

The treatment of brain abcess by unroofing and temporary herniation of abcess cavity with the avoidance of usual drainage methods : with notes on the management of hernia cerebri in general / by Joseph E.J. King.

Contributors

King, Joseph E. J.

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THE TREATMENT OF BRAIN ABSCESS BY UNROOFING AND
TEMPORARY HERNIATION OF ABSCESS CAVITY WITH THE
AVOIDANCE OF USUAL DRAINAGE METHODS

With Notes on the Management of Hernia Cerebri in General

BY JOSEPH E. J. KING, M.S., M.D., New York

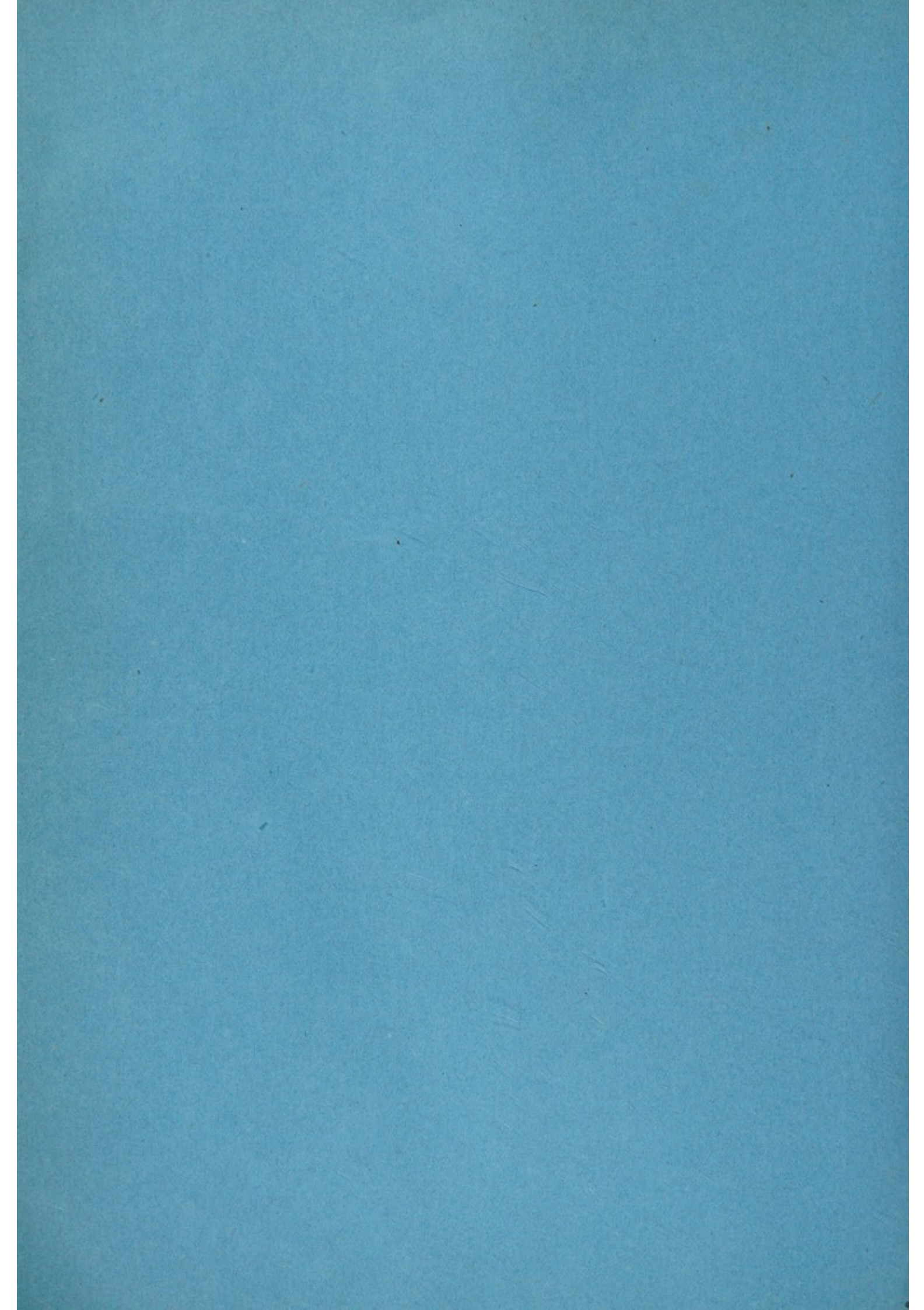
From the Service of the Second (Cornell) Surgical Division, Bellevue Hospital

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THE TREATMENT OF BRAIN ABSCESS BY UNROOFING AND TEMPORARY HERNIATION OF ABSCESS CAVITY WITH THE AVOIDANCE OF USUAL DRAINAGE METHODS¹

WITH NOTES ON THE MANAGEMENT OF HERNIA CEREBRI IN GENERAL

By JOSEPH E. J. KING, M.S., M.D., NEW YORK

From the Service of the Second (Cornell) Surgical Division, Bellevue Hospital

ALL operative procedures heretofore described in the treatment of brain abscess have been based upon three well recognized principles:

1. The drainage of the abscess cavity,
2. Prevention of extension of meningeal infection,
3. Prevention of hernia cerebri.

Various authors have described different methods of exposures for the purpose of drainage of an abscess cavity. Adson (1) has advised an osteoplastic flap with drainage of the abscess cavity, the drain being brought out through a separate trephine opening made through the osteoplastic flap. Eagleton (3) has advised the osteoplastic flap for abscesses located in the middle fossa and frontal region. Dowman (2) and Kerr (4) have advocated exploration for and drainage of the abscess cavity through a small trephine opening in the skull. However, in each of the procedures advocated, without regard to the type of exposure, the intention of the surgeon has been to locate and drain the abscess cavity by means of some kind of drainage material and to prevent herniation of the brain.

In the rather large number of fatal cases, death usually occurred from rupture of the abscess cavity into the ventricular system, meningitis, or compression of the brain, or death may have resulted from any two or all of these causes.

DIFFICULTIES AND DANGERS OF USUAL DRAINAGE METHODS

Although numerous isolated cases of recovery have been reported, secondary abscess not infrequently develops in the neighborhood of the intended drainage tract or substance employed for drainage and the case ends fatally. In many cases, rather than a real "secondary" abscess developing, a pocket of

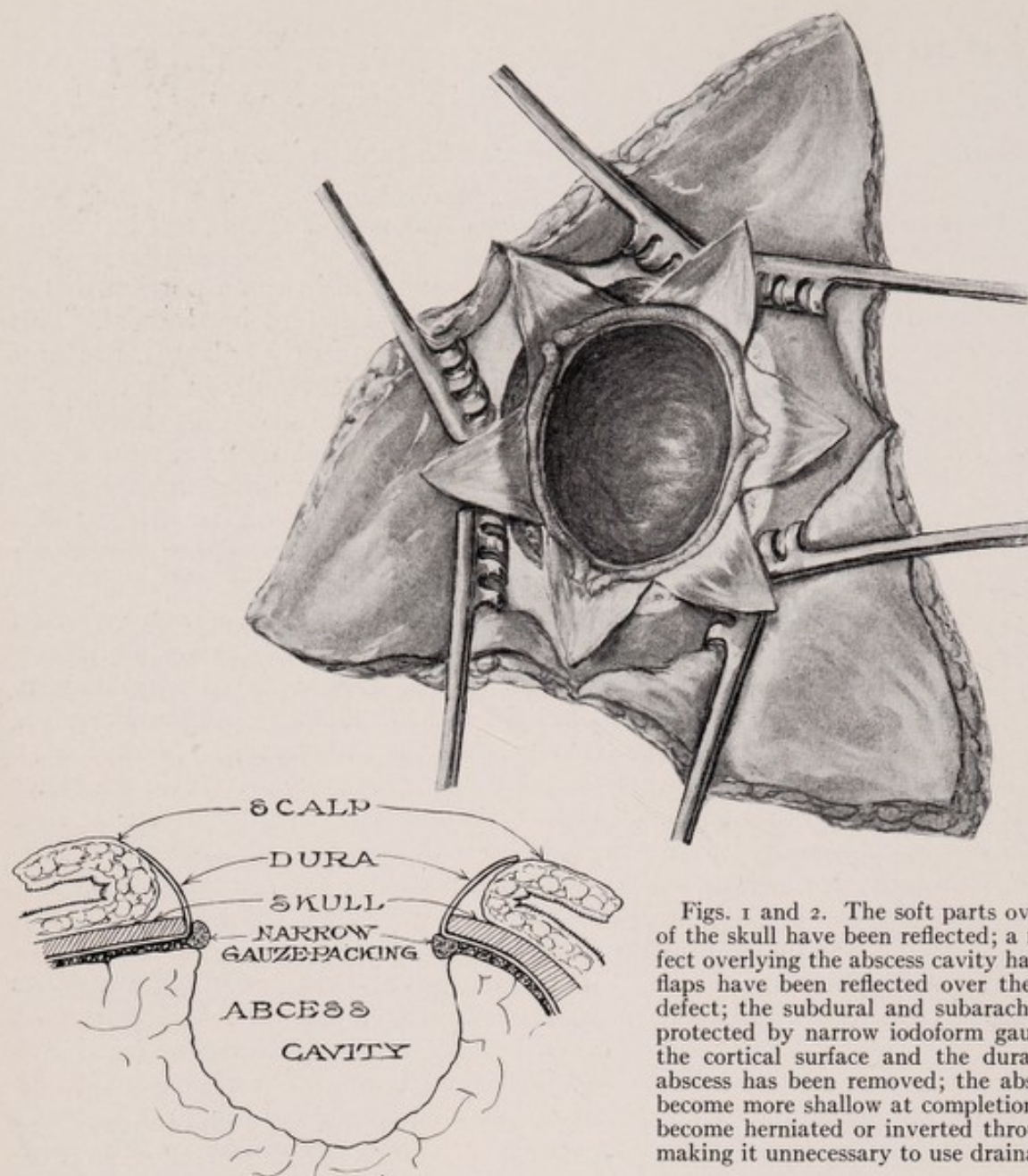
pus may accumulate in some portion of the abscess cavity and fail to be drained. This type of abscess frequently enlarges, ruptures into the ventricle, and results in death.

Numerous drainage materials have been suggested, devised, and used, among which are: gauze packing, glass tubes, rubber tubes, rubber tissue, strips of rubber dam, tubes made of wire mesh, conical shape wire mesh drains, metal searchers, etc. Although isolated cases of recovery have been reported with practically every type of drain enumerated, no author has reported any lengthy series of cases of recovery by any type of drainage, nor has the average operator been able to claim a low mortality rate. In other words, no type of drain really "drains"; that is, drains in the sense that a complete permanent obliteration of the abscess cavity takes place, followed by a high percentage of recoveries.

It has frequently been observed by various operators, that following the drainage of an abscess cavity when drainage material has been introduced and allowed to remain in position for a long period of time, the patient's condition gradually improves to the point where he is able to leave his bed and be up and walking about, and then a secondary abscess develops and terminates fatally. In my own experience with the use of rubber drainage tubes and rubber tissue, I have seen several patients recover from a stuporous or semicomatose condition, to the point where they state that they feel well, they eat and sleep well, and are able to be up and about the ward without any serious symptoms. After a period of perhaps several weeks, a secondary abscess develops which ruptures into the ventricle and death ensues.

Drains may become dislodged and are replaced with difficulty. In fact, it has been

¹ Read before the New England Otological and Laryngological Society, Boston, Massachusetts, November 27, 1923.



Figs. 1 and 2. The soft parts overlying the outer table of the skull have been reflected; a rather large cranial defect overlying the abscess cavity has been made; the dural flaps have been reflected over the bony margins of the defect; the subdural and subarachnoid spaces have been protected by narrow iodoform gauze insinuated between the cortical surface and the dura. The "roof" of the abscess has been removed; the abscess cavity which has become more shallow at completion of operation can now become herniated or inverted through the cranial defect, making it unnecessary to use drainage material.

found at autopsy that drains have not been replaced in the sense that they follow the original tract, but are found to be inserted into the brain tissue outside of the tract. Early removal of drains and attempt to replace a dislodged drain have undoubtedly been frequently followed by fatal results. Even at the time of operation, after the abscess cavity has been partially evacuated, it has been observed that the attempt to insert a drain into the abscess cavity has failed, and at autopsy we find that the drain is in the brain tissue outside of the cavity. This is especially likely to occur in encapsulated abscesses, in which partial evacuation of the contents of the

cavity is followed by a partial collapse of the cavity; and the cavity becomes "lost," so to speak. Death may also follow pressure of tubes or the displacement of a dressing. Fatal results have also followed perforation into the ventricle by drainage tubes, in attempts to replace a drain.

REASONS FOR DISCARDING USUAL DRAINAGE METHODS

In the past I have used various types of drainage material, such as rubber tubes, rubber dam, and rubber tissue and have seen the cases terminate fatally, although improvement may have taken place immediately after

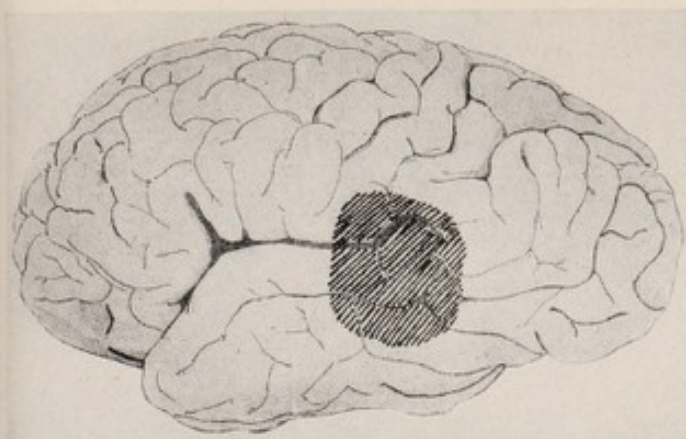


Fig. 3. Case 1. M. L. Temporosphenoidal lobe abscess, left, showing approximate position and relative size of the encapsulated abscess. There was a definite right facial paresis.

the operation and progressive improvement continued for several days or weeks. However, in 1920, I operated upon a case of encapsulated temporosphenoidal lobe abscess of the left side, following a simple mastoidectomy. Exposure of an area of dura about the size of a half dollar piece was made. The capsule of the abscess cavity was covered with about $\frac{1}{2}$ -inch thickness of brain cortex. The cavity was entered and exploration, irrigation, and cleansing of the cavity were accomplished through a crucial incision in the dura and a tract made through the cortex and capsule with an artery clamp. After the cavity had been thoroughly irrigated with Dakin's solution, we inserted drainage materials through the crucial incision, consisting of the following: a rubber tube about 2 inches long and about $\frac{1}{2}$ inch in diameter, with a lateral opening at the distal end, was placed against the floor of the abscess cavity and four narrow gauze packing strips, wet in Dakin's solution, were placed about the tube. Irrigation of the larger tube was done every 2 hours by placing a small rubber tube in the lumen of the larger tube without removal of the drain.

After several days it was observed that herniation of the brain was taking place. The tube was displaced outward with the abscess cavity and about 3 weeks after operation the hernia had protruded to such an extent, with a resulting shallowing of the abscess cavity, that the tube had to be considerably shortened. A few days later the entire remaining piece of the drainage tube was removed for



Fig. 4. Case 1. M. L. Temporosphenoidal lobe abscess, left, showing the operative cranial defect through which herniation of the abscess cavity occurred.

the reason that the abscess cavity had become so shallow that it would not retain the tube. In the meanwhile the operative site including the brain hernia was irrigated with Dakin's solution. With this treatment, the hernia began to recede and after 2 months, following the operation, the hernia had completely receded and had become covered with epithelium except for a central area about the size of a quarter. One week later, the site of the hernia was completely covered with epithelium. The patient was discharged from the hospital with complete recovery and has remained well up to the present time.

Comment. Although it was the intention of the operator to drain the abscess cavity and prevent herniation of the brain, hernia cerebri developed with extrusion of the drainage tube. In spite of the herniation which occurred with no other treatment than dakinization of the wound and dressings which prevented pressure on the hernia, the hernia receded and the wound was completely healed within 2 months and 1 week following the date of operation.

About 3 weeks after operation upon the above mentioned case, I operated on another temporo-sphenoidal lobe abscess of the left side, practically identical with the case described above. In this instance, I located the abscess cavity, entered and evacuated its contents, irrigated the cavity with Dakin's solution and instituted the same type of drainage as in the previously described case. In this instance I



Fig. 5. Case 1. M. L. Temporosphenoidal lobe abscess, left. Photograph of patient about 2 years after operation.

was able to drain the abscess through a much smaller opening in the skull, so that herniation of the brain did not take place. The patient recovered from a semicomatose condition to the point where he was able to be up and about the ward and about the hospital grounds. Secondary pockets formed on two occasions after the patient had been up and walking about, each time necessitating his return to bed, with a return of the stuporous, semicomatose condition. In each instance the cavity was again entered and drained. Following the evacuation of the first secondary pocket or abscess, the patient's general condition again improved and he was up and walking about, after which another secondary abscess formed and drainage was again instituted. Although the patient improved to a certain extent following the drainage of the second secondary abscess which developed, he never recovered to the extent observed following the drainage of the original abscess and the first secondary abscess. The infection finally spread and the patient died as a result of rupture of the abscess into the ventricle.

Several months later I operated upon a frontal lobe abscess and instituted drainage which allowed the patient to recover from a semicomatose condition to the point where he was up and about the ward, when a secondary abscess occurred with rupture into the lateral ventricle, terminating in death.

After having had this experience, I began to consider closely the questions of drainage and the desirability or undesirability of temporary herniation of the brain. In the first

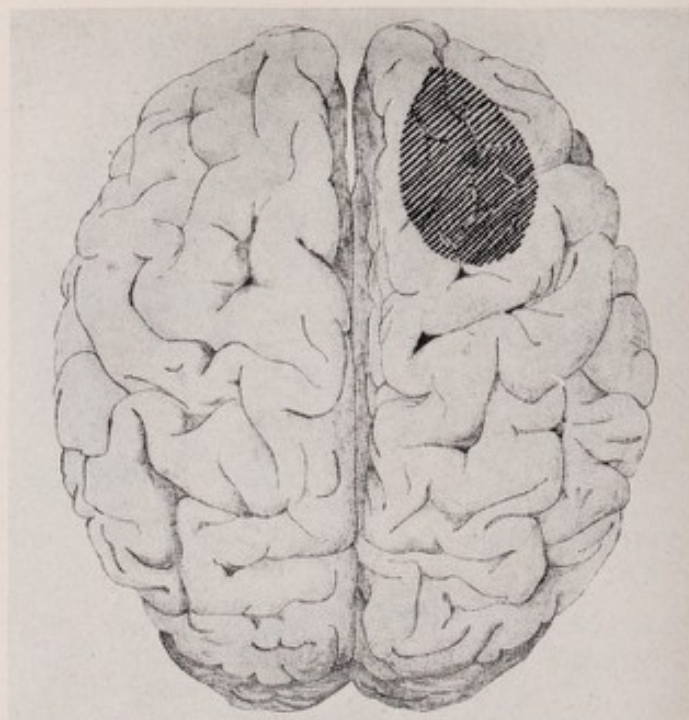


Fig. 6. Case 2. T. W. Frontal lobe abscess, right, showing the approximate position and relative size of the encapsulated abscess. There was definite left-sided hemiparesis.

case, evacuation of the abscess cavity had been accomplished through a rather large trephine opening through which a hernia cerebri subsequently occurred. The patient recovered. In the other two cases briefly described, similar drainage had been instituted through smaller trephine openings in which herniation did not occur. Both patients died.

It is also well known that during the late war, a number of deaths were prevented in cases in which there was gross cranial and intracranial injury by removal of a large mosaic of fragments of skull and considerable amounts of damaged brain tissue, with the result that subsequent herniation of the brain occurred. A great number of these patients recovered and came under the observation of the chiefs of the neurosurgical services here in hospitals in the United States, where the cranial defects were repaired. We have had cases of compound depressed fractures of the skull in Bellevue Hospital, in which the wounds were infected, suppuration occurred, and hernia cerebri developed. The hernia receded with no other treatment than protective dressings and dakinization of the wound.

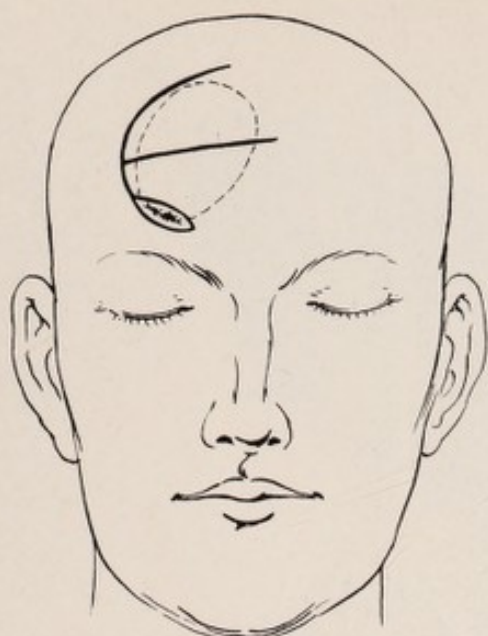


Fig. 7. Case 2. T. W. Frontal lobe abscess, right, secondary to old infected depressed fracture of skull, involving right frontal sinus. The incisions outlining the flaps for exposure of the outer table of the skull are indicated by the heavy black lines. The curved incision includes, at its lower extremity, the infected scalp wound which is excised. The approximate size of the oval shaped cranial defect to be made is indicated by the dotted lines.

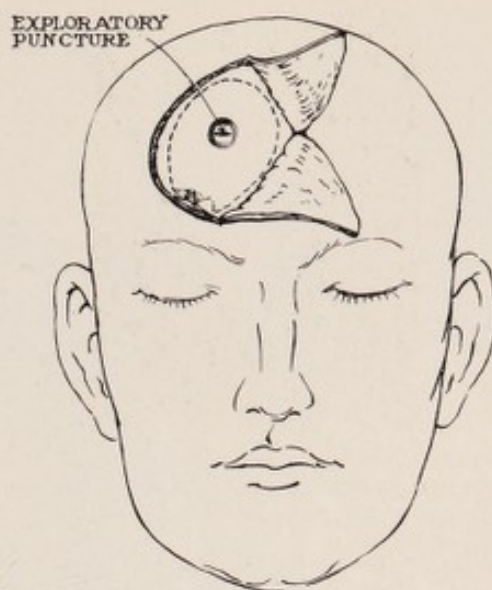


Fig. 8. Case 2. T. W. Frontal lobe abscess, right. The sketch shows the site of the trephine opening made for the purpose of exploratory puncture.

This question then arose in my mind: Why not, at the time of the original operation, provide a rather large trephine opening or cranial defect, directly over the site of the abscess; pack off the subdural and subarachnoid spaces to prevent extension of infection; "unroof" the abscess cavity by completely removing the overlying brain substance; completely empty the remaining portion of the abscess cavity; allow temporary herniation of the brain to take place through the cranial defect produced so that no drainage with drainage materials will be required; and let the subsequent treatment consist of irrigation of the area with Dakin's solution and prevention of trauma to, and early compression of, the hernia by protective dressings, which would be followed by recession of the hernia and epithelialization of the wound? After prolonged consideration, I came to the conclusion that this was the proper procedure and that cases which should come under my observation thereafter would be treated in such manner.

Three patients with brain abscess consecutively operated upon by me in this manner recovered, are well today, and are self-sup-

porting. Upon observations made in these three cases, I have made conclusions as set forth in this paper. The etiology, pathology, symptomatology and diagnosis of brain abscess will not be discussed, as the literature is replete with papers on these phases of the subject.

TECHNIQUE OF OPERATION

Anæsthesia. Local anæsthesia with novocain solution 1 per cent and $\frac{1}{2}$ per cent with suprarenin, is the anæsthesia of choice. I have seen no ill effects in the patients operated upon from the use of this solution. In most cases the patient is already drowsy, stuporous, or semicomatose.

The solution is injected in a circular direction around the site where the cranial defect is to be created. The diameter of the field is about 4 inches. This method makes it possible to inject the field rapidly and at the same time obviates entering an infected field, thus spreading the infection in case an infected wound is present. Not more than 100 to 125 cubic centimeters of the solution will be required. Dunn's apparatus for the injection of the solution has proved to be satisfactory.

Incision. The preferred incision is either three limbed, or crucial so that the point of apposition of the apices of the scalp flaps will coincide with the site of the trephine opening (Fig. 1). If a wound be present, its situation

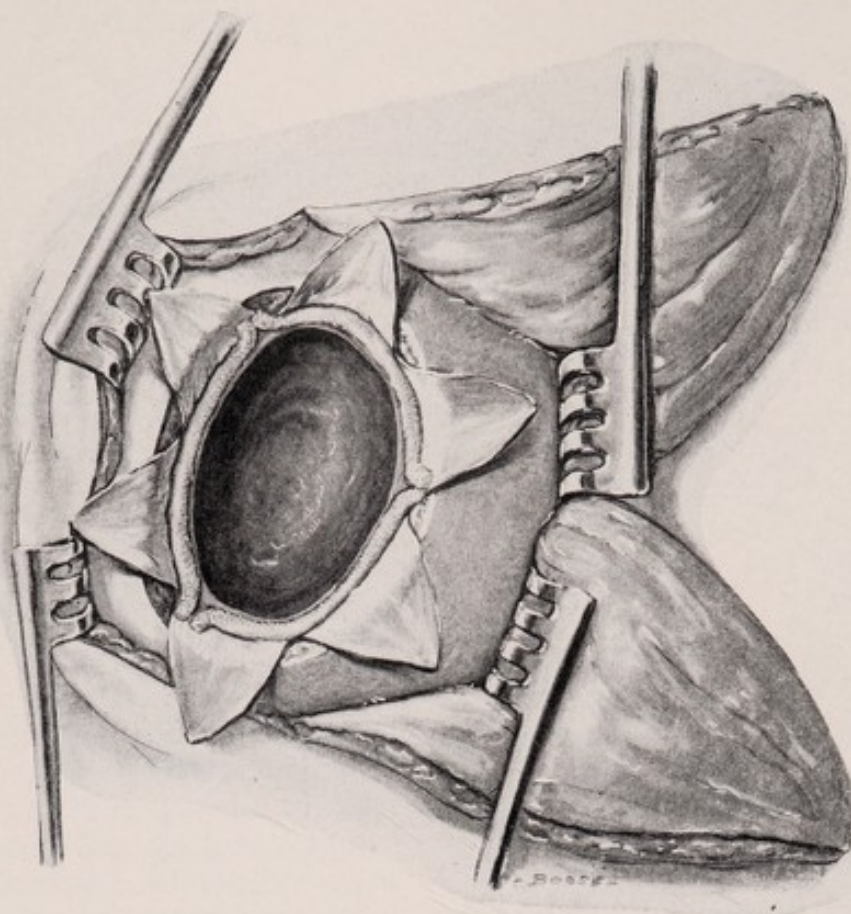


Fig. 9. Case 2. T. W. Frontal lobe abscess, right. Illustration shows the operative field as it appeared at completion of operation.

and direction may require the making of two or four flaps instead of three (Figs. 7, 8, 9). The incision is carried through to the outer table of the skull and the flaps consisting of the scalp, subcutaneous tissue, musculature and pericranium are elevated, reflected, and held with self-retaining cranial retractors (Figs. 9 and 14). The apices of the flaps are turned outward and sutured loosely to the flaps so as to prevent their becoming adherent too early to the surface of the hernia which will form, and to prevent the apices of the flaps from turning under and becoming adherent to the undersurface of the flaps. The retractors afford adequate exposure and prevent hæmorrhage from the margins of the flaps by traction and pressure, so that no artery clamps will be needed for this purpose. The exposure of the skull is therefore more rapid and is accompanied by practically no hæmorrhage. If an infected wound of the soft parts is present, this is excised along one limb of the operative incision. A trephine opening is

made in the central portion of the exposed outer table of the skull with a Hudson bone drill, bits A and B being used. A small incision about $\frac{1}{4}$ inch long is then made in the dura, so as to allow of exploration with a blunt hollow needle or cannula (Fig. 9). When the abscess cavity is entered by the needle and pus is obtained, a small amount of pus is removed for bacteriological examination, the location of the abscess is indicated, the needle is withdrawn and the trephine opening is enlarged with rongeurs, until it is about the size of a silver dollar or larger. It is enlarged in a direction to correspond with, and overlie, the abscess cavity. If the abscess is located directly beneath the trephine opening, enlargement of the cranial defect will be concentric with the trephine opening. If the abscess cavity is located more anterior or more posterior or inferior, or more superior, then the opening is enlarged in the direction indicated, so that the original trephine opening may be in the periphery of the cranial

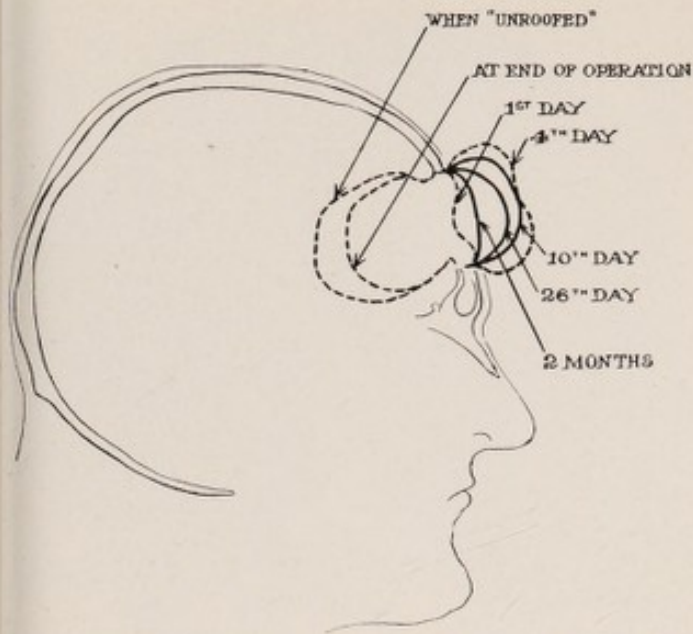


Fig. 10. Case. 2. T. W. Frontal lobe abscess, right. Schematic representation of the approximate relative size of the abscess cavity when "unroofed" at end of operation and progression and recession of hernia.

defect created. The dura is incised in a stellate fashion, creating six pennant shaped flaps which are reflected over the bony margin of the cranial defect, and sutured with fine plain catgut to the underlying surface of the scalp flaps. Small narrow strips of iodoform gauze (three pieces) are then lightly packed or "insinuated" beneath the margin of the circular defect created in the dura, so as to wall off the subdural and subarachnoid spaces and prevent extension of infection into these spaces. (Three short pieces of gauze are more easily removed than one long piece). The blunt exploring, hollow needle or cannula is again inserted into the abscess cavity, so as again to locate the cavity definitely, after which a $\frac{1}{2}$ inch incision is made with a sharp Bard Parker knife (blade No. 11), through the brain tissue (and capsule, if one be present) overlying the cavity. A soft rubber catheter, about No. 18 F., with a 20 cubic centimeter Luer syringe attached, is inserted into the incision and most of the contents of the cavity are carefully withdrawn, to prevent the contents of the abscess from running over and soiling the field of operation.

The incision in the cortex or "roof" of the abscess is carried to a point on the margin of the cavity, then thence around it in a circular manner, so that the entire "roof" of the cavity

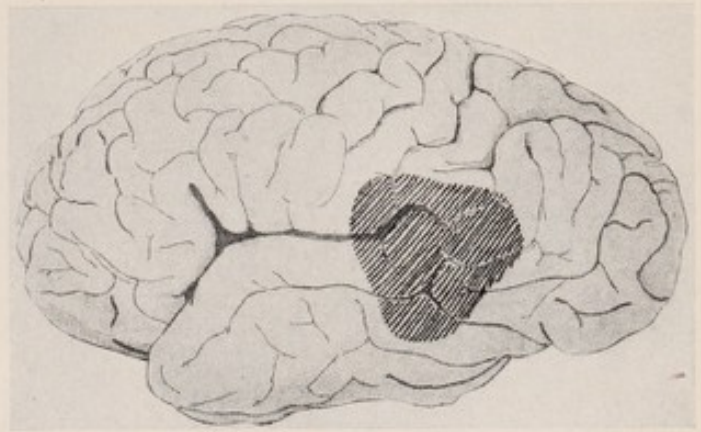


Fig. 11. Case 3. C. D. Temporoparietal lobe abscess, left, showing the approximate position and relative size of the non-encapsulated abscess, with extensions into the parietal lobe, occipital lobe and temporoparietal lobe. There was definite right facial paresis.

is removed, completely "unroofing" the cavity. It is essential that a short knife should be used for this purpose. When normal brain tissue is cut, one anticipates a considerable amount of bleeding. But only slight oozing occurs when the brain tissue overlying an abscess cavity is cut and removed.

As soon as the abscess is evacuated, the patient's condition improves. The pulse which in most cases is slow, now rises to between 70 and 110. Respiration and the general condition improve, so that he is less stuporous, is more susceptible to the external influences, oftentimes is able to talk and answer questions, and may become restless and may have to be restrained on the table.

The cortical margins about the abscess cavity will fall away from the dura unless adhesions have already taken place. If adhesions are present, they should not be separated, as their presence will be of value in the prevention of spreading of infection into the subdural and subarachnoid spaces. In fact, these spaces may be completely shut off by the adhesions. The cavity is then thoroughly irrigated with Dakin's solution and gently sponged or wiped out with cotton pledgets, completely to remove the contents of the cavity. No attempt is made to remove the "capsule" if one is present. In fact, a "capsule" tends to prevent too marked herniation of the brain.

After the roof of the abscess cavity has been removed, it will be observed that the floor of

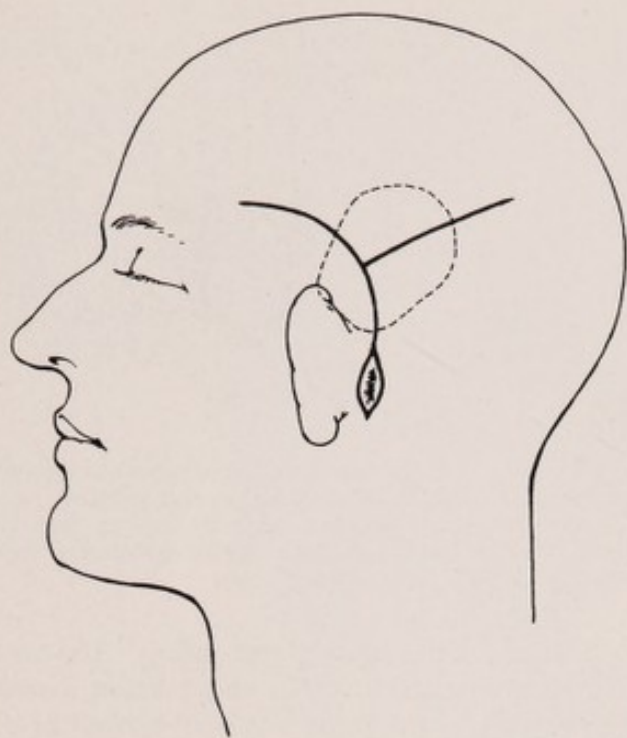


Fig. 12. Case 3. C. D. Temporosphenoidal lobe abscess, left, secondary to mastoiditis, with simple mastoidectomy. The incisions outlining the flaps for exposure of the outer table of the skull are indicated by the heavy black lines. The dotted lines show the approximate relative size of the cranial defect to be created.

the abscess cavity becomes less concave, flattens out and tends to rise somewhat into the operative field, thus diminishing the depth of the remaining portion of the abscess cavity (Figs. 10 and 15).

No drainage tubes or other drainage materials are inserted into this remaining portion of the abscess cavity. A fenestrated rubber dam is placed over the cavity, its margins coinciding with the operative field, over which small pieces of gauze wet in Dakin's solution are placed, so that the rubber dam "dimples" somewhat into the cavity. The original three pieces of iodoform gauze which were placed around the dural opening are not removed or changed. These pieces, during the procedure, adapt themselves to the margin of the subdural space and tend to prevent leakage into the subdural and subarachnoid spaces, better than if they were changed and new ones introduced.

The intention of the procedure, is: first, to remove the contents of the abscess cavity; and, second, to remove the roof of the cavity so as to allow the remaining portion of the cavity

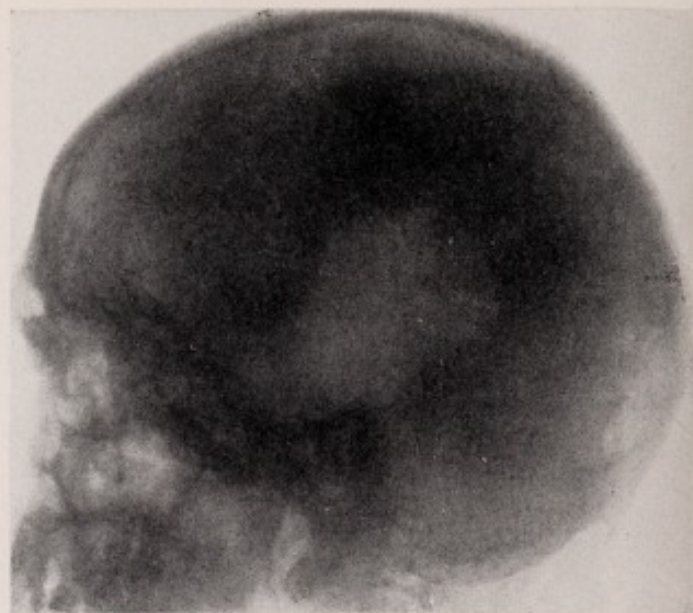


Fig. 13. Case 3. C. D. Temporosphenoidal lobe abscess, left, showing the operative cranial defect through which herniation of the abscess cavity occurred.

to herniate outward through a cranial defect which is intentionally placed directly over the abscess. The rubber dam is used to protect the surface of the after-forming brain hernia. The rubber dam offers better protection than does gauze or any other substance which might be used, in that there is no trauma to the hernia in its removal and at the same time when it is used it is possible to dakinize the hernia on account of its being fenestrated. The rubber dam is covered with a piece of gauze, wet in Dakin's solution and three perforated Dakin tubes are placed over the gauze, so that the entire area may be kept thoroughly wet with Dakin's solution¹ and a copious wet Dakin gauze dressing consisting of flats and headroll is applied.

And furthermore both ears are covered with several layers of vaseline gauze to prevent irritation by the solution. If the abscess is frontal in location, it is advisable to cover one or both eyes with vaseline gauze and include them in the dressing. Vaseline gauze is not applied to the scalp about the wound until the first dressing on the following day, as the scalp will withstand dakinization for 24 hours without irritation. The entire dressing is held in place with wet gauze bandages,

¹An apparatus, made of rubber, has lately been devised for the protection of the hernia cerebri, which at the same time allows of convenient dakinization of the wound, thus obviating the use of a rubber dam and tubes which are likely to be displaced.

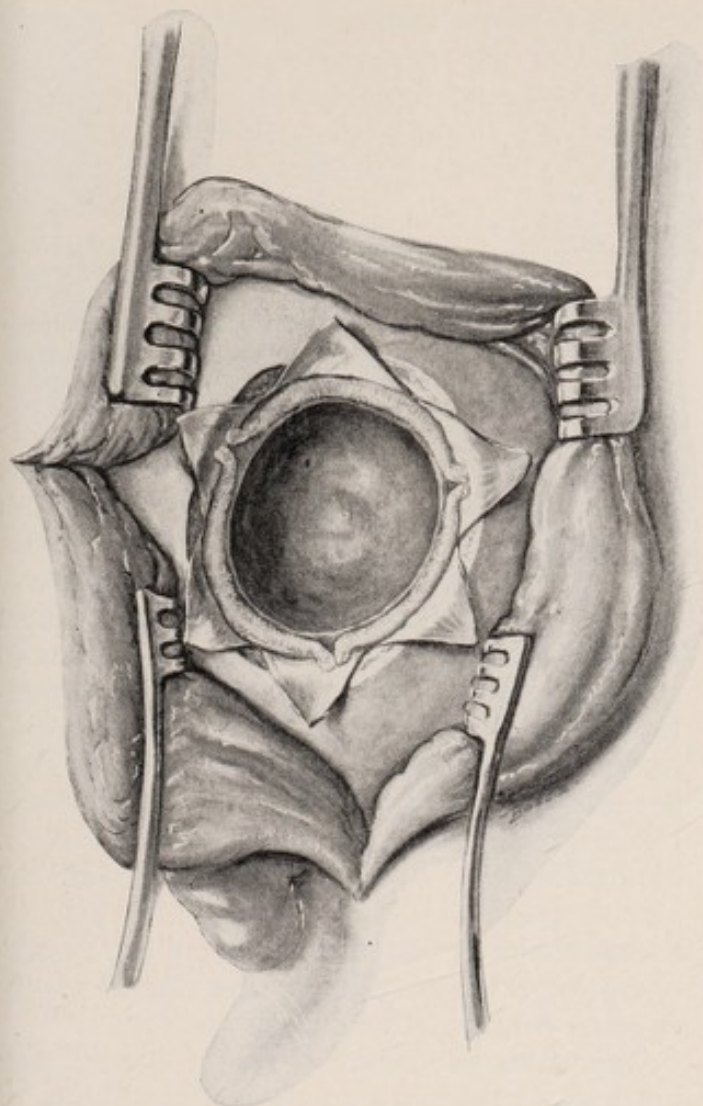


Fig. 14. Case 3. C. D. Temporosphenoïdal lobe abscess, left. Illustration shows the operative field as it appeared at completion of operation.

including the head and the lower jaw, to prevent removal or displacement of the dressings by the patient.

This procedure is equally applicable in the treatment of abscesses whether located in the frontal or temporosphenoïdal lobes (with or without extension into the parietal or occipital lobes) or cerebellar regions, or for those abscesses which are secondary to an old infected compound fracture or osteomyelitis of the skull. These groups form the greater majority of all brain abscesses. Likewise, single metastatic abscesses, which are comparatively rare, are amenable to this type of operation. For multiple metastatic abscesses, no surgical procedure can be expected to offer relief. If the abscess is located in the parietal lobe (which is unusual) necessitating a partial removal of

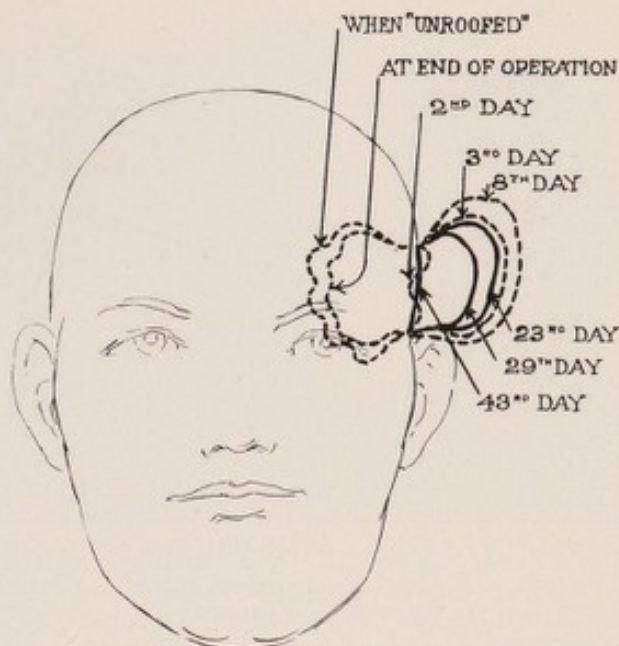


Fig. 15. Case 3. C. D. Temporosphenoïdal lobe abscess, left. Schematic representation of the approximate relative size of the abscess cavity when "unroofed" at end of operation and progression and recession of hernia. Non-encapsulation of the abscess is represented by the wavy dotted lines.

the cortex, a monoplegia, or even a hemiplegia, is to be preferred to a fatal result. In those cases of cerebellar abscess, where the abscess is situated on the anterior surface of the cerebellum, and the lateral sinus is involved, the approach described by Eagleton (3) with ligation and division of the lateral sinus probably will give best results.

In the small remaining group of cases where the abscess is basilar in position, and no opportunity is offered for removing the wall of the abscess to allow herniation, the two stage procedure described by Dowman (2) is probably the operation of choice, if the abscess can be located.

In recapitulation, the procedure described in this paper is applicable in all cases of brain abscess, in which the "roof" of the abscess can be removed and the abscess cavity can herniate through the cranial defect. Fortunately, these cases are most frequently met with and comprise the vast majority of all brain abscesses.

POSTOPERATIVE TREATMENT

The after-care of the patient, with attention to details, is most important and should be carried out by the operator himself or by



Figs. 16 and 17. Case 3. C. D. Temporoparietal lobe abscess, left. Photographs of patient made on November 1, 1923, about 10 months after operation.

an assistant who thoroughly understands the postoperative care. The patient should be dressed daily for a prolonged period of time. The cardinal points in the after-care of the patient, which will result in recovery, are:

1. Allowing of temporary herniation of the brain, carrying with it the remaining portion of the abscess cavity.
2. Combating of infection by the use of Dakin's solution.
3. Prevention of trauma to the brain hernia during the period of combating infection and the subsequent recession of the hernia.
4. Prevention of overdilatation of the ventricular system by means of lumbar puncture, if indicated.
5. Strapping of the wound with adhesive strips after the slight necrosis on the surface of the hernia has ceased and the surface of the hernia has become covered with healthy granulations followed by epithelialization and recession of the hernia.

Dressings. For several weeks the dressings should be done daily, beginning on the first day after operation. Dakinization of the wound is commenced immediately after the patient is returned to bed from the operating table, the instillation being made every hour.

Vaseline gauze should completely cover the scalp for protection from Dakin's solution and be removed and replaced at each dressing.

At the first dressing, all of the dressings should be removed with the exception of the

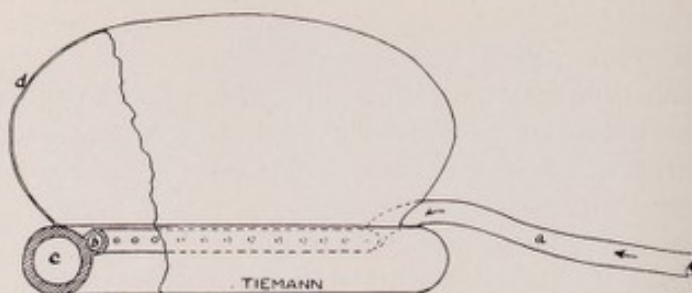


Fig. 18. Apparatus designed for irrigation of operative field with Dakin solution, and protection of brain hernia. *a*, inflow tube; *b*, circular, perforated Dakin tube; *c*, pneumatic rubber tube ring which is fastened to head to prevent displacement; *d*, perforated rubber cap to enclose hernia.

rubber dam over the defect (or the rubber protecting apparatus if used) and the three small pieces of iodoform gauze which have been placed about the margin of the defect to protect the subdural and subarachnoid spaces. At this time, i.e., 24 hours after operation, it will be observed that the abscess cavity has become somewhat herniated outward, has become much more shallow and may have reached the level of the inner table of the skull. If not, this level will have been reached by the second or third day (Figs. 10 and 15). A dressing similar to the one applied on the operating table is again applied, and the scalp covered with vaseline gauze.

This same procedure is repeated each day until about the sixth day, when the hernia of the brain will have passed out of the cranial defect and the abscess cavity will have become everted, or "turned inside out" so to speak, so that the concave floor of the abscess cavity has now become the convex surface of the hernia. The hernia is smaller in cases in which a capsule is present than in those cases of non-encapsulated abscess. At this time the hernia will have assumed a mushroom shape, overlapping the small iodoform gauze packings about the margin of the defect. These should at this time be carefully removed, so as not to traumatize the hernia. If the gauze packing is not re-inserted between the scalp flaps and base of the hernia, the scalp flaps will become attached to the lateral surfaces of the hernia, which might result in the adherence of flaps to the hernia and in the forming of small pockets at the base of the flaps in the space between the base of the flaps and the base of the hernia. In order to prevent

such an occurrence, it is considered advisable to pack lightly strips of gauze wet in Dakin's solution, between the scalp flaps and the brain hernia so as to allow the flaps to first become attached to the hernia, at the base. Throughout successive dressings, these light gauze strip packings are inserted to a lesser depth than on the preceding day, thus allowing the scalp flaps to become gradually attached to the hernia from the base upward. When the space between the base of the flaps and the base of the hernia has been obliterated, the loose sutures which have held the apices of the flaps in an everted position are removed, and the flaps allowed to become adherent throughout to the lateral surface of the hernia. Care should be taken that the apices of the flaps do not roll inward upon the flap and become adherent to the undersurface of the flap or that the margins themselves do not roll in. If so, the hairs from the scalp will grow outward and downward against the surface of the brain hernia, irritate the surface of the hernia, prolong infection, and delay epithelialization at this area. The holding of the apices of the flaps in an everted position for several days will prevent this occurrence.

The hernia may become of considerable size, from the size of a small lemon to that of a small orange; that is, a mass from about $1\frac{1}{2}$ inches in diameter to that of 3 or more inches in diameter and protrude above the level of the scalp for a distance of 1 to 2 inches. *The hernia should not be cut away; neither should it be compressed at this time.* To prevent compression, if the apparatus suggested for this purpose is not used, a ring made of cotton wrapped with gauze (such as is placed about a patient's heel to prevent a pressure sore), is placed about the hernia and strapped to the head to prevent displacement of the ring. The hernia is kept protected with a rubber dam or apparatus and the entire area is kept thoroughly irrigated with Dakin's solution. In other words, after the hernia has formed, it is necessary to (1) protect the hernia from pressure and trauma, (2) prevent overherniation by lumbar puncture, (3) keep the area thoroughly irrigated with Dakin's solution, (4) keep the patient quiet in bed during the first 3 or 4 weeks, while the hernia

is at its maximum size, and to prohibit physical exertion. Bowels should move daily.

To prevent excessive herniation of the brain after the abscess cavity has become everted, lumbar puncture, with removal of 10 to 25 cubic centimeters of fluid from time to time should be done, after the first 2 weeks have passed. By this time the area about the defect has become well walled off and the likelihood of spreading of infection in the meninges will have passed. The size of the hernia will immediately decrease during the lumbar puncture, while the fluid is being withdrawn. The herniating mass instead of being tense will become soft, "flabby," somewhat flattened out, and may even become depressed in its central portion. In case of temporo-sphenoidal lobe abscess, where the herniating mass consists of brain tissue for the most part, the recession of the hernia following lumbar puncture will not be as great as in the case of a frontal lobe abscess, where the herniating brain substance is thinner and the surface of the anterior horn of the lateral ventricle is nearer the surface of the brain hernia. In such a case, that is, a frontal lobe abscess, the hernia recedes entirely within the cranial cavity and forms a depression. In such cases, the amount of fluid removed by lumbar puncture should be less, so as not to create a negative pressure within the ventricle and thus bring about the danger of possible rupture into the ventricle from without. The intention should be to remove only enough cerebrospinal fluid to lessen the intracranial pressure sufficiently to do away with the possibility of rupture of the ventricle from within outward, through the hernia, from marked increase of intracranial pressure. Lumbar puncture should not be done in the first few days following the operation, for fear of extension of infection.

In the cases observed there were slight areas of superficial sloughing of the hernia. These areas of sloughing were on the surface and were not greater than one-sixteenth to one-eighth inch in depth. It has not been observed that they have been deep seated or tended to extend into the depth of the hernia, but have always been limited to thin superficial sloughing. These superficial sloughs should not be

removed until after they have become completely loosened (except that the margin which has already become loosened should be clipped away with scissors), i.e. no attempt should be made to dissect the slough away from the brain tissue. If so, slight bleeding will occur with the possibility of extension of infection into the hernia and a repetition of the sloughing at this site. The slough which has been observed has been chiefly that of the wall of the everted abscess cavity itself and the cut margin of brain substance about the original abscess cavity, made by the knife in "unroofing" the cavity. Gross sloughing of the hernia itself has not taken place.

After about 3 or 4 weeks, the surface of the hernia will become covered with healthy red granulation tissue, which will give a greater resistance to the surface of the hernia. The surface will become somewhat fibrosed and will not increase suddenly in size with coughing and sneezing as it does in the earlier stages before fibrosis or partial cicatrization has taken place. The hernia will also begin to diminish in size, becoming less and less from day to day. It will be observed that epithelium has begun to grow out over the surface of the hernia, extending from the margin of the scalp flaps. At this stage the surface of the hernia should be covered with strips of perforated adhesive plaster exerting slight pressure. To fix the adhesive so that it will not be loosened by the Dakin's solution, a strip of adhesive about 2 inches wide should be placed around the head so that the ends come to within about 3 inches of either side of the site of the hernia. To this strip of adhesive the several smaller pieces of adhesive covering the hernia can be fastened and they will not be loosened by the Dakin's solution. These strips should be removed daily during the first week or two of strapping of the hernia, on account of the secretion which accumulates about the strips. A gauze dressing wet in Dakin's solution should be applied over these strips and it should be kept wet with Dakin's solution and a syringe, from without, every 2 or 3 hours. At this stage, it will no longer be necessary to use the Dakin tubes. The epithelium grows rather rapidly beneath the adhesive strips, so that finally only a

small granulating surface remains after the area has been strapped for about 2 weeks. The patient ordinarily will be up and about the ward by the time the strapping is commenced. The small granulating area in the center of what was the hernia, finally becomes completely covered with epithelium, leaving a healthy non-hair-bearing scar, usually somewhat triangular or crucial in shape, this being the space between the margins of the retracted scalp flaps.

The average time which will be required from the time of operation until the hernia has completely receded and the granulating surface has become covered with epithelium is about $2\frac{1}{2}$ to 3 months. The level of the site at which the hernia occurred, has now become flattened, the hernia is completely subsided, or the area may even be slightly depressed. The case will then show the typical physical signs of the usual cranial defect, i.e. there will be present, pulsation corresponding to the heart beat, impulse on coughing or sneezing, a tendency to slight herniation when the patient leans toward the side on which the cranial defect is situated and a slight depression when the patient leans in the opposite direction.

Hernia cerebri in general. The treatment described above applies to hernia cerebri in general. We have demonstrated this to our satisfaction in the last 2 years in Bellevue Hospital. All cases which I have seen treated in this manner, at this hospital, have recovered.

LATER OPERATIVE PROCEDURES

Scalp plastic. After a period of 1 year or more, following complete healing of the wound a scalp plastic with excision of the non-hair-bearing scar and approximation of hair-bearing scalp edges, is advisable for the following reasons, in certain cases:

1. Elimination of the rather thin scar overlying the brain substance, which might be more easily traumatized than true scalp, thus resulting in a secondary infection.
2. Preparation of the site for cranioplasty or repair of the cranial defect at a much later date, in case this is desired.
3. Protection.

4. Cosmetic reasons.

The scalp plastic, however, should be deferred for a period of 1 year to 14 months, so as to avoid the possibility of latent infection.

Cranioplasty. After a period of about 1½ to 2 years, following the original operation, the cranial defect can be repaired according to the method used by us in the neurosurgical services in the late war and also in the hospitals in civil practice. This subject will not be discussed as it was fully covered in a previous paper (5).

REPORT OF CASES

CASE 1, M. L. New York Eye and Ear Infirmary, No. 2838. Register No. 7558. Age 28. Russian Hebrew. Occupation, cutter of men's clothes. Admitted to the Service of Dr. John McCoy, on July 5, 1920.

History. Four weeks ago patient had a severe pain in left ear. On the following day, the ear drum was punctured. It drained for about 10 days, when drainage suddenly ceased. The bone behind the ear then began to pain, and although discharge from the ear again appeared, the pain continued behind the ear. This condition lasted for about 12 days. On the day previous to his entering the hospital, there was swelling behind the ear. The right ear was negative on examination. The past and family history were negative.

Physical examination. Bulging of tympanum, sagging of the canal wall and swelling behind the ear over the mastoid area. Temperature 101.2 degrees; pulse 84; respiration 22.

July 3, 1920. Roentgenographic examination, plate No. 10102 (ordered from Dispensary). Right is fairly clear, pneumatic. Left is very cloudy and there is evidence of breaking down over the lower part of the sinus.

Operation, July 7, 1920. Operator, Dr. McDougall. Anæsthesia, gas and ether. Simple mastoidectomy, left. Usual postauricular incision, perforation through cortex, midway between knee and bulb, cortex removed, free pus found. Mastoid cells broken down, filled with free pus. Dural exposure in mid-fossa, reveals epidural abscess or collection of pus. Free pus oozing from antrum. Perisinus abscess. Large area of dura exposed in mid-fossa by disease. Sinus exposed from knee to bulb. Three pieces of iodoform gauze inserted and wound closed with silk-worm gut sutures.

July 9. First dressing.

July 13. Discharge from canal, slight; from posterior wound, moderate. Patient complains of pain in temporal region at night; also daily, and constant headaches.

July 16. Red blood cells, 5,200,000; white blood cells, 18,200; polynuclears, 90; lymphocytes, 10.

July 16. Canal, almost dry. Thin purulent discharge from wound. Granulation tissue healthy.

July 20. Wound in healthy condition.

July 20. 10 a.m. Patient seems dull and does not answer questions. He is unable to return to bed without assistance on account of tendency to fall forward. A few minutes later he answered questions intelligently but did not remember his dressings or any of the above instances. Pupils unequal. Right larger than left; both react to light. (Atropine yesterday). No vomiting; no nystagmus; no dizziness (?). Aphasia. Patient unable to name objects but can tell what they are used for; says he has trouble in remembering names for past few days. Slow cerebration, astereognosis.

July 20. Ophthalmological examination: O. S. A slight lateral nystagmus present. Cornea clear. Anterior chamber normal. Pupil reacts to light and distance. Lens and media clear. Fundus examination shows myopia, about 5 diopters. There is a hyperæmia of the nerve head. The physiological cup is obliterated. The vessels are somewhat tortuous and there is a break as if it were a very small hemorrhage. O. D. A slight lateral nystagmus; Cornea clear; Anterior chamber normal depth. Pupil reacts to light and distance. Lens and media clear. Fundus examination: Myopia about 5 diopters. The nerve head is congested. The physiological cup is obliterated. The vessels are apparently normal. There may be very slight swelling of the nerve head. Diagnosis: O. S. Beginning neuritis. O. D. Suspicious of beginning neuritis.

July 20. 4 p.m. Was called in consultation by Dr. Stuart L. Craig of Dr. McCoy's Service. The probability of the diagnosis of brain abscess, temporo-sphenoidal lobe, left, made by Dr. McDougall is very likely. His diagnosis was based on the following findings: (1) astereognosis, (2) sensory aphasia, (3) drowsiness and stupor, (4) constant headaches, (5) symptoms coming on following simple mastoidectomy, left, 13 days ago. However, on account of the dura having been exposed at the time of operation, it is considered advisable to revise the wound and explore for possible extradural abscess, after further removal of bone. If no abscess is found, extradural, it is the intention to pack the wound with gauze, wet in Dakin's solution, apply a wet gauze dressing and observe the patient for a day or two. If the patient's condition does not improve, exploration through the cranial defect which had been enlarged above the site of the mastoid process could be performed. In the meanwhile, the dura will have become adherent to the cortex and exploration beneath the dura could be more safely done on account of the area being walled off. The pulse is not slow (80); temperature is 99.2 degrees.

July 20. Lumbar puncture; cerebrospinal fluid clear, Fehlings, 1 plus; globulin, 1 plus; cells, 30 per cubic millimeter. Culture negative.

Operation, July 20, 4:30 p.m. Revision of wound. Simple mastoidectomy, left. Operator, Dr. King. Assistant, Dr. McDougall. Anæsthesia: gas, oxygen, and ether.

Wound was opened up, small collection of pus beneath skin flap. The cranial defect which was

created by the disease and by the operator at the time of the last operation was enlarged especially upward and forward, to about the size of a five cent piece. No extradural pocket of pus was found by enlargement of the defect. It was considered advisable to wait and observe patient's condition for a day or so and not open the dura at this time. The wound was packed with gauze wet in Dakin's solution and a copious gauze dressing, wet in the same solution, was applied over the wound.

July 21. Fundus examination. O. S. Slight increase of swelling of nerve head. Vessels are a little more engorged and the tortuosity a little more pronounced. O. D. The same applies to this eye, though not as bad as left.

July 22. Neurosurgical note: Patient made on improvement following exploration of the wound 2 days ago. Temperature rose to 101 degrees yesterday, but today is 99.4. Pulse 76. Patient is still stuporous; stupor has increased; very slight facial weakness, right. Aphasia and astereognosis more pronounced. The vessels of both sides are more engorged and the tortuosity of the vessels is somewhat more pronounced. There is no doubt that the diagnosis of brain abscess, temporosphenoidal lobe, left, is correct. Operation is advised.

July 22. I am of the opinion that there is just a slight increase in the development of a neuritis in each eye.

Operation, July 22, for brain abscess, temporosphenoidal lobe, left. Operator, Dr. King; assistant, Dr. McDougall. Anæsthesia: gas, oxygen and ether.

Pathological findings. The dura was under considerable pressure. After the cranial defect had been somewhat enlarged, upward and forward, and a crucial incision had been made in the dura, in the center of the defect, a blunt exploring hollow needle was inserted into the cortex which bulged into the incision. The needle was passed in a direction slightly upward, forward, and inward, and on the first puncture, it encountered resistance at a depth of 1.25 centimeters. It was stated at the time that this resistance which was comparable with that which might be offered by a rather thin, hollow rubber ball in thick mush, was due to the capsule of an abscess cavity. A slight push carried the end of the needle beyond this resistance, the stylet was withdrawn, and after waiting for a short time, thick yellow pus welled up through the needle. A specimen was collected and sent to the laboratory for bacteriological examination. After about 3 drachms of the pus was removed, a pointed artery clamp was gently pushed alongside the needle into the abscess cavity. This was followed by an outflow of a considerable amount of thick, yellow pus, homogeneous throughout. It was not considered that there was grave danger of a spreading meningitis following the outflow of the pus, as the subdural and subarachnoid spaces had been obliterated by the adhesions between the dura and the cortex. After the tract into the abscess cavity had been enlarged by blunt dissection

or spreading of the sinus by the opening of an artery clamp in several directions, the contents of the cavity were aspirated by means of a soft rubber catheter and syringe, and the abscess cavity was irrigated and cleaned out with Dakin's solution until clear. The capsule was about 1.5 millimeters thick. The approximate capacity of the cavity was about 1 ounce. It was fairly spherical or globular in shape and had no extension or prolongation in any direction, other than a somewhat neck-like prolongation downward toward the site at which the dura had been exposed by the disease in the mastoid.

Procedure. The incision made 2 days ago for exploration of the mastoid wound was extended upward and forward, parallel to the ear and about $\frac{3}{4}$ inch posterior to the ear, for a distance of about 2.5 inches. The incision was carried down through all the soft parts to the outer table of the skull, the flaps were elevated from the outer table of the skull, reflected and held with selfretaining cranial retractors. The cranial defect was considerably enlarged upward and forward over the temporosphenoidal lobe (Fig. 4). There was practically no bleeding from the bone margins.

The pathology as described above was noted, and the procedure was carried out as stated under "pathology."

After the abscess cavity had been well irrigated with Dakin's solution, the following material was used for drainage: a $\frac{1}{2}$ -inch rubber tube, with a lateral opening at the distal end and about 2 inches long was inserted into the abscess cavity and 4 strips of narrow packing gauze, wet in Dakin's solution were loosely packed into the cavity at sites corresponding to the points of the compass. Two safety pins were passed through the drainage tube to prevent its being pushed in too far or its removal. Small gauze strips were placed in a circular manner beneath and above the safety pins. The entire wound was packed with gauze, wet in Dakin's solution and left wide open—no sutures were placed. The area was covered with a copious gauze dressing wet in Dakin's solution, covered with a head roll and held with a bandage and adhesive strips, including the lower jaw. The patient was returned to the ward in this condition.

Note: July 23. Wound was dressed twice today. Gauze packing and drainage tube not removed. Tube and cavity irrigated by inserting the end of a small rubber tube into the drainage tube and passing it through the lumen of the tube to the floor of the abscess cavity. This tube was left in position. Dakin's solution was instilled through the small tube 9.2 hours. The patient's general condition was improved. He was less stuporous and could talk better. Highest temperature 101.2 degrees. Dressings done by Dr. McDougall.

July 26. Culture of pus removed from brain abscess, streptococcus.

July 30. Fundus examination. O. D. The physiological cup is present. The vessels are more normal. O. S. There is a decided improvement in the nerve

head in every way. All of the daily dressings were made by either Dr. McDougall or some of his co-workers on the house staff. The following notes were made.

August 4. Canal dry. Moderate discharge. Pulsation at site of wound marked. Wound healthy in appearance. Tube is protruding.

August 15. Part of drainage tube cut off.

August 16. Irrigation with Dakin's solution continued.

August 17. Both the drainage tube and irrigation tube were removed. Sinus from which they were removed almost closed.

August 21. Hernia markedly receded into cranial cavity.

August 31. Sinus entirely closed.

September 3. Epithelial edges or margins growing in from three sides.

September 5. Wound in good condition.

September 10. Fluctuating swelling at site of old mastoid scar. This was opened through scar and proved to be a small superficial pus pocket leading toward the area of antrum.

September 14. Mastoid wound has slight discharge. Canal almost dry.

September 17. Canal dry. Mastoid wound almost closed. Epithelium spreading over granulating surface of scalp incision over area at site of recession of hernia (hernia completely receded).

September 21. Posterior wound almost healed. Granulating surface covered with epithelium except over the area about the size of a quarter. Epithelium growing in from all sides.

September 24. Mastoid wound almost healed. Canal dry. Granulating surface which is still uncovered with epithelium about the size of the end of a lead pencil.

September 25. Wound almost healed.

September 28. Wound completely healed.

October 9. Discharged from the hospital.

Practically all the notes made by the house staff referred to the local condition of the wound. Notes of the general and neurological condition throughout the convalescence were not made.

In a conversation with the patient, he stated that he was out of bed on the thirty-ninth day, that his speech defect had completely cleared up by the fourteenth day and that he was able to walk on the forty-second day. When he was discharged from the hospital he had no complaint and felt entirely well. The highest temperature throughout his stay in the hospital was 101.2 degrees, on the first day after operation.

Summary. Male, 28, cutter. Otitis media, left, followed by puncture of tympanum on day after onset. Operated upon for mastoiditis about 4 weeks later. July 7, 1920. Operated upon for temporo-sphenoidal lobe abscess, 15 days later. Abscess drained through rather large cranial defect, rubber tube and gauze packing used for drainage material. Thirteen days following the operation herniation of brain carrying with it abscess cavity, rather marked.

Thirty days following operation hernia markedly receded. Fifty-seven days following operation hernia completely receded with no other treatment than keeping area clean with Dakin's solution. Sixty-eight days following operation wound completely healed. Area completely covered with epithelium. Ready for discharge. Remained in hospital for further observation until discharged from hospital on the seventy-ninth day following operation for brain abscess, apparently entirely recovered. Highest temperature 101.2 degrees, second day.

In this case, brain hernia was not intended or desired; it occurred, however, resulting in practically a complete eversion of the abscess cavity, without formation of secondary abscess. Patient recovered.

Follow-up note. November 14, 1923, patient stated that he was discharged from the New York Eye and Ear Hospital on October 9, 1920, to his home. He was not confined to the house at any time after his discharge from the hospital. He went out daily and looked for work. He felt perfectly well. He was unable to obtain work until about 10 weeks after his discharge from the hospital on account of a strike, at the end of which time he succeeded in getting a position as a cutter of men's clothes, a position similar to the one which he held before his illness. He continued at this work without interruption, except for his yearly vacation, until September, 1923. He then gave up his position and opened his own store at Coney Island, near Seagate. He is the part owner of a cigar and stationery store and ice-cream parlor, and he has continued at this work until the present date. This work in addition to his usual duties within the store, entails delivery of newspapers to the residents of Seagate, requiring a considerable amount of walking. In November, 1921, he was married. At the present time he is in a perfect state of health and has no complaints whatsoever. While in the New York Eye and Ear Infirmary in July, 1920, before the mastoid operation, he weighed 135 pounds. Upon discharge from the hospital he weighed 155 pounds; after having remained at Burke's Foundation for about 2 weeks, at which time he returned home, he weighed 165 pounds. At the present time, his weight is 175 pounds; 3 years and 4 months following the operation.

Report of otological examination made by Dr. Stuart L. Craig on November 2, 1923, is as follows:

"His hearing is practically normal. The drum shows some scar tissue in the posterior segment and some thickening, but is in fair position. The mastoid area shows a depressed scar which is smooth and entirely healed. The area over the temporo-sphenoidal lobe shows no hernia."

CASE 2. T. W. Brain Abscess No. 15. Age 46. Blacksmith. Admitted to Ward B-1 Second (Cornell) Medical Division, on the Service of Dr. Eugene F. DuBois, Bellevue Hospital, March 17, 1923.

Present illness. (Patient is Polish and speaks and understands English rather poorly.) About 3 weeks

ago, patient fell down and hurt the front part of his head. Since then he has had a continuous pain in his head; yesterday he was drinking. Does not remember who brought him to the hospital. (Before patient was discharged from the hospital, he gave a more correct and detailed history of his injury. He stated that 3 months before he was admitted to Bellevue Hospital, while working as a blacksmith for a railroad in Pennsylvania, he fell down some steps with a kit of tools which he was carrying on his shoulders. He struck the right side of the front part of his head. He was given first aid treatment but was not operated upon. He received a wound in the right frontal region; no X-ray plates were made. The wound never completely healed up. He felt fairly well for about 2 months, with the exception of a headache. He began drinking to relieve his headache. He stated that the pain in his head finally became so severe that he decided to come to the hospital. During all this time, however, he was up and walking about.)

Physical examination. Patient fairly well nourished and developed; no cyanosis, dyspnea or cough; does not appear ill. Strong odor of alcohol from breath.

Eyes. Pupils equal; round; regular. React to light and accommodation. No icterus. Extra-ocular movements normal.

Ears and Nose. Negative externally.

Eardrums. Normal.

No perforation of nasal septum.

Mouth. Tongue slightly coated; moist; no tremor; scars or atrophy. Tonsils and pharynx not infected.

Teeth. Fairly good.

Scalp. There is a scar in the right frontal region; it is reddened, inflamed, and somewhat elevated. No fluctuation; it is about 1.5 inches long, almost horizontal in direction over the right supra-orbital ridge, the inner extremity of which is about 1 inch above the supra-orbital ridge.

Neck. No rigidity; no masses; no tenderness.

Heart. Regular; sounds of good quality; no murmur.

Pulse. (70; temperature, 98 degrees; respiration 20) equal, right and left radial; no sclerosis.

Lungs. Resonant; breath sounds vesicular; no adventitious sounds; no changed voice or fremitus.

Abdomen. Negative. Abdominal reflexes equal.

Other reflexes. Knee and ankle jerks equal, not increased or diminished. No clonus; no Babinski. Provisional diagnosis, alcoholism.

March 18, 1923. Blood Pressure 130-70.

March 18. Urinalysis: Color, amber; clear; specific gravity, 1028; acid; albumin, 2 plus; sugar, 0; casts, 0.

Notes from progress sheet. (Made by various attending and associate physicians and staff men.)

March 19. Can find nothing wrong with this man except that he appears drowsy. Eye grounds, negative. Do not think scar on forehead has any significance. Inasmuch as he walked to the hospital and there are no physical abnormal findings, see no reason why he should be in hospital.

March 20. There is slight weakness in the left side of his face.

March 22. History of head injury with infected scar, somnolence, lethargy, absence of focal signs, suggest abscess of the frontal lobe. Appearance suggests encephalitis, which is more likely. Abdomen is scaphoid and abdominal reflexes are not obtained. Left pupil slightly larger than right. Both react sluggishly to light. No paralysis determined. Other reflexes present and active. Tongue possibly deviated to the left. Recommend X-ray of the skull and lumbar puncture.

March 23. Leucocytes 11,200; polymorphonuclears, 70; lymphocytes, 28.

March 24. Lumbar puncture. Fluid clear; cell count 40 per cubic millimeter, Fehling's reduces; Noguchi negative. To laboratory for Wassermann.

March 24. Patient continues lethargic, but when roused can talk; says he cannot use urinal properly; he is unstable so far as use of hands is concerned. Physical findings are slight left facial weakness; spasticity of left arm and leg; choking of both discs (which I think has developed in last week); increased reflexes on both sides and very slight deviation of tongue to left. History of injury to head several weeks ago.

Provisional diagnosis. Disturbance in right motor area, possibly an abscess.

March 24. *Neurological note.* Patient states that his health before his fall was perfect. Pupils under mydriasis. No strabismus or nystagmus. Fundi, 4 diopter; refractive error; veins moderately congested; discs obscure; left greater than right; hemorrhage near right disc at 6 p.m. Papilloedema present, but cannot be easily measured because of restless eye movements. Involvement of left facial marked, of central type. Cornea reflexes unequal, but patient states feeling is the same. Tongue moved well, but on protrusion is deviated to the left. Speech clear. Motor: patient makes restless movements; holds left arm and leg rather rigidly. Left arm, paretic; left leg slightly paretic. Sensory: cannot be determined, but seems normal. Reflexes: abdominals not obtained. Left plantar: right is definite. Right and left weak clonus at ankle. Left knee and ankle jerks greater than right. Addenda: percussion over right temporal and frontal regions definitely painful. Interpretation: inclined to favor suppurative lesion, osteomyelitis of right frontal bone with possible involvement of sphenoid and ethmoid cells, and pachymeningitis of right frontal lobe, going on to abscess. Other alternative is lues.

March 25. Leucocytes, 17,000.

March 25. No change in patient's condition, except perhaps slightly greater weakness of left face and more tenderness on percussion over right frontal and parietal regions.

March 25. *Ophthalmological note.* No nystagmus. No paresis or paralysis of ocular muscles determined (very poor co-operation on patient's part). Right pupil is greater than left; very slight response to

direct light. Fundi: papilloedema, right, with circumscribed retinal oedema. Numerous hæmorrhages and spots of exudate. Left fundus: optic neuritis with a little elevation of disc.

March 26. No change in patient's condition, except that pulse is slower (54); heart action is more deliberate and there is greater spasticity of left arm and leg.

March 26. On account of papilloedema and spasticity increasing, it is considered that intracranial pressure is increasing and operation is advised. Diagnosis: abscess of brain.

March 26. Neurological note. Patient shows definite left sided symptoms with papilloedema and from previous notes it is evident that there has been a steady progression of symptoms. If lues can be eliminated, would advise a right frontal exploration for possible abscess.

March 26. Roentgenographic plate of the skull shows area of softening of the skull in frontal region; osteomyelitis. This plate has not been interpreted by X-ray Department. Final diagnosis: Osteomyelitis of the right frontal bone with brain abscess.

March 26, 6:30 p.m. *Neurosurgical note.* It is believed that the diagnosis is: abscess, frontoparietal region, right, secondary to an old C. C. F. of skull, right frontal region.

1. There is definite sequestration, i.e. presence of fragments of dead bone, in a cranial defect, about the size of a five cent piece, right frontal region, directly beneath an inflamed and infected wound of scalp.

2. Drowsiness.

3. Spasticity of left leg and arm with facial paralysis, left.

4. Choking of discs, especially right.

5. Engorgement of veins, right eye.

6. Slow pulse, 52. (Varied since admission, 48-80).

It is advised that operation be done as soon as possible.

Patient was transferred to Ward M-4, Second (Cornell) Surgical Division, and was operated upon at 8:30 p.m. on the same date.

March 26, 8:30 p.m. *Operation* for brain abscess, frontal, right.

Operator, Dr. Joseph E. J. King; assistant, Dr. Russell.

Anæsthesia. Novocain solution, 1 per cent with suprarenin.

(Before scrubbing up for operation, I made a sketch for the house staff on the blackboard, indicating the site of the old depressed fracture of the skull with pieces of dead bone fragments and the probable location of the abscess in the right frontal region, extending into the parietal lobe, showing its extent and relative size. My opinion in this case was based on a case of frontal lobe abscess, previously observed by me, in which the physical findings and symptoms were practically identical. The sketch so drawn represented practically the exact condition found at operation.)

Pathological findings. Through a trephine opening made with a Hudson bone drill, with bits A and B, about 1 inch posterior to the site of the old infected, compound, depressed fracture, a small incision was made in the dura. A blunt, exploring needle (a small brain cannula devised by me for ventricular puncture) was inserted in the dural incision and was passed into the brain substance. At a depth of about 1.5 centimeters a definite resistance was encountered. The resistance offered was similar to that which might be offered by a thin, hollow rubber ball, imbedded in mush. This springy resistance was believed to be caused by the capsule of an abscess. With somewhat greater pressure being exerted, the end of the cannula passed through the resistant substance (capsule), the stylet was removed from the cannula and after waiting a short interval of time, thick yellow pus slowly welled upward through the cannula, confirming the diagnosis of brain abscess. A specimen of the pus was collected for bacteriological examination. The needle was withdrawn and the trephine opening was enlarged in a somewhat circular manner until the cranial defect, which resulted, was larger than a silver dollar, extending forward so as to include the old compound, depressed fracture. Several pieces of dead bone, which were lying free in the original cranial defect were removed. A stellate incision was made through the dura, thus creating 6 pennant shaped dural flaps, with the bases directed toward the periphery of the defect. The dura was firmly adherent to the inner table of the skull, around the site of the old fracture and at this location was likewise adherent to the surface of the cortex, but it was not adherent more posterior to the site of the fracture; that is, the cortex overlying the posterior half of the abscess was not adherent to the dura. After removal of the cortex overlying the abscess cavity ("unroofing" of abscess cavity) about 2 ounces of thick yellow pus was evacuated. The consistency of the contents of the abscess was the same throughout; that is, there was no supernatant thin fluid with thicker masses of pus and brain detritus in the lower portion of the abscess, as is more frequently found in a case of recent brain abscess without encapsulation. There was a definite abscess wall or capsule about 2 millimeters in thickness. The cavity had not ruptured into the lateral ventricle. There were no prolongations or side pockets associated with the cavity. On the contrary, it was a definite walled off cavity, somewhat pear-shaped, with the more conical portion being directed toward the site of the fracture and with the larger portion of the cavity directed backward into the parietal region. This was due to the fact that the dura had become adherent at the site of the fracture and the cortex directly beneath had become infiltrated, fibrosed, and hardened, and, therefore, with the pressure within the abscess cavity being equal in all directions, it had extended in the direction of least resistance, toward the softer,

less resistant brain substance in the depth and away from the site of the fracture. The anterior horn of the right lateral ventricle was not exposed and there was not sufficient intraventricular pressure to produce a bulging of the wall of the anterior horn at any place. The remaining brain substance on the lateral, medial, and inferior surface of the abscess cavity, was probably not greater than 2 centimeters. Further exploration forward, along the anterior border of the old cranial defect, which resulted from the original fracture, revealed the fact that the fracture had extended into the right frontal sinus. The sinus was filled with granulation tissue and a small amount of pus. The nasofrontal duct had evidently become walled off or obliterated, as there was no nasal discharge.

Procedure. With the patient in a dorsal position, on the table, and with his head supported on the Bellevue head-rest devised by us, with the face upward, an oval shaped incision was made about the site of the infected wound in a transverse direction and the incision from the outer angle of this oval shaped incision was carried upward, backward, and inward in a curved direction for a distance of about 2.5 inches. The medial flap thus marked off was bisected for a distance of about 2 inches, and the two flaps, consisting of all the soft parts down to the outer table of the skull, were reflected and held with cranial self-retaining retractors, which gave adequate exposure and controlled bleeding by traction. A trephine opening was made with a Hudson bone drill (bits A and B) about 1 inch posterior to the site of the old fracture. An incision about $\frac{1}{4}$ inch long was made in the dura, through which a blunt brain cannula was inserted as described above (Figs. 7, 8, and 9). After pus was obtained, the cannula was withdrawn and the trephine opening was enlarged to a somewhat oval shaped cranial defect, larger than a silver dollar. There was no necessity for leaving the exploring cannula in position, as it was known that the abscess cavity was directly beneath the small incision in the dura and its superior portion of its wall or capsule was about 1.5 centimeters below the cortex. Stellate incisions were made in the dura from the center of the cranial defect, outward to the margin of the cranial defect, the six pennant shaped dural flaps were reflected and sutured to the under surface of the scalp flaps on the median side. On the lateral side there were no scalp flaps to which the dural flaps could be sutured. The brain substance bulged into the cranial defect.

The subdural space had been obliterated in the anterior portion of the dura exposed, but in the posterior portion the subdural space had not been obliterated, so that the free subdural space was exposed in making the posterior pennant shaped dural flaps. This area was well walled off, with three narrow strips of iodoform gauze; the gauze was slightly insinuated beneath the dura, but was not really packed firmly into the subdural space. Four pieces of sequestered bone fragments were

removed from the site of the original cranial defect.

With a sharp, pointed, Bard-Parker knife (blade No. 11) an incision was made through the cortex and capsule of the abscess cavity, through which the end of a rubber catheter with a syringe attached, was inserted and the major portion of the contents of the abscess cavity was removed. The incision through the cortex and capsule was then enlarged for the purpose of exploration of the cavity and to determine the extent and size of the cavity, after which the "roof" of the cavity, consisting of brain tissue and capsule which measured about 1.75 inches in the anteroposterior diameter and about 1.5 inches in the transverse diameter, was removed with the knife (Fig. 7). There was but slight oozing from the cut surface of the brain. The average thickness of the "roof" was about 1.2 centimeters. The capsule was quite firm. The floor of the abscess cavity was about 2.5 inches below the inner table of the skull in its central and posterior portions, when first exposed, but it became somewhat elevated at the termination of the operation. The amount of pus was not measured but it was estimated that the amount was in excess of 1.5 ounces.

A few minutes after evacuation of the abscess cavity, the patient's general condition improved; the pulse rose from 52 to 86; his respiration became more normal and he aroused from his stuporous condition and his arms and hands had to be restrained.

After the cavity had been thoroughly irrigated with Dakin's solution, it was covered with a fenestrated rubber dam, somewhat "dimpled" into the cavity, but not packed into it. Over the rubber dam, small strips of iodoform gauze were placed so as to maintain the rubber dam in a slightly depressed position, within the abscess cavity. The right frontal sinus was then explored, thoroughly curetted out, the rough margins were bitten away and smoothed off with rongeurs and the frontal sinus was packed with several narrow strips of iodoform gauze. Three perforated Dakin tubes were placed over the rubber dam, so as to properly distribute Dakin's solution to the operative area and were fastened with adhesive to the scalp to prevent displacement. The wound was then covered with a copious wet Dakin gauze dressing, headroll and bandage, which included the cranium and the lower jaw, to prevent displacement of the dressing. The right ear and eye were covered with vaseline gauze and were also included in the dressing.

Comment. The anæsthesia was satisfactory. The patient, after resting on the operating table for about one-half hour, was sent to the Ward and placed in a semi-sitting position in bed. His condition was very much improved. Following this procedure, it is expected that brain hernia will develop in a few days, that the floor of the abscess cavity will later become the outer surface or covering of the brain hernia, that is, the abscess cavity will "turn inside out." In this event, a secondary abscess cannot develop for when the abscess cavity is treated in the

usual manner, with only partial collapse and improper drainage of the cavity. It is the intention of the operator to leave the rubber dam in position with dakinization of the operative field and not remove it until the brain has herniated through the cranial defect, which was intentionally made to allow of herniation. After herniation has occurred, the rubber dam can be removed and replaced with a similar one for protection of the hernia, rather than by the use of gauze. The iodoform gauze packing, which was insinuated about the margin of the cranial defect to prevent infection spreading into the subdural and subarachnoid spaces and that which was packed in the frontal sinus, are not to be removed for about 4 to 6 days, at the end of which time the spaces will have become well walled off.

It is believed that this type of operation in brain abscess will give the best results, that is, removal of a large portion of bone, thus creating a cranial defect, removal of the "roof" of the abscess, so as to allow the abscess cavity to evert itself through the cranial defect by herniation, dakinization with recession of the brain hernia, and epithelialization of the granulating surface.

Postoperative course. March 27. First dressing. The entire external dressing was removed. The rubber dam covering the brain hernia (which is on the level with the margin of the cranial defect at its periphery but is depressed in its central portion) was left in place with the gauze on the outer surface of the dam which lightly holds the dam into the somewhat boot-shaped remaining portion of the abscess cavity. The marginal iodoform gauze packings placed about the defect and in the right frontal sinus, were left in position. The vicinity about the wound was cleaned with cotton balls wet in Dakin's solution and covered with vaseline gauze. Fluffed pieces of gauze, wet in Dakin's solution, were placed about the wound in a circular manner, so as to form a ring about the wound to prevent pressure on the brain hernia and its rubber dam and gauze covering. Two Dakin tubes with a large number of perforations were placed beneath and above the margins of the rubber dam and a copious gauze dressing, wet in Dakin's solution was applied and held with a headroll and bandage including the lower jaw. The right ear and eye which were covered with vaseline gauze were included in the dressing. The dressing is to be kept wet with Dakin's solution, through the tubes q. 2 h. The patient's condition has remained good. He is entirely conscious. Temperature, 99.5 degrees; pulse, 96. He talks, is orientated as to the place of his birth, etc., and is not restless.

March 28. Second dressing. Similar dressing as applied yesterday. The hernia is larger. The central piece of gauze placed over the rubber dam was removed and the hernia was covered with a piece of fenestrated fresh rubber dam, with two Dakin tubes beneath and about the margin of the dam, placed so as not to press on the hernia. A third tube was placed over the rubber dam. Temperature 99. Pulse which rose to 120 last night, is now 90.

Patient is not noisy but is somewhat restless while sitting up in bed. Magnesium sulphate and an enema ordered for tomorrow. Lumber puncture to reduce intraventricular pressure, has not been done, as the herniation has not been excessive.

March 28. Culture taken at operation. *Streptococcus hæmolyticus*.

March 29. Third dressing. The surface of the hernia has become smoothed off somewhat under the rubber dam. The central depressed portion observed at the first dressing has practically disappeared. The herniation of the abscess cavity through the cranial defect made directly over it, at the time of operation, has taken place at about the rate and extent as had been hoped for and anticipated. The marginal iodoform packing in the frontal sinus and about the margin of the cranial defect, has become brownish, due to blood acted upon by Dakin's solution, but it is believed that it should not be removed as yet. The left facial paralysis is rapidly disappearing. The left grip is becoming stronger but is, however, not equal to the right.

March 30. Blood culture sterile in 72 hours.

March 30. Fourth dressing. The marginal iodoform gauze packing about the cranial defect and the base of the hernia was removed. The packing in the frontal sinus is allowed to remain. It is desired that this portion of the packing should remain for several days to assure of firm adhesions at this site. While removing the gauze from about the margin of the cranial defect, it was wet with Dakin's solution through a syringe. The gauze when first placed in position at the time of operation, circumscribed the wound at the craniodural site. As the hernia became more pronounced, the marginal or basal portion of the hernia protruded against the gauze at various points, so that fairly firm adhesions had taken place. There was but slight bleeding, however, and the hernia was traumatized but little when the gauze was removed. As the herniation proceeded outward, the tip or apex of the lower internal skin flaps became adherent to the hernia, so that the gauze at this point was more fixed and was "tunnelled," so to speak, beneath the flap. After it was withdrawn the apex of the flap was freed easily by blunt dissection without damage to the brain tissue. A small piece of gauze wet in Dakin's solution was placed beneath the apex of the flap to allow the flap to gradually become adherent to the lateral surface of the hernia, first at the base of the flap, to prevent any pocketing or accumulation between the base of the flap and the surface of the hernia where the piece of iodoform gauze had previously been removed. A dressing as described above was applied.

The patient's condition has gradually improved. The herniation has not increased since yesterday. The facial paralysis of the left side is less. The grip in his left hand is considerably stronger and he can move his left arm and leg much better. His temperature is normal; pulse normal. His bowels have moved well. His chief desire is to smoke cigarettes, which, however, is not allowed in the ward.

March 31. Fifth dressing. Usual dressing. There is no pocketing beneath any of the skin margins or flaps. The change in size and position of the hernia, that is elevation and depression, with inspiration and expiration, and heart beat, is not so marked as it was 2 or 3 days ago; also not so much if patient coughs. The wound has the appearance of a well dakinized wound. The surface of the hernia cerebri, has smoothed off and has more of a fibrosed appearance.

April 1. Dressed at 5 o'clock this morning by Dr. Gove, after the patient had removed the dressing. Patient is slightly restless.

April 1. 4 p.m. Seventh dressing. There is less herniation than yesterday. There is an increased amount of a somewhat yellow secretion on the gauze about the wound; this probably is due to the superficial sloughing of small areas here and there on the surface of the hernia. This is meant to apply to the marginal cut portions of the brain about what was the abscess cavity, and to a less extent to the capsule of the abscess, but not to the hernia as a whole. There is a somewhat funnel-like central depression about 1 centimeter in anteroposterior diameter and about 4 millimeters in transverse diameter. This is more apparent than yesterday, corresponding inversely to the diminution in the size of the hernia. There is no evidence of rupture or leakage of the anterior horn of the right ventricle. Temperature and pulse normal. Diet increased. Dakinization continued.

April 2. Eighth dressing. The more superficial portion of the iodoform gauze packing in the frontal sinus was removed. The deeper portion still remains. General appearance of the wound and hernia is much improved. Some portions of the hernia covered with red healthy granulations—other portions with brownish areas of slough. The amount of herniation is about the same as yesterday. The skin flaps have become firmly adherent to the hernia. The sudden drop of temperature recorded (96 at 8 a.m.) was probably due to his temperature being taken by mouth, probably after having had a cold drink; his general condition does not warrant such a temperature. He is taking larger amounts of food and enjoys it.

April 3. Ninth dressing. Condition about the same as yesterday. A portion of the frontal sinus gauze packing removed; similar dressing. Wound has the appearance of being well dakinized.

April 4. Tenth dressing. Hernia subsided. Surface for the most part is considerably fibrosed and appears to be much firmer. The superficial sloughs not yet removed. All the frontal sinus packing removed and a small piece of gauze, wet with Dakin's solution, inserted in the outer portion of the defect, in the frontal sinus. Condition of the wound and patient improved.

April 5. Eleventh dressing. Similar dressing. Patient has been interfering with his dressing, unintentionally, it is believed. The dressing is carried down over the right eyebrow and it is believed that

he pushes it up with his fingers. The wound on the anterior side or margin does not appear to be as clean as usual, while on the posterior margin it appears clean. The dressing was found pushed up on his head from over the right eye and forehead. After dressing, patient's hands were tied to the side of the bed to prevent his disturbing the dressing.

April 6. Twelfth dressing. Patient did not disturb the dressing. The wound looks well. The herniation is less; the surface is clean and it has the appearance of being a well dakinized wound.

April 7. Thirteenth dressing. The condition of the wound is improving. Herniation is less and the surface of the hernia appears to be more fibrosed and firm. Hernia moves, as repeatedly observed, with respirations. During the dressing the patient had three coughing spells. These were accompanied by marked bulging of the hernia which immediately receded as soon as the coughing ceased. That is, it is somewhat comparable to the impulse and coughing of an inguinal hernia, which disappears when coughing ceases. There was no tendency for the hernia to remain enlarged; hands again tied to keep them in proper place. General condition good. Since the day on which the patient first removed the dressing, there has been a slight daily elevation of temperature; the average being about 99½ and at times reaching 100. This is believed to be due to slight re-infection of the wound.

April 16. Dressing. Patient has been dressed every day or every other day. There is an increase in the size of the hernia; general condition has remained good. Patient is out of bed at times. Went out to the toilet to smoke cigarettes. It is believed that some of the increase in size of herniation is due to increase in amount of intraventricular cerebrospinal fluid. Therefore, lumbar puncture was done with the dressing removed. The hernia was observed by Doctors Turgeon, Rogers, and myself, while the fluid was allowed to drip slowly away from the end of the needle with the stylet partly withdrawn from the needle. The hernia slowly receded and finally became so depressed that the central portion was about 1 centimeter below the inner table of the skull. The hernia appeared to have "shrivelled up." About 35 cubic centimeters of clear fluid were removed. No evident change in the patient's general condition, other than that he stated that he felt better. During the release of the fluid, through the lumbar puncture needle, the stylet was removed for an instant and then replaced. It was observed that the cerebrospinal fluid was under rather marked increased pressure. Similar dressing.

April 18. Dressed. The hernia has again increased in size but it is not as large as it was 2 days ago before the lumbar puncture was done. There is a slight superficial slough especially over the "apex" of the central portion of the dome of the hernia where it comes into contact with the rubber dam. This portion was once the floor of the abscess cavity. Therefore, at this dressing, the hernia was covered with gauze, wet in Dakin's solution, and the three

Dakin tubes were placed about the hernia. The dressing to be kept wet with Dakin's solution as heretofore. At this stage, after the surface of the hernia has become quite firm, it is believed that gauze, wet with Dakin's solution, serves as a covering better than does a rubber dam, for the reason that gauze stimulates granulations more than does the rubber dam. No trauma is produced by its removal, because it has been kept wet with the Dakin's solution all the while and merely falls off rather than its having to be pulled off. No bleeding occurs when it is removed. After the dressing the patient got out of bed, replaced his bedside table along side of his bed, returned to bed and went to sleep. Patient's mentality is poor; that is, he cerebrates poorly, laughs at remarks which ordinarily would not provoke laughter, etc. But it is not known whether this varies from his former state of mind before his development of the abscess or not. He is a Russian Pole and it is questionable whether he has had any education. He speaks and understands English very poorly.

April 19. Dressed. The facial paralysis and spasticity of the left upper and lower extremities have disappeared.

April 21. Dressed. The size of the hernia has markedly decreased with compression dressing without any untoward symptoms being produced. The hernia was found to be flattened and less oedematous. A portion of the superficial slough which had become detached was removed. A similar compression dressing was reapplied.

April 25. Dressing. The hernia has subsided considerably. The surface is of healthy appearance covered with granulation tissue almost completely. The hernia has flattened with compression dressing. A low ring of gauze placed about the hernia and compression slightly increased. Patient allowed up to toilet tonight and ordered out of bed tomorrow. States that he has no complaint whatever. Reads Russian newspaper, talks intelligently with a Polish fellow-patient and his mentality is apparently normal.

April 27. Dressing and lumbar puncture. Sixty cubic centimeters of cerebrospinal fluid removed without untoward symptoms. The hernia entirely subsided and formed a cup-shaped depression or cavity, somewhat "crevice like" about 2 centimeters deep. He is to remain in bed today and tomorrow. The change in size and shape of the hernia was striking.

May 5. Neurological examination negative. Abdominal and knee reflexes equally active.

May 5. Dressed. In order to hasten epithelialization of the hernia or granulating surface of the hernia and also to help reduce the hernia to the scalp level, adhesive strips about $\frac{3}{4}$ inch wide, sterilized by flaming over an alcohol lamp were applied and fastened to a 2-inch adhesive strip, which had been placed around the head, so that the strips could be fixed to it. These strips overlying the hernia to be removed in 2 days and renewed. The size of the

hernia is less. There is an area of superficial slough over the upper, inner portion of the hernia, which corresponds to the site of a portion of the original capsule of the cavity. The remainder of the hernia which is not already covered with epithelium has a healthy appearance. Several small islands of epithelium are seen over the surface. The thickness of the cortex or the brain substance overlying the anterior horn of the right lateral ventricle is not known. A wet gauze dressing, wet with Dakin's solution, was applied and held with a bandage around the head, to be wet q. 2 hr. This dressing is only a small dressing applied to the local area about the hernia, and does not cover the entire head. This type of dressing has been used for the last 4 or 5 days. It is not necessary to use a Dakin tube but merely wet the dressing. The patient is able to do this himself. He is up and about the ward and helps with the ward work.

May 7. Dressed. Condition of hernia improved. It is flatter, herniation less marked, it is not tense and the epithelium is spreading rapidly from the scalp margin. A similar dressing as applied yesterday.

May 9. Similar dressing. The epithelial margin is about 1 centimeter wide; the superficial slough partly removed; remainder slightly adherent. It appears that the dressing has not been kept properly wet with Dakin's solution during the last 2 days.

May 10. Adhesive strips not removed. A wet gauze Dakin dressing applied. Hernia under the adhesive practically on level with scalp margins. General condition excellent.

May 15. General condition of wound and hernia improving. There is still a very superficial sloughing of the surface in one area about 2 by 3 centimeters, through which small islands of granulation tissue have appeared. It is believed that the superficial necrotic layer will soon be cast off. The hernia in this case has not subsided as rapidly as it has in the case of C. D. on Ward L-4. This is believed to be due to the fact that the hernia in this case consists of a rather thin wall with a large dilated anterior horn of right lateral ventricle beneath, while in the case of C. D. the hernia consisted for the most part of inflammatory brain substance with a greater thickness of brain tissue between the floor of the abscess and the lateral wall of the ventricle. In the latter case, as soon as the inflammatory process disappeared, the hernia rapidly subsided. The epithelium is not spreading over the surface as rapidly as it is in the case of C. D. A lumbar puncture is indicated and advised.

May 16. Patient refused lumbar puncture which was ordered and effort at persuasion proved futile. Therefore this procedure was not carried out.

May 17. Dressing. The area about the hernia was shaved and the scalp cleaned. The surface of the hernia is much cleaner in appearance. The superficial sloughing area is decreasing. The granulating area is decreasing and the epithelium is spreading. The following observation is made:

Where there is no skin flap, i.e. on the outer side of the hernia, where the adhesive strips extend directly from the skin margin onto the hernia, the epithelium has spread very rapidly. On the other hand, where the hernial surface comes in contact with the skin surface of the apex of the upper scalp flap which had rolled under itself and become adherent to the scalp flap, there is no epithelium. Shortly after the development of the hernia, the apex of this scalp flap became turned under and was allowed to remain in this position, while the apex of the lower flap did not do this. Therefore, in order to hasten covering of the hernia, after sterilization has been done with Dakin's solution, one should be careful to see that the apices of the skin flap do not turn under and become adherent. The scalp flap should be replaced slowly over the surface of the hernia, so that they will become adherent throughout and as the hernia recedes, the scalp flaps will be drawn over the cranial defect like a trap-door or covering over an automatic cellar elevator beneath the street, leaving only a small area of non-hair-bearing scar between the healed margins of the flaps. It probably would be advisable to suture the apices back for about six or eight days until herniation is complete and then loosen them and allow them to fall back over the hernia and become adherent. The surface of the hernia in apposition to the enfolded skin edges was covered with a piece of adhesive interposed between the hernia and the rolled in under-surface of the skin, in the belief that epithelialization will be more rapid. The more rapid the covering of the hernia with epithelium and the subsequent contracture, the more rapidly will the hernia diminish in size, and finally completely recede into the cranial cavity.

The patient feels well. He has no complaints. Before his original injury, he weighed 166 pounds; before he came to the hospital he lost 34 pounds and weighed 132 pounds. He now weighs 153 pounds and says that he feels well.

May 19. Dressing. The narrow margin of the hernia beneath the skin flaps which was covered at the last dressing with adhesive, already shows moderate epithelialization. A similar dressing was re-applied with pressure, so that the hernia surface was brought almost to the level of the scalp. This makes no ill impression on the patient. He shows no changes, whether the hernia protrudes somewhat under ordinary pressure or, if on the contrary, pressure is made. The patient's general condition continues to improve.

May 21. Dressed. The epithelium is gradually spreading over the surface of the hernia. Surface almost level with scalp. Patient's general condition is good. He now weighs 163 pounds.

May 28. Has been dressed every 2 days. The improvement in the wound is gradual but slow. Does not have the appearance of a well dakinized wound. The dressing is not kept wet and the wound has not the same appearance as that of C. D.

June 1. Dressed. The wound is not healing as rapidly as it should. Does not appear to be properly

dakinized. Head nurse instructed to see that dressing is properly wet with Dakin's solution q. 2 hr., *without fail*.

June 3. Dressing. Condition of wound following proper dakinization so much improved that one can scarcely believe it. Similar strapping with adhesive.

June 5. There has been a brownish discoloration on the dressing which is probably due to the decomposition of the potassium permanganate (which is in the Dakin solution), when the patient goes into the sunlight. Condition of the wound improving.

June 6. Dressed. Condition of granulating area is good. The hernia area is completely covered with granulating surface of epithelium, with the exception of two small central areas which are vertical in direction, each about 1 centimeter wide and 1.5 centimeters long with an interval of healthy granulating surface about 8 millimeters wide intervening. These areas are yellowish in color and are probably the last portion of the capsule of the abscess which formed the floor of the cavity to disappear by the action of Dakin's solution. His general condition is good. He has been insisting for the last several days on being discharged.

June 8. Neurological note. Cranial nerves normal; motor system normal; powerful on both sides. Sensory system normal. Reflexes are normal. Cerebellar tests normal; gait normal. Psychical function apparently normal in every respect. With help of interpreter answers questions intelligently. Nurses and his friends find him normal in every respect. Has a good sense for a joke.

July 4. Patient has been dressed daily or every 2 days since the last neurological note was made. The area of granulating surface is now completely covered with epithelium, with the exception of a small area which measures about 2 centimeters by 1.5 centimeters nearer the median side of the former site of the brain hernia. This area is covered with healthy granulation and it is believed that in about 1 week's time the area will be completely covered. The treatment which has been followed during this time, was: covering of the granulating area with a fenestrated adhesive strip, over which a small piece of gauze, wet with Dakin's solution, was held with a bandage. His general condition has remained excellent. He now weighs 170 pounds. He insists upon going home, where he thinks he can get more to eat and he promises me that he will not drink intoxicating drinks. He is to return for daily dressings. When the area is completely healed over it will be allowed to remain so for about 6 months or more when a scalp plastic will be performed for the purpose of excision of the cicatrix and approximation of the scalp edges.

July 4. Patient apparently behaves normally in every respect. Intelligent interest toward various topics. One of his Russian friends with whom he spends much of his time, finds him normal.

July 5. Discharged from hospital, on the one-hundred-and-first day following the operation. C. D. who was operated upon the day following the opera-

tion in this case was discharged on the sixty-seventh day following the operation, with the area at the site of operation, which was still uncovered with epithelium, being about the size of one's finger nail. It is believed that the factors in this case which tended toward slower healing of the wound are mainly two: first, the hernia receded more slowly due probably to the fact that the tissue at the site of the hernia overlying the anterior horn of the right ventricle was much thinner, so that the direct pressure of the cerebrospinal fluid within the ventricle into the hernia was greater and more prolonged, while the hernia, in the case of C. D. was much larger, and receded much more rapidly. Second, improper dakinization of the operative area after the patient was up and about the ward. This was due to neglect on the part of both the nurse in charge and the patient and when corrected, the healing of the wound was more rapid. In the case of C. D. there were special nurses who attended to the dakinization of the wound until the patient was up and about the ward. After this time, the patient himself kept his dressing properly wet with Dakin's solution, due to the fact that he had more intelligence than T. W. and did as he was directed.

Summary. Male: Russian Pole: About 46. Blacksmith. Fell about 3 months before entering Bellevue Hospital and sustained a compound, depressed fracture, frontal region, right, involving frontal sinus. Bone fragments not removed; wound infected; suppurative process in right frontal sinus. Operated upon for brain abscess, frontal region, right, under local anæsthesia, on March 26, 1923. "Roof" of abscess cavity removed; no drainage material used; temporary herniation with complete eversion of abscess cavity; hernia completely receded in 71 days, aided by 2 lumbar punctures, first of which was on the thirtieth day; Dakin's solution used throughout; dressing to protect and prevent compression for 22 days, after which compression dressings of gauze wet in Dakin's solution and bandage for 17 days; after which granulating surface was strapped with adhesive plaster to hasten epithelialization and to exert slight compression. Highest temperature was 100.6 degrees on third day after operation. Superficial areas of sloughing from the sixth to the forty-second day. No leakage of cerebrospinal fluid. Discharged from Bellevue Hospital on the one-hundred-and-first day following operation with no complaint. Weight before injury 166 pounds. Weighed 132 pounds just before admission. Weighed 170 pounds when discharged from hospital. General condition excellent.

Follow-up note. July 16. The patient has been dressed every other day since his discharge from the hospital. The wound is completely healed. There is but slight tendency to bulging at the site of the cranial defect. His general condition is good. He has been looking about for work.

The patient was lost sight of and on August 22, 1923, I learned through an attorney for the Polish Missions, for the Diocese of Pennsylvania, that he

was in Philadelphia. On November 8, I received information through the same attorney that the patient was in West Virginia where he was again at work. Photographs and late roentgenographic plates which I requested him to send to me have not been received.

CASE 3. C. D. Brain Abscess No. 14. Age, 26. Occupation, fireman, New York City Fire Department. Admitted March 26, 1923, to Ward Ground L, on the Service of Dr. T. A. Smith, director of the 4th Surgical Division, Bellevue Hospital.

Present illness. Patient stuporous and could give but little history. Three weeks ago was operated upon in a hospital on Staten Island; a simple mastoidectomy for mastoiditis, left side, being done. Previous to this operation, had influenza and later had his ear-drum on left side lanced.

Past history. Influenza for 1 week before operated upon for mastoiditis. Operated upon on nose in Bellevue Hospital 1 year ago, on account of an old fracture of nasal bones.

Physical examination. Patient stuporous; aroused by the examination. Answers questions slowly: is apparently toxic. Blood pressure, 120-80. Temperature, 100 degrees. Pulse, 70.

Eyes. Pupils equal, pin-point (under morphine). Dilate equally under homatropin. Slightly prominent orbits both sides. Eye grounds show moderate venous engorgement. Both discs boggy in outline and reduced. No elevation.

Nose and Ears. Negative to external examination.

Mouth. Teeth in poor condition. Tongue coated. Breath foul. Slightly cyanosed lips.

Cranial nerves. Slight facial weakness, right. Others negative.

Neck. Negative.

Chest. Lungs and heart, negative.

Abdomen. Negative.

Motor. Negative. Voluntary grips in hands equal. Voluntary motions present.

Sensory. Negative.

Reflexes. Abdominals present. Knee jerks and ankle jerks, equal and active.

Local condition. Mastoidectomy wound, left, stuffed with dirty gauze packing. Wound has but little discharge.

March 26. History obtained from sister states that 1 month ago patient was taken ill with influenza, during which illness his left ear was lanced twice. Two weeks following his initial illness, patient was operated upon for acute suppurative mastoiditis, left, in a hospital on Staten Island. He was discharged from the hospital on March 21, 1923, and was taken care of at home. Became stuporous on March 25 and was brought to Bellevue Hospital on the following day.

Provisional diagnosis. Abscess of temporo-sphenoidal region.

March 27. *Neurological note.* Patient stuporous and therefore unco-operative. Local condition not examined. Bilateral early papilloedema, right greater than left. Slight right facial weakness and

pyramidal signs on right side. Astereognosis right side. Impression on superficial examination: brain abscess, temporoparietal, left.

March 27. *Neurosurgical note.* Diagnosis of brain abscess, temporosphenoidal lobe, extending into parietal lobe, left, secondary to mastoiditis, with simple mastoidectomy, left. Cardinal points: (1) drowsiness or stupor; (2) infected postoperative wound following operation for mastoiditis, left, with inflammatory zone about wound and unhealthy granulation tissue in wound; (3) astereognosis, right; (4) history: symptoms beginning about 2 to 3 weeks after radical operation for mastoiditis; (5) engorgement of retinal veins, especially of left eye; (6) sensory aphasia; (7) slight right facial weakness; (8) slight elevation of temperature (99.5).

Opinion: Advise operation for brain abscess as soon as is possible.

March 27. Urine: negative.

March 27. Leucocytes, 11,700; polymorphonuclears, 79 per cent; lymphocytes, 21 per cent.

March 27. Ear, nose, and throat consultation: Nose congested and crusty. Mouth filled with a yellowish mucoid secretion. Throat is congested and parts are hidden by the secretion. Right ear negative. Left ear shows a postoperative simple mastoidectomy. The drum is gray. Necrotic surface which is compatible with a postoperative condition. There is no bulging or signs of an acute middle ear infection. Postauricular wound has small piece of old gauze packing. On removal a dirty wound was seen, filled with a serous pus; the granulations seen beneath are of an unhealthy type. No connection is noted between the antrum region and the wound. No cord-like mass is felt in the neck; even though I can get no history from his family of dizziness, vertigo, vomiting, convulsive attacks and also bearing in mind that his pulse is normal in rate, I am inclined to think that he has a temporosphenoidal abscess on the left side, as he has (1) drowsiness, (2) postauricular wound filled with unhealthy granulations, (3) low temperature, (4) aphasia, (5) constant headaches, (6) facial weakness, right.

Through the courtesy of Dr. T. A. Smith, the patient was transferred to our Service and was operated upon at 8:30 p.m. on this day.

March 27. *Operation for brain abscess*, temporosphenoidal, left. Operator, Dr. King; assistant, Dr. Russell. Anæsthesia: Local-novocain solution one per cent with suprarenin.

Pathological findings. The external mastoidectomy wound was as described in the E. N. T. note, made previous to operation. The dura had been exposed at time of operation for mastoiditis, the area being about the size of a dime. The dura overlying the site of the abscess in its upper portion was not adherent to the cortex, but in the lower limits, toward the site of the operative wound the dura was adherent. The outer wall of the abscess cavity consisting of brain tissue was about 1 centimeter thick. No resistance was met with when the exploring small blunt brain cannula was inserted into the

cavity. Therefore it was concluded that the abscess was not encapsulated. The contents removed from the cavity, through the cannula, at the first puncture, were quite thin and had an oily appearance. The contents thus obtained came from the upper portion of the abscess cavity with the patient lying on his right side. When this kind of fluid was obtained, rather than the thick yellow pus which is frequently removed from a brain abscess, it was at once surmised that the abscess was of recent formation and that the fluid obtained was the supernatant fluid from which the heavier thicker contents had settled to the bottom of the abscess cavity and therefore did not come in contact with the exploring needle. Also there was no distinct sensation of going through a definite abscess capsule, as is the case with an old chronic abscess. Upon these two findings, it was therefore assumed, that the abscess was of recent formation. This was also borne out by the clinical history, in which the abscess developed and was operated upon 19 days following the original radical operation for mastoiditis. The lateral wall or covering of the abscess for an area of about 1.5 inches in diameter, was removed, i.e., the actual cortex was cut away to allow herniation of the floor of the abscess through this opening, to obviate the use of drainage material. The abscess cavity was somewhat saddle back in shape. There was an extension backward and upward into the occipitoparietal region, while the other extended down into the temporosphenoidal lobe toward the base of the skull (Fig. 9). When the abscess cavity was thus opened widely, there was a gush of a considerable amount of thin, yellowish, oily liquid and later on, while washing out the cavity with Dakin's solution through a syringe and soft rubber catheter, a considerable amount of thick yellow pus and detritus was evacuated. It was practically impossible to determine the actual capacity of this cavity, but the approximate amount of contents removed, was about 2.5 ounces. The lateral ventricle was not entered and there was no leakage of cerebrospinal fluid of the ventricle. The patient's pulse increased in rate from 70 to about 96. He became less drowsy and was talking when he left the table. The contents of the abscess removed at the first puncture was sent to the laboratory for bacteriological examination.

Procedure: (It was assumed that the major portion of the abscess was in the usual position, i.e., directly above and slightly anterior to the base of the mastoid process, on account of the signs and symptoms.)

Therefore, with the patient on the head-rest, designed by us, with the left side of his head directly upward, a curved incision was made, beginning at a point about 1 inch above the ear and just anterior to it, and was continued downward and backward parallel to the ear and surrounding the old mastoid operation wound, so that the granulation tissue which filled the wound, with the margins of the wound, was excised. A second scalp incision was

made from about the midpoint of the first incision, upward, backward and inward, over the parieto-occipital region, thus creating three flaps (Fig. 12). The larger one, just above the ear, was reflected downward; the other two flaps were reflected respectively upward and forward and upward and backward, thus exposing an area of the outer table of the skull about 2.5 inches in diameter. An opening was made in the skull about the center of the exposed area, with a Hudson bone drill, bits A and B being used; the site selected for this trephine opening was about 1.25 inches above the anterior portion of the base of the mastoid process. A small incision about $\frac{1}{4}$ inch long was made in the dura, and a blunt brain cannula was inserted through the incision in the dura and directed into the brain substance. At the first puncture, after the cannula had been inserted about 1.5 inches, the yellowish fluid described above was obtained. The cannula was then removed and a large bony opening, fairly circular in shape for the most part, but with an extension downward and forward, was made, the average diameter being about 2 inches. Six pennant shaped dural flaps, made by stellate incisions in the dura, were turned back and sutured to the pericranium of the scalp flaps. The sub-dural and sub-arachnoid spaces were then packed off with three strips of narrow iodoform packing gauze, to prevent soiling of these spaces. The abscess cavity was again punctured at the site of the previous puncture for corroboration and then incised with a knife. An area of the cortex overlying the cavity (about 1.5 inches in diameter and about 1 centimeter thick) was removed with the knife and discarded. There was but slight oozing from the cut margins of the brain. This converted the cavity from a bottle shaped one into a somewhat boat shaped cavity (Fig. 14). A large amount of pus as described above, was evacuated, the cavity was well washed out with Dakin's solution and was inspected. The bony parts overlying the cavity were removed throughout its extent, with the exception of that overlying the extension of the abscess cavity far downward and forward into the temporosphenoidal lobe. This could not be accomplished as much as was desired on account of possible injury of the ear.

The "unroofing" of the abscess cavity was for the purpose of evacuation of the abscess cavity and allowing the floor of the abscess to herniate through the cranial defect which was made, i.e., allowing the cavity to "turn inside out." This would assure no retention of secondary pocketing, as oftentimes follows attempts to drain a brain abscess. This will allow a sufficient herniation without a doubt, except possibly the extension downward and forward into the temporosphenoidal lobe. Even this portion may likewise herniate and become everted; this is the intention and hope of the operator. The manipulation within the abscess cavity itself was carefully done; exploration of the cavity was carried out with proper lighting facilities, so that the entire abscess cavity could be thoroughly inspected. It

is not believed wise to explore the abscess cavity with the finger in order to determine its extent. By so doing, one is very likely to lead to extension of the cavity or perforation into the ventricle. Therefore exploration with the finger was intentionally not done. The ventricle was not entered. There was no capsule, but the floor of the abscess was irregular and uneven and consisted of broken-down and infiltrated brain tissue.

This procedure was adopted only on account of the recovery which followed a similar procedure about 2 years ago in a case at the New York Eye and Ear Infirmary. In this case, there was a herniation of the abscess cavity through the cranial defect and the patient entirely recovered.

A fenestrated rubber dam was placed over the abscess cavity, over which loose, iodoform gauze was placed so that the dam was somewhat "dimpled" into the cavity. This will afford protection to the abscess wall during its herniation, which herniation should require 2 to 3 days before the floor of the abscess has reached the level of the cranial defect. A circular ring-like dressing of fluffed gauze, wet in Dakin's solution, was applied about the wound. The left ear was well covered with vaseline gauze. Three Dakin tubes were placed over the rubber dam and the entire head, with the exception of the right ear, was covered with a copious gauze dressing, wet with Dakin's solution, a headroll, bandage and adhesive plaster strips, the lower jaw being included in the bandage.

After a short rest on the operating table, the patient was returned to the ward in a very much improved condition. The head was elevated on one pillow. No stimulation was necessary.

Postoperative course. March 28. First dressing, 8 p.m. (23 hours after operation). There is moderate herniation of the brain, carrying with it the rubber dam overlying the abscess cavity and the iodoform gauze placed on the outer surface of the rubber dam (Fig. 15). This part of the original dressing consisting of rubber dam with its overlying iodoform gauze and the narrow strips of iodoform gauze, placed about the craniodural margins, beneath the skin flaps, was not disturbed. The area about the operative field including the left ear was abundantly covered with vaseline gauze, over which was placed a circular ring-like coil of gauze, wet in Dakin's solution, to form an elevated wall about the site of the operation, in order to allow of herniation without compression. Two perforated Dakin tubes were placed about the rubber dam, these being covered with gauze wet in Dakin's solution. Headroll and a bandage including the lower jaw. Dakin's solution to be instilled through the tubes, q. 2 h. The general condition of the patient has markedly improved since yesterday before the operation. His temperature has ranged about 100.5 degrees; pulse between 80 and 90.

March 29. Second dressing. Similar to above. Hernia has increased in size, thus bringing the floor of the abscess cavity, for the most part, out of the

cranial cavity. The rubber dam with its gauze packing and the marginal gauze packing, together with the gauze packed in the old mastoidectomy wound, was not disturbed. Dakin's irrigation continued q. 2 h. General condition improved. Pulse about 90. Temperature 99.5 degrees. There is no evidence of spreading meningitis. Patient is rational. Sensory aphasia still present.

March 30. Culture taken at operation; "staphylococcus aureus."

March 30. Third dressing. Same as yesterday. Gauze packings not disturbed. The hernia has increased markedly in size, especially from the upper half of the cranial defect, so much so, that the abscess cavity which is now extracranial, is on the inferior surface of the hernia. The hernia is somewhat mushroom shaped, measures about 3 inches in diameter across its surface (Fig. 15). The rubber dam and gauze overlying it removed. After the circular gauze had been placed about the wound, two Dakin tubes were placed surrounding the hernia and both tubes and hernia were covered with a fenestrated rubber dam to protect the hernia from trauma being produced by the gauze, and at the same time, partially retain the Dakin's solution at the site desired, i.e., about the brain hernia. Over the dam another Dakin tube was placed to keep the superficial part of the dressing wet. General condition about the same. Talks with his wife and friends. Cathartic given. No morphine necessary.

March 31. Fourth dressing. A portion of the gauze about the margin of the cranial defect, placed at time of operation to prevent spreading of infection into the subdural space, was removed; similar dressing was applied yesterday. Bowels have moved and patient feels much better. Slept well last night. Is on soft diet and has good appetite. The hernia has not increased very much in size. There is no protrusion and recession of the hernia with respiration as is seen in the case of frontal-lobe abscess on ward M-4 (T. W.) but there is pulsation with the heart beat. The wound has the appearance of a well-dakinized wound.

April 1. Fifth dressing. All of the remaining gauze packing about the cranial defect between the hernia and skin flaps removed with but slight bleeding. A fresh piece of gauze, wet in Dakin's solution, was inserted beneath each skin flap to prevent pocketing beneath the flaps; to be removed tomorrow. The old mastoidectomy wound has improved in appearance. The granulations have become more healthy. At the lower angle of this incision which terminated about the old mastoidectomy wound, there was a small pocket of pus from which a few small pieces of old sequestered bone fragments were removed. These were evidently created at the time of the original mastoid operation. General condition is good. Aphasia (sensory) clearing. Eats and sleeps well. There is no evidence of rupture of the ventricle.

April 2. Sixth dressing. The wound has the appearance of a well dakinized wound. The original

abscess cavity now shows as a somewhat cleft-like depression on the inferior surface of the brain hernia. The reason for this is as follows: through the upper and posterior part of the cranial defect, most of the herniation has taken place, due to the fact that the brain cortex at this part of the defect, was not fixed to the dura by adhesions, before the operation. While the brain substance beneath and below the lower part of the defect was fixed by adhesions, directly beneath the site of the old mastoid wound, it was much more thinned out by the abscess and therefore it could not herniate as rapidly as could the upper portion. It is believed that all of the abscess cavity has now herniated out of the cranial defect, i.e., that no part of it has remained intracranial, so that a secondary abscess or pocket can form.

April 3. Seventh dressing: 6:30 p.m. There is a leakage of clear, cerebrospinal fluid at a point about 4.5 centimeters posterior to the anterior margin or border of the hernia. It is believed that the descending horn of the left lateral ventricle has sustained a slight rupture, because of the following: with the herniation of the posterior portion of the temporo-sphenoidal lobe through the defect, the descending horn has been displaced outward and has formed an angulation outward about its middle and posterior portion. A continuation of the secretion of the cerebrospinal fluid has taken place from the choroid plexus into the lowermost part of the descending horn. The fluid from the upper portion of the descending horn has passed unobstructed into the body of the ventricle and thus the pressure in the upper portion of the descending horn of the lateral ventricle has become equalized by such escape of the fluid into the body of the ventricle. The fluid in the shut-off distal portion of the descending horn has had no avenue of escape and with the increased pressure within the distal end of the descending horn which would accompany the continued secretion of the cerebrospinal fluid, the pressure finally became so great that the external wall of the descending horn gave way and allowed the fluid to escape through a small opening on the surface of the hernia. Slight exertion on the part of the patient increased the amount of fluid which escaped, during the observation. The amount was lessened when the patient was quiet. Similar dressing applied.

April 4. Eighth dressing. Condition improving. The skin flaps have become adherent to the lateral margins of the hernia without any retention beneath the flaps. Cerebrospinal fluid continues to escape. The old mastoidectomy wound has become clean and almost healed over with the exception of a small sinus at the lower angle from which small pieces of bone fragments had been removed from time to time. It is believed that these fragments have been left over from the mastoid operation and that they are not true sequestration fragments. It is believed that as soon as all have been discharged or removed, the mastoidectomy wound will heal. The hernia is no larger, except on the lower margin, where it appears that this margin has rolled out somewhat

more since yesterday, and it is believed that complete herniation, or eversion of the abscess cavity has taken place. The surface of the hernia has become somewhat more fibrosed and firmer. There are areas on the surface, some of which appear to be partly organized blood clots left over from the removal of the gauze packing about the hernia and some of which are believed to be superficial areas of necrosis or slough. There is practically no discharge from the surface of the hernia and the entire wound appears to have been well dakinized. Bowels move well; appetite good; food allowance increased. Temperature normal today. No spreading infection following leakage of cerebrospinal fluid through the hernia.

April 5. Ninth dressing. The granulating margin of the scalp, touched with silver nitrate, 10 per cent solution,—not to the hernia however. General condition improved. Slight recession of hernia.

April 6. Tenth dressing. Dressed. The flow or escape of cerebrospinal fluid continues. The fluid is clear. Patient has remained in a semisitting position since the first day following the operation. He is now allowed to sit up in bed.

April 7. Eleventh dressing. Several small bone fragments removed from the small sinus at the lower angle of the mastoid incision. The slight pain accompanying the removal of the fragments produced exertions or movements by the patient. The amount of cerebrospinal fluid which escaped from the ventricle at this time was increased. It is clear. The weakness of the right facial has almost disappeared. Dr. Rogers stated that the patient has an homonymous hemianopsia. This condition has not previously been noted. He is able to see well on the left side but not on the right. This was partly confirmed by me after the dressing. To observe tomorrow.

April 8. Twelfth dressing. Condition of the wound good. Hernia has not increased in size. There is no leakage of cerebrospinal fluid this morning. The reason for this is not known, unless it is because the small opening through which the leakage occurred has been closed by granulation tissue, because the hernia has contracted and there is a decrease of intra-ventricular pressure. Patient's condition has improved. Homonymous hemianopsia is present as previously observed and stated by Dr. Rogers.

April 9. Almost complete anomia. However, no abraxia or sensory aphasia in the accepted sense. Slight right facial weakness.

April 16. Dressed. The size of the hernia has not appreciably increased since seen last time on April 12, by this examiner. There is some extension of the superficial sloughing of the hernia surface. The skin flaps are firmly adherent about the base of the hernia. There is no part of the skull uncovered. There is no leakage of cerebrospinal fluid. The area about the wound was shaved and cleansed and the usual dressing applied. Dakin's solution continued. Patient has been out of bed in a chair for a greater part of the time, during the last few days.

He is able to stand erect but is not allowed to walk. He has been dressed the last 3 days by Dr. Rogers, during my absence.

April 18. The hernia has not increased in size. There is a superficial brownish slough over the most prominent part of the hernia. This portion of the hernia has been in contact with the rubber dam. The lateral surfaces of the hernia are clean, free from slough, and are covered with healthy granulations. Therefore the rubber dam was discarded, and the surface of the hernia was covered with gauze wet in Dakin's solution, surrounded with two perforated Dakin tubes coiled about the hernia, and one tube was placed over the piece of gauze covering the hernia; to be kept wet with Dakin's solution. Patient is up on balcony. His general condition continues to improve.

April 18. The aphasia has narrowed down somewhat and seems now to be predominating inability to name objects verbally and by writing. He has some difficulty in diction, and is unable to repeat some words even when repeated for him by the observer so that he seems to have some verbal aphasia. However, with the observer opposite he can carry out the imitation tests quite easily and with no mistakes. This cannot be done with a motor aphasia of any extent. He can read printed words although he cannot say them aloud. He can carry out commands. He can count well but cannot repeat the alphabet. The type of speech present corresponds very well with a lesion of the posterior part of the superior temporal gyrus of the left side.

April 19. Dressing. Hernia somewhat smaller. A compression (slight) dressing applied. Patient up on porch in wheel-chair. Is able to stand and walk. Eats well, sleeps well, has no pain.

April 25. Patient has been dressed daily, with the exception of the 22nd, since the last note. Two days ago a piece of superficial black slough was removed (after it had become almost separated) with forceps and scissors. No leakage of cerebrospinal fluid. The hernia is smaller, flattened out, and fibrosed in appearance. A compression dressing of gauze and bandage has been used during the past 4 days. Dakin's solution continued. Patient can see more on the right side than several days ago. He noticed this today. Therefore the anopsia has decreased. Can write better. Has learned a number of new words. Can speak words correctly, i.e., he selects the proper words. Formerly he would say "her" for "him," "he" for "she," etc. Eats well; sleeps all night. No pain or headache. The improvement has been marked.

April 27. Dressing and lumbar puncture. Lumbar puncture with patient on right side. Fifty-six cubic centimeters of clear fluid removed slowly. Other than slight frontal headache, no untoward symptoms. Hernia diminished markedly in size; surface changed from convex to concave; hernia mass considerably flattened and became "flabby." Two superficial dark sloughs removed. Patient's general condition has improved. Also his memory.

To remain in bed tomorrow following lumbar puncture.

May 3. Dressed. Patient has been dressed daily since last note. Hernia much diminished in size; is flat and "flabby" in appearance, and not distended as formally. The surface of the hernia is covered for the most part with healthy granulations and has become much firmer. His vocabulary is increasing.

May 5. Dressed. Condition of hernia good; diminished in size; is firmer; no sloughs. Therefore, to hasten epithelialization of the surface of the hernia, it was covered with adhesive strips, $\frac{3}{4}$ inch wide, passed around the head and fastened. Area covered with gauze wet with Dakin's solution and held with bandage. No further irrigations needed, but the dressing is to be wet from without by use of syringe q. 2. h. Also ear to be vaselined daily. Telephoned to his mother in Staten Island yesterday.

May 6. Dressed. No evidence of infection following strapping hernia with adhesive yesterday. Hernia remains flattened. Patient went to church today. Goes about ward and has no complaint. Hemianopsia gradually clearing up after an almost complete homonymous hemianopsia following the herniation. Charts of visual fields requested.

May 7. Dressed. Adhesive strips removed from over hernia and renewed. Condition of hernia much improved. Hernia is more flat, surface is firm, and epithelial margin is spreading across from scalp edges. Gauze dressing wet with Dakin's solution applied and slight pressure made with bandage.

May 9. Dressed. The spreading of epithelium from the skin margins over the granulating surface of the brain has been very rapid. The surface of the hernia (brain surface) is on a level with the scalp margin, i.e., there is practically no herniation. There is no complaint on the part of the patient. Vision is improving on the right halves of the visual fields with recession of the hernia. Adhesive strips removed and others applied. This to be continued until the area is completely covered with epithelium. A small gauze dressing wet in Dakin's solution applied and held with a circular bandage about the head. Complete head dressing not necessary. Temperature, normal.

May 10. Dressed. Similar dressing without removal of adhesive strips. These to be changed every 2 days.

May 11. Dressed. Area about granulating surface shaved and cleansed with cotton balls wet in Dakin's solution. The central portion of the area is now somewhat concave for the first time, i.e., the hernia has now receded until the scalp level is above that of the hernia.

May 21. Patient has been dressed each day or every other day since last note. The measurements of the scalp defect are 8 centimeters by 13 centimeters, the defect being somewhat triangular in shape, with long, narrow, pointed apices. The area in the center of the defect not yet covered with epithelium measures about 2 centimeters by 3.5 centimeters.

The epithelium has spread rapidly across the granulating surface and remains firm without "blistering." The pulsation has markedly diminished. No tenderness. General condition very good. Mentality (is excellent, is happy, and helps about the ward. Now weighs 171 pounds.

May 23. Dressed. Granulating area becoming smaller. Scalp about wound shaved, so as to clean the area and allow adhesive strips to adhere. Flamed adhesive strips reapplied, Dakin gauze (small) and bandage.

June 1. Ophthalmological note. Vision: R. E. 20/25-2. L. E. 20/25-1. Pupils react to light and accommodation. Convergence is poor. Fundi: suspicious pallor of temporal side of discs of both eyes. Return to K1 for fields and measure of accommodation.

June 2. Ophthalmological examination: visual fields. R. E. Quadrilateral anopsia, with tendency to hemianopsia-temporal field; test objects 1 square centimeter; daylight; approach from in out. L. E. Quadrilateral anopsia, upper nasal field; test objects 1 square centimeter; daylight; approach from in out. From nature of anopsia, would judge that lesion is in left optic tract. Patient apparently knows colors but has difficulty in naming them.

June 2. Ophthalmological examination: Measure of accommodation.

Power 5 acc. R. E. 5 D. L. E. 5.5 D. Both eyes 6.5 D. Near points convergence 150 M. M., pupillary convergence reaction present. Impression: patient has insufficiency of convergence with paresis of accommodation. Condition is common after prolonged or severe illness and will no doubt clear up; advise abstinence from reading for 2 months. Should have refraction. Fields on next sheet.

June 2. Discharge note. Dressed. There is no longer a herniation at the site of the original hernia, but on the contrary, there is a slight depression. Only a small point-like area, about 3 millimeters in diameter, remains uncovered with epithelium. A piece of adhesive plaster about 4 centimeters long and 1 centimeter wide, with a small hole in center, was applied so that the small opening coincided with the small central area which is not covered with epithelium. A small piece of gauze about 2 inches square, wet in Dakin's solution, was applied over adhesive and held with a narrow bandage about head. The left ear droops, because the scalp flaps with base directed toward ear, have become fixed at a lower level than they occupied before they were turned down at operation. He appears to be well and healthy, is strong and powerful. There is still a hesitation in speech. To be discharged to his home and return for dressings every 2 days.

Summary. Male. Age 26. Fireman New York City Fire Department. Acute mastoiditis, left, following influenza. Simple mastoidectomy March 5, 1923, following which a temporosphenoidal lobe abscess, left, developed. Was operated upon for brain abscess, under local anæsthesia, on March 27,

1923. "Roof" of abscess cavity removed; no drainage material used; temporary herniation with complete eversion of abscess cavity; hernia completely receded in 44 days, aided by only 1 lumbar puncture on thirty-first day; Dakin solution used throughout; dressings to protect and prevent compression for 39 days; after which, compression dressing with granulating surface covered with adhesive plaster strips. Highest temperature 100.8 degrees—first day after operation. Superficial areas of sloughing from eighth to thirty-seventh day. Leakage of clear cerebrospinal fluid through anterior portion of hernia (probably from descending horn of left lateral ventricle) from seventh to twelfth day. Discharged from Bellevue Hospital on sixty-seventh day following operation for brain abscess. Slight hesitation in speech due to "searching" for proper words. Weighed 145 pounds first time weighed when able to walk about after operation; weighed 170 pounds when discharged; general condition excellent.

November 14, 1923. *Follow-up note.* After discharge from Bellevue Hospital on June 2, 1923, patient was dressed every 2 days for about a week when area was completely covered with epithelium. This dressing necessitated his coming over a distance of about 11 or 12 miles in an automobile. A few days later, surface became somewhat excoriated, for which a dressing was applied every 2 or 3 days, for about 2 weeks longer. During this time, he came alone by trolley, ferry, and subway. Afterward he was seen about once a week; no dressings. He now remembers the events which took place before he was brought to Bellevue Hospital, the latter part of his operation in this hospital, his return to the ward, and everything which took place during his stay in the hospital.

He returned to duty as a fireman in the New York Fire Department on September 7, 1923, 5 months and 11 days after operation—"watch" duty and messenger. This entailed his being on duty at night, or in the day, and sometimes both during the night and day. He continued on such duty until about October 6, when, at my request, he was transferred to day duty by Dr. Smith, chief medical director of the New York Fire Department. He has been on this duty, in the capacity of inspector of garages, fire hazards, etc., until the present time.

Patient's normal weight before he contracted influenza was from 185 pounds to 195 pounds. When he first weighed after operation for brain abscess, weight was 145 pounds. When discharged from the hospital, he weighed 170 pounds. At the present time, he weighs 190 pounds. Aphasia almost completely cleared up.

Hearing normal; reads without glasses; no difficulty; no headache; good appetite; sleeps well.

Ophthalmological examination made by Dr. William B. Doherty, reveals the following:

"Examination under homatrophine showed that he had a high degree of myopia and a moderate amount of myopic astigmatism in the right eye and

a high degree of myopia and a moderate amount of myopic astigmatism in the left eye. I obtained 20/20 plus vision in the right eye with a minus 350 sphere combined with a minus one cylinder 75 degrees nasal and a similar amount of vision was obtained in the left eye with a minus 350 sphere combined with a minus 050 cylinder 75 degrees nasal. The lids, conjunctiva, cornea, media and fundi of both eyes were negative; the tension normal, and the fields were normal for both form and colors. The blind spots were not enlarged and there was no scotoma in any part of the visual fields. He had single binocular vision for both distance and reading and the muscle balance was unimpaired. Examination also showed that he had perfect perception of color."

November 23. Patient stated that he has no trouble with his vision and that he can see as well on the right side as on the left, although he used glasses for three weeks after he was discharged from the hospital. He has now discarded the glasses and is able to read as well as ever without any difficulty.

CONCLUSIONS

1. Various operative procedures heretofore described, in which numerous kinds of drainage materials were used, have usually been followed by a high mortality rate.

2. In all of these procedures described, prevention of hernia cerebri has been desired.

3. In this paper the following is advised:

a. Creation of a rather large cranial defect directly over abscess cavity;

b. Complete "unroofing" of the cavity;

c. Complete herniation or eversion of the cavity;

d. Dakinization of area throughout treatment;

e. Prevention of trauma and early compression of hernia cerebri;

f. Recession of hernia;

g. Adhesive plaster strapping;

h. Epithelialization.

4. Results. Three cases which were consecutively operated upon and treated in this manner have recovered. There was no mortality in this series of cases.

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