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PATHOLOGY

On the invasion of the brain tissue with micro-organisms, a localized encephalitis is produced. The infection may reach the cranial contents by direct extension, as from an infected middle ear (adjacent abscess of Eagleton's classification), or by septic emboli from a distant chronic process (metastatic abscess). Direct invasion may occur through a phlebitis of the tributary veins of the thrombosed blood sinus or by osteomyelitis, localized meningitis and encephalitis. At the onset, the process is what used to be called "acute softening of the brain." The condition may progress with rapidly advancing symptoms, ending in death. On the other hand, when the local encephalitis has completely broken down, a pyogenic membrane may be produced which encapsulates the pus for a longer or shorter time (encapsulated abscess). In this way, a quiescent stage is produced, lasting over many months or even years. Eventually, however, one of two things occurs: The abscess ruptures, or a secondary encephalitic process starts, progressing rapidly to a fatal issue. Rupture of a brain abscess may occur when the presence of an abscess is not suspected, the resulting condition suggesting a vascular lesion. For anatomic reasons and because it is a so-called "silent area," the frontal lobe is peculiarly susceptible to this condition, as is illustrated in the following cases.

CASE 1.—A. G., woman, aged 23, first seen, Dec. 8, 1921, in consultation with Drs. Hough and Burns, had suffered from headache for the last two years, more severe during the last three months. Three weeks before consultation, she had fainted in her office and since than had not returned to work. She spent some days in bed, on others she was up and around. Two days before consultation, she went, by street car, to have a roentgen-ray examination of the head made, at the suggestion of Dr. Gill. Involvement of the left frontal sinus and antrum was found. December 7, the patient had a convulsion in the morning, a second at noon and a third at night. A spinal puncture was made by Dr. Hough about midnight, from 20 to 25 c.c. of bloody fluid being withdrawn very slowly and intermittently. This was followed immediately by unconsciousness and apnea. Artificial respiration was started, and was continued until 4 a. m., when I first saw the patient.

The left ventricle was tapped from above, and a few cubic centimeters of bloody fluid spurted out under great pressure. The right ventricle was negative. With artificial respiration continued, the patient was transferred to Garfield Hospital, in an ambulance, where a left subtemporal decompression was performed under local anesthesia. The brain was found under great pressure, white and nonpulsating, and there was no bleeding from the cortical vessels. A right subtemporal decompression was immediately performed, with similar findings. Following the last operation, the cortical vessels bled freely and the brain became pinker. An intratracheal tube was introduced and attached to a positive pressure motor, and the air driven in at a pressure of about 10 to 15 mm. of mercury. Cyanosis and impaired heart action came on gradually, so that rhythmic pressure had to be applied over the chest in addition. Spontaneous respiration was never established. Cardiac action grew gradually weaker until death occurred, at 11:30 p. m., twenty-three and one-half hours later.

Necropsy revealed a small abscess, about the size of a walnut, under the anterior horn of the right ventricle, the abscess having ruptured, with hemorrhage into the ventricle. Both the lateral ventricles, especially the right, and the third and fourth ventricles were found filled with a recently formed clot. Some small scattered clots were found in the subarachnoid space around the base. The tip of the cerebellum on the right side showed a rimlike depression, as if it had herniated into the foramen magnum.

SYMPTOMS

The symptoms of brain abscess are general and focal. The general symptoms are those of an infection plus increased intracranial pressure. The chief complaint is headache. There may be vomiting, convulsions or stupor. Temperature in the latent stage may be normal or subnormal; when increased, it varies in degree according to the acuteness of the condition. Leukocytosis, usually of low grade, is common, but this also is occasionally lacking in the latent stage. As the process destroys the brain tissue rather than displaces it, pressure symptoms are usually inconspicuous.

Cerebellar Abscess.—When the cerebellum, the second most frequent site of abscess of otitic origin, is involved, one finds nystagmus, adiadokokinesis, a positive Romberg and a positive Bárány sign and respiratory difficulties.

Cerebral Abscess.—When the process occurs in the temporosphenoidal lobe, secondary to otitic infection, the following symptom-complex is seen: Abscess in the right temporosphenoidal lobe, in right-handed individuals, produces transient weakness of the lower left side of the face, diminished left abdominal and cremasteric reflexes, increased left deep reflexes and a left Babinski reflex. Abscess in the left temporosphenoidal lobe in right-handed individuals gives rise to the foregoing phenomena, plus sensory aphasia, difficulty in naming objects seen and recognized and word forgetfulness. A careful mapping of the visual fields shows the existence of an incomplete hemianopsia.

When the motor area is involved, jacksonian convulsions, followed by paresis or paralysis, point to the focus.

In occipital lobe lesions, subjective or objective eye symptoms appear. When the frontal lobe, the so-called "silent area," is affected, focal symptoms may be entirely lacking. Diagnosis of an abscess in this region is most difficult because there are no characteristic focal signs of frontal lobe involvement for the chronic cases and the signs in the acute cases differ very slightly from those of the causative, neighborhood lesion.

In the cases reviewed by Eagleton, clinical evidence of intellectual and psychic disturbances were generally found wanting. Change of disposition and poor memory, according to this author, may be present, although they have been but infrequently observed. Mental dulness,

stupor and coma may occur. Mental dulness and stupor were noted in four of my six cases. Headache was almost a constant symptom. Of the six cases, in one (Case 3) no record was made of this symptom. The patient was admitted for cerebral hernia following gunshot wound of the head. The hernia was caused by the pressure produced from a frontal lobe abscess. The decompression associated with the hernia explained the absence of headache. It was a pronounced feature of the five other cases. Convulsions occurred in three. There was evidence of increased intracranial pressure on fundus examination in all the cases. In four, there was a frank choked disk. This is contrary to the views expressed by Eagleton, who states that "in frontal lobe abscess, papilledema is rarely present.

The accompanying table gives the chief symptoms noted in the six cases.

DIAGNOSIS

In the early and acute stage, the diagnosis must rest on the evidence of intracranial involvement from a neighborhood infection and the elimination of other possible localization. Certain objective signs may be of great importance. Indeed, the localization of the lesion may rest entirely on these signs. In Case 2, Macewen's sign of altered percussion note and tenderness were the only positive signs of a right frontal lobe abscess.

CASE 2.—A. K., boy, aged 15 years, referred to Drs. Campbell and Hough, Dec. 11, 1921, at 5 years had an acute otitis media on the left side, followed by persistent foul discharge. About two years before admission, there was some disturbance of the left eye, for the relief of which a submucous resection of the nasal septum was performed. Two months later, cerebrospinal rhinorrhea developed. This persisted unchanged for twenty months. Two months before admission, the rhinorrhea suddenly ceased, and pneumococcus meningitis developed. The patient recovered, following repeated spinal puncture. Two weeks before I saw him, headache and vomiting began. On examination, he showed slight elevation of temperature, and a leukocytosis of 16,000. Choked disk was developing. Neurologic examination was absolutely negative. Percussion, however, brought tenderness over the right frontal region, with a decided change in the percussion note. Roentgen-ray examination revealed nothing except increased intracranial pressure. The question of internal hydrocephalus following meningitis was considered, but the local tenderness and changed percussion note pointed to a right frontal brain abscess. Craniotomy in this region was performed. Several ounces of greenish pus (pure culture pneumococcus Type IV) was evacuated from an abscess about 3 cm. deep in the right frontal lobe. Drainage was maintained for six months and was followed by complete recovery.

With the history of chronic infection, especially of the middle ear or head sinuses, and of headache, choked disk, mild temperature and leukocytosis, plus the focal symptoms outlined above, the diagnosis of

Summary of Cases—Frontal Lobe Abscess

Case	Patient	Age, Years	Source	Organism	Length of Time Between Onset of Causative Lesion and First Symptom of Abscess	Time Between First Symptom and First Consultation	Symptoms	Complications	Operation	Outcome
1	A. G.	23	Probably infected frontal sinus and antrum	Unknown	Unknown	Over 2 years (chronic)	Convulsions, headaches, fainting spells, apnea following lumbar puncture	Rupture of abscess into ventricle	Subtemporal decompression, bilateral	Died 24 hours later; necropsy
2	A. K.	16	Cerebrospinal rhinorrhea	Pneumococcus	1½ years	16 days (acute)	Macewen's sign (right front), frontal headache, beginning choked disk, leukocytosis, vomiting, slight temperature, stupor	None	Craniotomy; drainage for 6 months	Well
3	W. M.	29	Gunshot wound of frontal lobe	Staphylococcus	Unknown (weeks)	2 years (chronic)	Cerebral hernia, convulsions, choked disk, vomiting, slight rise in temperature, fast pulse, paresis on left side, no headache	Cerebral hernia	Craniotomy; drainage for 2 months	Well
4	F. B. D.	17	Ethmoiditis	Staphylococcus, streptococcus	15 days	5½ months (chronic)	Convulsions, frontal headache, choked disk, leukocytosis, slight rise in temperature, mental dulness, diplopia, Macewen's sign (right front)	Surgical shock	Right frontal osteoplastic flap	Died several hours after operation; necropsy
5	M. S.	10	Infected naso-pharynx	Unknown	Days	4 months (acute)	Headache, choked disk, projectile vomiting, slight rise in temperature, leukocytosis	.....	Craniotomy during terminal encephalitis	Died 24 hours later; no necropsy
6	W. D.	28(?)	Frontal sinusitis and osteomyelitis of frontal bone	Streptococcus	7 months	Days (acute)	Leukocytosis, fever, headache, hemiplegia (right side), convulsions, aphasia, drowsiness	Extradural abscess, unrecognized	Exploratory craniotomy and drainage	Died 7 days after operation; necropsy

brain abscess, with the possible exception of abscess of the frontal lobe, can be made sufficiently early for surgical intervention to give a fair chance of recovery.

Because of the more or less complete absence of focal symptoms, abscess of the frontal lobe is likely to be overlooked until too late for surgical interference to save the life of the patient. The presence of infection of the frontal sinuses of the ethmoid, or orbit, should place one on guard with respect to the possibility of abscess of the frontal lobe. Persistent frontal headache in the presence of such infection, with good drainage, points directly to involvement of the frontal lobe. The other symptoms enumerated, together with a suggestive history, leave little doubt as to the diagnosis. In view of the small size of the area concerned in frontal lobe abscess and the consequent possibility of rupture before the abscess has attained sufficient size to give rise to the symptoms which would otherwise be manifest, suspected cases should be studied closely and operation performed before rupture occurs.

DIFFERENTIAL DIAGNOSIS

Brain abscess must be differentiated from generalized encephalitis, meningitis and sinus thrombosis. Lumbar puncture carefully performed is an aid in the differentiation. A high cell count, especially of leukocytes, points to meningitis. A slight increase in cells, especially lymphocytes, points to encephalitis. Percussion of the skull may elicit a higher-pitched note and tenderness, an aid to the diagnosis and localization.

TREATMENT

The treatment of brain abscess is surgical. When pus is located, incision and drainage must be made. The surgical principles are the same as for pus elsewhere in the body, but the means of evacuation and the after-treatment are very different.

Exploratory Craniotomy.—The diagnosis of brain abscess depends on a preponderance of either the general or the focal symptoms. If the focal symptoms are only suggestive or even wanting, an exploratory craniotomy may be indicated. Exploration should be made with the brain needle. A small trephine craniotomy under local anesthesia exposes the dura and permits the insertion of an exploratory needle in several directions to a depth of 6 or 7 cm. A blunt hollow needle made with a stylet and with several openings on the side should be used. As the pus may be under slight pressure, the needle should be inserted slowly and allowed to remain long enough in each suspected area to allow a possible thick pus to find its way out. In chronic abscess it will be necessary to force the needle through the pyogenic membrane. With the use of more than one brain needle, the exact location of the abscess can be determined.

If the abscess is in the neighborhood of a local bony infection, such as mastoiditis or frontal osteomyelitis, the question of exploration through the infected area or through a sterile field is to be decided. Each method presents its disadvantages. Exploration through an infected field may carry organisms into a sterile subarachnoid space, thus initiating a fatal meningitis. On the other hand, when there is a positive finding beyond a sterile region, infection may be carried from the abscess into a sterile subarachnoid space, with the resultant meningitis, though this is less likely.

The otologist is rather prone to explore through the infected wound. As a rule, the infection has reached the brain by direct extension; the underlying meninges have been agglutinated, and there is little danger of spreading the infection. A subdural abscess may even be encountered, which, of course, is best attacked by this approach.

In exploring through a sterile field, the increased intracranial pressure will have temporarily obliterated the meningeal spaces. A few hours packing outside the dura will produce adhesions sufficient to allow subsequent drainage without danger. This is illustrated by the following case.

Case 3.—W. M., man, aged 29, referred by Dr. Fritz Reuter, May 15, 1921, was suffering with cerebral hernia following a gunshot wound received two years previously. From the history and neurologic examination, it was believed that an abscess was present in the neighborhood. An exploration through a sterile field located pus at a depth of 4 cm. The brain needle was withdrawn and the extradural space packed with gauze. On removal of the packing in twenty-four hours, occlusion of the underlying meningeal spaces had occurred, allowing a free opening for drainage. Prompt recovery ensued, with a spontaneous cure of the cerebral hernia.

Local anesthesia is to be preferred.

In my opinion, an osteoplastic flap should very seldom be used to attack a brain abscess.

It is contrary to good surgical judgment to open widely the region most susceptible to infection—the subarachnoid space—to drain an abscess. If it cannot be reached through its own avenue of invasion, already occluded by a plastic meningitis, a more accessible route should be provided. Packing may be placed outside the unopened dura over as large an area as may be desired and left for twenty-four hours or more. This will produce sufficient intradural reaction to set up aseptic occluding adhesions and prevent the inception of an acute meningitis when the abscess is drained at a subsequent sitting.

When the abscess is located with the brain needle, either at the primary operation, through the already occluded meninges, or at a secondary operation, the needle should never be withdrawn until ample

drainage is established. A grooved director or similar instrument should be passed along the needle and the track gradually enlarged until a tube of sufficient caliber can be inserted.

In the chronic abscess with a firm membrane, it is wise not to allow the cavity to empty itself through the searching needle, for fear of collapse and the difficulty of again finding the lesion. I have never used the encephaloscope and feel that the additional trauma in its use is unnecessary.

With the increased pressure there is a tendency for a decompression through the craniotomy opening and extrusion of the drain. The type of drain used varies with different operators. Gauze packing, glass tubes, rubber tissue and rubber tubes all have their advocates. Tubes made of wire mesh were used in the British Army and have found favor in this country.

Two points must be emphasized: (1) Prevention of extrusion of the tubes in the presence of pressure and (2) prolonged drainage.

I have devised a tube which I have used for the last year with gratifying success. It is an ordinary rubber drainage tube with a rubber cuff fixed about 3 cm. from the end. The tube is split down to this cuff, and to each half a tape is sewed. When the tube is in place, the tapes are tied around the head and effectually prevent extrusion.

Once the drain is properly placed, it should not be disturbed. If withdrawn to be cleaned, there may be difficulty in replacing it, as its pathway may disappear within a few minutes in the soft cerebral tissue. The drain may be kept open by applying a dressing soaked in glycerin, or a small rubber catheter may be inserted through the drain daily and aspiration practiced. Irrigation is not indicated and is fraught with danger, but the instillation of dichloramin-T after aspiration helps, I believe, to overcome the infection.

No matter what form of drain is used, it should not be disturbed until all symptoms have completely disappeared, and then only to shorten it very carefully. For this reason, rubber tubing is advantageous. The danger of pocket formation at the bottom of the sinus and recurrence of the abscess are obviated if the tube is not cut off more than a length equal to its diameter. I would urge that drainage be maintained for too long rather than for too short a time. There is no *vis a tergo* of muscular action and movement which helps to squeeze empty a pus pocket in other soft tissues in the body; and we must rely entirely on the healing process to cure an abscess of the brain.

The accompanying table summarizes the six cases of frontal lobe abscess in which I have operated to date, including the three briefly recorded above.

CONCLUSIONS

1. Brain abscess in general is difficult of diagnosis and especially difficult of treatment.

2. Abscess of the frontal lobe of the brain has been recognized before death in only about one half of the reported cases.

3. The high mortality indicates the need of a more careful study of such cases.

4. Persistent headache, with sustained leukocytosis, and especially the presence of retinal changes indicative of pressure, in cases of drained frontal sinusitis or ethmoiditis, indicate exploration.

5. Exploration by the two-stage operation through a sterile field may be indicated.

6. Direct drainage with a minimum trauma should be established and should not be disturbed until all symptoms have subsided.

7. It is of paramount importance to drain a brain abscess for too long rather than too short a time.