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THE TREATMENT OF BRAIN ABSCESS

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THIS review of a personal experience of the management of cases of brain abscess during the last five years is based upon 31 cases. Although 17 died, there has been a steady improvement in results, due in part to an increasing experience, and to a more mature judgment, for in no other branch of neurosurgery is an unremitting personal attention to details more essential for success. Much of the improvement, however, is due to a complete change in the fundamental method of treatment, namely, from drainage to the closed method of Clovis Vincent.

In 1936 there were two cases: the abscess was drained in each, and both died. In 1927 all of four cases were treated by drainage and only one lived. There were seven cases in 1938: in four, the abscess was drained and three of these died; in the other three the abscess was aspirated and in one of these a decompression was also performed—all of these three cases recovered. During that year I was impressed by the value of aspiration and I decided to employ it more frequently. Drainage was practically abandoned, for during the remaining period under review it was used in only two cases; one of these died, and in the other aspiration and a subtemporal decompression preceded drainage and the patient recovered. In 1939 there were nine cases, treated by various closed methods and by drainage in one case, and four lived. Four out of five cases recovered in 1940, and in 1941 two of four cases have lived.

In the following analysis are set out the various procedures and their results:

12 Cases Drained:

5 cases; drainage alone	3 Lived (25%)
3 cases; aspiration+drainage	1 lived
1 case; decompression+drainage	1 lived
3 cases; aspiration+decompression+drainage	0 lived
	1 lived

19 Cases—not Drained:						11 Lived (58%)	
6 cases; aspiration alone	..	..	..	..	..	..	3 lived
5 cases; decompression+aspiration	..	..	..	..	..	..	1 lived
(One death from epilepsy while awaiting enucleation.)							
2 cases; aspiration+enucleation	..	..	..	..	..	..	2 lived
5 cases; decompression+aspiration+enucleation	..	..	..	..	..	..	4 lived
1 case; enucleation alone	..	..	..	..	..	..	1 lived

Various methods of draining an abscess were employed in the first series, by catheter, by “uncapping” and packing the cavity, by two-stage operation, and by marsupialization. The results can be fairly described as disastrous. On the other hand, the figures of survival for treatment by closed methods are much more favourable.

No attempt has been made to separate cerebral from cerebellar abscesses, for the fundamental principles underlying closed methods are valid wherever the abscess is situated. Nor will etiology and bacteriology be discussed; cases have survived which exemplify all the recognized paths of infection, and once an abscess has developed the treatment of the primary focus is usually of secondary importance. Identification of the responsible micro-organism naturally demands appropriate chemo-therapy, but does not modify the surgical manœuvres. Sulphonamides were given in 15 cases, seven of which died; two of these had acute diffuse suppurative meningitis at autopsy. Chemo-therapy doubtless combats meningitis but it is questionable if it exerts any beneficial effect upon the abscess proper.

In order to determine, if possible, the reasons why treatment may fail, an analysis of the post-mortem findings has been made, and is instructive. An autopsy was performed in 16 of the 17 fatal cases. Extensive and massive œdema of the brain was observed in six cases (three drained, three aspirated); œdema to some degree is found around every brain abscess, but in these examples it involved a very wide area. In two of these cases pronounced brain herniation was noted. Diffuse leptomeningitis was present in five cases (four drained, one aspirated), and ventriculitis in three (all drained). Multiple abscesses were found in four cases—in three they were localized to one lobe, in the other they were scattered throughout the brain. Pulmonary embolism caused the death of one patient. Another died in status epilepticus whilst temporarily discharged from hospital awaiting final enucleation of the abscess which had been aspirated several times; the autopsy revealed a shrunken thick-walled abscess with no recent spread of the infection. Thus it would appear that treatment failed on account of multiple abscesses, massive œdema, or acute meningitis (including ventriculitis). Since the difficulties of successfully treating a solitary abscess are at present so great, it seems to me justifiable to concentrate one's attention upon them, and to leave out of consideration at present those presented by the case of multiple abscesses.

Of the etiology of brain œdema there is but little knowledge, and indeed there is no unanimity of opinion as to the pathological criteria of its lesser degrees, nor of its precise mechanism of development and spread. But when present in the severe degree to which reference has been made, its post-mortem recognition by the unaided vision is simple and unequivocal (Fig. 1*a*, *b*). Its

presence may be assumed clinically if there is marked drowsiness, lack of improvement as a result of treatment (in the absence of meningitis), and the neurological signs of brain herniation. Its treatment—in both abscess and tumour of the brain—constitutes perhaps the most urgent and the most formidable problem in neuro-surgery. Dehydration methods have had

Fig. 1(a).—Walled-off left frontal abscess, approximately 4 weeks "old," situated antero-lateral to tip of frontal horn of ventricle. Gross œdema, and cavitation of softened white matter. (b) Gross œdema of frontal lobe: cavitation, communicating with ventricle. No macroscopic communication with abscess cavity.

(Case not included in series; sudden death before treatment could be started; severe temporal lobe herniation.)

and are still having a great vogue. In my experience I must confess that all the methods of dehydration have proved disappointing. Occasionally there has been a transient diminution of drowsiness, but I can recall no case of suspected severe brain œdema in which enduring and indisputably curative effects have been obtained by energetic dehydration. Autopsy has revealed severe œdema in spite of such treatment. It is possible that in the lesser

degrees or in the early stages of brain œdema, dehydration therapy may control the process by diminishing a raised intracranial pressure and improving the cerebral circulation; but this remains to be proved. I have been frequently impressed how in some cases œdema persists and spreads in spite of treatment, in a manner best described as fulminating and malignant.

By reason of the observations at autopsy of the disturbances of the brain that œdema causes, and of the results of treatment, my opinion is hardening that the only hopeful line of attack is surgical decompression. This is by no means always successful, probably because it is not resorted to sufficiently early; and if advanced œdema is an irreversible change, this is almost certainly true. Decompression for brain abscess may be obtained by the Clovis Vincent procedure, and some measure of relief of tension results from the mere aspiration of the abscess. But the unopened dura mater beneath a bone flap will slowly give, and by reason of its greater degree of elasticity than the skull, affords an immediate though slight amount of relief to the brain and its blood vessels. Subtemporal decompression, and in cases of cerebellar abscess suboccipital decompression, are of similar value, and further details of the application of these methods will be given later.

The avoidance of meningitis and the treatment of the established condition vie with brain œdema in difficulty and importance. Chemo-therapy has helped, but other methods must be employed at the same time. Diffuse meningitis may occur at the same time as the spread of infection into the brain, or it may be due to the surgical activities. During drainage it is very liable to occur as a direct spread over the surface of the brain, and the two-stage method was introduced to cope with this. Infection may also spread centrifugally, probably as a result of the dislocation of the infected area towards the craniotomy and the consequent disruption of the delicate newly formed natural barriers to micro-organisms. Operative and autopsy studies show that at the deepest pole of an abscess its wall is thinnest, and it is from this area that secondary loculi commonly form. From this poorly walled-off pole of an abscess there is a most important potential pathway of infection to the subjacent ventricle; œdema softens the intervening white matter, and the ependyma of the underlying ventricles may rupture into this softened area. (Fig. 1*b*) Finally, as is well recognized, the ventricle tends to wander as a diverticulum through the softened white matter towards the brain fungus which may develop as a result of drainage, and the diverticulum can easily rupture on its surface. On several occasions, during the enucleation of an abscess its wall has been found adherent to that of the ventricle; treatment by drainage would almost certainly have led to ventricular infection, either by penetration by the drainage tube, or in methods relying on the extrusion of the abscess wall by rupture of the contiguous ventricle.

The accepted treatment of acute suppurative meningitis uncomplicated by abscess is to maintain the patency of the cerebrospinal fluid channels by frequent lumbar puncture and the free administration of fluids—"forced drainage"—and chemo-therapy. Of the latter no more will be said. If an abscess is present, the subarachnoid spaces are inevitably obstructed by the

swelling of the brain and by the herniation of brain into the various cisterns. Thus attempts to drain cerebrospinal fluid by lumbar puncture lose effectiveness, and indeed are dangerous by accentuating herniation. Thus some decompressive measure is as logical a form of treatment for the meningitis as for the œdema.

These experiences with various methods of treating brain abscess show how results led to the adoption of closed methods, and why these methods may be expected to give better results than drainage. The various procedures which are undertaken in a given case will now be outlined.

Successful treatment depends upon accurate diagnosis; this must include precise localization, an estimate as to the "age" of the abscess, and the presence or otherwise of meningitis. These matters cannot be discussed here except to state that so essential is early and accurate localization that no ancillary method should be ignored. A diagnostic burr-hole and tapping may be all that is necessary for confirmation in some cases; on the other hand, one should never hesitate to employ ventriculography. In the latter event—parallel with tumour surgery—an osteoplastic flap should be reflected forthwith, and the abscess contents evacuated through a wide-bore blunt needle. At what point in the course of the evolution of an abscess should operation be undertaken? While there is good clinical evidence that the patient is successfully resisting the infection and localizing the process which is in its early stages a suppurative encephalitis, surgical interference should be withheld. But when the clinical state is clearly deteriorating, or if the surgeon is in doubt, then it becomes necessary to aspirate with or without some type of decompression. In the second series of cases, aspiration was undertaken in the first week of the illness in two cases, the second week in nine, and in the remaining seven cases during the third, fourth, fifth, eighth, and twelfth weeks. When aspirating an abscess, the operation field should be swamped with a bactericide such as proflavine, to avoid its infection. It will often be found that with the emptying of the abscess, the dura mater becomes quite slack. If, however, tension is not sufficiently relieved, the dura mater should be opened so as to provide an orthodox osteoplastic subtemporal decompression. Even if the dura mater is not opened, bone should be removed from the base of the flap so as to provide a gradual decompression. A burr-hole is made in the bone flap over the most superficial part of the abscess through which it may be subsequently aspirated, as recommended by Clovis Vincent. When a diagnostic tap reveals an abscess conveniently accessible, or where there is but little swelling of the brain, decompression may not be needed. It may be postponed if the patient's condition is too grave to allow of it, or it may be needed at a later date if evidence of œdema accumulates. In cases of cerebellar abscess, provided the patient's condition allows of it, I think that the dura mater of the posterior fossa should be fully exposed in every case; the abscess can be aspirated more easily than through a burr-hole behind the mastoid process. But the dura mater should never be widely opened owing to the proximity of the cisterna magna, and the consequent ease with which diffuse meningitis can occur. The aspiration of a cerebellar abscess affords much

greater relief of tension than aspiration of a hemisphere abscess, owing to its strategical position in causing an obstructive hydrocephalus.

At the time of aspiration, the cavity of the abscess is irrigated with electrolytic sodium hypochlorite (Milton). Using small quantities (less than the amount of pus obtained), 50 per cent. Milton is allowed very gently to flow into the cavity and is then aspirated. This is repeated several times, and a large quantity of ropy pus can usually be obtained, which would otherwise be too viscid to pass through the needle. When the fluid returns fairly clear, it is valuable to leave in the abscess a small quantity of 5 per cent. Milton or of 1 in 1,000 buffered solution of proflavine. A bactericide in such a closed cavity appears to aid in the destruction of organisms (three abscesses have become sterile under treatment) and to accelerate the localization of infection and the maturation and contraction of the abscess. It is also a prophylactic against infection of the needle track. At first it may be necessary to repeat aspiration every few days, but the intervals will gradually lengthen. The patient's condition, the amounts of pus obtained, and the resistance of the abscess wall are all factors which should be weighed in making a decision to re-aspirate. In temporal or cerebellar abscess the aspirating needle must be inserted through layers of muscle, and to facilitate this it may be wise on each occasion to reopen the small wound made for "tapping" purposes so as to expose the dura mater and under direct vision to make a small nick in it, through which the needle is passed. Elsewhere, a small incision through scalp and dura mater made with the point of a tenotome is all that is necessary; in each case the skin (and muscles) are completely closed again by sutures at the end of the aspiration. These precautions are taken to avoid any force being communicated to the cranial contents, and to prevent sinus formation and secondary infection.

Thorotrast (1-2 c.c.) injected into the abscess at one of the early aspirations is of great help. It gradually becomes "fixed" in the wall of the abscess and the size and the position of the abscess can be demonstrated radiologically. One might expect that the need for re-aspiration would be indicated by an increase in the size of the opacity. However, such helpful information has rarely been obtained, and this suggests that deterioration in the patient's condition is more frequently due to increase of œdema (or spread of infection) than to increase in the quantity of pus. But much aid of a different character is obtained. In the course of time, the thorotrast opacity diminishes in size and gains in crispness of outline, assuming a somewhat crenated appearance, *pari passu* with the organization of a well-formed abscess wall (Fig. 2). Thorotrast may fail to depict the whole of an abscess if there are several loculi. This happened in one case (Fig. 3*a, b*); over confidence in the X-ray appearance led me to forget the possible presence of a deeper loculus, which was thus inadvertently ruptured and the patient died of a diffuse meningitis.

What criteria guide one as to when to enucleate the abscess? The pathological desiderata are the subsidence of all acute inflammation and the formation of a tough wall. This will correspond with the disappearance of toxæmia and of meningitis, diminution of symptoms of raised intracranial pressure—

and a softening of the decompression—and diminution in the neurological signs of a focal cerebral lesion. These signs may in fact disappear or they may become a crisp and stable residuum. The toughness of the abscess wall can be estimated by the blunt aspirating needle, and by the radiological appearance of the thorotrast shadow. I consider that there is a well-defined optimum period for successful enucleation. The above pathological criteria

Fig. 2.—Thorotrast visualization of abscess cavity and of abscess wall.

must be satisfied for obvious reasons. But if operation is unduly postponed, it becomes technically more difficult owing to the formation of an excessive degree of scarring around the abscess; firm trabeculae may radiate from the abscess, leading to an unnecessarily wide excision of tissue. Secondary loculi or separate deeply placed abscesses may develop if a case is left too long. In contrast, during the optimum period, the abscess wall is well defined, is sufficiently tough to handle, and separates cleanly from the surrounding white matter. In this series, the age of the “youngest” abscess has been six weeks, and of the “oldest” six months, estimating age from the first symptoms of intracranial disorder. I judge that the third month (i.e. between 8 and 12 weeks) is usually the “time of election” for enucleation.

Enucleation is facilitated by uncapping the wall of the abscess excising with that portion of brain the adherent area of dura mater, which constitutes

the scarred track of the aspirating needle. When dissecting around the abscess, one must be ever alert for any prolongation of the abscess in a totally unexpected direction. The deeper the dissection the greater the care to be exercised to avoid rupturing its wall. If the abscess is large and tense it is

Fig. 3 (a).—Radiograph of specimen: thorotrast in one loculus of abscess. (b) Specimen: thorotrast in only one of three loculi: the largest and thin-walled was deepest in the brain.

helpful partially to aspirate its contents, taking precautions against contaminating the field and the instruments, and the small hole must be closed by sutures. When the abscess is adherent to the wall of the ventricle, an opening into the latter may be unavoidable. In cerebellar abscess, the dis-

section is more difficult owing to the proximity of cranial nerves, and the abscess may be adherent to the dura mater covering the posterior surface of the petrous bone.

It is well recognized that epilepsy may follow the healing of an abscess, and enucleation may very likely avoid or diminish the frequency of this unfortunate sequela. But until the abscess has been finally eradicated an anti-convulsant should be given. In two of the present cases, fatal status epilepticus occurred after the patient left hospital. In one case the abscess had been drained, and had healed completely; the other has already been referred to. In neither case did an autopsy reveal any recent exacerbation of infection.

It is clear that closed methods of treating a brain abscess necessitate primary union of all incisions. Consequently, a brain abscess which develops underneath an open wound such as might result from an infected compound fracture of the skull, may have to be treated by drainage; and a small superficial abscess (which could be considered as virtually subdural in position) might possibly be more suitably treated by drainage. But these are the only cases in which I should now discard methods of non-drainage, although each must be considered upon its own merits.

If the results of treatment by open and closed methods are examined again, it will be seen that they really reflect the morbidity of the disease at different stages in the course of treatment. Some die in the early stages, and extensive œdema was present at autopsy in all three cases which died following aspiration; the fatal issue might have been prevented by decompression, but there is no good reason to suppose that drainage would have been more successful. Of the five that died after aspiration and decompression, in only two was there extensive œdema. Only one case died out of seven in which enucleation was carried out, and this roughly indicates the relatively low risk of a fatal issue provided the early dangers can be safely overcome.