relation to the cisterna pontis, at the foramen magnum on the anterior and lateral aspects of the medulla and spinal cord, and also at the opening in the

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tentorium cerebelli. It is worthy of note that, in some cases, the cisterna magna and even the posterior part of the upper portion of the spinal sub-arachnoid space remain free from exudate, even though the fluid in the ventricles is markedly turbid. The degree of affection of the middle and anterior fossæ varies considerably.

When the infection follows septic thrombosis of the lateral sinus, the trabeculated sub-arachnoid space is involved primarily and the cisterna pontis secondarily. As might be expected, the exudate indicating the region of maximum infection is mainly on the cerebellum of the side affected, and has, in addition, a distribution similar to that found when the cisterna pontis is directly affected.

Meningitis Following Abscess of the Brain. — The commonest cause of death in patients with abscess of the brain is meningitis. The term "abscess of the brain" has been used rather loosely, the diagnosis having been made in many cases that are really instances of abscess of the sub-arachnoid space. A clear distinction should be made between these two types of intra-dural abscess. The sub-arachnoid abscess, more common in the posterior than the middle fossa, is a localised meningitis, and has commonly associated with it some definite changes in the cytology of the cerebro-spinal fluid, whereas in abscess of the brain these changes may be but very slight. Again, with sub-arachnoid abscess there is often mass destruction of tissue from the middle ear to the abscess. This abscess "stalk," as described by Ballance, is often microscopic in true abscess of the brain. The method of spontaneous infection of the meninges, beyond the region of the abscess, is obscure, but when it has occurred the pathological process is similar to that found in the condition above described.

Symptoms and Signs of Meningitis.

In every case of aural sepsis there lies the possibility of intracranial complications, and we must endeavour, by complete examination, to lessen any risk of missing the earlier stages of meningitis. Even when all care is taken, the early clinical signs of the disease will sometimes be so obscured by the symptoms and signs of the acute or subacute inflammation in the ear as to appear to be part of the effect of the latter.

The analogy between peritonitis and meningitis is not,

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perhaps, perfect, but it may serve to emphasise the importance attaching to any clinical investigation that may help to define the site of maximum infection. It is on this basis that I intend to attack the question of symptomatology. It is only within the last few years that the importance of this aspect of meningitis has become clear to me, and as we do not see many cases in the early stages, there has not been, so far, sufficient material to allow of complete corroboration of my thesis. There are doubtless some helpful symptoms and signs that have not yet been recognised.

Early Symptoms and Signs in Relation to Site of Primary Infection.—The character of the early symptoms and signs depends, firstly, on whether the primary infection has occurred in the cisterna, or in the trabeculated sub-arachnoid space, and secondly, on whether the invasion is in the posterior or middle fossa.

Primary infection of the cisterna pontis can only occur through the labyrinth. In all the early cases of such infection that have come under my notice, the meningitis has followed soon after the destruction of the labyrinth. Recognition of this early stage is due to the fact that in all cases of acute labyrinthitis I have regarded meningitis as a probable complication, and have therefore made a complete examination to decide whether or not the inflammation has extended beyond the labyrinth.

When meningitis has followed an extension of infection from a labyrinth which has been destroyed at some remote date, the inflammation has usually passed beyond the early stage before the patient applies for treatment, and the surgeon sees him for the first time with symptoms of meningitis which are obvious. In cases of acute septic labyrinthitis, the patients apply for treatment because of the severe and alarming symptoms due to this condition, which usually completely mask those of the associated meningitis when present. We need not consider the details of the symptomatology of acute labyrinthitis, but may content ourselves with reference to the great nausea, vomiting, and occipital pain, which are common to both conditions. In the cases of acute labyrinthitis that have been under my care in recent years, the lumbar puncture fluid has always been examined, and has usually been found to be normal.

The path of infection is probably by the internal auditory

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meatus, and as the sub-arachnoid space in the canal is a kind of "backwater," it is conceivable that the infection may, for a short time before invading the cisterna pontis, remain local and not give rise to any symptoms or signs (beyond the comparatively slight changes in character of the cerebro-spinal fluid) that would not be overshadowed by the effects of the acute labyrinthitis. With the invasion of the cistern, however, there arises a further set of symptoms and signs due to the effects on the cerebro-spinal fluid system, and associated mainly with a rise in the intracranial pressure. The symptoms may still be obscured to some extent by the labyrinthitis, but there are certain features which are distinctive. One of the most obvious signs of the change is the appearance of a slight torpidity without irritability, a feature recognised by the friends if not by the surgeon. Vomiting commonly occurs, but this may, of course, be due to the labyrinthitis. The temperature is seldom more than 100° or 101°. In the early stage of involvement of the cistern the pulse rate is not, in my experience, in proportion to the temperature, and is usually low. The occipital headache is bilateral, not localised to the side of the affected ear; there may be some frontal headache as well. At a later stage the pain may be described as general, but more intense over the occipital region. Sometimes there is distinct tenderness at the attachments of the posterior cervical muscles to the occiput, and rigidity of these muscles gradually develops. This rigidity is sometimes difficult to demonstrate until a more advanced stage has been reached, but by extending the dorsal spine by means of pillows placed under the patient, it is often made more obvious. Kernig's sign is usually present, and, as the intracranial pressure rises, the knee-jerks tend to become sluggish, or even to disappear on one side or the other. If continuous sub-arachnoid drainage be satisfactorily established at this stage, all these symptoms and signs may disappear, leaving for the time being only the general picture of a local sepsis, with the symptoms of a labyrinthitis. If, however, the intracranial tension is not relieved, and the inflammation progresses, then the familiar symptoms of advanced meningitis make their appearance. In regard to the significance of changes in the fundus oculi, I am inclined to think that the condition of the fundus does afford some evidence as to the progress of the disease, but I believe that papillœdema is not usually present in the earlier stages.

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Otitic Meningitis

The following is an example of the examination of the cerebro-spinal fluid obtained by lumbar puncture from a case of early affection of the cisterna pontis. The patient had bilateral acute mastoiditis with acute labyrinthitis on the right side. There were no symptoms or signs of meningitis beyond the changes in the cerebro-spinal fluid:—

1. Fluid turbid, 5 c.c. withdrawn; total cells, 400 per c.mm.; lymphocytes, 95 per cent.; plasma cells, 4 per cent.; polymorphonuclear, a few; sugar increased in amount.

2. Fourteen hours after the radical mastoid operation on the left side and labyrinthotomy on the right side, 5 c.c. of cerebro-spinal fluid yielded: total cells, 2120 per c.mm.; polymorphonuclears, 90 per cent.; lymphocytes, 10 per cent.; sugar diminished; globulin well marked; no organisms seen and cultures sterile.

3. Twenty-four hours after translabyrinthine drainage, 5 c.c. of cerebro-spinal fluid yielded: total cells, 900 c.mm.; polymorphonuclears, 70 per cent.; lymphocytes, 25 per cent.; plasma cells, 5 per cent.; sugar diminished; globulin less than before; no organisms and cultures sterile; recovery.

There seems strong evidence in these changes, taken together with the clinical aspect of the patient, that the condition was progressive and would probably have ended in general meningitis if the translabyrinthine drainage had not been done. Although there was no direct evidence that the organisms had reached the sub-arachnoid space, I venture to state that they had, in all probability, reached at least as far as that "backwater" in the internal auditory meatus.

Primary Affection of the Trabeculated Sub-arachnoid Region.—Inflammation in this part of the sub-arachnoid space usually spreads comparatively slowly, and the early symptoms are therefore more those of a local than those of a spreading inflammation. The infection does not occur through the labyrinth, in my experience, and so the symptoms of meningitis are masked only by those of the acute condition in the middle-ear tract. In the early stage of involvement of the temporo-sphenoidal region, the only complaint may be one of indefinite pain in the region just above the affected ear, or immediately anterior to this. Constant well-defined pain, in this region, in a case of acute aural sepsis, strongly suggests meningeal inflammation. In the early stages the pain may be only slight, but later it may become so severe as to prevent

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sleep and to obliterate all other symptoms. Not uncommonly this area is tender on percussion. Associated with the increased pain of the later stage, there is often marked irritability. The temperature is usually raised to 101° or 102° F., the pulse rate being in proportion to the temperature (*c.f.* early stage of cistern infection). There may be signs of cerebritis before there are any marked indications of increased intracranial pressure. When the disease reaches the cisterna basalis and the whole series of cisterns becomes involved, the pathological conditions of general meningitis obtain, and the resulting clinical picture is similar to that produced by primary infection of the cisterna pontis with secondary extension on to the surface of the cerebrum.

It is peculiar to this distribution of the meningitis that the lumbar puncture fluid shows comparatively slight changes until an advanced stage is reached, probably until the inflammatory process involves the cisterna basalis.

It is the early stage of this type of lepto-meningitis that most often of all passes unrecognised, probably because otologists pay too little attention to what the patient complains of, and are apt to rely too much on physical signs. Headache, especially when localised to the affected side, should be considered with the greatest respect, even when unsupported by any other symptom or sign, no matter whether the ear condition is acute or chronic.

Affections of the sub-arachnoid space in the posterior fossa have, in my experience, always been secondary to lateral sinus thrombosis, or to abscess (sub-arachnoid or intra-cerebellar), and, in these conditions again, the symptoms of meningitis are obscured until the disease has reached the cisterna pontis.

It is well to remember that the symptoms and signs of a well-advanced lepto-meningitis may be entirely removed by morphia, and its administration is obviously undesirable until the clinical examination has been completed. It seems possible that atropine may also affect the clinical picture by altering the intracranial tension.

The general effects of lepto-meningitis are those of any other localised septic process, though at times obscured by the local effects. A cytological examination of the blood is sometimes of importance, and on two occasions has afforded valuable evidence that enabled me to give a prognosis other than that which I might have given without this information. Usually the

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leucocytosis is very great, but in some cases, when the resistance is low, the leucocyte count in the blood is low. In the two cases referred to, an examination of the lumbar puncture fluid was made, and there were about 2000 polymorphonuclear cells per c.mm. in both cases. Neither case had operative treatment beyond repeated lumbar puncture. In each case there was a sudden drop in the numbers of polymorphonuclear cells in the cerebro-spinal fluid. On cytological examination of the blood it was found that the leucocytes had diminished here also. The patients had septicæmia.

The statement, so commonly made, that septic meningitis should not be diagnosed unless organisms can be demonstrated in the cerebro-spinal fluid is, in my view, not only wholly erroneous, but dangerous. It is a matter of common knowledge that in many cases of very advanced meningitis, in which there have been no two opinions as to diagnosis or prognosis, all attempts to grow organisms from the cerebro-spinal fluid have failed. It is precisely this text-book attitude of mind in regard to the diagnosis of the condition that is responsible for our failure to adopt operative measures for the treatment of septic meningitis at a stage when there is some hope of success.

Treatment of Lepto-meningitis.

It may be regarded as fundamental in the operative treatment of lepto-meningitis, in whatsoever stage, that the causative ear disease should be eradicated as completely as possible, no matter what other additional procedure is adopted. Such treatment should be sufficient to bring about a satisfactory result in all the milder affections of the meninges (*méningite de voisinage*), when the organisms have not invaded the sub-arachnoid region. There can be no doubt that many cases of this condition are unrecognised, the more so on account of the fact that all symptoms are often entirely cleared up after adopting the radical operative measures usual in the treatment of ear disease. The diagnosis of *méningite de voisinage* is by no means easy, but, even when it has been established, it is advisable at the operation to expose the dura mater over a small area in the posterior or middle fossa, or in both these regions, and twelve hours afterwards to remove, by lumbar puncture, 5 or 6 c.c. of cerebro-spinal fluid for examination purposes; this would be a sufficient lapse of time to allow

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of the appearance of such changes as might indicate the necessity of further surgical interference.

The number of cases of lepto-meningitis treated by repeated lumbar punctures must be enormous, but in only a few of them has recovery been recorded. Lumbar puncture cannot be seriously regarded as a method of treatment for the following reasons:—Cerebro-spinal fluid is an excellent medium for the growth of micro-organisms; the intervals between successive punctures must, of necessity, be considerable, and allow ample time for the multiplication of the organism; furthermore, only a comparatively small portion of the total fluid can be removed at each puncture.

When there is no doubt that the infection has invaded the sub-arachnoid region, there can be no longer any question as to the correct procedure; drainage must speedily be established at the point of maximum infection. When, in spite of all endeavour, there is still uncertainty, then we have to balance in our minds the relative risks involved in leaving a potentially dangerous condition on the one hand and, on the other, in unnecessarily opening the dura mater. Knowing that the risks of the operation as such are practically negligible, there are probably few surgeons who, in these circumstances, would hesitate in their choice. As the endeavour throughout this paper has been to regard otitic meningitis as a condition which is at first local, and having a regional distribution over a varying period of time, it must follow that the treatment, in the earlier stages, at least, should also be regional.

Treatment of Early Affections of Cistern Region.—In a primary infection of the cisterna pontis, the natural course of the operative procedure is along the track of the infection, viz., through the labyrinth to the internal auditory meatus. This was first realised by West and Scott, who advised opening into the internal auditory meatus after performing an inferior labyrinthotomy.

Prior to the operation on the middle ear cleft which is conducted preferably under ether anæsthesia and without preliminary morphia or atropine, 5 to 6 c.c. of cerebro-spinal fluid are withdrawn slowly by lumbar puncture. The pathologist conducts his examination and makes his report before the mastoid operation is completed. If the cerebro-spinal fluid is found to be normal, the labyrinth is dealt with as seems best according to the circumstances; but in

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all cases in which there is acute labyrinthitis, superior and inferior labyrinthotomy are carried out. If, however, the report indicates that the inflammation has extended to the meninges, translabyrinthine drainage of the cisterna pontis through the internal auditory meatus is at once proceeded with.

It is important that all bleeding should be stopped before opening the internal auditory meatus. The lodgment of a clot may interfere with subsequent drainage of the cerebro-spinal fluid. The whole operation cavity is first cleaned out with hydrogen peroxide and normal saline, and even the labyrinth is syringed through and the parts are then douched with a 2 per cent. solution of iodine in alcohol. A clean set of instruments is used for the further stage of opening into the internal meatus. The flow of cerebro-spinal fluid should be free. If this does not take place, it is strong evidence that a considerable amount of exudate has formed at or in the meatus itself or possibly about the foramen magnum.

The whole cavity is now rubbed over with iodoform paste, an iodoform gauze wick is placed in the anterior part of the cavity from the inferior labyrinthotomy opening through the external auditory meatus, the remainder of the cavity being then lightly packed with iodoform gauze; the posterior wound is left open or closed, according to circumstances.

Pituitrin is given subcutaneously on the advice of Weed, who asserts that the extract of posterior lobe increases the flow of cerebro-spinal fluid; bromides are given per rectum. The foot of the bed is raised about 12 inches, and the patient lies with the sound ear uppermost.

A remarkable feature in the further progress is the extremely rapid emaciation, which is much more marked if there has been a very free flow of cerebro-spinal fluid. This may possibly be explained as being due to a loss of sugar, and for this reason I give a liberal supply of sugar with the food.

Drainage of the cisterns by the internal auditory meatus has been adopted for many reasons. In the first place, it is in the internal auditory meatus that the maximum infection must be, and therefore any procedure which leaves this back-water undrained must allow the persistence of a dangerous focus of infection. Secondly, the meatus is a natural drainage tube; the sub-arachnoid space is patent to the fundus, and the tube cannot by any means be closed by pressure of the cerebellum; whereas by any other route, with the use of india-

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rubber tubes, metal tubes, etc., there is always the possibility of the tube moving, and the orifice being plugged by brain or other tissue.

Treatment of Early Affections of Trabeculated Sub-arachnoid Region.—Treatment of early stages of lepto-meningitis in the region of the temporo-sphenoidal lobe must be on a different principle from that described above. It is necessary to do a radical mastoid operation in order to obtain free access to the region which is suspected of infection, even though the local ear condition requires only a simple Schwartze. From the upper extremity of the usual mastoid incision, I make another incision horizontally forwards and backwards, extending it upwards at either end, as necessary. The skull is exposed and removed over a considerable area in relation with the lower part of the external surface, and the outer part of the inferior surface of the temporo-sphenoidal lobe. In doing this, due care must be taken to find, if possible, the track of the sepsis from the middle ear. This area of dura having been exposed, the whole of the wound is thoroughly cleaned by douching with hydrogen peroxide (10 vols.), then with normal saline, and finally, with 2 per cent. solution of iodine in alcohol.

It is my custom at this point to withdraw a certain amount of fluid from the sub-arachnoid region by means of a hypodermic syringe for examination at a later time. I now make a crucial incision in the dura mater, turn aside the flaps, and examine the outer surface of the arachnoid. Sometimes the pus and exudate can be easily seen, but in the early stage in which I propose this operation and hope for success, the changes are not obvious, and can only be detected by microscopic and bacteriological examination of the fluid removed. The operator must be sure that he has exposed the trabeculated sub-arachnoid space by removing some of the arachnoid. This is very resistant to the passage of fluids, and must be removed in part at least. The dressing of the wound is carried out on the same principle as described above.

In treating meningitis secondary to lateral sinus thrombosis, the drainage of the cisternæ must be an important consideration, as the earlier stage of affections of the trabeculated sub-arachnoid tissue in this region is not recognised clinically. In one fatal case I removed the lateral sinus in the region of the mastoid with the surrounding dura mater, as far in as about

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the posterior semi-circular canal, and I also took away some of the arachnoid mater. The cistern was drained by means of a tube passed through the operation wound. After the operation there was complete relief from intracranial pressure, but the septic process advanced and ultimately caused death.

The Treatment of the Later Stages of Lepto-Meningitis.—How often it is felt that if the patient had been operated on sooner, there might have been some chance of success. We naturally hesitate to resort to severe operative treatment until the patient is obviously in a serious state, and thus possibly we lose the opportunity of being able to do good. The suggestion is that the maximum that can be done by drainage and washing out of the cisternæ, should be done in those cases in which the meningitis has only just passed the early stage, and has not advanced so far that the septic process has involved the pia mater, invaded the brain, or extended into the trabeculated sub-arachnoid region. This stage is difficult to recognise clinically, and it is for this reason that I examine the lumbar puncture fluid removed twenty-four hours after the translabyrinthine drainage. I feel that the probability of a satisfactory result has been increased by the adoption of this routine measure. It is only by experience that we shall learn whether twenty-four hours is or is not too long an interval; very probably it is.

If any changes in the lumbar puncture fluid indicate that the disease has advanced, and that an intermediate stage of lepto-meningitis has been reached in spite of the trans-labyrinthine drainage, then this measure must be regarded as insufficient. It is necessary to establish free drainage, not only of the cisterna pontis but also of the cisterna basalis, and I think it advisable at the same time to wash out the cisternæ with a modified Ringer's solution (glucose is omitted). The cisterna pontis may be drained by the internal auditory meatus, and in addition, by a tube in front of the cerebellum. The cisterna basalis may be opened by two routes, both of which I have found efficient; in one case I incise the dura mater near the floor of the middle fossa, and pass a No. 9 rubber catheter along the superior border of the petrous bone to the posterior part of the cisterna basalis; in the other case, by an operation in the frontal region, I introduce a catheter by the side of the falx cerebri to the cisterna chiasmatis.

The cisterna magna is usually the last part to be affected

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and may, at this stage, contain more or less healthy fluid, the bactericidal properties of which are valuable, and therefore this space should not be drained, but rather the fluid should be encouraged to flow to the affected area by drainage of the region of maximum infection.

The washing out of the cisternæ has been done in my cases, when possible, by a head of fluid (modified Ringer's solution) from the lumbar region, but the flow is usually obstructed at the foramen magnum by exudate. It is remarkable how often it is possible to draw off a large quantity of cerebro-spinal fluid, and yet find it impossible to wash through to the drainage tube in the cisterna pontis or to the internal auditory meatus, owing to the fact that the communication with the cisterna magna is maintained, whilst that with the cisterna pontis has been shut off.

In cases of obstruction to the flow of fluid from the lumbar puncture, the cisterna pontis has been washed through, in a few occasions, by a tube passed in front of the cerebellum from the opposite side into the cistern.

After due consideration, my conclusion is that the drainage and washing out above described follows the principles of treatment of a localised sepsis as nearly as possible in such a complicated region, and that my results might have been more satisfactory if the operation had been carried out at an earlier stage in the disease. I believe that the irrigation of the cerebro-spinal system advocated by Eagleton for the general "suppurative meningitis" (in which micro-organisms have been found by lumbar puncture) should be tried in this intermediate stage, which may be diagnosed by the methods described above, but I am convinced the irrigation should, if possible, be from the healthy to the diseased area.

The use of antiseptics in this region is admittedly not without danger, and may seem unreasonable; but even bearing in mind the recent work of Weed and others, I do not think this method of attack should be completely abandoned.

There are cases that must be regarded as being beyond surgical aid, and in this group, in my opinion, should be placed all those in which both the trabeculated sub-arachnoid region and the cisternæ have become involved, and a micro-organism found in the lumbar puncture fluid. Those familiar with the extent of the inflammation found in such cases on post-mortem examination must know that the probability of success from

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any surgical measure is very slight, unless some means can be found of rapidly and materially raising the resistance of the individual to the organism. I think it may be taken as proven that Haines' operation is not sufficient in such instances, and I believe that Sir Charles Ballance's suggested treatment would likewise prove a failure.

The *conclusions* arrived at from the study of this aspect of otitic meningitis are as follows :—

Firstly, we must endeavour to recognise lepto-meningitis at the early stage, when the infection is local (though this may be only for a very short period) and there is evidence of a region of maximum intensity of inflammation, since treatment at this stage has a fair chance of success. Secondly, there is an intermediate stage of the disease, the treatment of which is still a matter of investigation and experiment. Thirdly, there is a stage in which, without some great advance in internal therapeutics, the patient is beyond surgical aid.

Advance in the treatment of meningitis would, doubtless, be greatly facilitated if only it were arranged in each of our large hospitals that all cases of meningitis, from whatsoever cause arising, should be placed under the care of one team of observers, and not scattered throughout the hospital.

A detailed statement of five cases of lepto-meningitis successfully treated are reported in the *Journal of Laryngology and Otology*, 1922, pp. 354 *et seq.* Three additional cases are recorded here :—

Case VI.—E. H., female, aged 40. Admitted 12.3.16. Discharge from right ear since early life; has long been giddy; headache for ten days; no vomiting. 16th—Temperature since admission, 100° to 102° F.; continuous occipital headache; head retraction; normal reflexes; papillitis in left eye; torpidity. Radical mastoid operation; cerebro-spinal fluid very turbid; mainly polymorphonuclears and some lymphocytes. Consequently, inferior labyrinthotomy and translabyrinth drainage; small escape of cerebro-spinal fluid. 17th—No improvement; slight flow of fluid; anæsthesia and lumbar puncture combined with lavage with normal saline and eusol; fluid passed freely through internal auditory meatus. Recovery.

Case VII.—E. B., female, aged 17. Admission 1.4.14. Left ear discharged five to six years. During last two months twice brought home with "sickness and faintness." Three weeks ago, vomiting, pain at back of head and in left eye; stiffness in neck; never giddy. At 8.30 A.M., 1st April, found unconscious; she had been vomiting.

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On admission, very lethargic; winces with pressure upon left mastoid; abdominal reflexes present and equal; knee-jerks absent; left plantar extension; no papillitis; pulse 60 to 68.

Radical mastoid operation; cerebro-spinal fluid turbid; many polymorphonuclears; streptococci and short thick bacilli in films; temporo-sphenoidal lobe and cerebellum explored; lateral sinus normal; labyrinthotomy and translabyrinth drainage; turbid cerebro-spinal fluid. On 3rd, cessation of flow of fluid, and patient restless and vomiting. 5th—Flow re-established. Recovery.

Three other cases of meningitis in the cisterna pontis were treated similarly and recovered, but the records are incomplete.

Case VIII. — R. C., male, aged 16. Admitted 21.3.22 with discharge from ears off and on since infancy; from the right ear for about three weeks; slight earache and headache on right side; no vertigo; R.T.M. inflamed and perforated; no mastoid tenderness. L.T.M. cicatrised; Weber to right; whisper reduced slightly on right side; no nystagmus; Schwartze operation on right side.

4.4.22—Patient groans and is irritable; constant right-sided headache, also frontal; no occipital pain; vomiting; photophobia; no vertigo or nystagmus; reflexes good and equal. Percussion is painful on right side of head. Lepto-meningitis over right temporo-sphenoidal lobe diagnosed.

Radical mastoid operation; cerebro-spinal fluid clear; total cells 48 per c.mm.; lymphocytes 84 per cent.; polymorphonuclears 10 per cent.; plasma cells 4 per cent.; chlorides 0.715; protein 0.03; sugar slightly diminished; no organisms in films.

Mastoid incision extended above forwards and backwards; bone removed from roof of middle ear and an extra-dural swab yielded a pure culture of streptococcus longus. Bone from roof of middle-ear cleft and outer surface of temporo-sphenoidal region was removed; area thoroughly cleansed and dura mater punctured with needle; from the fluid a pure culture of same organism grown.

A crucial incision was made in dura mater and pieces of arachnoid mater removed, and the parts swabbed with sterilised iodoform and lightly packed with gauze. Recovery.

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