**Discussion on the diagnosis and treatment of abcess of the brain : opening papers.**

# Section of Otology

President—Mr. W. J. Harrison.

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## DISCUSSION ON THE DIAGNOSIS AND TREATMENT OF ABSCESS OF THE BRAIN

Opening Papers: (I) Hugh Cairns, F.R.C.S., and Charles Donald, F.R.C.S. (II) Sydney Scott, F.R.C.S.

**(I) Mr. Hugh Cairns and Mr. Charles Donald:** In opening this discussion on abscess of the brain, we will first describe methods of operation and then analyse our own material, especially the failures.

### Thick-walled Chronic Abscess

Abscesses of long duration usually have thick walls, 0·5 cm. or more in width. This group includes abscesses that for long periods have given rise to no symptoms, and abscesses which after one or more operations have continued to discharge through a sinus. Our experience shows that for these cases complete removal of the abscess and its wall is the only satisfactory treatment. Thick-walled chronic abscesses tend to be loculated or even multiple, and treatment by drainage alone will rarely result in collapse of the abscess sac. Moreover, the wall of the abscess will never be absorbed and will persist in the brain as a foreign body, which produces gliosis and is likely to result in further abscess formation at a later date. The first two cases provide examples of abscesses of this type, the one treated unsuccessfully by drainage, the other successfully by complete excision.

*Case* 1.—*Chronic abscess of right temporal lobe following gunshot wound thirteen years before. Drainage of abscess and removal of foreign body. Progressive fungus cerebri.* B. pyocyaneus meningitis. *Death. Latent chronic abscess in right occipital lobe.*

*History.*—G. S., aged 34, referred by Mr. Charles Goulden, had been wounded in the right parietal region by a bursting shell in 1915. A piece of shell was taken out of his brain twenty-four hours later, and he returned to light duty within three months. In 1919 he began to have paroxysmal attacks of headache, and in 1921, generalized convulsions. From 1924 onwards visual hallucinations occurred. He came to the London Hospital in April 1928 because his vision had been failing during the previous nine weeks.

*Examination.*—He had severe bilateral papillœdema, and visual acuity was $\frac{6}{60}$ in the right eye and $\frac{6}{9}-$ in the left eye. There was left homonymous hemianopia. Smell was lost at the right nostril. The abdominal reflexes were diminished on the left side, and the left plantar reflex was extensor. X-rays showed a foreign body in the right temporal lobe and an oval hole in the right parietal bone (fig. 1).

*Operations.*—On April 4, 1928 an abscess of the right temporal region was drained through a small incision. It lay at a depth of 2 cm. below the surface of the brain, and its capsule was so thick that a scalpel was needed to open it. The abscess was imperfectly exposed owing to great tension of the surrounding brain. Films of the pus showed staphylococci, but no organisms could be cultivated.

After this operation a fungus cerebri formed at the site of exploration (fig 2). The visual acuity and hemianopia became worse, and accordingly a second operation was performed on May 15, 1928, at which the capsule of the abscess was partially dissected out; the foreign body was removed and a hitherto undiscovered loculus of the abscess passing forwards was opened and drained. The condition was as shown in fig. 1. During the course of this operation a diverticulum of the right lateral ventricle into the fungus was opened.

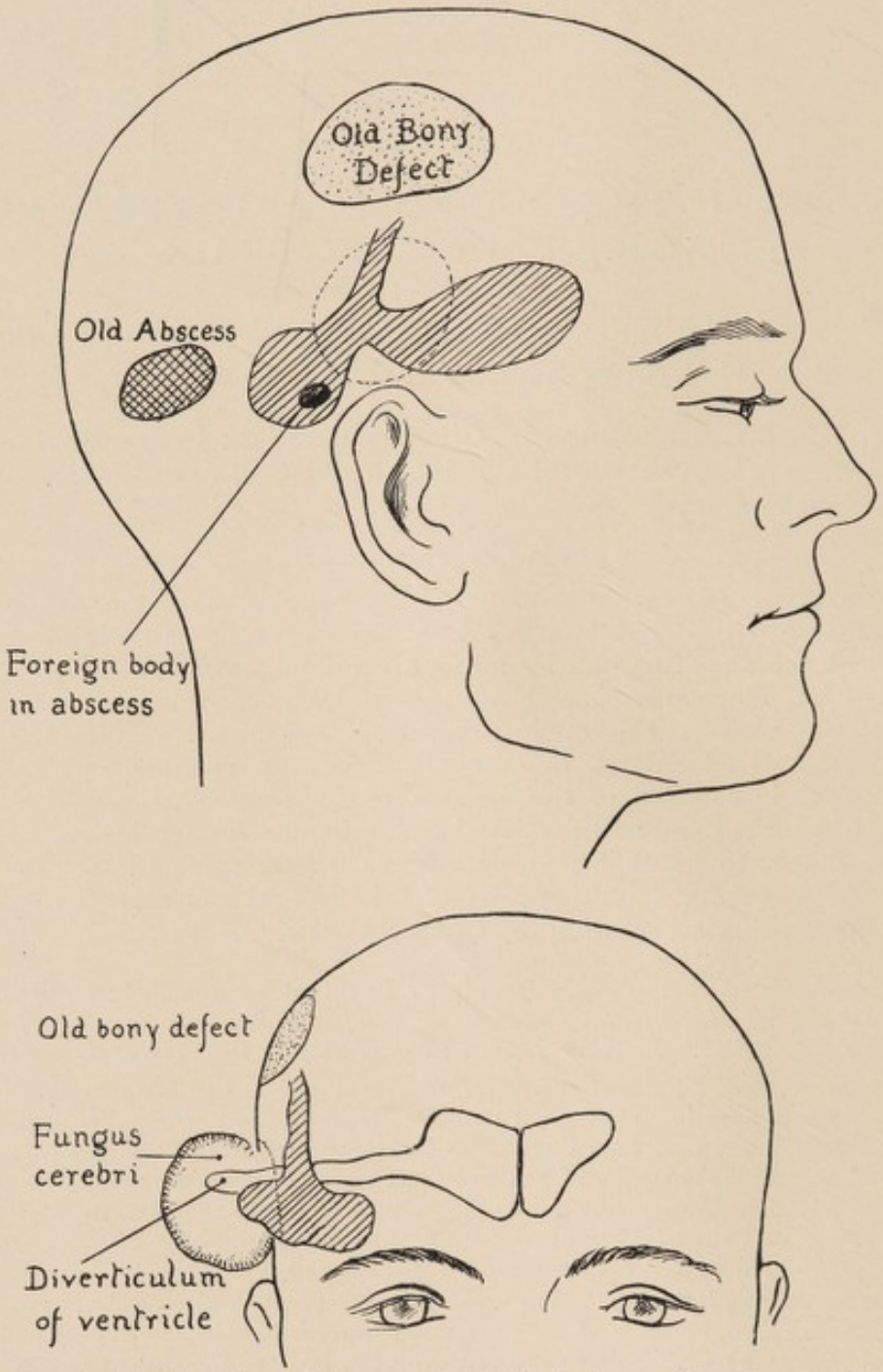



FIG. 1. *Case* 1.—Multilocular right temporo-frontal brain abscess following gun-shot wound. Latent abscess in right occipital lobe.

*Subsequent course.*—For the first two weeks after the second operation progress was satisfactory: the leakage of cerebrospinal fluid lessened and the fungus became smaller and began to heal. On June 4 signs of meningitis developed (*B. pyocyaneus* on culture of the cerebrospinal fluid) and the patient died on July 5. During the last two days of his life he had hæmatemesis, presumably from an ulcer in the œsophagus or fundus of the stomach.

Necropsy showed a moderate degree of basal meningitis and purulent ventriculitis. The abscess cavity in the right temporal lobe was empty and communicated with an outward prolongation of the right lateral ventricle. In the right occipital lobe (fig. 1) there was a solid

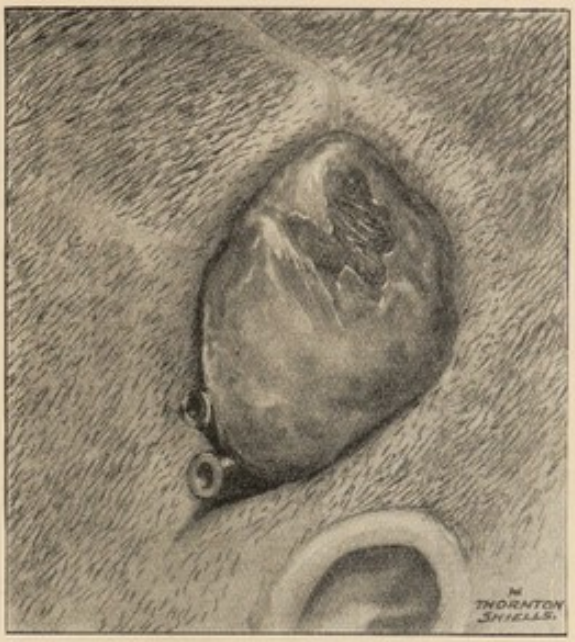


FIG. 2. *Case* 1.—Fungus cerebri following drainage of right temporal abscess. Two drainage tubes are seen at the postero-inferior edge of the fungus.

FIG. 3. *Case* 1.—Abscess of right occipital lobe. Areas of pus-cells are surrounded by dense layers of collagen. × 20.

mass of glistening white and yellowish-white tissue measuring 4·0 by 2·2 cm. which in places was almost cartilaginous in consistence, and which was found microscopically to consist of hyaline fibrous tissue interspersed with numerous old abscesses (fig. 3).

The only satisfactory way of dealing with this case would have been to dissect out the whole abscess, and to do this a wide osteoplastic exploration would have been necessary. Even if this had been done, it is likely that the latent abscess in the right occipital lobe would have been overlooked and would have become active later. From this case we learnt that it is futile to treat a chronic abscess with very thick walls by drainage, and accordingly, in the next case of this type exploration was made through an osteoplastic flap.

*Case 2.--Chronic abscess of right parietal lobe following gunshot wound nineteen years before. Complete removal. Recovery.*

*History.*—A. G., aged 47, referred by Dr. Henry Cohen, was first seen on February 5, 1934. In 1915 he had been wounded by a bullet which cut a groove in the right parietal bone but apparently did not perforate the brain. He was unconscious for a few moments only and was able to walk back to the dressing station. He was discharged from hospital six weeks later apparently well, though from that time onwards he considered that he was a little sluggish mentally. He returned to duty, but in 1921 he suffered for about a year from numbness of the left arm and leg and a strong tendency to deviate to the left when walking. The condition was diagnosed as peripheral neuritis and he was put on half pay. After several months the symptoms cleared up completely, except that from that time onwards he had numbness in the sole of the left foot whenever he was tired. In the following year he began to have occasional generalized headaches, but these were only slight until 1930, when they became severe after stooping in the garden. In 1931 he had an attack of tingling in the left upper limb spreading to the left lower limb, which was followed by clonic movements of the left upper limb. The attack lasted five minutes and there was no loss of consciousness or any residual symptom. He continued living a fairly active life until November 1933, three months before admission, when he began to notice difficulty in seeing to the left while driving a car. Shortly after this the headaches changed in type, becoming frontal rather than generalized and worse on the right side, present on waking in the mornings, and much more violent and frequent. He began to lose control of his left hand: "It did things on its own" if he didn't watch it, as for example putting his table-fork into his pocket. After he had put his matchbox away in his pocket he would still "feel" it in his hand for a long time. At other times he would find it difficult to put down an object held in his left hand: he would still be holding a cigarette case in his left hand when he wanted to use the hand for something else. At times, for no reason that he could discover, he would have his left fingers and thumb outstretched while walking about.

This loss of control in the left upper limb was progressive and was accompanied by clumsiness of the left foot. He could walk quite well but the toes of the left foot caught in every rug and it was not easy for him to put his left leg into his trousers. When walking he had difficulty in readjusting his direction: he would walk from a room into a corridor and instead of turning right or left would go straight ahead into the opposite wall, "as if his brain wasn't working." There was no difficulty in finding objects that were in his field of vision, nor any other evidence of visual disorientation. He described it as being unable to concentrate on the direction in which he should walk.

Nine weeks before he was first seen he had a second Jacksonian attack exactly similar to the one three years before. Shortly after this there was temporary improvement in the functions of the left arm and leg, but this lasted only three days and soon his leg began to give way at times, and once he fell. He became mentally slower.

*Examination.*—He was slow in answering questions, but otherwise his intelligence appeared normal. There was a groove in the posterior part of the right parietal bone with a depressed scar adherent to it. X-rays showed an irregular fragment of bone in the depths of this bony defect. The optic discs were swollen (right, 4 D; left, 4·5 D). Visual acuity, $\frac{6}{12}$ in each eye. Incomplete left homonymous hemianopia, more in the lower than in the upper quadrants. Slight ptosis of right upper eyelid. Slight weakness of the lower part of the face on the left side.

The left upper limb was a little smaller than the right and was slightly weak at all joints. At times, when he was concentrating, the left upper limb would assume some unusual posture: for example, during fixation while his visual fields were being tested, his left forearm was flexed and his left hand was held rigidly outstretched in front of him against gravity for the duration of one series of tests. Tone was slightly increased in the left arm and leg. The

upper limb-jerks and the knee-jerks were all diminished, more so on the right side than on the left. The ankle-jerks were absent.

There was severe sensory loss on the left side. There was anæsthesia of the left leg below the knee, relative analgesia of the left leg and, to a less extent, of the left forearm and hand, severe postural loss in the left thumb and big toe, gross defect of two-point discrimination in the left arm and leg, considerable impairment of tactile localization and relative astereognosis of the left hand. The leucocyte count was 7,520 per c.mm.

*Operation.*—February 10, 1934. Under avertin and local anæsthesia a right osteoplastic flap was reflected. It was felt that the lesion might be an abscess or a tumour, but that in either case a wide exploration should be made. A chronic abscess was found occupying the inner half of the right parietal lobe. Its anterior extremity was just behind the site of the old gunshot wound; its posterior extremity extended to within 4 cm. of the tip of the occipital lobe. On the convexity the dura was densely adherent to its central part. Medially it was separated from the falx by a thin shell of white matter. The abscess and its capsule

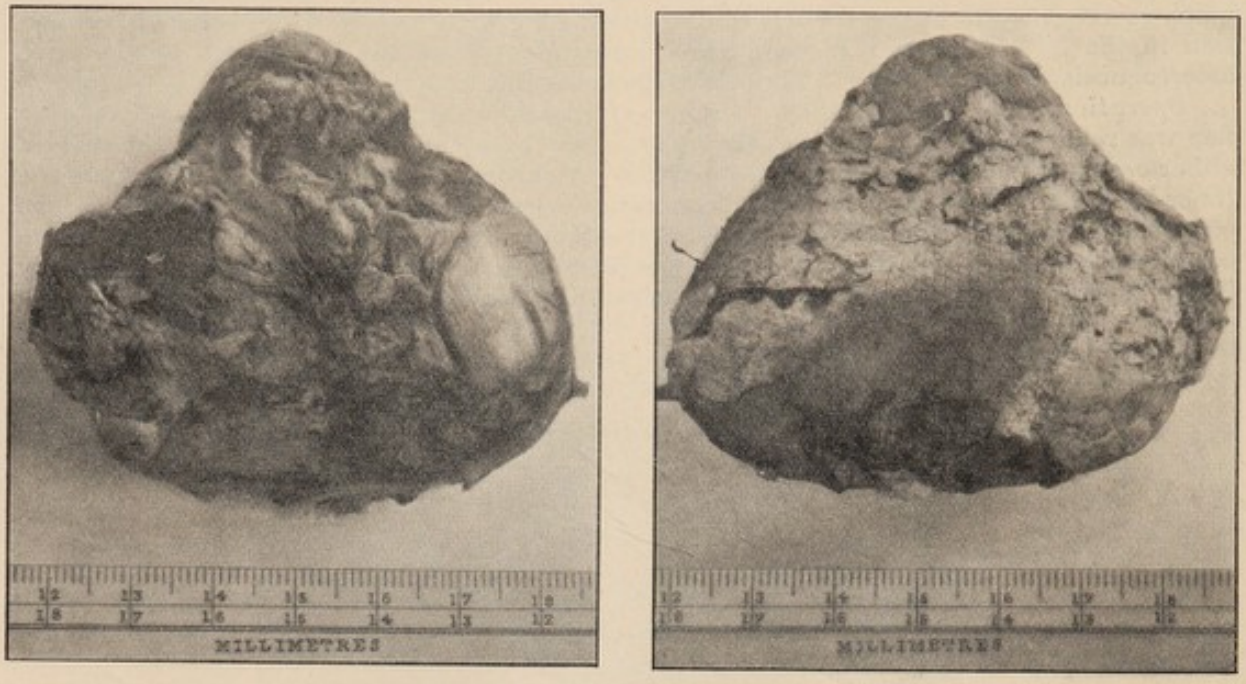
FIG. 4. *Case* 2.—Right parietal abscess, following old gun-shot wound, dissected out intact with its capsule.

were dissected out intact and the resulting cavity measured 7 by 4 by 5 cm. (fig. 4). A gutta-percha drain was put into it and the flap replaced and sutured in the usual way.

*Pathology.*—The abscess and its wall weighed 85 grm. (fig. 5). After removal it was aspirated and the pus, examined by Dr. Panton, contained degenerated pus cells, numerous Gram-positive cocci, and fatty crystals. Culture yielded a pure growth of *Staphylococcus aureus*. The organism was hæmolytic and in broth grew in " rough " form.

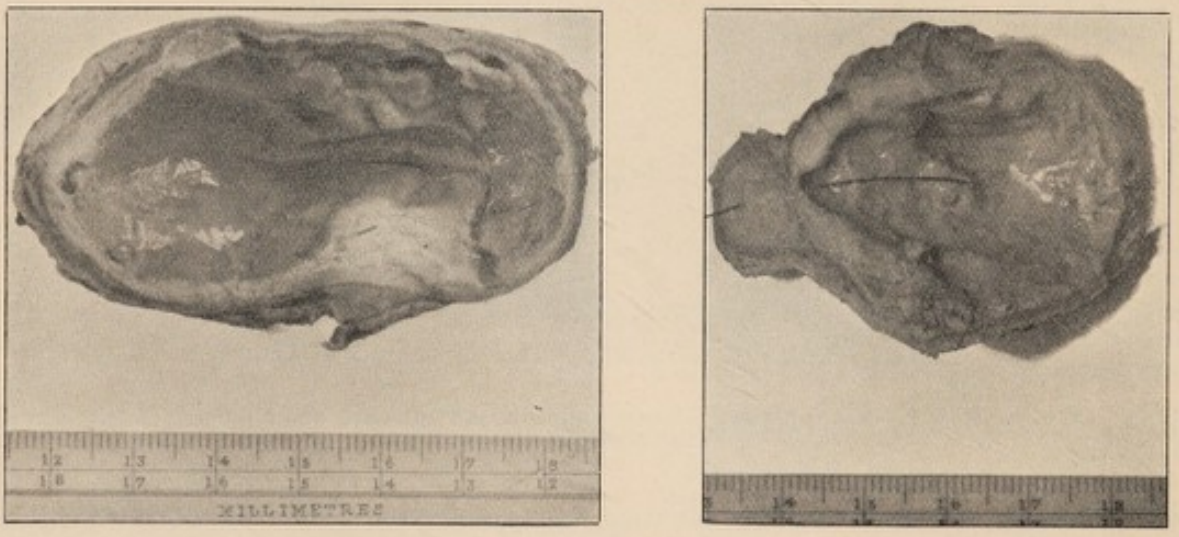
Section of the abscess showed that it consisted of a single large cavity and a smaller loculus occupied by inspissated pus which communicated with the main cavity by a foramen, 0·3 cm. diameter (fig. 6). Its wall measured up to 0·6 cm., thick and that part of it which had been beneath the old gunshot wound in the parietal bone was found to contain a fragment of lamellar bone, measuring 0·5 by 0·3 cm. Contrary to what was thought at the time when the patient was wounded, a small fragment of bone had evidently been driven through the dura and formed the starting point of the abscess.

*Subsequent course.*—Convalescence was uneventful, except for one focal attack of a sensory character in the left arm and leg, on the second day after operation. Papillœdema subsided with preservation of good vision and the visual fields expanded to their normal limits. There




(*a*) (*b*)

FIG. 5. *Case* 2.—Abscess after removal: (*a*) superficial surface showing adherent dura; (*b*) deep surface, showing white matter adhering to the wall of the abscess.




(*a*) (*b*)

FIG. 6. *Case* 2.—Abscess after removal: (*a*) interior of abscess cavity; (*b*) horsehair leading from small loculus into main abscess cavity.

was complete recovery of all forms of sensibility in the left upper and lower limbs, and all disability of motion disappeared. The ankle-jerks were still absent. At the last report six months after operation the patient was living a normal life.

This case has not been observed long enough to allow one to judge of the ultimate result but the immediate result provides a great contrast to what happened in Case 1. There is little doubt that drainage alone would have been unsuccessful in Case 2 because the small outlying loculus could never have been drained satisfactorily, and

moreover, the capsule of the abscess was so thick that it would never have been absorbed. The appearance of the latent occipital abscess in Case 1 (fig. 3) probably represents the best that can be hoped for when an abscess of this type is drained or subsides spontaneously.

It is probable that recurrent or very chronic abscesses secondary to infection of the temporal bone should be treated in the same way, but in such cases the capsule is not usually so thick and there is almost always a discharging sinus, a fungus, or a cerebral hernia which will make it difficult—if not impossible—to reflect an osteoplastic flap because of the risk of spreading meningitis from organisms around the sinus. We have had no personal experience of such cases but one of us saw Dr. Harvey Cushing deal very successfully with such a problem in a case of frontal abscess. The patient was a young girl with a left frontal abscess following frontal sinusitis. This abscess had been opened and drained some ten months before, but the resulting sinus had never healed completely and a large cerebral hernia formed at the site of operation, from which pus discharged spontaneously from time to time, with temporary improvement of symptoms. At operation Dr. Cushing enlarged the bony opening of the sinus, dissected out a thick-walled abscess cavity the size of a hen's egg from the left frontal lobe, and then found behind this two other abscess cavities which extended back an amazing distance into the left hemisphere. Their walls were not so thick as those of the first abscess and accordingly, after they were partially drawn out of the wound, they were sutured to the skin. The huge cavity was drained with large gauze wicks each surrounded by gutta-percha. Eleven weeks later the whole wound was healed with complete subsidence of the hernia, and the patient had regained normal health.



### Acute and Early Chronic Abscess

A chronic abscess has a distinct wall, composed from within outwards of pyogenic membrane, a zone of chronic inflammatory cells, a zone of fibrous tissue and, outside that, a zone of gliosis. This wall offers a variable degree of resistance to the passage of a brain needle. An acute abscess has no such wall; it is lined by shaggy soft material and a brain needle entering the abscess cavity meets no resistance. Acute abscesses are rarely encountered at operation, except those that are secondary to bronchiectasis, and it is doubtful whether abscesses should be operated on in the acute stage. It is impossible to drain an area of acute purulent encephalitis and it is probably unwise to disturb an abscess before it is localized. Diagnosis of abscess thus does not always indicate immediate operation.

*Finding the abscess.*—The best chance of getting complete and satisfactory drainage of an abscess is to drain it at the point where it is nearest the surface of the brain. If every abscess spread from neighbouring foci of infection along a visible track, this would be a relatively simple business, but, as W. Evans [1] has shown, even abscesses arising from mastoid and frontal sinus infection are very often entirely subcortical and without tracks visible to the naked eye. Evans found, when investigating the post-mortem records at the London Hospital, that in 43 of 109 cases of brain abscess secondary to otitis media and mastoiditis, there was to the naked eye no evidence of a track or of direct spread.[1]

The problem of finding the abscess is primarily a clinical one, of diagnosing the general situation of the abscess, then of going through the history and signs again to see if there are any points indicating greater precision in diagnosis. For example, in temporal abscess after mastoid infection, the type of field defect may indicate that

[1] In histological studies of what appeared to the naked eye to be a subcortical abscess of the left frontal lobe Dr. Dorothy Russell has found a minute track leading from the extradural space through the dura into the abscess cavity. This observation is of importance in indicating that subcortical abscesses without a visible track from the surface are not necessarily the result of infection by the blood-stream.

the abscess is higher than usual, or the type of aphasia may indicate that a left temporal abscess is further back than usual.

It is best to be prepared to explore over a wide field. The scalp should be shaved over a wide area, and in males, if the case is not urgent, the whole scalp may be shaved, not only to give freedom in exploration, but also to facilitate dressings after drainage of the abscess has been established.

The method of exploration is as follows: The scalp is infiltrated with 1% novocain, and a hole about 1·5 cm. in diameter is made in the skull with perforator and burr. The dura is opened and the brain is explored with a graduated brain needle. The needle passes unusually easily through œdematous brain matter around an abscess, and the first definite indication that it has reached the abscess is usually a distinct resistance, as its point impinges against the capsule. It may be necessary to use for a moment firm pressure in order to perforate this capsule. When the abscess cavity has been entered its extent may be ascertained by passing the needle very gently onwards until the resistance of the opposite wall is felt. At the same time it is necessary to decide if possible whether the abscess has been tapped at the point where it is nearest the surface. If the brain needle has been passed very obliquely, it is better to make another opening in the skull so that another needle passed at right angles to the surface will enter the abscess. The first escape of pus may sometimes be preceded by bubbles of gas, and this indicates that the uppermost part of the abscess has been entered. In one of our cases the needle entered the abscess, but yet no pus escaped even when aspiration was performed; when the needle was withdrawn its eye was found to be blocked by fibrino-purulent material. Sinus forceps and needles with sharp points should be avoided.

There are various ways of draining an abscess after it has been found. Dandy [2] has recommended repeated tapping of the abscess without aspiration, without any form of drainage between tappings.[1] We have not found this satisfactory. There is a brisk interchange of fluid between the œdematous brain and the abscess, and the abscess cavity may sometimes fill remarkably quickly. Some form of continuous drainage is necessary, and this can be done blindly by the closed method, or under direct vision by the open method.

### Drainage by the Closed Method

After the abscess has been encountered at a favourable site the following is our usual procedure: The depth of the abscess from the dura is carefully noted on the graduated brain needle, and the needle is withdrawn before much pus has escaped. The bony opening is enlarged to 2 or 2·5 cm. diameter. The dura is then opened more widely and the distal end of a new Jacques rubber catheter (size 10), or an old-fashioned webbed intratracheal catheter is pushed into the brain in the same direction as the needle to the required depth. But first the distance of the brain abscess from the surface is measured off along the catheter from its eye and a piece of black silk is tied around the catheter at a point 1 cm. beyond this. Otherwise it is impossible to judge accurately how much of the catheter should be passed into the brain.

If the catheter enters the abscess, as is shown by a free flow of pus from its lumen, the catheter is left in situ and is cut off about 2 cm. above the surface of the skin and a dressing is then built up around it and the whole head encased in starch to ensure that the catheter does not move (fig. 7). Coleman [3, 4], who has been chiefly responsible for introducing this method of drainage, has advised that the catheter should be stitched to the skin.

[1] More recently Dandy [9] has advised that this method of treatment should be supplemented by subtemporal decompression on the side of the lesion, in order to give an added margin of safety against rise of intracranial pressure, and at the same time to provide direct indication, from the tension of the cerebral hernia, when further tapping is necessary.

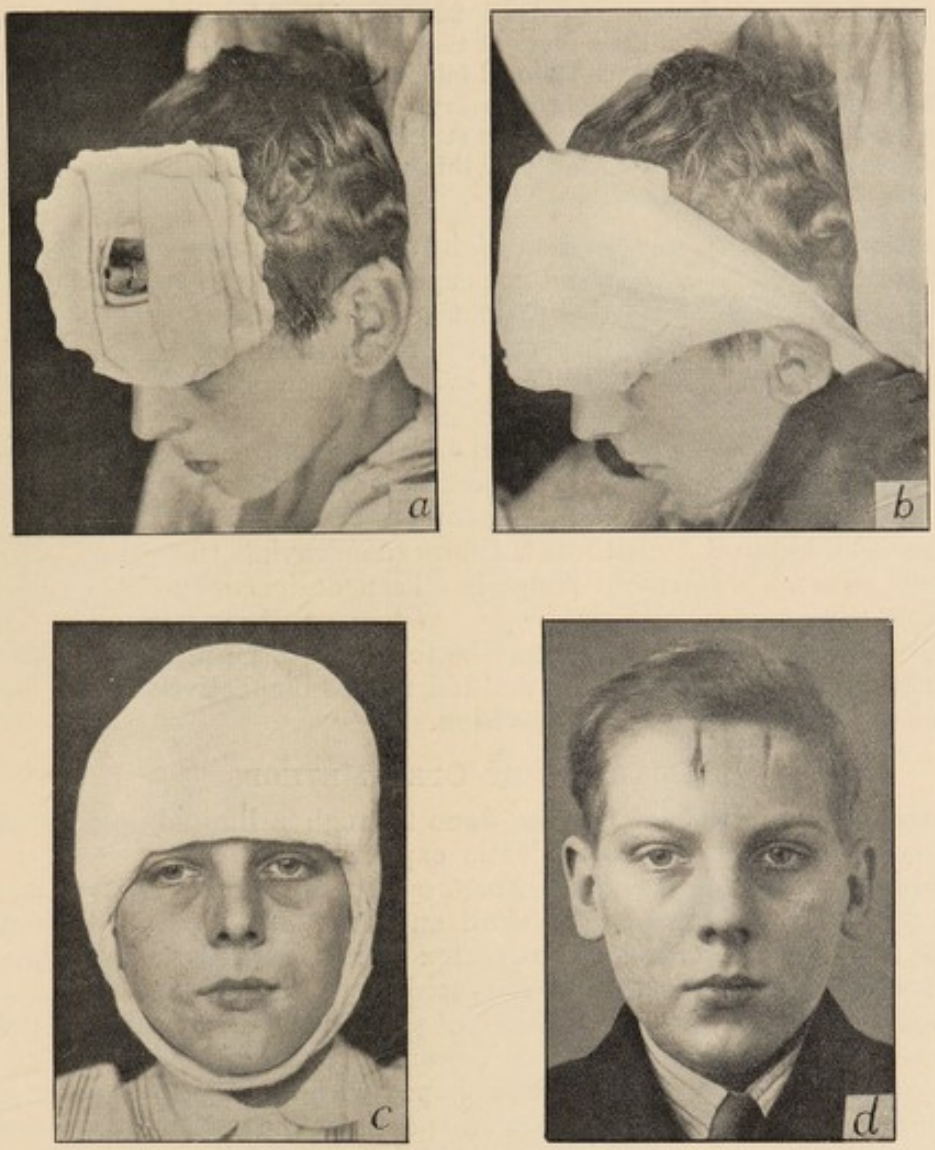



FIG. 7. *Case* 5.—Left frontal abscess after localized acute osteomyelitis of frontal bone. Stages of dressing: (*a*) A dressing is built up around the tube which has been passed into the abscess cavity; (*b*) an assistant holds this dressing in place with a long piece of gauze while the casing of gauze and starch bandages (*c*) is applied; (*d*) the patient on discharge from hospital. The osteomyelitis was drained through the mid-line incision, the left frontal abscess through the smaller incision.

Sometimes the catheter will not perforate the abscess wall. If the condition of the patient is not extremely urgent, it is best then to leave the tube lying against the wall of the abscess for a few days. Then at the next dressing manipulation will usually result in the tube penetrating the now softened abscess wall and the pus will be promptly discharged.

*Case* 3: *Right frontal abscess.*—E. N., a woman aged 25, referred by Dr. O. Leyton, was operated on for a right frontal abscess following frontal sinusitis on April 16, 1930. Under novocain anæsthesia a burr hole was made above the right frontal sinus. Pus was encountered at a depth of 3 cm. and 10 c.c. were withdrawn. A rubber catheter was then passed into the brain to the requisite depth and 1 cm. beyond, but no pus was obtained. It was left alongside the abscess wall and a dressing was applied.

During the following days she vomited several times and her temperature rose to 101° F. and the pulse-rate to 110, but she was free from headache. Five days after the operation (April 21) she complained of headache and the dressing was then done for the first time. When the indwelling catheter was twisted pus began to flow through it and 20 c.c. were

collected. At the second dressing on April 25 a considerable amount of pus was found in the dressings, and there was a little more at the next dressing on April 30. On May 3 the tube was removed and replaced by a strip of folded gutta-percha and this was removed on May 7. The patient made a complete recovery.

Skiagrams, taken while the catheter was still in the brain (fig. 8), show that it had been passed in a somewhat medial direction and this probably explains why it did not enter the abscess cavity at the time of operation.

This patient had fairly severe rise of intracranial pressure before operation, but she was not drowsy or lethargic and consequently there was no need for immediate evacuation of the abscess. If the patient's condition is so urgent that immediate drainage of the abscess is necessary, and the rubber catheter will not go in, it is best to use a firm intratracheal catheter and even to put a stilette in its interior while it is being passed.

If the abscess is very deep-seated (i.e. 4 to 5 cm. or more) and the catheter cannot be pushed into it, it is usually best to leave the brain needle in situ, or, as recommended by Coleman, to mount a cannula on the brain needle and when the abscess has been entered to withdraw the needle leaving the cannula in place. A brain needle with an adjustable flange has been designed by one of us [C. D.] for cases of this type.

Sometimes the pus encountered may be too thick to pass through a brain needle. In such cases drainage by the closed method will be ineffective and the abscess must be emptied by suction under direct vision.

### Drainage by Open Methods

Drainage by open methods may be done through a limited opening in the skull over the abscess, or by wide osteoplastic exploration.

(*a*) *Through a limited opening.*—For drainage by direct vision it is usually necessary to have an opening in the skull and dura 3 to 4 cm. in diameter. After the pus is found with a needle, the cortex is incised and some special form of retractor such as a bivalve speculum is passed down into the abscess. Adherents of this method lay stress on the importance of passing the drain down to the depths of the abscess cavity (McKenzie [5]). Various forms of drainage are employed; a large drainage tube, gauze packing, cone-shaped wire-mesh drain and so forth.

We believe that this form of operation is satisfactory when the abscess is superficial, but there are serious objections to it in deep-seated abscesses. Everyone who has tried to use this method for deep-seated abscesses will have experienced the great difficulty in getting exposure of the abscess through such a small opening. The œdematous brain overlying the abscess pushes itself into the wound, no matter what form of retraction is used, and rapidly obscures the abscess, which may not be found again. In operations of this type opportunity of inspecting the abscess may be very fleeting and everything has to be done so rapidly (the evacuation of the pus, and insertion of the drainage tube to the bottom of the abscess cavity), that there is no room for the slightest hitch. Just at the moment of exposure of the abscess the depths of the field may be hidden by fresh bleeding from cortical vessels, which have been ruptured by the deeper and stronger retraction that is necessarily though unconsciously made when the abscess is exposed. The method is too hazardous for deep-seated abscesses, though it is probably the method of choice for superficial ones. With this method also it is possible to irrigate the abscess cavity, a procedure employed by Macewen [6] in his conspicuously successful group of cases.

(*b*) *Through an osteoplastic flap.*—Neurological surgeons occasionally come upon a brain abscess when exploring for intracranial tumour by the usual wide osteoplastic exploration. In such cases the abscess is generally a chronic one of fairly long duration and perhaps for that reason these cases often make complete recovery. Nevertheless, one cannot help being impressed with the ease with which an abscess

FIG. 8b

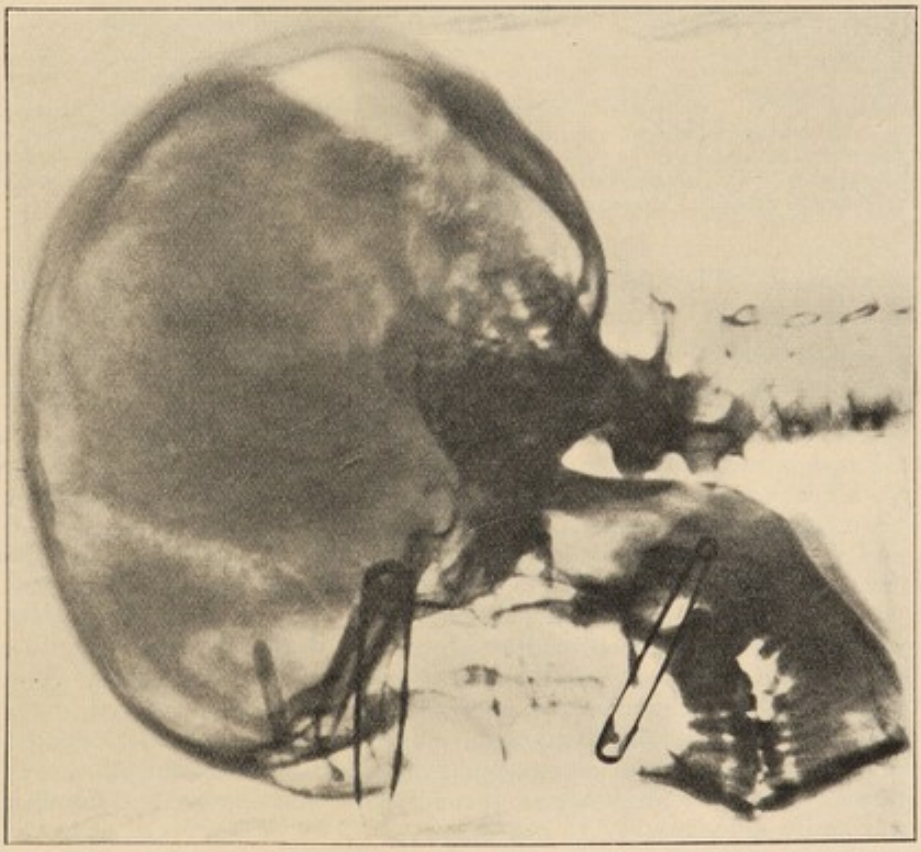


FIG. 8a

FIGS. 8a and 8b. *Case* 3.—Right frontal abscess. Lateral and antero-posterior radiograms showing rubber catheter in the abscess cavity.

cavity can be thoroughly emptied by this method, and with the minimum of trauma to the brain (fig. 9). We have treated four cases by this method; two cases of staphylococcal abscess secondary to inconspicuous infection of the skin and subcutis,[1] one case of streptococcal abscess probably secondary to temporal bone disease and one case of pneumococcal abscess. This last was the only case in which the patient did not recover, and at operation there were found indications that the infection was

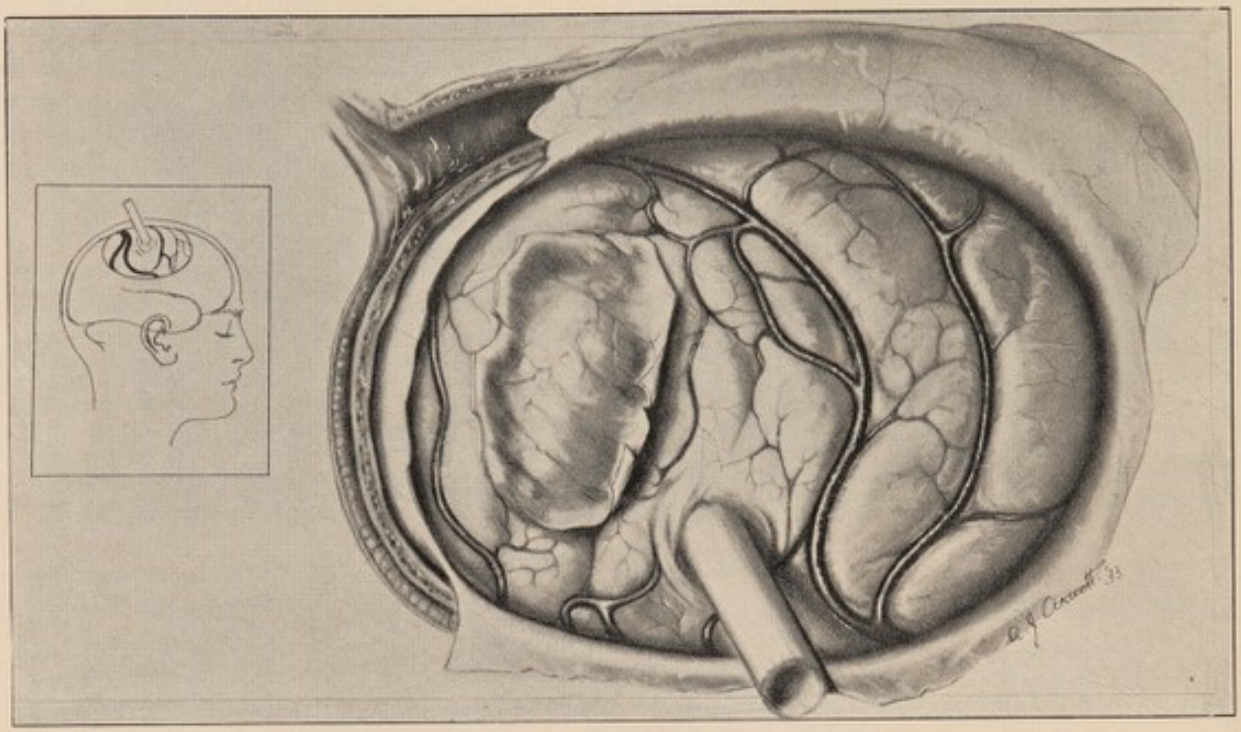


FIG. 9.—Sketch of an osteoplastic operation for subcortical pneumococcal abscess of the right parietal lobe. The drainage-tube passes into the abscess cavity. In front of it and not connected with the abscess there is a focal area of pachy- and lepto-meningitis and here the dura is seen to be firmly adherent to the cortex. The patient died of diffuse pneumococcal infection of the leptomeninges and ventricles three weeks after the abscess was drained.

not localized (fig. 9). The patient died of pneumococcal meningitis three weeks after the abscess was drained. None of the other cases in which the abscess was drained through an osteoplastic flap showed any clinical evidence of meningitis after operation in spite of the fact that in two of them at least there was obvious spread of infection through the field of operation. The following case is an example:—

*Case* 4: *Staphylococcal abscess of right precentral gyrus.*—I. W., a girl, aged 7, referred by Dr. A. G. Maitland-Jones, had a trivial cut on her right knee and a few weeks later suddenly began to have Jacksonian motor attacks in the left side of the face, violent frontal headaches and vomiting. Four weeks after the onset of these symptoms a right osteoplastic exploration was made and an abscess 3 cm. in diameter was found immediately beneath the surface of the lowest part of the precentral gyrus. The abscess was emptied by suction without any obvious contamination of the operative field, and the cavity was drained through a small incision in the temporal region, the original incision being closed. The pus from the abscess showed *Staphylococcus aureus* in films and cultures.

One week after operation this patient developed *S. aureus* infection along the line of the scalp incision and continued to discharge pus from various points during the next six weeks (fig. 10). She never showed any signs of meningitis and her general condition throughout this time was quite satisfactory.

[1] Since this paper was written another staphylococcal abscess has been successfully treated by the same method.

When an abscess near the surface of the brain is exposed through an osteoplastic flap, or is seen at necropsy, it is usual to find streaks of yellow material in the sulci immediately over and around the abscess, and histological examination shows pus or chronic inflammatory cells, not only in these sulci but also in the perivascular spaces of the white matter around the abscess. There is probably considerable local

FIG. 10. *Case* 4.—The patient after drainage of a staphylococcal abscess of the right precentral gyrus through an osteoplastic flap. The sinuses are the result of staphylococcal infection of the scalp after operation. There were no clinical signs of meningitis.

resistance to the spread of the infecting organism and the leptomeningeal spaces immediately over the abscess are probably sealed off. This appears to us the reason why spreading meningitis is not set up after osteoplastic exploration, though, as we shall see later, infection of the leptomeninges probably does occur in slight degree after every abscess is drained.

### AFTER-TREATMENT OF ACUTE AND CHRONIC ABSCESS

Whatever method is employed in treatment of these abscesses, the after-treatment is the same. The patient should be nursed in such a position that gravity assists drainage of the abscess. Dressings, we believe, should be done only at long intervals. We leave the first dressing undisturbed as long as possible, usually about a week, sometimes ten days or even more, only doing the dressing if some complication ensues, or if the patient is becoming uncomfortable because of the discharge.

*Case* 5.—*Left frontal abscess after localized acute osteomyelitis of frontal bone.*—S. H., a boy, aged 13, was struck on the right side of the forehead by a cricket ball and six weeks later developed a tender swelling on the forehead just to the right of the middle line, accompanied by fever, headache and vomiting. At operation the swelling was found to be an area of osteomyelitis with extradural and sub-pericranial pus around it. This was drained. He gradually developed signs of left frontal abscess and this was drained by a rubber catheter about seven weeks after the first operation.

The first dressing was done eight days after the abscess had been drained (fig. 7), the second on the fourteenth day, the third on the twenty-ninth day, the fourth on the forty-sixth day and the tube was finally removed on the sixty-first day.

It is necessary to add that dressings are only left for such a long time if the clinical condition of the patient is satisfactory. The point that we wish to emphasize is that when a tube is well placed in an abscess, daily dressing and manipulation of the tube probably does more harm than good.

Dressings are done in the operating theatre, and by the surgeon who performed the operation, and they often take one-half or three-quarters of an hour to do. The tube is not removed, except when intracranial pressure suddenly pushes it out as the dressings are removed, and this we try to avoid. It is left in as long as possible and is gradually shortened.

The next important factor in after-treatment of brain abscess is prolonged rest in bed. It is a wise measure to keep a patient who has had an operation for brain abscess in bed for several weeks after operation, if possible, and to keep him very quiet and under fairly close observation for a period of three months.

## Material

Excluding abscesses secondary to bronchiectasis, which constitute a different problem and with which we have only had one temporary recovery in ten cases, our material is as follows :—

Table.

| Source | Total cases | Died | Cases operated on | Recovered |
|---|---|---|---|---|
| Pyæmia from skin and subcutis ... ... ... | 3 | 1 | 3 | 2 |
| Direct infection (G.S.W. 2, Rodent ulcer 1) ... | 3 | 2 | 3 | 1 |
| Osteomyelitis of skull ... ... ... ... ... | 5 | 2 | 5 | 3 |
| Frontal sinus ... ... ... ... ... | 4 | 3 | 3 | 1 |
| Sphenoidal sinus and nose ... ... ... ... | 2 | 2 | 2 | — |
| Middle ear and mastoid ... ... ... ... | 13 | 10 | 7 | 3 |
| Totals ... ... | 30 | 20 | 23 | 10 |

It would not be profitable to analyse this material in detail, for various reasons. Several of the cases operated on were in a hopeless state at the time. In two, for example, operation was performed under artificial respiration. On the other hand, mistakes of diagnosis should count in mortality rate just as much as mistakes of operative treatment, but there was too much divided responsibility in this group of cases to allow of that being accurately assessed. The main value of the figures is to give an idea of how bad the results are and to show how much room there is for improvement in diagnosis.

## Post-operative Complications

In this section we consider the complications that occurred in the cases that recovered. They may be so disturbing as to result in further and unnecessary surgical interference.

*Rise of temperature* is usual. Whereas in the pre-operative course the temperature is often subnormal, after operation it shows an irregular rise up to 102° F., and this may persist for up to three weeks (fig. 11).

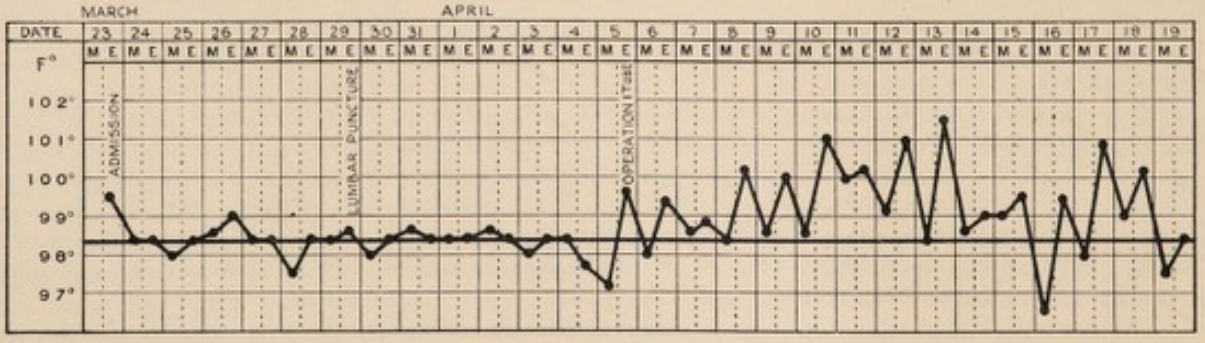



Fig. 11. *Case* 4.—Temperature before and after drainage of a staphylococcal abscess of right precentral gyrus.

*Œdema and meningitis.*—These two conditions are here grouped together because they both probably play a part in the recurrence of symptoms that occasionally follows temporary improvement after operation. An abscess is drained and there is prompt improvement in the general condition of the patient and in the local symptoms, but after a day or more the local symptoms become again severe, the temperature rises and the patient lapses into stupor.

These symptoms are probably due to increase of local œdema after the abscess has been drained. Before operation œdema is always present in the white matter around a brain abscess, sometimes to such an extent as to produce false localizing signs (fig. 12). The white matter around the abscess is soft and glistening, and histological sections show that it contains many clear spaces. The extent to which brain swelling, presumably œdema, may increase after drainage of an abscess is shown by the following case:—

*Case* 6. *Left temporal abscess.*—W. M., aged 17, referred by Dr. George Riddoch, was operated on on January 15, 1929, for an expanding lesion in the left temporal lobe, of which the predominant symptoms were headache, vomiting, slight confusion and Witzelsucht, and slight nominal aphasia. An osteoplastic flap was turned and a large abscess (*Staphylococcus aureus*) was found 1·5 cm. beneath the surface of the anterior half of the left temporal lobe, surrounded by a firm capsule, 0·1 to 0·2 cm. in width. The abscess was emptied and was drained through a stab incision in the temporal region; the bone flap was replaced and the wound was closed.

After the operation the patient was drowsy and restless, and after twenty-four hours he had a convulsive seizure beginning with clonic movements in the right arm and leg. He failed to recover consciousness, his respirations became slow and laboured, and the flap was very tense. It was feared that he might have post-operative extradural clot, but when the flap was re-elevated thirty-five hours after the first operation very little clot was found. The swelling was due to diffuse bulging of the brain. The abscess cavity was empty. After this operation there was prompt recovery.

This case was rather unusual because the symptoms of œdema came on immediately after operation, but it is cited because the symptoms were so clearly shown to be due to swelling of the brain. More commonly the symptoms of œdema come on somewhat later, as in the following case, seen by one of us in consultation with Mr. Donald Wheeler:—

*Case* 7.—The patient was a boy of 14 who was drowsy and dysphasic. On April 28, 1929, Mr. Wheeler drained a large subcortical abscess in the left temporal lobe. On the following day the patient was much better; his pulse-rate had risen from 65 to 76, he was more alert and his dysphasia had practically disappeared. On April 30 he became again very drowsy and dysphasic, his temperature rose to 102, and his pulse-rate slowed to between 60 and 70. He remained in this condition until May 3, when he was more alert and co-operative though still showing considerable dysphasia. The temperature did not become normal and the pulse-rate did not rise again to 76 until May 12, by which time his speech was greatly improved, though he still had some nominal aphasia and dyslexia. Throughout the period of drowsiness both before and after operation there was considerable rigidity of the neck.

When symptoms recurred after operation the drainage tube in the abscess was manipulated; but neither then nor at any time later was there any large amount of purulent discharge. The patient made a quick recovery and by May 30 there was no trace of aphasia except for slowness in reading aloud.

A lumbar puncture was carried out before operation in this case and the cerebrospinal fluid was found to be turbid. No cytological or bacteriological examination was made. During the post-operative period no further lumbar punctures were done, but it is to be noted that rigidity of the neck, which was present before operation, persisted throughout the period of drowsiness.

The nature and cause of post-operative œdema after drainage of brain abscess are obscure. At necropsy the white matter around a brain abscess frequently contains

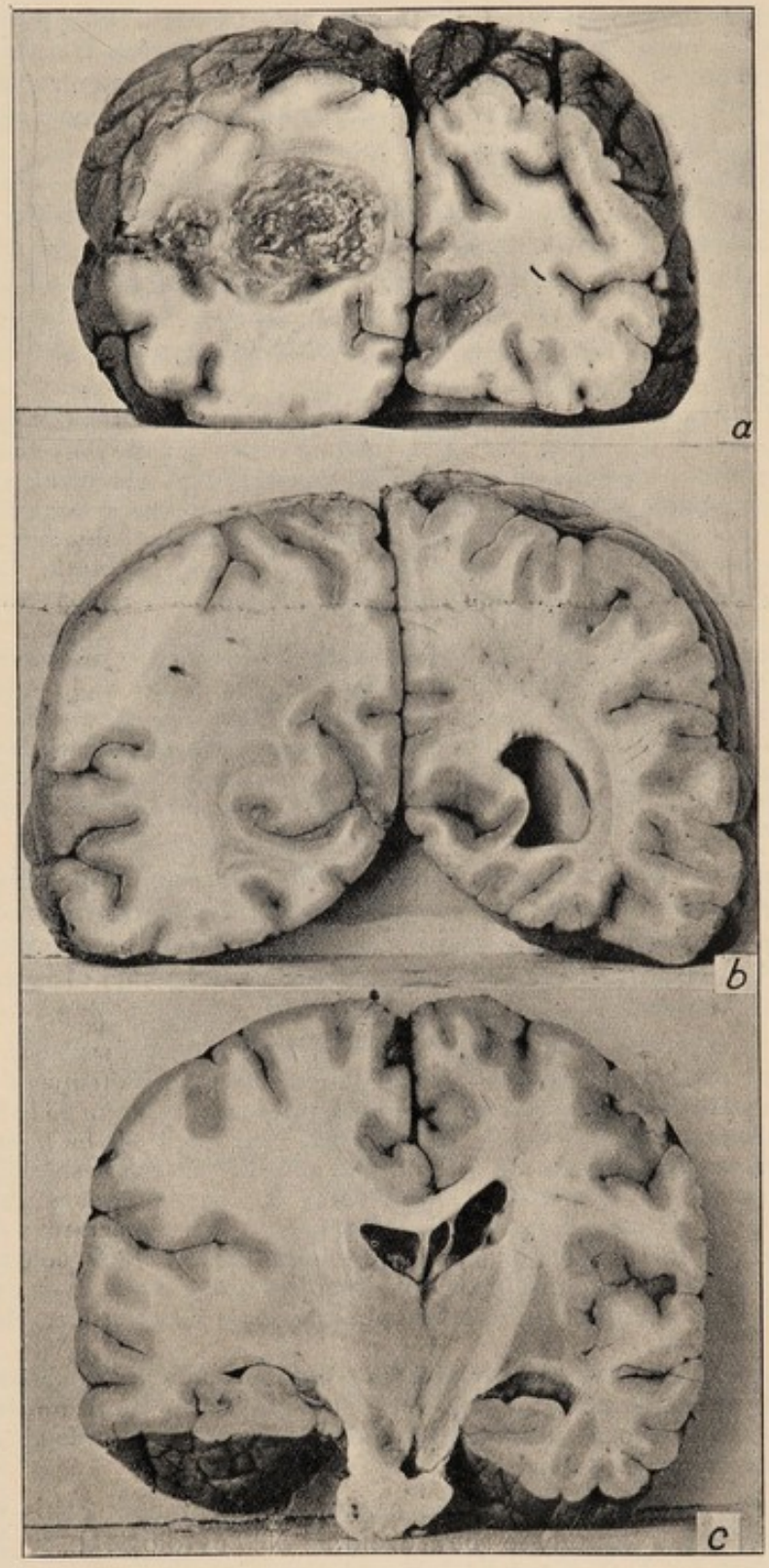



FIG. 12.—Œdema of the brain secondary to a staphylococcal abscess of the left occipital lobe (*a*). The swelling of the white matter of the left hemisphere (*b*, *c*) extended forwards into the frontal lobe. The occipital abscess was drained but the pus was very thick and the abscess did not empty. Subsequently the patient developed considerable weakness and spasticity of the right arm and leg and a grasp reflex in the right hand. The left frontal lobe was explored for a second abscess with negative result.

an excess of watery fluid between the nerve-fibres, visible not only in histological sections but sometimes to the naked eye. In fatal cases the white matter around an abscess is often broken up by collections of this fluid in a way that suggests that these may form the starting point for fresh abscesses. When draining an abscess it is a common observation that the flow of pus is followed by escape of turbid watery fluid, and the operator fears that there has been rupture of the ventricular wall. But we have direct observations that this fluid does not come from the ventricle but from the abscess wall by a process of generalized exudation. Thus in the fatal case of pneumococcal right parietal abscess already described (fig. 9), during the hour that followed complete emptying of the abscess cavity by suction, turbid watery fluid dripped from the drainage tube in the abscess. This abscess was a long way from the ventricle which at necropsy was seen to be intact. From our observations we are forced to the conclusion that there is an active circulation of fluid in the white matter around brain abscesses. The fluid under certain circumstances may pass rapidly into the abscess cavity, while in other cases, as in post-operative œdema, it may accumulate in large amount in the white matter.

It is possible that post-operative œdema may be wholly or partly caused by spread of infection in the meninges and brain itself at the time when the abscess is drained. Spreading meningitis can exist without any of the classical signs of meningitis and we believe that a certain amount of meningitis probably always occurs after an abscess has been drained, but that it does not always give recognizable clinical signs. The only way that it can be recognized is by day-to-day study of the spinal fluid, and the surgeon is not unnaturally averse to daily lumbar punctures after he has drained an abscess.

[Since this paper was written, observations of this nature have been made by us in a case of right prefrontal abscess secondary to boils on the face three months before. The abscess was encountered after an osteoplastic flap had been turned, and was removed with its capsule. During removal the abscess wall ruptured slightly at one point and a little of the contained pus escaped. After operation lumbar punctures were done at frequent intervals to see whether any meningitis had occurred. On the first day after operation the cerebrospinal fluid contained 57 cells per c.mm.; on the second and again on the fourth day 200 cells, on the sixth day 1,400 cells, on the ninth day 150 cells, on the fourteenth day 100 cells, on the twentieth day 56 cells, on the twenty-sixth day 10 cells. There were no constitutional signs of meningitis during this period. Before operation there was only slight weakness of dorsiflexion of the left hand. Left hemiparesis developed slowly in the first few days after operation and gradually cleared up completely, its degree varying approximately with the degree of pleocytosis of the spinal fluid.]

Whatever the cause of the œdema, it is clear that it should not be treated by further surgical intervention. When symptoms recur during the first day or so after an abscess has been drained, the surgeon is apt to think that the drainage tube has become blocked, and often proceeds to manipulate it or to replace it by another tube, without recovering a significant amount of pus. If at operation the tube has been satisfactorily placed in the abscess cavity and the abscess has thereupon been emptied, it is probably better not to interfere if symptoms of œdema arise.

*Squint.*—Squint and double vision may come on after a brain abscess has been satisfactorily drained. Thus in a case of right frontal abscess (Case 3) a right third-nerve palsy was found when the right eye was first uncovered on the tenth day after operation. Sixteen days later this had practically cleared up, though ptosis of the right upper eyelid persisted for several months. This third-nerve palsy occurred at a time when the rise of intracranial pressure had been relieved, and it persisted in slight degree for much longer than it would have done if it had been due to rise of intracranial pressure. The most likely explanation is that it was due to a patch of fibrino-purulent material in the cisterna interpeduncularis on the right third nerve. Similar, and to the naked eye isolated, areas of fibrino-purulent material have been

observed in the basal cisterns at necropsy in other cases, where death has been caused by rise of intracranial pressure rather than by generalized meningitis. This explanation is in accord with our more recent observations on the occurrence of slight lepto-meningitis after an abscess has been drained.

*Incomplete drainage.*—In the more severe infections incomplete drainage of an abscess may prove fatal, but that it is not always so is shown by the following case:—

*Case* 8.—*Bronchopneumonia. Local osteomyelitis and extradural abscess of right parietal region. Subcortical abscess of left parietal lobe (cultures sterile). Three operations for drainage of brain abscess. Recovery.*—A. B., a male aged 28, referred by Dr. Robert Hutchison, fell ill with bronchopneumonia on December 15, 1928.

December 28: An abscess developed on the sole of the right foot and was opened. The pus was sterile on culture, but films showed Gram-positive cocci.

January 5, 1929: An abscess appeared in the neck, but it subsided in the next two weeks without being opened.

January 20: The patient began to have frontal headaches.

January 25: A swelling appeared in the right parietal region.

January 31: There were sensory and motor attacks of Jacksonian epilepsy beginning, it was said, in the right upper limb and at times spreading to the right and, to a less extent, the left lower limb. There was no loss of consciousness. Examination showed disturbance of postural sensibility in the right big toe and, to a slight extent, in the right thumb. The plantar reflex on the right side was doubtfully extensor.

*First operation.*—January 31: The right parietal swelling was explored and a sequestrum removed, and an extradural abscess was drained. This did not spread across to the left, but stopped 1 cm. to the right of the middle line. After this operation there was complete relief from headache, and neurological examination showed none of the signs observed after the epileptic attack on January 31.

February 13: Headache in the last two days. This morning he had a Jacksonian seizure without loss of consciousness which began with "pins and needles" and twitching in the right leg, and was followed by temporary paralysis of the right upper and lower limbs.

February 19: Headache worse. Vomiting. Slight hemiparesis and severe loss of postural sensibility in the right arm and leg.

*Second operation.*—February 19: Drainage of subcortical left parietal abscess, 2·5 cm. below the dura, by rubber catheter. About 5 c.c. of thick pus only were obtained.

February 24: Vomiting. Drowsy. Almost complete paralysis of left external rectus. Right hemiparesis now complete in the leg and much worse in the arm. Analgesia to pin over right half of body.

*Third operation.*—February 25: Further exploration of left parietal lobe by brain needle. Abscess not found.

February 28: Slight recovery of voluntary power in right leg. Still very severe postural loss on the right side.

March 20: About 4 c.c. of pus escaped from skin incision in left parietal region.

March 24: Power in right arm began to recover.

April 1: Recurrence of headache and vomiting. Right hemiparesis again practically complete. Right-sided sensory loss as before. Dysarthria. Slight papillœdema.

*Fourth operation.*—April 2: Subcortical abscess of left parietal lobe drained. Evacuation of 30 c.c. of thick greenish-yellow pus. Drainage of abscess cavity by catheter.

April 9: Great improvement in power of right side. Slight recovery of postural sensibility at right ankle. An attack of Jacksonian epilepsy beginning in right foot.

May 9: Walking with assistance.

May 27: Discharged from hospital. External rectus weakness has practically disappeared. Slight weakness and spasticity of right arm and leg. Defect of postural sensibility, slight in right hand, considerable in right foot.

July: Returned to work.

March, 1934: Regularly at work as a labourer. Turns right foot inwards a little as he walks, but no other disturbance of power. Defect of postural sensibility, very slight in right thumb, slight in right big toe.

In this case the left parietal lobe was explored three times before the abscess was satisfactorily drained. It is probably only on account of the low intensity of the infection that this was possible. Although there was practically complete hemiplegia and very severe sensory loss on the right side for more than five weeks the ultimate recovery of function was nearly perfect.

*Recurrence.*—Recurrence of an abscess after a long interval may be the result of incomplete drainage. It often means that the abscess is multilocular, owing to injury of the capsule of the primary abscess either at the original operation or from partial rupture into the surrounding white matter owing to tension of its contents.

*Case 9.—Recurring left temporal abscess.*

*First admission.*—G. C., aged 29, was admitted to the London Hospital under the care of Mr. Muecke, on April 25, 1928. He had suffered for six years from discharge from the left ear and he sought treatment on account of a polyp which was protruding from the left ear.

*First operation.*—April 27, 1928: An incomplete mastoidectomy was performed on the left side.

*Second operation.*—May 22: A left temporal abscess was opened and drained. Exposure of the abscess was difficult and drainage was incomplete.

*Third operation.*—July 5: Owing to recurrence of symptoms the wound was reopened and an extradural abscess was drained. The brain was not explored.

*Fourth operation.*—July 27: The abscess was thoroughly drained after its stalk had been mobilized. He was discharged from hospital on September 2, 1928.

*Second admission.*—He was readmitted on August 17, 1929, on account of headache and nausea.

*Fifth operation.*—August 27, 1929: A left temporal abscess was drained and most of its capsule was dissected out. The wound healed quickly but right upper quadrantic hemianopia persisted, and early in October he developed again other local signs of a left temporal abscess.

*Sixth operation.*—October 13: A large posterior left temporal abscess was emptied and drained. It had a thin capsule and lay behind a fibrous mass at the site of the previous operation. It was evidently a different abscess from the one which had been treated at the previous operation.

He was discharged from hospital on November 11, 1929, free from symptoms but still showing right upper quadrantic homonymous hemianopia.

From the end of 1928 onwards, that is after the fourth operation, he had suffered from occasional generalized convulsions and from a discharge of cerebrospinal fluid from a pin-point opening in the lower part of the mastoidectomy incision.

*Third admission.*—In an attempt to relieve these symptoms he was admitted once more to hospital.

*Seventh operation.*—January 23, 1930: The tough yellowish-white remnants of the old abscesses in the left temporal lobe, forming a mass about 2 cm. in diameter, were exposed and in the process the left lateral ventricle was widely opened. A track lined by dura was found passing through a small hole in the anterior surface of the temporal bone medial to the limits of the previous mastoidectomy. This track was excised.

This operation was unsuccessful, for both the fits and the occasional leakage of cerebro-spinal fluid persisted, as did the right upper homonymous hemianopia. In other respects the patient was well and free from symptoms and he remained thus during the ensuing four years, up to the time of this report.

The details of this case-history have been omitted in order to conserve space. There is little doubt that recurrence of the abscess in this case was due to imperfect drainage at the first operation, when the brain overlying the abscess was also injured in attempts to get the abscess exposed. The persistent cerebrospinal fistula also calls for comment. We have not seen it in any other case.

Imperfect drainage is probably not the only cause of recurrence. Persistence of the original focus of infection must doubtless at times play a part. Thus we have had one case of subcortical abscess of the centrum semi-ovale secondary to bronchi-ectasis, in which the abscess was very satisfactorily drained at operation; five

months later, however, there was a recurrence at the site of the former operation. This rapidly spread to the ventricle without attaining any considerable size and the patient died from generalized leptomeningitis.

The cases in which recurrence of abscess is most to be feared are those in which neurological signs still persist to any extent. For example, we have under observation at present a young woman in whom we found and drained an abscess of the right occipital lobe in August 1932. Drainage of the abscess was complete and her subsequent course was satisfactory and she has been at work since November 1932, without symptoms. Before operation she had complete homonymous hemianopia. Nine days after operation the right upper quadrants of the fields began to recover and eventually regained normal vision, but there has never been any recovery in the lower quadrants. This lack of recovery probably indicates scar

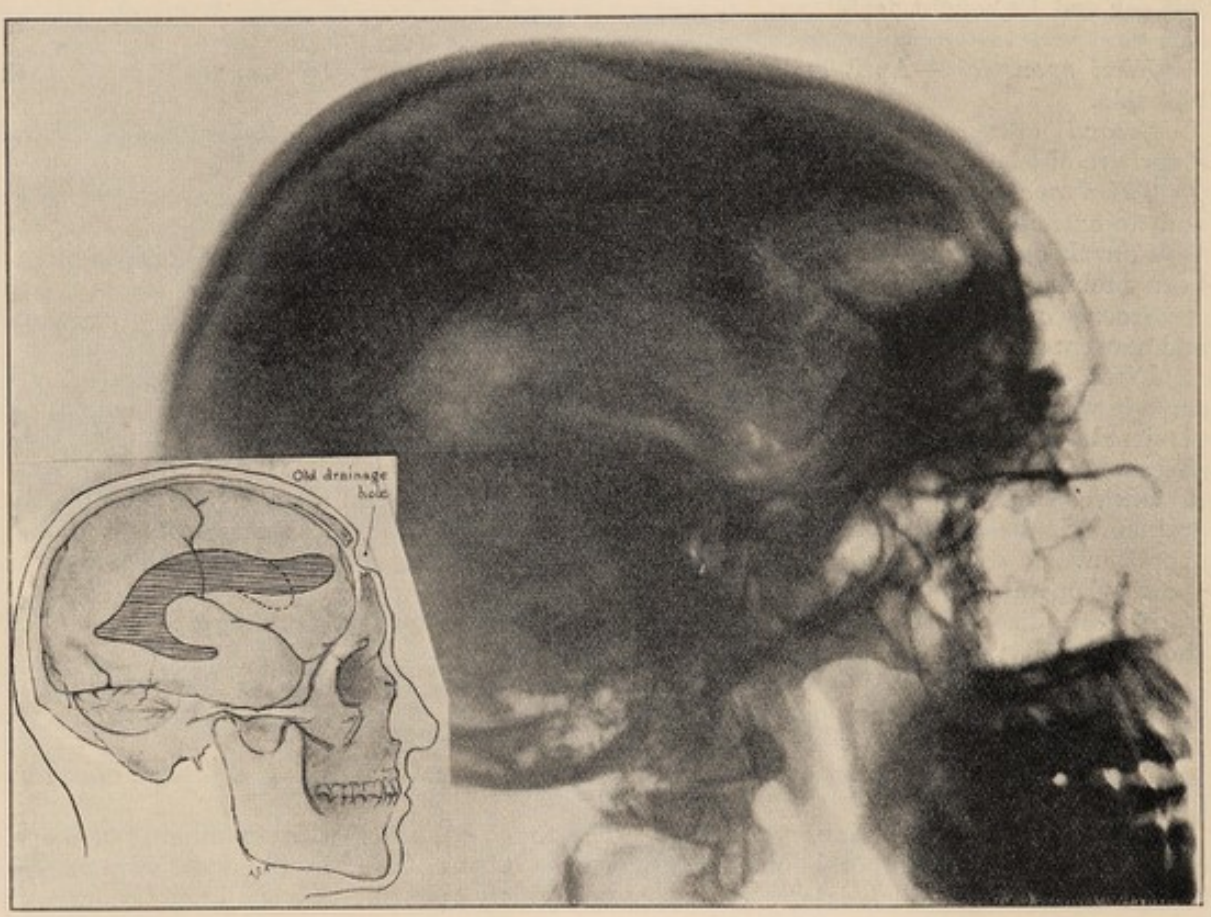



FIG. 13.—Encephalogram showing traction diverticulum of frontal horn of left lateral ventricle at site of old brain abscess.

tissue and where there is scar tissue there are likely to be areas of pus cells from which recurrence might take place later.

*Epilepsy.*—Fits occurred during the first few weeks after operation in four of the 10 patients who recovered, but in only one of them did the fits continue after the patient left hospital. This patient (Case 9) has been subject to fits ever since his abscess was drained, in spite of the fact that the scar tissue resulting from the abscess was radically excised down into the lateral ventricle.

We have also studied a further case of epilepsy following frontal abscess in which the original operation for left frontal abscess had been carried out elsewhere seven years before. Epilepsy began immediately after the patient had recovered from the abscess and consisted of dreamy attacks associated with hallucinations

of smell which occurred daily, and attacks of falling without warning, which completely interfered with his work. When he came under our care he had evidence of intense scarring at the site of the old abscess with a traction diverticulum of the frontal horn of the left lateral ventricle (fig. 13). Free excision of the left frontal pole failed to relieve his fits.

### Mistakes in Diagnosis and Treatment

In certain cases, owing to the intensity of the infection and low resistance of the patient, the chances of a successful result from surgical treatment are probably extremely poor from the very beginning. Thus, cases in which the pus shows a free and abundant growth of bacteria, and cases in which most of the accessory sinuses are heavily infected fall into this group. But there are many cases in which death is due not so much to the inability of the patient to localize and limit the infection as to our inability to find and deal adequately with the abscess. Undoubtedly the greater number of failures of this type are due to mistakes in diagnosis, but we will first consider errors of treatment.

### Errors of Treatment

Assuming that the surgeon approaches an operation for brain abscess with a clear idea of how abscesses of varying types should be drained, and that he is reasonably gentle in his handling of the brain, the mistakes that he can make in treatment are relatively few. For, though after a death in a case of brain abscess he may feel that some detail has been responsible for a bad result, yet in the light of the post-mortem examination and later reflection this often proves to have been false. If an abscess has been operated on at the right time and the right type of operation has been done there is a good chance of recovery.

(1) *The wrong type of operation is performed.* — Thick-walled multilocular abscesses cannot be treated satisfactorily by drainage but require dissection and total removal, or marsupialization. Abscesses in which the pus is very thick are probably best treated through an osteoplastic flap.

(2) *The abscess is missed with the exploring needle.*—This happened in one of our cases of chronic recurrent frontal abscess in which the correct diagnosis was made. At necropsy the abscess was a thick-walled abscess containing a little thick pus, and it was so low in the frontal lobe that its capsule presented on the inferior surface of the brain. The patient was comatose from cerebral œdema at the time when he came into hospital, and there is little doubt that the only possible chance of success would have been an immediate osteoplastic exploration with dissection of the abscess and a wide decompression. If the abscess had been found with the exploring needle, the major operation would probably have been performed.

In one of our cases treated by an osteoplastic flap the exploring needle entered the abscess cavity but no pus escaped. When the needle was withdrawn a plug of fibrino-purulent material was found in its eye. The material in a needle after exploratory puncture of the brain always repays examination.

(3) *The tube is blocked.*—Coleman considers that pus can usually escape around the sides of a blocked tube, but in one of our cases of frontal abscess blockage of the tube undoubtedly contributed to the patient's death. Gauze became plugged against the opening of the tube. It is preferable to cover the drainage tube with sheet guttapercha which will not stick.

(4) *Oblique drainage.*—Abscesses that are drained obliquely, instead of at right angles to the skull at the point where the abscess is nearest the surface, do not drain satisfactorily.

(5) *Operation too early* will produce an unfavourable result in a case that otherwise might end well if operation was delayed until a capsule formed. Thus in a patient with a streptococcal frontal abscess following infection of the maxillary

antrum and sphenoidal sinus, the abscess was drained ten days after headache began. No capsule could be felt. The pus was quite fluid but rather thick, and it was blood-stained. The abscess was emptied easily of about 2 oz. of pus, and the catheter was lying nicely in the cavity. On the fourth day after operation at the first dressing twisting of the tube produced about ½ to 1 oz. of pus. The patient appeared to be making a good recovery, but on the seventh day after operation she began to be irritable and developed signs of meningitis from which she died three days later. At necropsy the track for drainage of the abscess was found to be freely open, and the abscess was partially collapsed, but nevertheless there was a perforation (0·3 cm. in diameter) from the posterior part of the abscess into the frontal horn of the lateral ventricle, and there was severe pyocephalus and diffuse lepto-meningitis. It should be noted that this perforation occurred in the posterior wall of the abscess which was never interfered with or injured during operation. There was very severe œdema of the white matter around the abscess.

There is no doubt that cerebrospinal fluid is continually leaking through the abscess wall from the surrounding white matter. One would expect it to wash out the infection and to promote recovery from the infection. But, if the infection is not yet limited and walled off, drainage of the abscess seems to increase the œdema of the surrounding white matter and the infection can then spread through the brain more easily, with the result that fresh abscesses form in the surrounding white matter, or infection spreads into the lateral ventricle.

(6) *Œdema* of the white matter around abscesses is little understood and provides a problem in treatment not only in this type of case but also in many cases of intracranial tumour.

(7) *Errors of nursing.*—Cases can be lost as a result of imperfect nursing care after operation, especially care about swallowing. This is a continual anxiety in all intracranial surgery. The patient who is drowsy and whose swallowing and cough reflexes are depressed is very apt to get fluid nourishment into his trachea, with resultant bronchopneumonia and purulent bronchiectasis. In one of our fatal cases in which there was an abscess in each frontal lobe, bronchopneumonia undoubtedly contributed to the fatal issue.

## Mistakes in Diagnosis

There is often, to be sure, very little time in which to make the diagnosis, as the following case shows :—

*Case* 10.—W. B., aged 20, was admitted to hospital in coma. Since childhood he had had purulent discharge from the left ear. Three weeks before admission he caught cold and one week before admission he had acute pain in the left ear and copious discharge from it. Two days before admission he went to the cinema and on the following day he was walking about and, according to his parents, had no complaints. On the morning of admission he got up, walked a few steps and complained of weakness. He went back to bed and within half an hour became unconscious.

On examination he was deeply unconscious and had marked rigidity of the neck. There was a purulent discharge from the left ear. The right upper limb was spastic and both plantar reflexes were extensor. Lumbar puncture yielded slightly turbid fluid containing 200 white cells per c.mm., and 0·1% of protein. Cultures were sterile. 8 c.c. of fluid were withdrawn.

Six hours after admission his breathing became bubbly and laboured and he died soon afterwards. Necropsy showed a chronic left temporal abscess with slight localized lepto-meningitis over it.

There was, we believe, a mistake in the management of this case to which we will have occasion to refer to shortly. But apart from that, the course of the illness was extremely rapid. We have seen other cases almost as rapid. Abscesses with such a rapid course are almost invariably of much longer duration than the history indicates and if the history could be obtained in detail (patients like this one are

usually poor and uneducated) we would get a story of previous headache, drowsiness and perhaps shivering, indicating either that the patient had at some former time had a cerebral abscess which subsided spontaneously, or that the initial infection had occurred some weeks before the illness appeared to begin. From post-mortem studies in our series there is no doubt that a cerebral abscess can subside spontaneously and another abscess can subsequently form rapidly at the same site.

Going through our cases we find many errors of diagnosis, mostly committed by ourselves.

(1) *Cases in which the diagnosis of brain abscess has been completely missed.*—These are the cases in which infection of the middle ear, mastoid or accessory sinuses is, or appears to be, insignificant. Such patients are admitted to the medical wards. Formerly they were often diagnosed as suffering from cerebral thrombosis or encephalitis. Recently in our experience there have been less mistakes of this type in diagnosis, though one of our patients was admitted as suffering from typhoid fever.

These cases merely serve to emphasize how slight may be the headache in brain abscess. Headache may be prominent in the picture at the onset of the abscess, and then may be completely superseded by a state of drowsiness and lethargy, which often does not arouse a feeling of anxiety among the nurses and doctors who are watching the patient. In this group mistakes sometimes arose out of the notion that absence of papillœdema excludes a diagnosis of abscess. It cannot be too widely known that while some patients develop papillœdema, many of the worst cases show little or no swelling of the discs at all.

(2) *Cases in which cerebral abscess is suspected but not diagnosed in time, or the diagnosis of cerebral abscess is rejected for some other.*—In this group many mistakes arise out of insufficient knowledge of the variations in cellular content of the cerebrospinal fluid in brain abscess. A patient becomes drowsy and complains of headache after otitis media ; a lumbar puncture shows purulent cerebrospinal fluid with cell counts of anything up to 1000 per c.mm. The bacteriologist reports organisms also in direct films of the cerebrospinal fluid and a diagnosis of generalized leptomeningitis is promptly made, though subsequently cultures of the cerebrospinal fluid are found to be sterile. In the meantime, drainage of the cerebrospinal spaces by lumbar puncture has been started, a procedure that almost invariably hastens the end if the patient has a brain abscess. High cell-counts in the cerebrospinal fluid are not infrequently found in abscess, especially abscess of the cerebellum, although there is is no generalized meningitis.

Diagnosis between general leptomeningitis and cerebral or cerebellar abscess may at times be very difficult, for cases occur in which both these varieties of infection are present before any intracranial operation has been done. But, as a rule, a careful history and neurological examination should enable us to distinguish between the two. It is important not to be put off a diagnosis of abscess by finding turbid cerebrospinal fluid in which are organisms and excess of protein. Abscesses may leak into the lateral ventricles or subarachnoid space without producing fatal diffuse leptomeningitis.

In some of our cases a diagnosis of abscess has been rejected because there was no increase of cells in the cerebrospinal fluid. In one case of abscess of one cerebral hemisphere the cell count and protein content of the spinal fluid were normal (Case 4). This, it must be noted, was a case in which the infection of the brain was by the blood-stream. We have not seen a cerebellar abscess without increase of cells in the cerebrospinal fluid. In another case the diagnosis between tumour and abscess of the left temporal lobe was made in favour of tumour because the cells, some thirty per c.mm., were all lymphocytes. Necropsy later showed an abscess.

While it is clear that more knowledge is needed about the variations of the cerebrospinal fluid in brain abscess, it should at the same time be emphasized that lumbar puncture may be a most dangerous form of investigation if much fluid is

allowed to escape. We have seen several cases in which sudden death occurred soon after the withdrawal of 10 c.c. of cerebrospinal fluid at a diagnostic lumbar puncture, for example, Case 10. Only 0·5 to 1 c.c. of fluid should be taken. This will give all the information that is required and will not upset the patient.

Before leaving this question of the diagnosis between abscess and generalized leptomeningitis it must be noted that diffuse leptomeningitis after middle-ear and mastoid disease may sometimes evolve so slowly as to simulate abscess of the brain, and may also show focal signs such as are found in abscess. The diagnosis is apt to be especially difficult if infection of the labyrinth has also occurred. Purulent pachymeningitis after frontal sinus infection may also simulate abscess though usually the clinical picture of this condition is quite distinct (Cairns [7]). When there is difficulty an exploratory tapping and ventricular estimation is justified.

Exploratory tapping.—This has been referred to in a previous communication before this Section [7], and it is only necessary to remind you that it will be especially valuable where the abscess is suspected to be in one or other cerebral hemisphere. The ventricle is always collapsed on the side of an abscess and is normal, or slightly larger than normal, on the opposite side. If made through a clean incision such an exploration is not harmful, but in the event of a positive result the abscess should be drained immediately, otherwise diagnostic tapping is likely to be followed by the same consequences that may attend withdrawal of cerebrospinal fluid by lumbar puncture. This method is also useful for distinguishing between patients with abscess and patients with tuberculous meningitis or meningo-encephalitis who happen to have a running ear.

In the chronic cases of abscess it is often difficult to make a differential diagnosis from tumour. As already described, in four of our cases an osteoplastic flap was turned. In three of the four cases abscess was considered as a possible diagnosis. In only one of the cases was there a history of middle-ear disease and even in that case the cause of the abscess was not certain. The difficulties of diagnosis are increased by the fact that we occasionally find tumours where abscesses have been suspected. One patient with a left frontal glioma had fairly severe left otitis media; another patient whose illness began after influenza and a discharging ear proved to have a subdural hæmatoma.

Another type of case in which diagnosis of intracerebral abscess may be at fault is that in which at operation an extradural or subdural abscess is found and is thought to be sufficient to account for the symptoms, and the brain is not explored. The difficulty here is enhanced by the fact that extradural suppuration can produce cerebral symptoms.[1] It might be considered that this is an error of treatment but we believe it to be an error of diagnosis. Is there anything observable at operation from which it can be foretold that a patient with an extradural abscess has or has not also an intracerebral abscess? Is it not rather a question of accurate diagnosis from thorough examination before operation begins? From limited experience we would expect that with further study, extradural and intracerebral abscesses could be differentiated clinically.

Lateral sinus thrombosis also gives rise to difficulties, especially as it is commonly associated with cerebellar and cerebral abscess.

(3) *Cerebral abscess is diagnosed but not accurately localized.*—We have nothing to add to the classic description of Symonds [8] of the localizing signs of brain abscess. These signs cannot always be demonstrated when the patient is drowsy or unconscious and then precise localization of the abscess may be very difficult as in a case which we saw recently for Mr. Norman Patterson.

The patient was a girl, aged 8 years, who had had a discharging left ear since infancy. Some weeks after tonsillectomy she suffered acute pain in the left ear and the discharge stopped, and this was followed by headache, drowsiness and vomiting. An incomplete

[1] We have even observed a case of orbital abscess for some time as a probable case of intracerebral abscess.

mastoidectomy was done: when we saw her three weeks later she had signs of a cerebral abscess. She was drowsy and uncoöperative, and her visual fields could not be examined but there were signs indicating clearly that the left cerebral hemisphere was involved: weakness of right side of the face and of the right upper limb, diminished abdominal reflexes and at times an extensor plantar response on the right side. It was concluded that there was a right temporal abscess, but exploration of the temporal lobe was negative. The child died and at necropsy a large abscess was found in the left frontal lobe. There was pus in the left frontal sinus, also a sequestrum which would probably have shown in postero-anterior skiagrams of the skull.

Accurate localization of an abscess like this, when a patient is not seen until stupor has set in, is practically impossible and the surgeon should always keep an open mind about the possibility of the abscess being in an unusual place and should make such preparation before operation that he is able to explore more widely without disturbing the operative field. Evans found among 109 cases of brain abscess secondary to otitis media and mastoiditis 6 in which the abscess was not

FIG. 14.—Cerebellar abscess, secondary to infection of right middle ear and mastoid, in an unusual situation in the upper part of the vermis.

temporal but occipital, parietal or frontal. In an unconscious patient one must be prepared to explore in more than one area.

In one case we failed to find a cerebellar abscess through exploring in the wrong place. The patient was in an advanced stage of stupor and obviously had a cerebellar abscess, but exploration failed to find it in the usual place. At necropsy the abscess was found high up in the vermis, strictly in the middle line (fig. 14).

In this group must be included those cases in which only one of multiple abscesses is drained. We have had several cases of this type following bronchiectasis and only one from other causes, a case of bifrontal abscesses both of which were drained. However, brain abscesses may be multiple after middle-ear and mastoid infection (7 out of 109 cases, Evans), especially a temporal and cerebellar abscess together after lateral sinus thrombosis.

Œdema of the brain, which so commonly accompanies cerebral abscess, may interfere with localization. One of our cases of occipital abscess gave symptoms of disturbance of the corresponding frontal lobe and these led subsequently to

exploration of the frontal region for abscess (fig. 12). In a case of right frontal abscess the patient had an intermittent complete left homonymous hemianopia which resulted in the first tap being made in the temporal lobe, though the second tap over the frontal region at the same operation revealed pus.

(4) *Other infective foci are overlooked.*—Many of these patients, especially those with frontal abscesses, have multiple sinus infections, and the success of treatment of the intracranial infection must surely be hampered if there is still pus in the sphenoidal sinus or antrum of Highmore.

## Conclusions

How are we to overcome these many difficulties of diagnosis? Many of them will be overcome by careful history-taking and neurological examination in the light of an accurate knowledge of the life-history of brain abscess. If every patient who has severe headache after ear trouble or mastoid operation were put through the mill of such an investigation the bad results of to-day would be improved. We would especially stress the importance of examining the visual fields. It is that part of the examination more than any other that cannot be done when the patient becomes lethargic and for want of which localization of the abscess in the stuporous patient may be so baffling. When intracranial complications are suspected neurological investigation should take precedence over mastoidectomy, since it will tell more about what is happening inside the dura than can be learned from looking at a small area of dura exposed in the mastoid region. Lumbar puncture should be done, but only 1 c.c. of fluid should be withdrawn. Diagnostic exploration as described is important in certain cases.

With each case of abscess there is need to form some estimate of when the abscess began and what stage it has reached, for this is the only way in which to gauge the right moment for interference. This can only be done by careful study of the history of illness.

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II.—**Mr. Sydney Scott**: To Sir Charles Ballance we are indebted for a full history of the treatment of otitic brain abscess.[1]

For many centuries the association of brain abscess with aural suppuration was generally regarded as purely incidental, though Hippocrates knew of the dangers threatening the brain in ear diseases.

Morgagni, to whom the medicine of the eighteenth century was richly indebted, was one of the first to show clearly that aural suppuration was the primary disease, and that brain abscess was secondary. Previously even Valsalva regarded the brain abscess as primary, though Bonetus stressed the significance of abundant discharge from the ear or from a "fistula" in cases of brain abscess, as being a sign of good omen.

1 Ballance, "The Surgery of the Temporal Bone," London, 1919.

### The First Successful Case

Morand published the first case of successful operation for otitic brain abscess in Paris in 1768 (" Opuscules de Chirurgie," p. 161).

This was the case of a monk aged 51, who in 1751 had otorrhœa and then a mastoid abscess which Morand opened. A sinus persisted and was repeatedly treated with the actual cautery : bony sequestra were removed exposing the dura mater. Eventually a T-shaped incision was made, and the sinus enlarged, exposing more dura mater. As pus continued to escape, a probe was passed fully one inch into the brain, and catgut tents were inserted into the cavity to dilate the aperture. Then a crucial incision was made through the dura and Morand introduced the tip of his finger into the brain ; on withdrawing it pus followed. The abscess cavity was irrigated with barley water, with a little turpentine and balsam, which the patient disliked but got used to! As the discharge persisted, more than a teaspoonful coming away at each dressing, Morand had a silver tube made, rather more than one inch long, and as large as an ordinary quill pen. No difficulty occurred after this, and the abscess healed as the tube was gradually shortened and finally removed.

The patient recovered and remained cured, but Morand did not publish the case until he had waited four and a half years to make sure that the cure was permanent.

As Sir Charles Ballance says, in reference to this case, Morand owed his success to his perseverance and determination to establish free drainage.

### Early Monographs on Brain Abscess

A hundred years later, Lebert wrote the first systematic account of brain abscess (1856), based on 80 records, 15 from the eighteenth century and five of his own.

Lebert overlooked Morand's successful case and also those of Roux, when he said that no case of recovery was known, and strangely enough cast ridicule upon any attempt at surgical treatment. He said :—

" We must speak more decisively against any attempt at operation, for opening a brain abscess is, even from the theoretical point of view, not rational."

He styles it a " foolhardy procedure."

As has happened many times, the pessimistic conclusions of one writer stimulate another to reinvestigate. William Gull, when assistant physician at Guy's Hospital, made a study of brain abscess, with painstaking observations and sound reasoning. In *Guy's Hospital Reports*, Third Series, 1857, iii, 261, Gull mentioned Abercrombie's review of a series of cases published principally to establish the fact that abscesses are met with in the brain. Gull recognized the " metastatic abscess " secondary to some primary disease in the lungs or elsewhere. He commented on the fact of the latency of brain abscess, and pointed out that :—

" A person may perform all his duties and be in apparently good health, though for many months he may have a large abscess in the cerebrum (Case XIII) " *loc. cit.*

These papers must have stimulated their colleagues to be on the watch for brain abscess, hoping that surgery, if given the opportunity, might bring relief.

In 1877 Erichson wrote that few surgeons would have the hardihood of Dupuytren, to plunge a bistoury into the substance of the brain, to open an abscess in this situation. (Dupuytren's Lectures, published 1839. " Leçons orales," 2nd ed., vi, 183.) But in 1873 Luther Holden had already been rewarded for such hardihood by the complete recovery of the patient, whose case was fully reported in the *St. Bartholomew's Hospital Reports*, 1873, ix, 96, and the late Alphonse Elkin Cumberbatch assisted at the operation.

During this period surgery was making a leap forwards following developments in anæsthesia and results of the discoveries and teaching of Lister and Pasteur. If there were anything to urge a surgeon to trephine and open an abscess of the brain, it was the further researches of David Ferrier and the observations of Beevor and Jackson.

### Further Successes by Drainage

In 1881, in Glasgow, Macewen diagnosed a temporo-sphenoidal abscess, and prolonged life though he did not cure the patient; this was the forerunner of a remarkable series of successes during the next ten years.

In 1886 A. E. Barker successfully drained an otitic temporal lobe abscess.

In 1887, in Edinburgh, Greenfield diagnosed a left temporo-sphenoidal abscess which Caird successfully drained and

In 1887, at Halle a/Saale, Schwartze had the first recorded successful operation for cerebellar abscess drained through the mastoid antrum, and von Bergmann a temporo-sphenoidal abscess.

In 1888 Horsley cured a left temporo-sphenoidal abscess.

In 1889 Macewen had his first success with a cerebellar abscess and cholesteatoma in the left mastoid.

In 1894 Ballance had his first case of successful operation for cerebellar abscess due to mastoid disease. The diagnosis was aided by the semblance of the symptoms to those produced by ablation of one cerebellar hemisphere in the monkey, with which he was familiar. After removing the diseased mastoid bone, he drained the abscess through a separate trephine opening, but came to the conclusion from subsequent experience that it was better to drain the abscess as advised by Hermann Preysing (*Zeitschr. f. Ohrenheilk.*), xxxv and xxxvii, 108 and 208) through the mastoid wound.

Since those days hundreds of successes have been published and many more important successes have been obtained. The *Proceedings of the Royal Society of Medicine* alone contain descriptions of many interesting recoveries from otitic brain abscess.

### Pathology of Otitic Brain Abscess

It has long been recognized that temporo-sphenoidal abscess, like cerebellar abscess of otitic origin, is due to the infection penetrating directly through the bony wall and dura mater to the adjacent part of the brain cortex. Rarely is it possible to show that a cerebral abscess is due to a retrograde thrombus in a tributary of the lateral sinus. The tegmen of the antrum or of the tympanum may appear intact to the naked eye, or else obviously destroyed by caries, exposing the dura mater. Often, but not always, the dura mater is also discovered to be involved, either covered with granulations or in a sloughing condition, and perforated, forming part of a fistulous track between the middle-ear cavity and a brain abscess, from which pus is seen to escape. Recently Dr. Dan McKenzie wrote an interesting paper discussing the difficulties in diagnosing such forms of leaking brain abscess (*Journ. of Laryng. and Otol.*, 1933, xlviii, 797).

Though the dura mater may look healthy externally, in some cases of brain abscess more or less extensive adhesions form between it and the arachnoid, pia mater, and adjacent brain, if there is any local encephalitis. These adhesions protect the general arachnoid space from diffuse infection, though sometimes we do meet with a circumscribed abscess on the inner surface of the dura mater. It would be a fortunate circumstance if we could tell beforehand exactly where such adhesions have formed in those cases in which the dura mater looks normal externally.

### When to Explore

It is sometimes necessary to explore the brain by incision through intact dura mater, to seek a presumed adjacent abscess, but it seems only justifiable to do so when the signs and symptoms are fairly manifest. For though such exploration in the absence of manifest signs may lead to the discovery and cure of an abscess in isolated instances, the practice of premature exploration yields frequent negative findings. An exploration which was negative at one stage may be followed by

manifest signs a week or two later, when an abscess is discovered by a second exploration in the same region as the first. We should feel doubtful whether the abscess then found was not the result of premature exploration. When only a day or two intervened between the operations, it is of course highly probable that the abscess was missed at first.

### Cerebral Symptoms

The signs and symptoms of brain abscess are quite straightforward in some cases, while in others the diagnosis presents a problem which baffles even experienced neurologists. Headache with sickness and lethargy and loss of flesh are common to many diseases. Accompanying or following otitis media, these symptoms arouse suspicion. Optic neuritis is more often absent than present. The temperature chart often misleads, for in some of our cases there was irregular pyrexia, in others the temperature was normal, and only in few was it conspicuously subnormal, and then only for short periods which might be easily missed. Patients who were lethargic sometimes became rapidly alert, answering questions intelligently, then lapsing into an apathetic state again. If the patient appeared to be troublesome or stupid, the condition was found to be associated with some loss of memory and lack of concentration. Insomnia, restlessness, yawning, hiccup, a ravenous appetite or great thirst have been noticed, also glycosuria.

In contrast with the state of lethargy are the occurrence of general convulsions and outbreak of apparent mania, which led to discovery of signs of brain abscess. Complete hemiplegia with involvement of the lower facial muscles and hemianopia, appeared rapidly in some cases, but was present hardly at all in others. Crossed lower facial paresis alone was sometimes intermittent and transitory. Similarly crossed wrist drop, which was also periodic and recurrent and was specially noticed in the case of a large slowly developing abscess, which implicated the whole of the temporo-sphenoidal lobe.

Many interesting examples of pseudophasia (which I suggest is a more expressive term than "auditory sensory aphasia") were met with in our series, and proved valuable as signs of disturbance of symbolism represented in the left temporo-sphenoidal lobe.

### Cerebellar Symptoms

In the cases of cerebellar abscess the characteristic nystagmus was not invariably found. Its absence led to fatal delay in at least one early case. It is worth recording that typical nystagmus, coarse towards the side of the abscess and fine towards the opposite side, was observed in one case one day, and the following day the asymmetry was reversed, while on the third day the characteristic form of nystagmus reappeared. In other cases in which nystagmus had been absent before the abscess was opened, it appeared afterwards when the intracranial pressure had been relieved.

Loss of muscle tone of the limbs on the same side, with incoördination, has been recognized most frequently. The useful finger-to-nose test generally revealed exaggeration of movement on the side of the lesion. Incoördination due to asynergia was observed in other purposeful movements of the limbs on the same side. Attempts to make a rapid succession of opposed movements, such as the rapid pronation and supination of the wrist, have been found even in children when they were able to give their attentive coöperation. Thus dysdiadokokinesia proved one of the most reliable signs of a lesion, but it was sometimes intermittent in cases observed from hour to hour.

Hypotonia of the limb muscles was generally detectable but was only occasionally so marked as to resemble paresis. On the other hand hypertonic conditions were rare though in one case they revealed a pronounced cataleptic feature. Ataxic gait and giddiness were seldom outstanding. These disturbances were more marked in the

early labyrinth cases than in uncomplicated cerebellar abscess. Pointing tests of Bárány proved valuable sometimes, the deviating error being towards the side of the lesion. In several cases of cerebellar abscess, as in some of cerebral abscess, the desperate state of the patient was not apparent until sudden loss of power, or of consciousness occurred, or even cessation of breathing. The latter has occurred after too rapid or excessive withdrawal of cerebrospinal fluid. When it is necessary to collect fluid for pathological tests in suspected cases of cerebellar abscess special care is taken to restrict the quantity and the rate of flow.

### Character of Abscess Wall; Enucleation, Drainage

Before considering the details of surgical treatment, it is necessary to direct attention to various forms and types of abscess.

Perhaps the character of the wall of the abscess is one of its most important features. Sometimes the wall is very thick and dense, completely encapsulating a pyogenic membrane. Occasionally fibrous trabeculæ form partitions, as seen in the dense multiloculated abscess. [Specimen shown.] It is obvious that such an abscess could not be effectively drained, but should be removed complete as this was done. The dense unilocular abscess [specimen from the Museum at St. Bartholomew's Hospital shown] is also best dealt with by enucleation. The specimen was successfully removed by Mr. L. B. Rawling. Many cases of otitic abscess, however, have no adventitious fibrous walls. Brain tissue alone seems to enclose the pus, and portions of the brain are disintegrating and gangrenous, and occupy the interior of the cavity. There appears to be no possibility of enucleating such abscesses, and they must be drained. The same procedure—drainage—is necessary in dealing with the thin-walled abscesses, as well as with those abscesses which are found already leaking.

### Diffuse Œdema of Brain

Another feature of brain abscess to which attention is directed, is the state of the white matter of the brain outside its walls. In fatal cases sections of the brain show the white matter swollen and œdematous. This inflammatory œdema tends to extend through the whole hemisphere, and accounts for the deflection of the normal median plane of the brain to the opposite side. The lateral ventricle on the affected side is usually occluded in these cases, though distended with cerebrospinal fluid on the normal side. Both lateral ventricles are equally distended in fatal cases of cerebellar abscess, but the white matter of the cerebellum is liable to the same kind of œdematous swelling, causing deflection of the vermis and roof of the fourth ventricle, similar to that which occurs in the cerebrum. In other fatal cases there is widespread leptomeningitis, and we sometimes find a secondary track from the abscess to the adjacent ventricle or to some other part of the cerebral cortex than that of the original path of infection.

### Clinical Groups of Cerebellar Abscess

A consideration of a series of cases of cerebellar abscess shows that there are three main different sequences of events concerned in its development. To the first group belong those cases of cerebellar abscess which follow lateral sinus infection. In the second group otitis media causes labyrinthitis, before cerebellar abscess supervenes. The third group comprises those cases of cerebellar abscess due directly to otitis media, without any intermediate lateral sinus infection or labyrinthitis. The pathway of infection can be found to correspond to each group, and the precise situation of the abscess in the cerebellum also corresponds to the group to which it belongs.

### Operative Procedures

When operating for brain abscess secondary to middle-ear disease, the first step has been to explore the mastoid and perform Schwartze's operation. It is unneces-

sary to perform the radical mastoid operation as a routine, and only when we know the labyrinth to be defunct or the disease in the middle ear to be very chronic, or find cholesteatoma, do we proceed immediately to remove the tympanic ossicles and posterior meatal wall.

The next stage comprises exposure of the dura mater, removing the roof and posterior wall of the mastoid operation cavity. In the case of cerebral abscess, the tegmen and the lateral wall of the middle cranial fossa are removed, working from below upwards with bone-cutting forceps. In the case of cerebellar abscess, the dura mater is exposed beyond and below the sigmoid sinus to the cerebellar fossa of the occipital bone. On the inner side of the sigmoid sinus Trautmann's area is often the pathway of infection from the antrum to the cerebellum. To attain this cranial exposure, a vertical incision of the scalp, temporal muscle and pericranium is made from the upper end of the original mastoid incision, and to expose the cerebellar fossa a horizontal incision is made in the plane of the Frankfort line (infra-orbital-supra-meatal level).

The trephine is unnecessary, for as soon as the dura mater is sufficiently exposed with a broad flat gouge the opening can be quickly enlarged, even as far as the foramen magnum if necessary, with double-lever bone-cutting forceps.

*Exposing the brain* : The dura mater is incised at the apparent seat of invasion whenever this can be determined, for this is more likely to lead directly into the brain abscess. Failing any definite guide, and when the diagnosis of cerebellar abscess is well founded, preference is given to an opening posterior to the sigmoid sinus, especially when this occupies a forward position.

We can easily detect a thin-walled abscess by the escape of pus when special brain-exploring forceps are introduced and opened. With the same instrument the resistance of a thick-walled abscess can be felt. The majority of abscesses we have met with could be penetrated when the instrument was sharp.

When possible I think it important to empty the abscess thoroughly in the first instance and better to use a suction apparatus than to attempt to irrigate the cavity. It is necessary to avoid force. Drainage tubes should be attached to the pericranium or dura mater, so that they remain in the same desired position even if there are subsequent swellings and œdema of the scalp.

The wound is only partly closed ; when it has been possible to enucleate the abscess, it is almost completely closed by suture.

### After-treatment

The most critical period is during the first five or six days following the discovery and emptying of the abscess. During this time especially, it is important to do as little as possible to the wound or tubes. Only superficial dressings should be touched. Macewen went so far as to leave the first dressing in some of his successful cases until the end of the second, or even the third, week. Perhaps we are inclined to dress our cases too frequently. Cases seem to do best when the head is kept elevated.[1]

If a case after the first five or six days is not doing well and yet does not show signs of meningitis it is probably the result of œdema of the brain. This is more frequent than retention of pus. It is therefore seldom necessary to re-explore the abscess, but an attempt to save the patient may be made by exposing a still larger area of brain, dividing the dura mater to permit herniation of the swollen œdematous mass, which sometimes relieves pressure symptoms. Many of these cases end fatally from gangrenous encephalitis, but even desperate ones sometimes recover. I propose to try the liberal direct application of magnesium sulphate in the next case affected by this complication which I may happen to encounter.

[1] As Otto Muck (Essen) emphasized.

Nothing exceptional can be claimed in the percentage of recoveries from otitic brain abscess treated on these lines. They conform with the common average between 25% and 30%. Nevertheless they include patients who were comatose, some with hemiplegia and more than one who had stopped breathing at the time of operation. Others recovered from brain abscess though also suffering from lateral sinus thrombosis, septicæmia, and proved leptomeningitis.

## Illustrative Cases[1]

*Chronic Suppurative Labyrinthitis. Cerebellar Abscess. Operation. Recovery.*

John C., aged 28. Admitted to St. Bartholomew's Hospital, July 15, 1908.

*History.*— Left otorrhœa for many years.

From October 1907 to February 1908, suffered from vertigo, vomiting and frequent headache.

February 1908, was back at work until June 15, 1908, when he had headache, vomiting, and staggering gait, but not vertigo.

*Condition on admission.* — Temperature 98° F., soon falling to 95·8° F; pulse 72, falling to 52.

Discharge from left ear, in which patient was absolutely deaf both to air and bone conduction. Severe headache, chiefly occipital; head slightly retracted. Rombergism; standing with feet together and eyes closed he would fall toward the right. Well-marked nystagmus to left.

Kernig's sign present. Knee-jerks obtainable; plantar reflexes flexor. There appeared to be definite hypotonia of the left lower extremity. Incoördination of upper extremity. Patient was observed to yawn frequently.

Blood examination revealed a leucocytosis of 19,400 cells per c.mm.

*Operation* July 15, 1908.—Radical mastoid operation on left side disclosed granulation tissue and pus in a small mastoid antrum. The facial aqueduct was eroded, exposing the nerve. The erosion led into the labyrinth. The dura mater immediately posterior to the labyrinth was covered with granulations, and though well exposed transmitted no pulsations.

An incision was made through the dura mater between the sigmoid sinus and the internal auditory meatus, and into the adjacent cerebellum, to which it was adherent. About 1½ dr. of foul pus evacuated, and a rubber tube introduced into the brain abscess.

July 17: Two days later the dural opening was enlarged with the object of allowing the cerebellum to herniate in order to relieve headache, which was still severe; July 18: Frequent hiccup; July 19: Large hernia of cerebellum; July 20: Hernia now pulsating; July 23: No headache, or nystagmus; July 31: Pulsation scarcely noticeable. Leucocytes 7,800 per c.mm.

August 2: Patient is much wasted. Still complains of headache occasionally. Nystagmus sometimes present and sometimes absent. The cerebellar hernia varies in size from day to day. Pulsation returns and disappears again. Incoördination of left upper extremity, as shown by finger-to-nose test, still present; August 12: General condition improving, enabling patient to get up for the first time; August 16: Hernia of cerebellum receding, not pulsating; August 19: Plastic operation, closure of the mastoid wound.

*Subsequent history.*—The patient completely recovered and returned to employment. He has been seen during 1934. Still has signs of facial paresis, but is otherwise well (twenty-six years after the operation).

*Cerebellar Abscess. Sudden Coma and Apnœa. Recovery after Operation during Artificial Respiration.*

W. J., a farm boy, aged 17, suffering from severe headache and chronic otorrhœa. Was admitted to St. Bartholomew's Hospital, on June 20, 1922, at 2 a.m. In spite of pain he could walk and stand, and showed no discernible physical signs apart from discharge from the right ear. The house-surgeon withdrew some clear cerebrospinal fluid, obviously under pressure, and arrangements were made to operate on the ear at 2 p.m. the same day. The patient became drowsy shortly before the time for operation, and had become quite unconscious when taken to the operating theatre. Apart from confirming the evidence of middle-ear suppuration, and finding that the patient's right upper extremity remained elevated when raised (cataleptic

[1] All under author's care.

state), no other observations could be made. An anæsthetic was given, though this hardly seemed necessary, and the operation on the mastoid was begun, but before the antrum had been opened the patient had ceased to breathe. Artificial respiration was applied and the operation stopped, but breathing remained suspended while the dura mater of the middle and posterior fossa was exposed. The tension of the dura mater was much higher in the posterior fossa, and no pulsation could be felt. It was not possible, in the circumstances, to see if any path of infection could be followed up, and the dura mater was incised posteriorly to the sigmoid sinus by several radiating incisions through the dura mater covering the lateral and inferior surface of the cerebellum. The cerebellum prolapsed freely, expanding over the edges of the dura mater. In the cerebellum a large abscess was found, and on the escape of an ounce or two of pus spontaneous respiration was resumed. It was, however, necessary to apply artificial respiration again for half an hour and the patient remained comatose for about two days, then he began to recover. The results of the usual tests corresponded with the signs of a cerebellar lesion, e.g. coarse nystagmus to the side of the lesion—asynergia and incoördination in limbs on the same side as the lesion.

Patient left hospital after three months, apparently perfectly well, and he is still well twelve years since the operation on the abscess.

*Otitic Cerebellar Abscess and Leptomeningitis. Recovery.*

Kenneth J. G., aged 6, admitted to St. Bartholomew's Hospital, June 29, 1927, having earache and delirium. Earache had begun in the left ear five days previously; discharge three days later.

*Condition on admission.*—Delirious at times; had photophobia; looked ill; temperature, 103·6° F.; pulse 140; respiration 28.

Muco-pus in left ear and palpable glandular swelling over left mastoid, which was tender. Right ear normal. Head retraction, Kernig's sign doubtful. Knee-jerks and abdominal reflexes equal; plantar response flexor. No paresis or nystagmus. A tache cérébrale was present.

June 30: Mastoid cells and antrum contained pus. Schwartze's operation performed and mastoid drained with four tubes. The cerebrospinal fluid collected by lumbar puncture was turbid.

For the next five days the temperature ranged between 99° and 100° F. and the pulse between 100 and 130.

July 6: Temperature beginning to keep between 102° and 103° Lumbar puncture repeated five times during the second week.

July 13: Temperature varied at lower levels (98°-102°) pulse 100-120.

July 20: In the third week the patient began to vomit daily; temperature assumed lower level but pulse was erratic, at first 120-140, then between 80 and 100.

July 21: Coarse nystagmus to left; and definite dysdiadokokinesia of the left forearm; no papillœdema. Seen by Dr. Geoffrey Evans.

July 25: Seen by Dr. Carmichael who found the cerebellar signs more marked; double Kernig's sign suggested the possibility of infection of the cerebrospinal méninges.

The left mastoid was reopened, and more dura mater on each side of the sigmoid sinus was exposed. Although it appeared normal it was incised. No adhesions were seen, but half an ounce of pus was evacuated from the postero-inferior and inner portions of the lateral hemisphere of the cerebellum. The cavity was emptied by suction and wicks, impregnated with bipp were introduced into the cavity for twenty-four hours, to maintain contact between arachnoid and dura mater. The next day these were removed and replaced by two rubber tubes, until August 16; one week later one tube was replaced because the pulse had risen to 140 and the temperature to 103° F. This tube was finally removed on August 29.

October 12: The herniated cerebellum was receding; a plastic operation was performed to complete the closure of the wound.

The boy returned home on November 6, 1927, and now, six years later, attends school where he works and plays games just like other boys.

*Chronic Suppurative Otitis Media. Labyrinthitis. Cerebellar Abscess. Operation. Recovery.*

Ernest R., aged 4, admitted to St. Bartholomew's Hospital, June 27, 1927. He had been seen in the out-patient department in 1925, when he had had left otorrhœa for three months: then measles a month later, and for one month the parents had remarked that he staggered

and had noticed a squint for one week. These symptoms had disappeared after two weeks, and the parents had not again noticed anything wrong until June 1927. He had caught a cold and the left ear was found discharging three weeks before admission. He complained of pain at the back of the head, and vomited occasionally. Ataxic, falling to left; a squint had been observed. Coarse nystagmus to left; hypotonia and dysdiadokokinesia of the left upper extremity. Pointing error of left hand; no Kernig sign; all tendon and superficial reflexes normal.

This appeared to be a clear case of cerebellar abscess. The left mastoid was opened; pus and granulations were found in the antrum and adjacent cells. No ossicles were present; pus was discovered oozing from a carious labyrinth immediately adjacent to which was a track leading directly into a cerebellar abscess containing 2 dr. of evil-smelling pus. Two rubber tubes were used to drain the cerebellum. The patient's temperature for the following seven weeks was between 97° and 99°; he then developed erysipelas: this lasted for a fortnight. Finally he completely recovered and left hospital on October 4, 1927, and remains well.

*Leaking Temporo-sphenoidal Abscess. Recovery.*

Edwin S., aged 9, was taken ill four days after Christmas, 1916, with sudden pyrexia, diurnal remittent fever, with excursions between 97° and 105° F., for three days.

January 6, 1917: Temperature was 101° (morning) and 97° F. (afternoon). Pulse varied between 110 and 64. There had been headache and vomiting, but no optic neuritis; abdominal reflexes were natural, and there was no "tache cérébrale."

The boy then had sudden pain in the left side of the body, and the possibility of an infarct arose.

The left ear had discharged since early childhood, and the external auditory meatus was full of pus and granulations. Dr. E. Lowry consulted Dr. Langdon Brown who diagnosed cerebral abscess, due primarily to the ear. An operation was carried out the same afternoon Owing to the possibility, suggested by the hectic temperature, that the lateral sinus was infected, the left internal jugular vein was first examined and ligatured, though full of blood without visible clot. Numerous soft enlarged cervical lymphatic glands were encountered.

The left mastoid was then opened and a fistula was found leading from the roof of the external auditory meatus into the mastoid antrum (an uncommon condition). The antrum was full of pus, granulations and cholesteatomatous material, in direct contact with the dura mater of the middle fossa, the tegmen having already disappeared. Adjacent there was a track leading up into a temporo-sphenoidal abscess which was evacuated. The lateral surface of the temporal lobe was exposed by radial incisions in the dura mater to prevent herniation of the œdematous brain, but no tube was left in the abscess cavity of the brain.

After completing the radical mastoid operation the skin incision was closed and the mastoid cavity only was drained. Strange to say the boy made a complete and uneventful recovery, and is now an active young man, aged 25, and a capable motor driver.

*Left Temporo-sphenoidal Abscess. Pseudophasia. Recovery.*

F. U., a girl, aged 10, said to have been deaf in the left ear for two years. Had been treated for otorrhœa until nine months previously, when the discharge ceased after removal of tonsils and adenoids. No other symptoms until about a month before admission. Attended the out-patient department, complaining of pain in the left ear and some otorrhœa, but her condition was not regarded as serious until after some kind of convulsion, followed by another two days later. She was then admitted, January 8, 1922, as an emergency case. The convulsions were said to have involved the right side of the face and right upper and lower extremities.

On admission she was conscious; no hemiplegia. Temperature 101·6° F., pulse 96; tongue thickly furred; some pus and débris in left external auditory meatus; no mastoid signs, but slight tenderness on left side. The knee-jerks were unobtainable. The superficial abdominal reflexes were weakened on the right side. The child said she had no headache, and liked to be left alone. On being questioned, to test her memory for names of objects, she soon made repeated mistakes, became confused, and explained she "could not be bothered to think." It seemed probable that the child had localized encephalitis of the left temporo-sphenoidal lobe.

*Operation* (left mastoid) on the day of admission. The antrum and aditus contained cholesteatoma and pus, and there was an extradural abscess in the middle cranial fossa. No pulsation of the exposed dura mater could be felt. When the dura mater was incised,

it was found to be adherent to the arachnoid and pia mater on the inferior and the lateral surfaces of the temporo-sphenoidal lobe. No pus escaped through the dura mater, nor did the brain tissue protrude.

The child's general condition did not seem quite satisfactory, though neurological examinations revealed no fresh signs. She was allowed up and walked in the ward. The nurses said she seemed "peevish and irritable," and "behaved like a spoilt child," and her mother said she was "unlike her real self." In the third week she vomited unexpectedly two or three times. Pseudophasia persisted, and it seemed justifiable to diagnose an abscess in the brain. On making an incision through the adherent membranes into the left temporal lobe the abscess was at once found. This was drained with rubber tubes, and the child's condition, temperament and memory, improved forthwith.

It is twelve years since this operation, and the patient is quite well and is now married.

*Recent Acute Otitis Media. Apathy. Pseudophasia. Left Temporo-sphenoidal Abscess. Hemianopia. Recovery.*

R. H. G., aged 36, an engineer, caught a severe cold on July 2, 1923, followed by spontaneous otorrhœa on July 5, lasting one week, after which all symptoms disappeared. The patient kept to his bed from the outset, and was symptom-free by the second week from the commencement of the otitis media. It was then observed that he was physically and mentally inert, lacking initiative, and using incorrect words. Temperature, pulse and respirations were normal. He was carefully examined, and nothing was found to account for this curious lack of interest in himself and his affairs. There was no headache or retraction, vomiting or giddiness. All superficial and deep reflexes were normal, and muscle tone was equal in all limbs. The only clue to the abscess was pseudophasia. For instance, he called wool in the ear a "stopper"; a scent-bottle was "for scent"; the glass stopper "a bung"; a tuning fork was "a constant"; a pencil, a watch, and a knife were each called a "calculator"; the colour of the knife was "steel"; a brush was "for the household"; a comb was "the same." There was no apraxia.

July 22, 1923: *Operation.*—The left mastoid was found to be acellular, and the tympanic membrane had healed. There was no pus in the antrum, but the lining was swollen and hypervascular. The dura mater of the middle fossa was tense, did not pulsate. The temporal lobe of the brain was then explored after incision of the dura mater, and about half an ounce of pus escaped immediately. The abscess was drained with rubber tubes and iodized gauze.

July 27: The patient was interested to know where he was, and what had happened. He had complete amnesia of events in which he had been concerned during the previous four or five days. He never remembered being examined, even when he had appeared to be perfectly conscious—in fact, an example of the "dream state" described by Hughlings Jackson.

After the operation he discovered that he could not see anyone on his right side. The visual fields were examined by Sir William Lister, and it was evident that there was homonymous hemianopia, but fortunately the macula had escaped, and the patient has adapted himself to the limited fields of vision and returned to the successful practice of his profession. Furthermore, a few years later he was insured as a first-rate life by a high-class insurance company.

*Acute Otitis Media with Temporo-sphenoidal Abscess of Brain on Left Side. Operation. Drainage. Recovery.*

S.P.C., a man, aged 44, admitted to hospital, September 28, 1924.

*History.*—Patient was well until three weeks before admission when he had pain in the left ear, associated with feverish symptoms attributed to influenza. Complained of headache; vomited frequently; had had a shivering attack, and at times was thought to be delirious. For twelve days before admission a discharge from the left ear had been noticed intermittently. He repeatedly called things by the wrong name.

*Condition on admission.*—Semi-comatose; incoherent; yawned frequently. Temperature 97·6°, pulse 52. Tongue dry and brown.

*Neurological examination* (Dr. Hinds Howell).—Paresis of lower part of right side of face. Impossible to test visual fields. Also impossible to test right lower extremity, owing to ankylosis of knee-joint. Knee-jerk on left side normal. Abdominal superficial reflexes

absent. Plantar reflexes extensor on right side, flexor on left side. No paralysis or spasticity of upper or lower limbs on either side.

*Ears.*—Right: normal; left: very little discharge; greyish-white débris obscuring the tympanic membrane. No mastoid tenderness. After the ear had been cleaned granulations were seen on the drum membrane.

*Operation* (on day of admission).—Schwartze's operation and drainage through the tegmen of a left-side temporo-sphenoidal abscess.

Mastoid cells and antrum contained œdematous mucosa and pus (streptococci isolated ater).

The mastoid incision was extended upwards vertically through the scalp and temporal muscle, and the outer wall of the middle cranial fossa was removed from an area extending to about 1½ in. above the level of the tegmen antri, and including that part of the floor of the middle fossa formed by the tegmen; the dura mater looked normal.

Owing to symptoms pointing to brain abscess, the dura mater was incised immediately above the tegmen and the adherent brain explored. Pus was found within an eighth of an inch from the surface. One ounce of pus was evacuated and the abscess cavity in the brain drained with a bunch of six small rubber tubes packed into place with bipped gauze. The scalp was not sutured until a month later. The abscess was tube-drained for four weeks, the tubes being removed one by one at intervals of a few days.

The patient made an uninterrupted recovery and left hospital on November 8, 1924. He resumed his work with the Great Western Railway Company and was seen again, July 1934,[1] keeping well and still doing his work.

*Chronic Suppurative Otitis Media. Lateral Sinus Thrombosis. Cerebellar Abscess. Recovery.*

Sarah B., aged 12, admitted to hospital November 9, 1924, with an offensive discharge of long duration from the right ear. For three days before admission she had had earache, vomiting and giddiness. The right mastoid region was tender and œdematous. The same day Schwartze's operation was performed; an extradural abscess was found in the posterior fossa and a thrombus was removed from the sigmoid sinus. On November 14 and 15 the patient had rigors, and the internal jugular vein, which had not been touched at the previous operation, was ligatured.

November 20-23: Severe headache.

November 26: Nystagmus appeared on looking to the right. Patient ataxic; muscle of right upper and lower extremities hypotonic; test movements revealed dysmetria and dysdiadokokinesia on the same side. Plantar reflex extensor on both sides.

A cerebellar abscess containing two drams of foul pus (hæmolytic streptococci and *Bacillus proteus*) was opened and tube-drained.

February 4, 1925: Wound was closed by plastic operation; radical mastoid operation completed. All signs of cerebellar lesion disappeared.

1934: Patient is now married and well.

*Abscess in Temporo-sphenoidal Lobe. Headache. Pseudophasia. Drainage. Recovery.*

Lily B., aged 22. First complained of deafness and discharge from left ear in May 1926: discharge continued, and patient began to have frontal headaches, owing to repeated attacks of which she was admitted to hospital December 30, 1926. The mastoid was opened and drained. The antrum was comparatively small but was full of pus. Patient seemed much better after this but was kept under observation. Five days later, had an attack of feverishness (temperature rising from normal to 103°), and appeared to have influenza. This gradually passed off and the temperature became normal in three days.

Blood-count, 8.1.27: W.B.C. 16,400; 9.1.27: W.B.C. 16,500.

After this the pulse became abnormally slow. On two occasions it was down to 56 and 48 but most of the time was from 70 to 80.

About January 8, 1927, when the temperature was normal, patient was irritable and wanted to sit up and wash herself as the other patients did. Was annoyed with herself because she could not remember names of various articles. Did not sleep well.

On January 10 I decided to explore the brain because she called a coat button an "envelope," and "keys" she also called an "envelope," though she could read and spell and count accurately. She could distinguish coins quickly and correctly, but a medallion puzzled her.

There was no contraction of the visual fields.

[1] i.e. since this paper was read.

The same night a large collection of pus was found in the left temporo-sphenoidal lobe immediately above the mastoid antrum ; the headaches were relieved, and ever since the operation—now seven years ago—the patient has been perfectly well and normal.

*Chronic Suppurative Otitis Media. Fits. Pseudophasia. Temporo-sphenoidal Abscess. Drainage. Recovery.*

T. C., aged 30, a printer, attended hospital 22.3.33 on account of an injury to the right pinna due to a fall. Apparently he had a sore throat and felt a little queer in the morning before going to work. He is said to have had a fainting fit when at work and was found unconscious on the floor with a slight lacerated and contused wound of the right side of the head. He had regained consciousness when seen in the casualty department. Examination of the central nervous system revealed nothing abnormal. Referred to the house physician for treatment of the sore throat and allowed to return home. Afterwards complained of headache, chiefly frontal, but a note says he "seemed queer."

April 1: Became delirious and unconscious; admitted to hospital April 2 for fuller investigation.

When roused, exhibited definite name-amnesia (sensory auditory aphasia or pseudophasia). Some cough, semi-conscious and irritable. Pupils unequal; right, medium sized, did not react to light; left small, feeble reaction. Abdominal reflexes absent, plantar response. 4.30 p.m. was roused; more irritable; both pupils reacted. 9 p.m. pupils equal and reacted well to light; still unconscious; tried to sit up.

April 5: Was drowsy; yawned often, but answered questions though not in detail. Temperature 98·2° to 97° F. Pulse 54 to 80. Respirations 15 to 20. Tongue furred and breath offensive: plantar reflexes flexor; pupils reacted; tendon reflexes brisk. Abdominal reflexes absent. Leucocyte count 9,800.

April 6: Lumbar puncture yielded clear fluid under more than 300 mm. pressure, containing 26 lymphocytes per c.mm.; chlorides were diminished; protein 60 mgm.%. sugar present; sterile.

The aural house surgeon was called in, and found pus in fundus of left meatus; he obtained a history of long-standing deafness in the left ear, with occasional earache. The last attack had begun with little discharge noticeable about two weeks before the "fainting fit" in March.

*On examination.*—Incoördination of movement of right hand; required aid of eyes when doing pointing tests.

No nystagmus, but some papillœdema, more marked on the left side. Name-amnesia and pseudophasia were well marked, he could not remember his name, although he recognized it when told. Wassermann reaction negative.

Dr. Geoffrey Evans considered "that immediate exploration for brain abscess was advisable," and I was therefore sent for. At 10 p.m. patient seemed to be in a natural sleep, but when roused he was very irritable and antagonistic; kept muttering "it is no good," and seemed anxious to be left in peace.

There was no localizing sign but owing to the high cerebrospinal pressure, the papillœdema, and the amnesia, and the suppurative otitis the left mastoid was immediately opened. The dura mater of the middle fossa was smooth, red and bulging, but no pulsation was observed. An abscess, close to the surface, was found, and four or five drams of foul pus were evacuated with the aid of the electro-motor suction apparatus. The interior of the brain abscess cavity was accessible to illumination and inspection, and the walls did not collapse. Two rubber tubes and bipped wick were inserted and the outer wound was packed with gauze. Pulsation of the brain became evident soon after the abscess had been opened.

Patient rapidly regained consciousness. Soon after reaching the ward he pulled off the dressings, wanted to know where he was and why, tried to get out of bed, and wished to go home "at once"—another example of the "dream state" through which he had passed.

He gradually became more reasonable but was continually using words incorrectly. One request was repeated frequently: he would call the house surgeon and say "I only want to speak to you for 'half an hour.' When do you think you will be giving me the 'lift?'"

He asked for "tweezers" to remove "a wooden" from his finger. He could not name a "key," though he explained its use. He called a spirit lamp a "mechanical light," and would often say after asking a question—"Well I leave the matter to your 'desertion,' (meaning 'discretion'").

April 25: Mr. Foster Moore found that the papillœdema had disappeared and the visual fields were normal.

After the operation there was throughout little disturbance of temperature 97° to 98° F., but the pulse was generally 90 to 100. On the fifth, sixth, seventh and ninth days it was below 70 but the average was 90 for the remaining six weeks that patient was in hospital.

At the end of one week after the operation he sat up and attempted crossword problems, but there was still some pseudophasia; this did not disappear until about three weeks after the operation.

About seven months later patient returned to work, and keeps well (September 1934).

**Mr. F. C. Ormerod:** In 1930 Professor Neumann addressed this Section on the subject of brain abscess.[1] He recounted his own experiences and those of many other otologists and showed that in the hands of most surgeons a recovery rate of about one-third of the cases of cerebral abscess was as much as could be expected. He recalled, however, that Sir William Macewen recorded some 80% of cures. In the case of cerebellar abscess Macewen's results were 100% of cures in four cases, to which no one else has ever approximated. Professor Neumann suggested that possibly Macewen's procedure of opening the abscess at a second operation, after exposing the dura mater and painting it with carbolic acid to obtain adhesion, might be responsible for the difference. Mr. Cairns, speaking at the same meeting, suggested that another factor might be Macewen's method of opening the mastoid bone with burrs instead of with the mallet and gouge employed by most otologists. In thinking over the cases that had come under my care up to this time I had been struck by the fact that the only two—out of seven—cases of cerebral abscesses in which the patients had recovered had been treated first by a temporal decompression by means of a trephine and drainage, and had had a radical mastoid operation performed later when the brain abscess was practically dry. Both these patients were comatose on admission.

The other five cases were all treated by a mastoid operation followed, either immediately or remotely, by drainage through the mastoid wound. In an eighth patient, in whom the temporo-sphenoidal lobe was explored by the mastoid route an abscess, lying rather more anteriorly than usual, was completely missed. I believe that this abscess might have been found by exploration through a temporal decompression. Of the five patients who died after drainage, one succumbed to rupture of the abscess into the lateral ventricle, with maniacal symptoms, one to spread of the abscess backwards, destroying the optic radiation on that side, and three to a diffuse encephalitis. None of the cases developed meningitis. Since the papers mentioned were read four years ago, I have only had one case of temporo-sphenoidal abscess, that is the case exhibited at this meeting (*see* p. 152). This patient, I believe, underwent the mastoid operation before the abscess developed, and at the subsequent operation the mallet and gouge were not used, but a very wide temporal decompression was carried out with bone forceps and the abscess was opened and drained high up on its lateral wall. I imagine that the abscess in this case began when the temperature rose, some four weeks after the original operation, and a rigor led me to perform what was, I now believe, unnecessary ligature of the jugular vein.

If one considers these nine cases of temporo-sphenoidal lobe abscess, one finds that in the three, in which the abscess was opened without operation on the mastoid process and without any hammering, the patients all recovered. Of the six patients who were subjected to mastoid operation, five died of extension of infection into the brain-substance and one of an undrained abscess. I feel that the trauma of opening what is often very hard bone with mallet and gouge is very likely to injure, by a kind of *contre-coup*, the so-called capsule of the abscess which is very friable. Decompression by trephine is not likely to injure the capsule. In addition to this, exploration is more easily carried out by a wide decompression definitely made over the lateral surface of the lobe than from the mastoid wound or any—other than a very wide—extension. Drainage through the lateral aspect is also more direct

[1] *Proceedings*, 1930, xxiii, p. 1045 (Sect. Otol. 41).

and more easily carried out than through the mastoid wound. I believe that in most cases the track from the ear is completely closed by the time the abscess gives rise to symptoms.

The danger of meningitis in either method of approach seems very slight.

**The President** said that the subject was fraught with so many difficulties that it would be possible to discuss them for days, and still be "in the wood."

With regard to exploration with the finger, he had had a striking lesson as to its value a number of years ago, in a case of cerebellar abscess. He explored with a Horsley's seeker but could not find pus, but with the finger he found a large abscess. The patient died and at the autopsy it was found that the seeker had passed right into and through the abscess four times. In another case he had found a second abscess when using his finger to explore the temporo-sphenoidal lobe; had he not used his finger this would have been missed. Even if pus had been found by other methods and the abscess opened, he considered it advisable to use the finger, if only to get some idea as to the size, etc., of the abscess.

The question of draining an abscess was most difficult. If a drainage-tube was used the brain closed down on it, drainage was unsatisfactory and there was great risk of pocketing of pus. Some years ago he began packing the cavity with bipp ribbon gauze, and removed a little each day, so that by the fifth or sixth day another strip had to be inserted. The first patient made an uneventful recovery, so did the second. The third did well until, when the cavity had become much smaller than it had been when the abscess was opened, he (the President) used a tube. Within twenty-four hours the temperature shot up, and the patient became very ill and died. In the next case the cavity was packed only, but a fatal result occurred. He had used packing in a number of cases with varied results, and, though he had not gone into the statistics, he thought it had proved more satisfactory than other methods of drainage.

**Sir Charles Ballance** said that Mr. Cairns had dealt with the treatment of brain abscess in general, a fact of immense advantage to members of the Section, because the best method of treating abscess in any part of the brain must also be the best method of treating brain abscesses of otitic origin. Incidentally all would agree with Mr. Cairns that a brain abscess was a tumour and that the ideal treatment was excision. He remembered a brain abscess which he had excised in the distant past. The wall was so thick that the abscess could be rolled about the floor as if it were a billiard ball. For such a tumour there could be no treatment but excision. Possibly some surgeons on occasion forgot that.

As to the statement that the finger was a clumsy exploring instrument for brain abscess, he (Sir Charles) would not admit that his finger was a clumsy instrument, rather he would say it was the best probe which had ever been invented. Often, with the finger he had found a brain abscess which it had been impossible to detect by any other method. Sometimes no pus could be obtained from a brain abscess by trocar and cannula, but one could always feel where the tumour was.

Much had been said about the diagnosis of these abscesses. He was extremely interested in that point. The reason for thorough and repeated neurological examinations was to ensure accurate diagnosis and no delay in treatment. Early diagnosis and early treatment were life-saving. A sign or symptom not observed was not a sign or symptom not present. He remembered several cases of abscess not only of otitic origin, but also in the frontal region, in one of which the mastoid operation had been performed and in another of which the frontal sinus had been opened. The operations had been carried out when there were definite signs of inflammation intracranially, and in the face of those signs it was of no use simply to perform a bone operation. The only intracranial inflammation which, he thought, would be resolved by a mastoid operation was meningitis serosa in cases of acute

mastoiditis in which the dura was inflamed. Even then, the mastoid operation was not enough if there were symptoms indicating meningeal trouble; treatment was not complete without lumbar puncture.

In cases of brain abscess secondary to bone disease, the disease represented one continuous disease-process; in almost all cases, therefore, one should be able to follow the disease from the temporal bone, through the meninges into the brain. If that was done and the abscess drained through the abscess stalk, the patient would be cured. Such a patient, so dealt with, would be exposed to no risk of meningitis, and there was practically no cerebral hernia. He had also performed this operation when there was an abscess in the frontal bone due to infection of the frontal sinus.

Four years ago while he (Sir Charles) was staying with him, his illustrious friend Harvey Cushing had operated in a case of brain abscess. The diagnosis between abscess and tumour in that case was somewhat doubtful. The abscess was large and was excised completely. It would not be untrue to say that the patient was well in a week; he (the speaker) saw him moving about in the ward ten days after the operation. Mr. Cairns had said that such patients ought to be kept in bed for a long time, but it was not always possible to keep them in bed when they felt quite well.

He agreed with Mr. Cairns that the surgeon himself should do the dressing in these cases. The reason why he (Sir Charles) had been successful in his first case was that he went to the hospital three times daily—morning, afternoon and evening—to look after the patient; this routine he followed for more than a fortnight, and the man recovered. When dealing with brain abscess every detail of treatment should be carried out by the surgeon himself.

**Mr. E. Miles Atkinson** said that both the openers had emphasized the fact that in many cases there were no definite localizing signs until late in the disease; there were only general signs—in particular headache, varying in degree and situation. It was still not sufficiently realized that this absence of localizing signs applied to cerebellar cases as much as to cerebral.

The reason for this, he (the speaker) maintained, was that cerebellar abscess was a cortical condition, starting not, as Fremel had stated, between cortex and central white matter, but actually in the white matter in the centre of a lobule, and remaining confined to that particular lobule.

The localizing signs depended largely on œdema, and if the abscess was of a chronic type, with a fairly thick wall, there was little surrounding œdema, and therefore no localizing signs. Dr. Gordon Holmes had suggested in 1922 that the localizing signs in cerebellar disease were due to involvement of the dentate nucleus.

If this was so, then the fact of the abscess being situated in the cortex far removed from the dentate nucleus and with little surrounding œdema, provided the explanation why many of them showed none of the characteristic cerebellar signs. In view of this, it was a mistake to wait before exploring until localizing signs appeared.

Another point was the transience of signs; it was, indeed, a diagnostic point. A sign " here to-day, gone to-morrow " was of great value in diagnosis.

Mr. Cairns had mentioned the difficulty with regard to " abscess in the wrong place." He (the speaker) had had a case of frontal lobe abscess which must have been metastatic from the ear, for no other infective focus could be found. There were no localizing signs; there were only headaches and the cell-count in the cerebrospinal fluid. He explored the temporo-sphenoidal lobe and the cerebellum, but failed to explore the frontal lobe in which an abscess was ultimately found.

He was sure that meddlesome surgery, such as washing out the cavity with antiseptics, etc., only served to increase the surrounding œdema, which it should be one's object to avoid.

**Mr. J. A. Gibb** asked whether Mr. Cairns would propose a larger opening and a free incision of the dura mater in cases of brain abscess, with the idea that if the abscess had been missed it might come towards the opening.

**Mr. F. Holt Diggle** asked whether Mr. Cairns had any objection to the use of a small scalpel for finding an abscess.

**Mr. Cairns** (in reply) said that when exploring for abscess something blunt must be used with which to appreciate resistance. If one was sure an abscess was present, a fine scalpel, used gently, would be useful for opening the abscess; Macewen used a scalpel. With regard to making a larger opening in the skull, that of course depended on what was found with the needle. If there was a deep-seated abscess, and one was not finding pus up to 4 cm. depth, it was futile to make a large opening. Deep-seated abscesses were best treated by closed drainage. If a catheter could not be got into the abscess, a stiff brain-needle should be left in situ for a few days. If there was an abscess near the surface, a larger opening could be made so that the abscess could be attacked under direct vision.

He had not had any experience of silver wire drains. Cahill, of Boston, had used them, and reported successful results from them. Neither had he (Mr. Cairns) used bougies.

With regard to dressing in these cases, when the mastoid was operated upon it might be necessary to disturb the dressings earlier, because of the discharge; for frontal sinus cases it was well to have a massive dressing.

He completely agreed with Mr. Sydney Scott's remarks about mastoid cases. Neurological surgeons did not contend that the mastoid should be disregarded, or that operation should not be done through the mastoid; often that was the right route, as it gave dependent drainage. But when there was doubt, exploration for temporal abscess should be made through a clean incision, the mastoid incision being sealed off. In some cases one was not sure about lateralization, and then both ventricles must be tapped. If both were greatly dilated, there was no supra-tentorial abscess; if one ventricle was collapsed and the other of normal size or larger, the abscess would be on the side of the collapsed ventricle.

He agreed that if the surgeon had a clear idea of what he wanted to do at operation, the battle in these cases was usually won or lost at the bedside in the stage of investigation before operation.

## CASES SHOWN

**Cerebellar Abscess.**—MAURICE SORSBY, F.R.C.S.

George D., aged 41, was admitted to hospital, August 10, 1932, with symptoms of right acute suppurative otitis media. He gave a history of headaches and occasional giddiness for two months, but there had been an exacerbation of the symptoms during the last three days.

*Operations.*—A right myringotomy was performed the same day and was repeated five days later. As the patient obtained no relief from the headaches and giddiness, a mastoid operation was performed on August 17, a week after admission. Pus was found in the few cells present and granulation tissue in the antrum. The dura mater and lateral sinus were exposed and found to be healthy.

*Post-operative progress.*—The headaches persisted, and patient vomited for the first time on August 24—a week after the mastoid operation—when definite signs of cerebellar involvement were noticed. Temperature subnormal; nystagmus to the right: dysdiadokokinesis on right; ataxy of right arm and leg. No papillœdema.

A lumbar puncture on August 24 gave the following figures: 134 cells per c.mm.; all lymphocytes; protein 0·2%; globulin increased; sugar content normal; chlorides 700 mgm. %. No tubercle bacilli or other organisms seen. Wassermann reaction negative; X-ray examination of skull revealed nothing abnormal.

Patient's local and general condition remained unchanged except for occasional

remission or diminution of above signs and symptoms. Mastoid wound healed; pulse varying between 60-80.

Two more lumbar punctures were performed with the following results:—

*August* 29, 1932.—40 cells per c.mm., all lymphocytes; protein 0·15%; chlorides 750 mgm. %. All other elements as before. No organisms seen.

*September* 16, 1932.—12 cells per c.mm., all lymphocytes; chlorides 720 mgm. %. All other elements as before. No organisms seen.

*Cerebellar exploration.*—On October 10, exactly two months after admission into hospital, patient became suddenly worse, and a cerebellar exploration was undertaken and, on needling, pus was found. The abscess was opened and two drainage tubes were inserted. *Bacteriological examination of the pus.*—Streptococci present.

*Post-operative progress.*—The cerebellar abscess drained well; symptoms and signs rapidly cleared up. Patient was discharged feeling fit and well on November 29, 1932.

**Temporo-sphenoidal Abscess.**—LESLIE POWELL, M.B.

T. L., aged 11. *History.*—Ten days' cold; vomiting; pain in left ear followed by discharge next day. Pain ever since. Temperature 102° to 103°. When seen by me, January 1, 1934, was in a condition of cerebral irritability, curled up, resenting any interference, and not speaking. Temperature 103·2°; pulse 108. Apparently not hearing watch with either ear. Right tympanic membrane normal; left showed perforation, pus, and mass of granulations. Left antrum dim.

*Operation* same day. Lavage of left antrum producing thick mucus; ear cleared of granulations. Lumbar puncture: no increase of pressure or cells.

2.1.34: Placid; no symptoms; temperature 100·4°. No change in reflexes or paralysis; could not produce words but imitated actions and appeared to understand what was said.

*Operation.*—Conservative mastoidectomy (left); lateral sinus and meninges freely exposed. Meninges covered with granulations: not tense: extensive cells. Uneventful progress after this, but patient only said a few monosyllables and was apt to repeat them. Temperature normal after three days, and remained so.

14.1.34: Vomiting repeated. Discs blurred on nasal side. Hearing (right) good: speech improving; could do small sums; drew well. Right pupil slightly larger than left. Slight right facial paresis (lower).

15.1.34: Vomited again: left frontal headache. Cerebrospinal fluid clear but under pressure.

16.1.34: Operation.—Temporo-sphenoidal abscess found and drained (culture: pneumococci). Metal drainage-tube with flange—later replaced by rubber catheter end; cavity washed out daily with saline solution; steady improvement ever since; now talks almost normally; hears watch at 6 in. (left ear). Wound nearly healed and meatus almost dry. Skiagram taken after injection of lipiodol shows position of abscess; tube still in, but very little discharge from cavity.

**Temporo-sphenoidal Lobe Abscess of Otitic Origin.**—F. C. ORMEROD, F.R.C.S.

Edward W., aged 14. Admitted to Westminster Hospital April 14, 1933, with symptoms of left mastoiditis. There was a history of two weeks' otorrhœa and of bilateral otorrhœa in early childhood. A cortical mastoid operation was performed the same day without any unusual features being noted. Convalescence was uninterrupted until May 14 when the temperature rose to 103° and varied between 99° to 103° until May 21 when it rose to 105° and the patient had a rigor. The mastoid cavity was reopened the same day and a little extra bone removed. The sigmoid sinus appeared normal but on account of the rigor the internal jugular vein was ligatured. The temperature returned to normal in six days and the pulse only to 100. The patient was well until June 6 when he became drowsy and irritable. On June 7 and 8 the temperature fell to 97° and the pulse to 70. He complained of headache on the left side and vomited twice.

All reflexes were normal except Babinski's, which was doubtfully extensor. The ocular fundi were congested but there was no papillœdema. The cerebrospinal fluid was under increased pressure and contained thirty lymphocytes to the cubic millimetre.

On June 8 a large area of bone was removed from the temporo-parietal area by means of bone forceps, the mallet not being used at all on this occasion. A large temporo-sphenoidal lobe abscess was discovered by means of a record needle and syringe. It was opened and drained by an incision through its lateral wall. No attempt at drainage through the roof of the middle ear or mastoid antrum was made.

The abscess contained several ounces of thin, flaky pus, from which a non-hæmolytic streptococcus was grown. The abscess was drained by means of a roll of thin rubber tissue and was irrigated daily. The convalescence was uneventful from the date of the abscess being opened.

**Otogenic Brain Abscess Secondary to Infection with the Streptococcus mucosus.**—MICHAEL VLASTO, F.R.C.S., and I. VITENSEN, L.R.C.P., M.R.C.S.

Mrs. B., aged 45, first seen in out-patient department, October 24, 1933. Both ears discharging: the left had been discharging for three weeks, the right for five days. Severe tinnitus; no pain; both drums red and thickened. Tinnitus diminished whilst patient was under observation, but deafness increased.

November 14, 1933.—Aspiration paracentesis [I.V.]. Report on culture: *Streptococcus mucosus*, both sides.

Tinnitus and deafness continued severe, and in view of the nature of the infection, it was decided to drain both middle-ear tracts.

December 2, 1933.—Bilateral Schwartze operation. [Right M. V.; left I. V.] Both mastoid cell-systems filled with granulations. Culture from right side showed *S. mucosus*; culture on left side was sterile.

The patient had become gradually more deaf, and could not hear shouting. The deafness was of the middle-ear type. We had not previously met with such profound deafness of this type.

The wounds were granulating satisfactorily, and it was hoped that the hearing would return with the subsiding of the infective process, but the patient then took a turn for the worse. On December 23 she complained of pain over the right temporal region; she appeared to be drowsy and her pulse-rate dropped from 50 to 60. On December 28 she was examined by Dr. G. Konstam, who reported as follows:—

"Complete deafness; very drowsy; when she is roused, it is almost impossible to fix her attention, although there are occasional lucid intervals. Pupils equal and react to light. Nystagmus to the right. Fundi normal. Weakness of the lower face on the left side. Weakness and increased tonicity of left arm. Cheyne-Stokes breathing. Diagnosis: right temporo-sphenoidal abscess. Lumbar puncture: 35 cells per c.mm.; polys. 44%, lymphos. 56%."

On the same day (28.12.33) abscess located [M. V.] about 2½ cm. from the surface, rather far back in the right temporo-sphenoidal lobe. About one ounce of pus came away and drainage was secured by a single small-bore drainage tube. "The pus showed a heavy infection with *S. mucosus*. It consisted mainly of broken-down brain tissue, polymorphonuclear cells being very scanty."

The immediate recovery of the patient was dramatic. The day following the operation she wished to be on full diet and inquired when she was going home.

*Present condition.*—The patient has now completely recovered, and her hearing is so far restored that she can hear a loud whisper with both ears.

The case seems to us of interest for several reasons as, e.g.: (1) Many points in connexion with infection of the middle ear with the *S. mucosus*, referred to in a previous communication [I. V.]; (2) the short time (ten weeks) which elapsed between the original ear infection and the evolution of the brain abscess; (3) the intensity of the middle-ear type of deafness; (4) the dramatic, immediate and permanent recovery which ensued after the evacuation of the abscess.

We are indebted to Dr. R. R. Elworthy for all the pathological reports.

Mr. VLASTO said that the credit for first recognizing the gravity of the condition was due to his Registrar, Mr. Vitensen. Although middle-ear infection by the *Streptococcus mucosus* had been suspected from the clinical history of the case, the diagnosis was clinched after culture of the middle-ear aspirates. For that moment, past experience had taught them how seriously the case would have to be watched and that operative drainage of the middle-ear tract could not long be delayed.

The middle-ear deafness—so characteristic of *S. mucosus* infection—was peculiarly intense.

**Cerebral Abscess with an Unusual Symptom.**—J. ALDINGTON GIBB, M.D.

S. B., male, aged 17. Chronic otorrhœa since childhood. Recently suffered from severe headache. Admitted to hospital 24.11.29 for the mastoid operation.

*On examination.*—Discharge from left ear; membrana tympani almost completely destroyed; hearing good; no vertigo, nystagmus or rombergism; no dysdiadokokinesis; reflexes normal; no sensory or motor aphasia; eyes, nothing abnormal.

25.11.29: Radical mastoid operation; extensive disease; foul smell.

1.12.29: Rise of temperature; nystagmus, 1st degree; no intra-ocular changes. On looking left there was slight diplopia; this cleared up on the following day. As the temperature remained high, although there were no meningeal signs, lumbar puncture was performed: pressure +29. *Bacteriological report*: Pus cells and intracellular diploccci. Culture showed pure colony of coliform bacilli.

30.12.29: Very cheerful; marked perseveration; chuckled to himself a great deal. From this last symptom I formed the opinion that there was an abscess in the temporal lobe the contents of which had not only leaked into the cerebrospinal fluid, but had in all probability found their way towards the tip of the temporo-sphenoidal lobe and intermittently touched the frontal lobe, the pressure apparently giving the patient a pleasurable sensation.

6.1.30: Trephined one inch posterior to the external auditory meatus and half an inch above it. Exploration unsuccessful.

13.1.30: Granulations in wound bulged and pus was seen to ooze. I deliberately removed about an inch of brain covering the flow of pus. *Bacillus coli* present in pus. Examination showed a smooth-walled cavity capable of holding about two drams of fluid. The main abscess cavity followed the posterior superior angle of the petrous bone, and communicated with a new tunnel-shaped cavity which was continued almost to the tip of the temporo-sphenoidal lobe.

It is of interest that, although no eye symptoms were ever present, on firm packing of the abscess cavity there was a sensation of seeing "green stars" in the right eye. Subsequent progress was uneventful.

Mr. HERBERT TILLEY said that the Section was to be congratulated on the series of successes which these cases represented, especially since, as Dr. Neumann had pointed out in the address to which Mr. Ormerod had referred, it was extremely difficult to get a high percentage of cures in cases of brain abscess.

The case of rapid recovery after the evacuation of a cerebral abscess reminded him of the first case of brain abscess upon which he had operated. A girl, about 7 years old, was brought to the hospital in a comatose condition, and with a long history of a chronic discharge from the left ear. The symptoms suggested a temporo-sphenoidal abscess on the left side. A light anæsthetic was administered, and during its induction there occurred a profuse discharge of foul pus from the meatus. The mastoid antrum and cells were explored, their infective material was removed, the temporo-sphenoidal lobe exposed, the abscess more fully opened and a drain inserted. Next morning the patient was sitting up in bed and singing. She made a rapid recovery.

Another case he might mention was one of temporo-sphenoidal abscess. This was opened and the patient recovered. Seven months afterwards, however, he began to develop epileptic fits, the aura preceding the attacks being that of a disagreeable smell. The patient, a young man, was in University College Hospital, and he (the speaker) asked the late Sir Victor Horsley to deal with this complication.

Sir Victor opened up the wound again, found the scar of the temporo-sphenoidal abscess, and removed it. That was twenty-five years ago, and the patient has had no recurrence of the fits.