Ludwig G. Kempe

Operative Neurosurgery

Volume 1

Cranial, Cerebral, and Intracranial Vascular Disease

Springer-Verlag Berlin Heidelberg GmbH

L.G. KEMPE · OPERATIVE NEUROSURGERY

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Cranial, Cerebral, and Intracranial Vascular Disease

By

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Fourth Printing

With 335 Partly Colored Figures

Springer-Verlag Berlin Heidelberg GmbH 1985

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First printing 1968
Second printing 1976
Third printing 1981
Fourth printing 1984

ISBN 978-3-662-12636-3 ISBN 978-3-662-12634-9 (eBook)
DOI 10.1007/978-3-662-12634-9

Originally published by Springer-Verlag Berlin Heidelberg New York in 1968
Softcover reprint of the hardcover 1st edition 1968

Library of Congress Catalog Card Number 68–22982.

Typesetting, printing, and bookbinding: Universitätsdruckerei H. Stürtz AG, Würzburg

2122/3130-54

To Sanitätsrat Dr. Ludwig Kempe

Dr. med. Georg Kempe

Foreword

A treatise on operative neurosurgery by an officer of the Regular Army would ordinarily be expected to emphasize management of trauma. But this is far from an ordinary effort and the reader will quickly realize that here we encounter a Handbuch in the classic mold. General neurosurgical procedures are presented with great clarity by an extraordinary individual.

Originally an ornithologist of repute and accomplished student of medieval history, Colonel Kempe received his residency training in the large and well-balanced neurosurgical program at the Walter Reed Army Medical Center. Later, he was assigned to that service and has been Chief of Neurosurgery at the Center since 1965. Through the years, he has made it a practice to sketch the steps and surgical anatomy of his operative procedures for inclusion in the hospital records, and these drawings have been used on rounds with young house officers as one of the many notable features of the Army's neurosurgical residency program. His remarkable talent with the sketchbook coupled with his devotion to detail in patient care and in teaching has culminated in an opus which will be of tremendous value.

The book is based upon the rich personal experience of the neurosurgeons at Walter Reed. The illustrations and text bring to the student an understanding of anatomy and the important minute details of surgical approaches which are unexcelled in any other presently-available text. The author indicates clearly and with modesty that the procedures described are those which he has found effective. That other neurosurgeons may differ with some of his methods is to be expected — "to each his own". I believe however that every neurosurgeon, old or young, will profit from the superb illustrations and clear description of the techniques used at the Walter Reed Army Neurosurgical Center.

The first volume alone is a symbol of the exhaustive labors of the author and should also be looked upon as eloquent evidence of the high professional calibre of our Army neurosurgical program, both in the care of patients and in the training of young men.

August 1968

Henry G. Schwartz, M.D., F.A.C.S.
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Preface

This work intends to present the major neurosurgical procedures involving the anterior and middle cranial fossae. Another volume of surgery of the posterior fossa, spine and spinal cord, peripheral nerves and autonomic nervous system is in preparation. Each operative procedure begins with an anatomical topographical demonstration of the lesion followed by a detailed step-by-step drawing of the pertinent technical operative maneuvers. The figures are planned to give the view the surgeon has at the time of the operation. At the start of each operation a wider view of the anatomical topographical relationship is depicted followed by an enlarged view of a small exposure of the operative field. If it seems necessary to regain the anatomical relationship it will only be necessary to review some of the preceding pictures.

The arrangement of the different subjects are chosen not as to their disease; as for instance, vascular lesions or tumors, etc., but as to their anatomical localization. In following this pattern the operative approach to any lesion of the sella turcica or anterior parasellar area will be described together. It is believed that in this way the three dimensional conception so necessary for the surgeon is presented again and again for different lesions at the same or nearly the same anatomical location. Neurosurgical diagnostic procedures (ventriculography, angiography) are not described. The latter have partly become the special field of the neuroradiologists. The treatment of congenital hydrocephalus has developed more in the use of different technical devices than in actual operative techniques and this subject is not presented.

The precise detailed operative technique shown in this book is intended to illustrate the basic techniques of the major neurosurgical procedures and to give guidance and necessary flexibility which is in constant demand for the execution of every surgical procedure. It should also give technical guidance to operations which are not specifically discussed; for instance, prefrontal lobotomy and fibrous dysplasia.

Most of the experience gained to prepare this book has been at Walter Reed General Hospital, Neurosurgical Service, Washington, D.C. The views of the author do not proport to reflect the position of the Department of the Army or the Department of Defense.

Great thanks go to my teacher Brigadier General George J. Hayes whose masterful technique is mirrored in many of these figures. Other neurosurgeons have certainly influenced my surgical judgement and technique and this is reflected in this book. Great thanks go therefore to Dr. Henry G. Schwartz and Dr. Hugo V. Rizzoli.

My thanks go to Mr. Hans Brandt (Heidelberg, Germany) whose great talent in medical artistry and our harmonious working relationship was a constant impetus in bringing the work forward.

I want to thank Mrs. Dolores G. Hipsley for her tireless effort in preparing the manuscript.

Thanks go to my assistant, LTC William M. Hammon, for his critical review and always available support.

Captain Thomas Ducker (research fellow in experimental surgery at Walter Reed Army Institute of Research) has my gratitude for review of the manuscript.

Certainly I will not forget the contributions of the residents in the Neurosurgical Service at Walter Reed General Hospital. Majors Albert N. Martins, Wilbur F. Helmus, David T. Pitkethly, Darwin J. Ferry, and Donald R. Smith by their questions and assistance in the Operating Room have added clarity to the presentation.

May I not forget Dr. Heinz Goetze, Springer-Verlag, for his generous help and in letting me have my wishes in every aspect of the reproduction of the pictures.

Washington, August 1968 L. G. Kempe

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Posterior Fossa, Spinal Cord, and Peripheral Nerve Disease

Chapter I

Craniotomy, Frontotemporal, Opening and Closure

One of the most frequently used craniotomy sites over the fronto-temporal area is selected to show the operative steps. The head is shaved just prior to bringing the patient to the Anesthesia Induction Room. While under anesthesia the patient is positioned for surgery, in our case of a left frontotemporal craniotomy the head is turned as seen in Figs. 1 and 2. Care is taken that neck muscles are not taut to prevent any compression of the venous circulation. This is accomplished by keeping a firm pillow under one shoulder, depending on the way the head is turned (Fig. 1a and b). Another important rule in positioning the patient is to keep the head always above the level of the heart. It may be necessary or helpful to lower or turn the head during certain operative procedures. This possibility should be kept in mind; however, even after repositioning the patient's head should remain above the heart level (Fig. 2). The head may be placed on a doughnut-shaped headrest or a three-pronged head holder, either of which permits repositioning of the head during surgery. The eyes are now covered with a rubber sheet after inserting into the conjunctival sacs a mild aseptic ophthalmic ointment. The scalp is prepared with soap and water and an iodine-containing solution.

Once the preparation dries, the midline of the cranium in the sagittal plane is accurately marked. Depending on the location of the craniotomy other fixed landmarks may be marked. Favorites are, for instance, the inion or a line perpendicular to the Frankfort horizontal line running immediately posterior to the external acoustic meatus. After having made these markings the actual craniotomy scalp flap is outlined. The scalp incision is always formed in such a way as to assure the main blood supply to the flap. The skin flap is usually larger than the underlying bone flap. In Fig. 3 we see the scalp incision outlined for the underlying frontotemporal craniotomy. The dark shaded area represents the part of the bone to be removed with the help of Hudson drill and rongeur. Fig. 4 gives the view the surgeon has of the patient in the correct operative position and Fig. 15 shows the skull alone with the frontotemporal bone flap. Draping of the operative field itself should not leave more of the scalp exposed than is absolutely necessary to prevent any contamination. The drapes are fastened by a few silk sutures. The draping of the rest of the body should not obstruct the draining veins. There should be ample room and slackness of the drapes also to permit any lowering or tilting of the head during the operation.

The initial incision of the scalp may be started over the scalp overlying bone to avoid any inadvertent incision into the muscle and fascia. Pressure exerted with volar aspects of the assistant's fingertips controls bleeding from the scalp (Fig. 5). The surgeon or assistant compresses the superficial temporal artery at the inferior end of the scalp incision. Undermining and slight elevation of the scalp overlying the temporalis muscle fascia also adds in preventing carrying the initial incision into these structures. Fine hemostats grasp the galea on the outer side of the incision and Rainey clips are applied to the inner side. Over the anterior lower section of the scalp incision the use of Michel clips is to be recommended for they are less traumatic to the more delicate skin of the forehead (Fig. 6). In infants Michel clips are used throughout, placing cottonoids over the skin edges to give additional protection to the delicate skin. The scalp flap is undermined bluntly with a periosteal elevator and then grasped by the surgeon and further reflected

(Fig. 6). Several strands of firm adhesions are cut with a curved scissor. The scalp flap is reflected over a roll of gauze to prevent too acute an angulation with subsequential embarrassment of the vascular supply to the flap. The scalp flap is then covered by a large moist abdominal tape after coagulation of all bleeding points of the galea. A sheet of Surgicel or similar hemostatic agent the size of the skin flap is useful to reduce bleeding if placed over the undersurface of the galea and can be later removed at the time of closure. The skin flap is held reflected by towel clips which in turn are secured in place by a folded gauze strip or umbilical tape running through the grip openings of the towel clips (Fig. 7).

In the same picture, Fig. 7, the temporalis muscle fascia sling is taken in patients with intracranial aneurysm. In later chapters the need and use of such slings will be discussed. The step by step procedure of taking the fascial sling is shown in Fig. 8.

The temporalis muscle fascia is now incised making small starting incisions with a scalpel and enlarging the incisions with straight scissor lifting the fascia from the underlying muscle. The muscle itself over the anterior frontal aspect is simply elevated and reflected from the bone by the periosteal elevator without any incision. This prevents any unnecessary bleeding. The temporalis muscle over the posterior temporal incision has to be incised, preferably with a straight scissor, after the muscle is freed from the skull with periosteal elevators (Fig. 9). The muscle is furthermore freed inferiorly from the sphenoid and temporal bones (Fig. 10).

Fig. 11 shows the placement of the burr holes. Great emphasis is made on the correct placement of the burr hole anterior to the inferior aspect of the superior temporal line of the frontal bone (Figs. 11 and 12). From this burr hole we will later start rongeuring down to the greater wing of the sphenoid (compare also Figs. 14 and 15). Prior to introducing the Gigli saw guide the dura is separated from the edges of the burr holes and the Gigli saw guide is advanced forward below the inner table making a sweeping movement with each advance. Should the saw guide accidentally tear the dura we will leave the guide in place and introduce a second saw guide from the opposite burr hole, for leaving the first saw guide in place will prevent the second guide from entering the dural tear (Fig. 13). The Gigli saw should be kept nearly tangential to the bone and held apart in a wide angle while sawing. The sawing will be smoother by moving from the shoulder rather than with the hands and forearms. Should the saw get stuck try first to pull on the longer end even if the other end is extremely close to the one burr hole. In most cases this will free the saw. The extent of the bone to be rongeured (Figs. 14 and 15) should be large and deep enough so that no great force is necessary to break the remaining bony bridge. This prevents a possible fracture down to the floor of the middle fossa.

The bone flap is first slightly elevated by two periosteal elevators. When the sound of the breaking bone is heard, the index finger is used to free the dura from the inner table of the bone flap and to protect it from the upturning bone flap. The finger also helps lifting of the bone (Fig. 16). The irregular rough part of the fractured bone is removed from both sides (Fig. 17). Should it be necessary to remove more of the bone from the greater sphenoid wing and inferior temporalis squama then the muscle should be freed from these parts first. Bone wax is applied to all diploic channels and the inner table of the bone flap. The reflected bone flap hinging on the temporalis muscle is covered preferably with a green nonglaring towel.

The opening of the dura is shown in Fig. 18. It may be easier to start the opening over the center of the outlined incision. The dura is elevated using a sharp dural hook and the small round blade is used for the initial opening by making repeated strokes to avoid penetrating the dura in one single move. The incision is completed with scissors protecting the underlying brain with an advancing wet brain spatula or cottonoid strip. Any bleeding from the dura is controlled by coagulation. Too extensive coagulation will shrink the dura causing it to retract from the inner table resulting in more bleeding. The shrunken dura will also be difficult to close. It is essential to always coagulate in

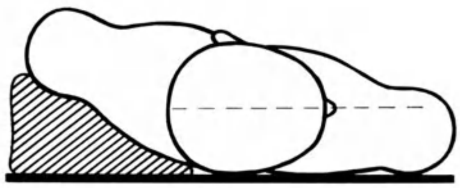


Fig. 1 a

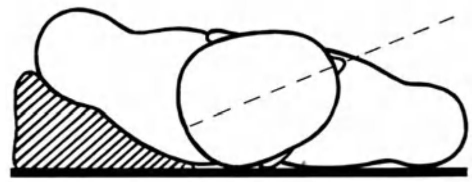


Fig. 1 b.

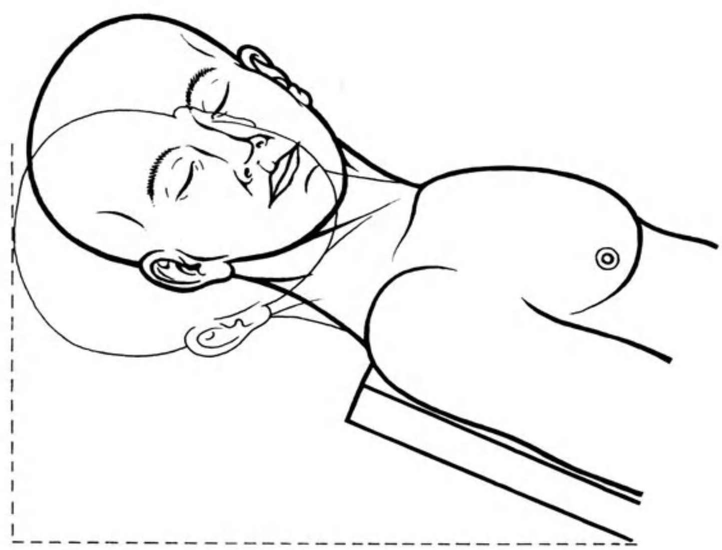


Fig. 2. Position of patient.
Observe: The head is always above the level of the heart.

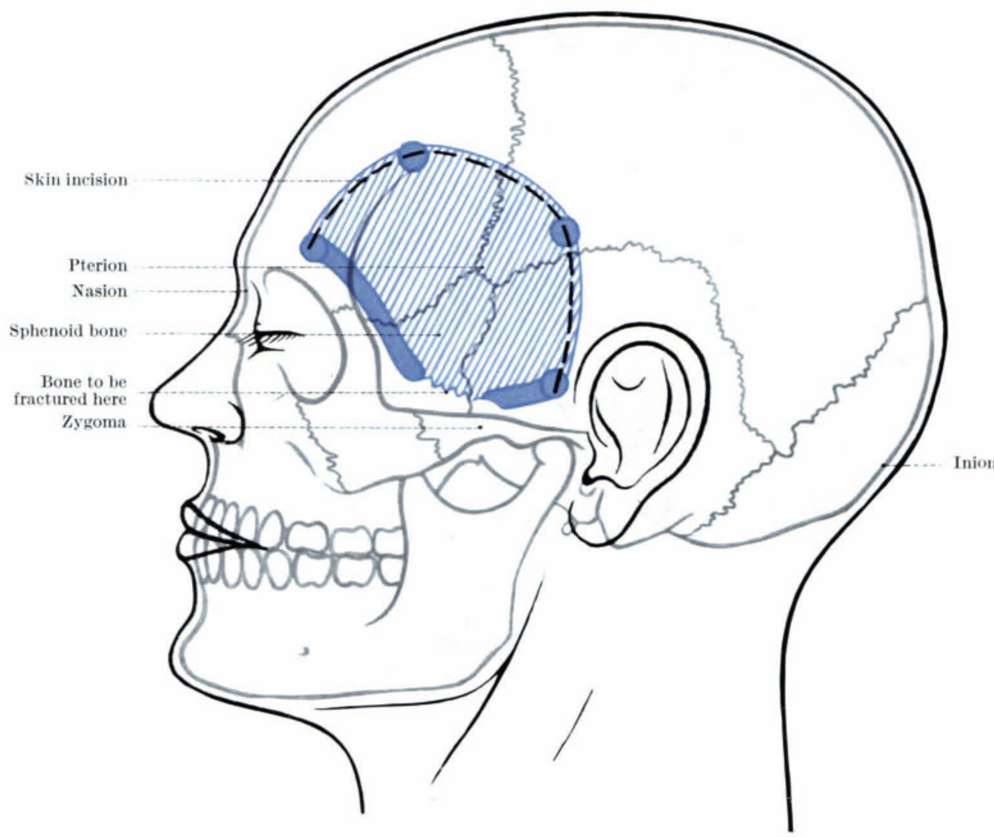


Fig. 3. Fronto-temporal craniotomy.

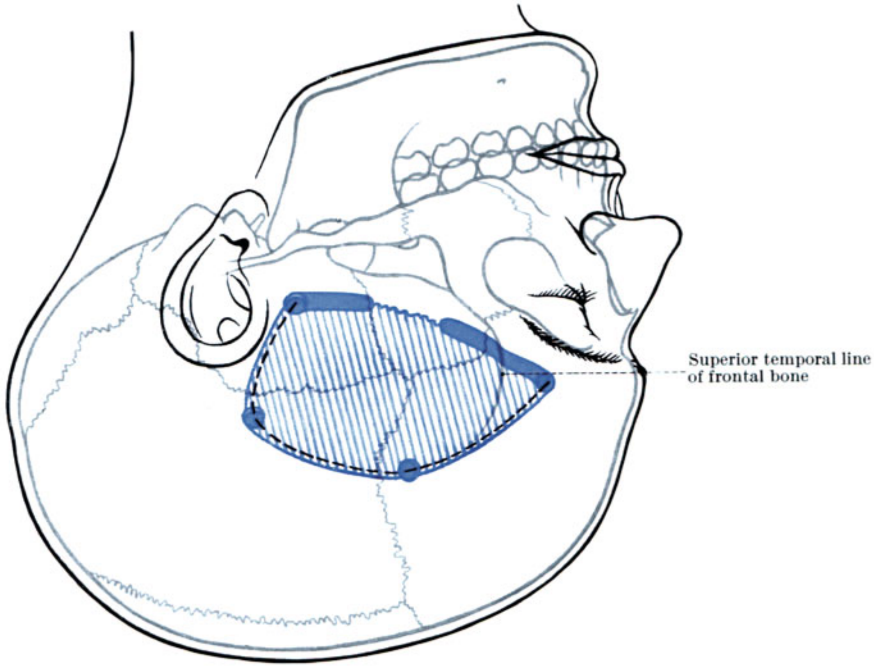


Fig. 4. Surgeons view. *Observe:* Burr hole in front of sup. temp. line.

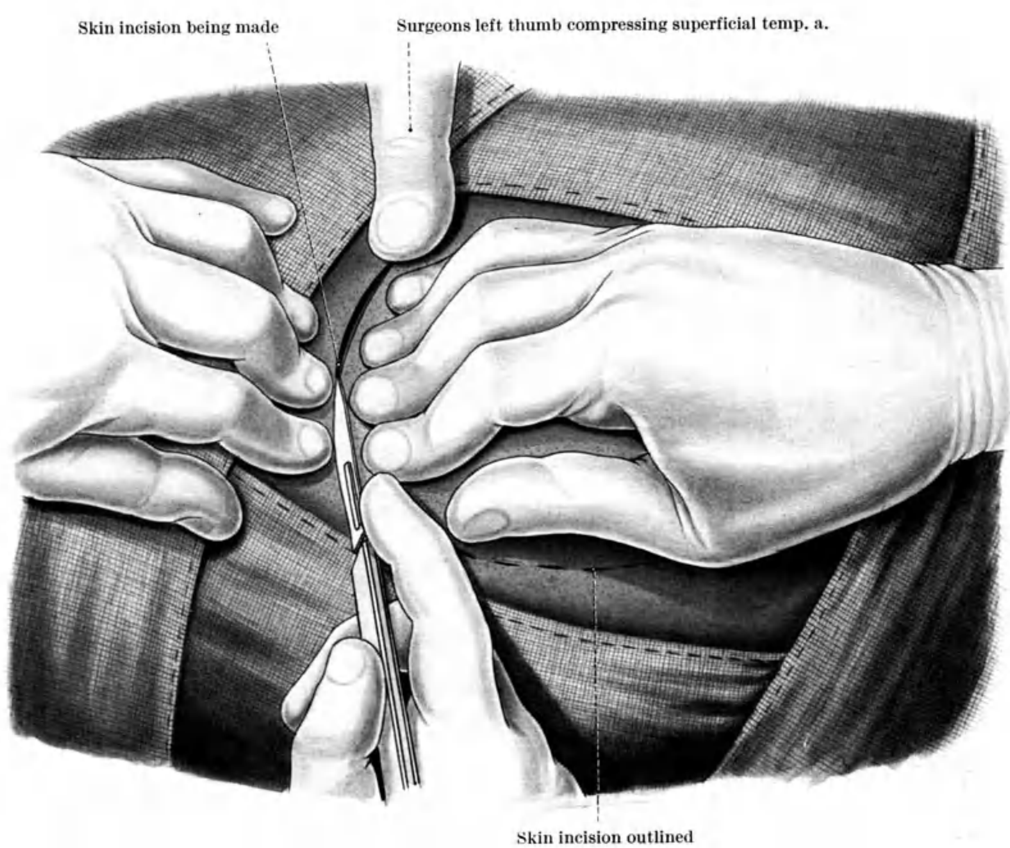


Fig. 5. Skin incision. *Observe:* The compressing fingers of the assistants should use gauze sponges on the skin. For clarity these sponges were not included in this drawing.

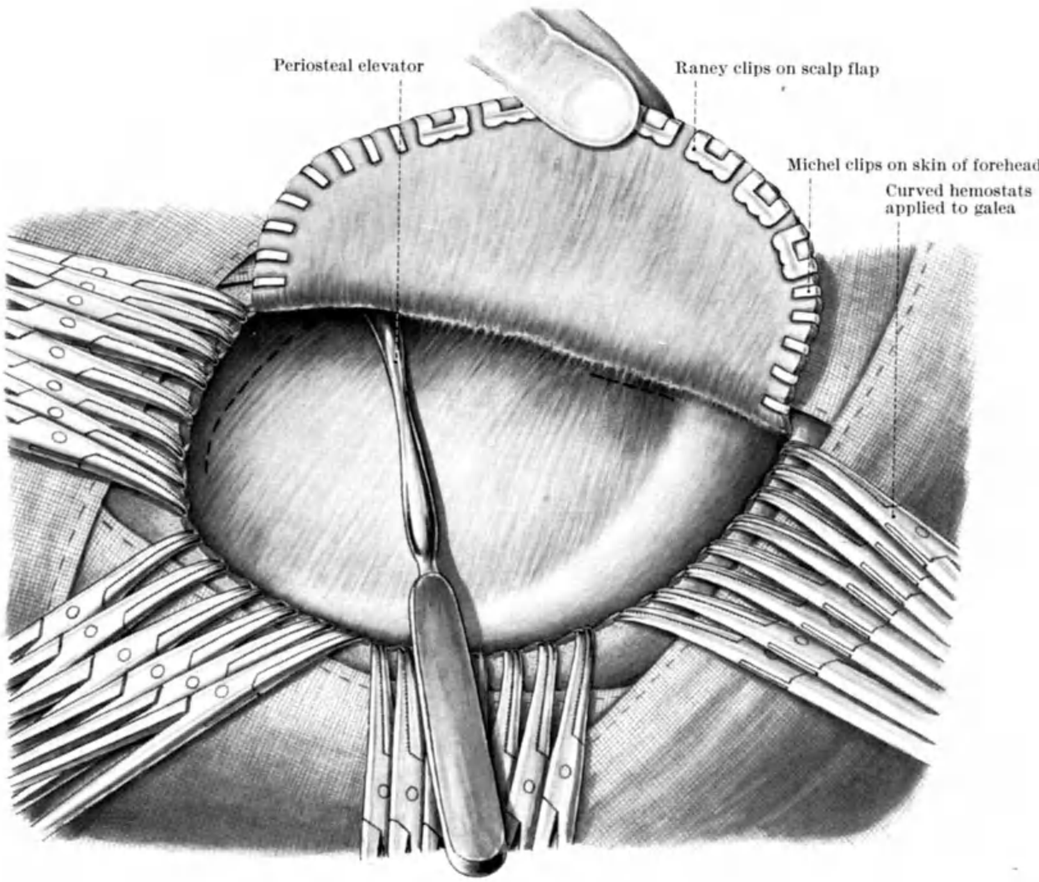
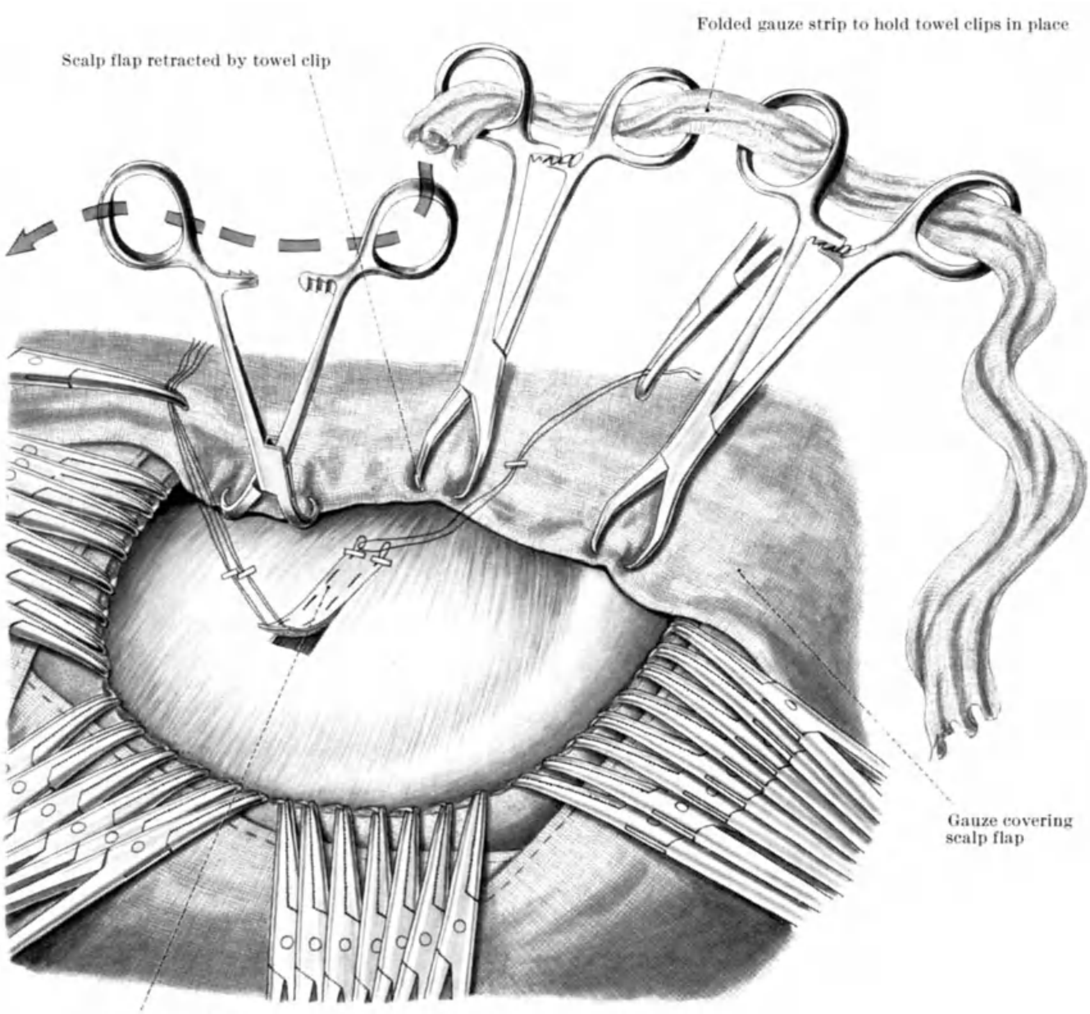


Fig. 6. Elevation of scalp flap.
Observe: 1. Hemostats on the outer rim of the scalp incision and Raney clips and Michel clips on the scalp flap. 2. Lines of incision over temporalis muscle fascia.



Folded gauze strip to hold towel clips in place
Scalp flap retracted by towel clip
Gauze covering scalp flap
Sling prepared from temporalis muscle fascia in cases of aneurysm surgery

Fig. 7.

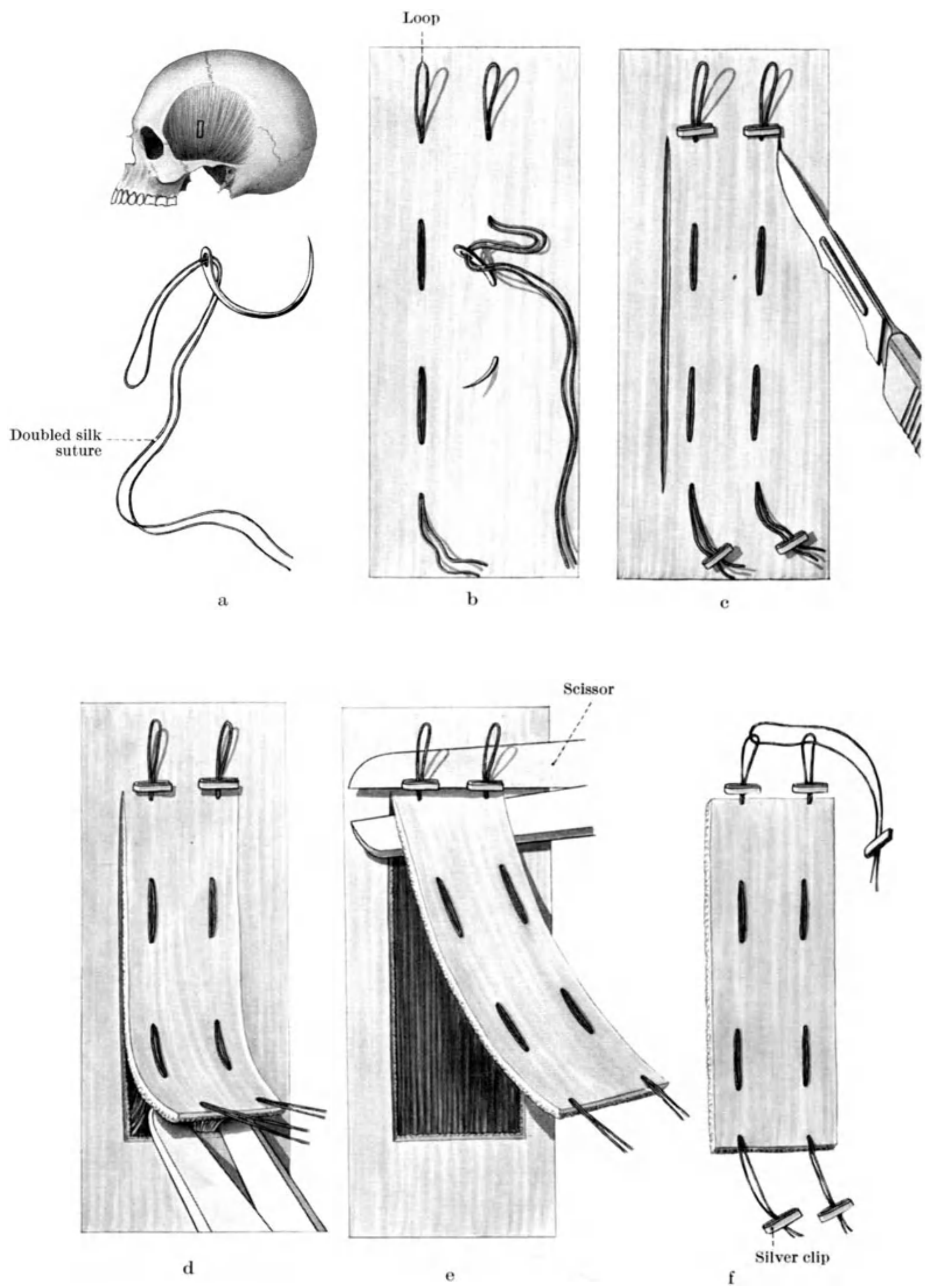


Fig. 8a—f. Preparation of temporalis fascial sling to be used in intracranial aneurysm surgery.

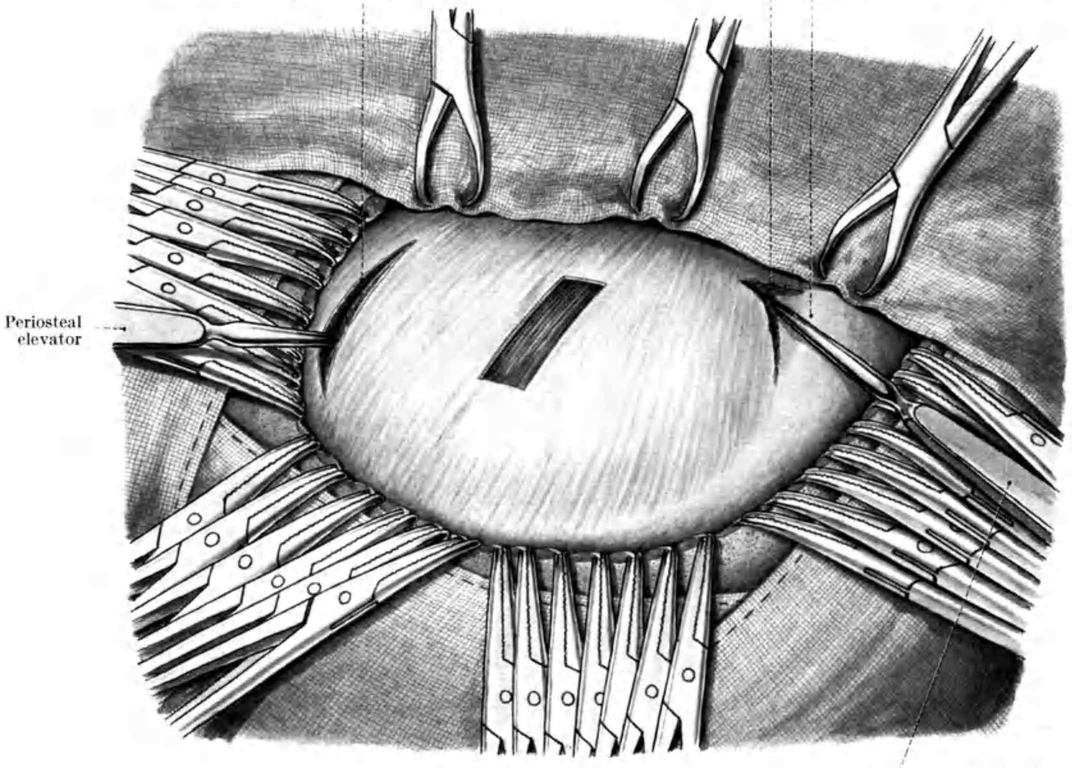


Fig. 9

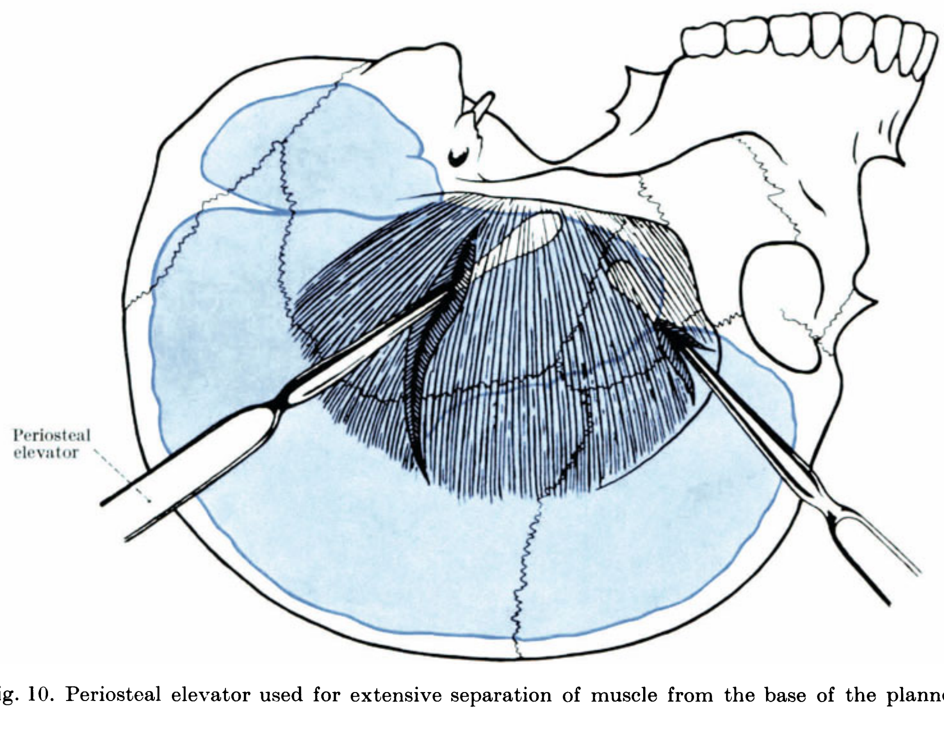


Fig. 10. Periosteal elevator used for extensive separation of muscle from the base of the planned bone flap.

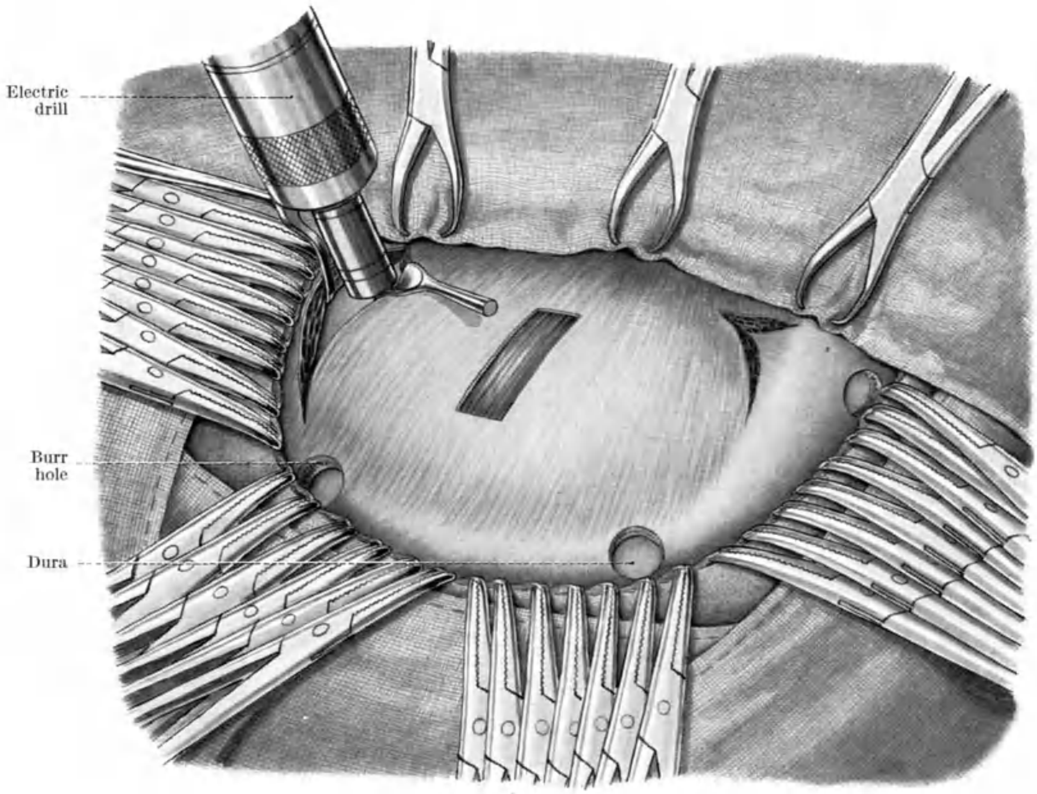


Fig. 11. Placement of burr holes.

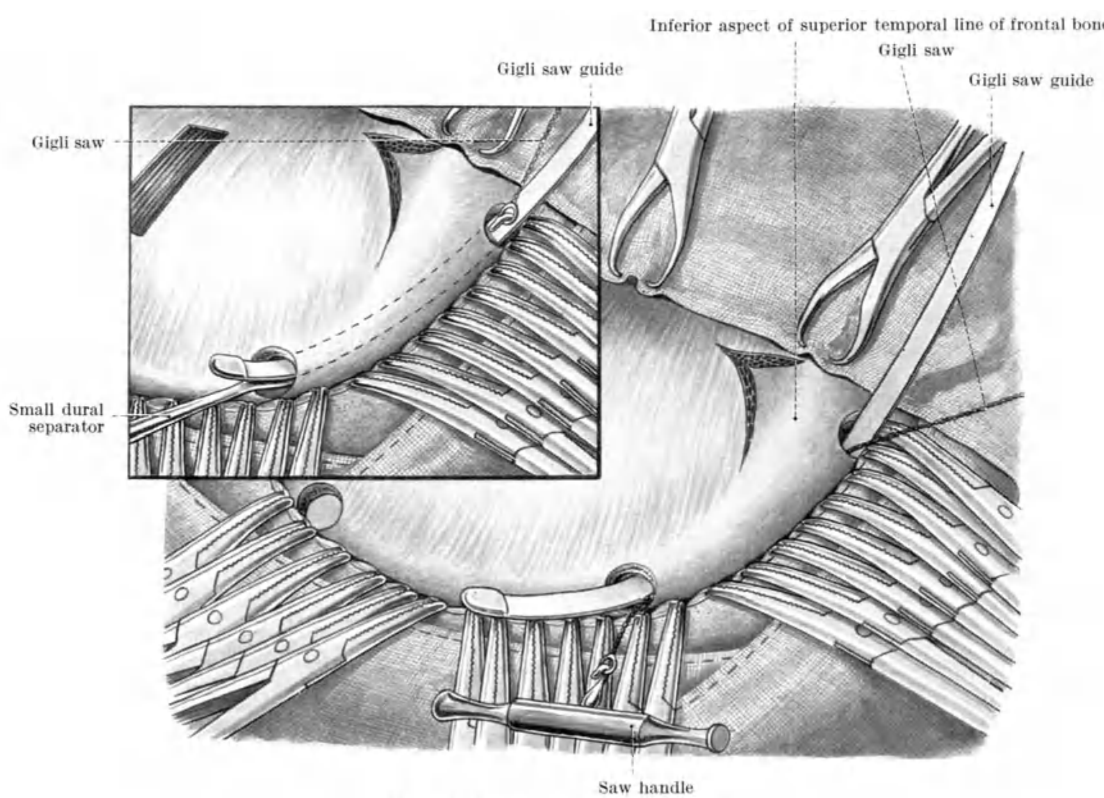


Fig. 12. Connection of burr holes.

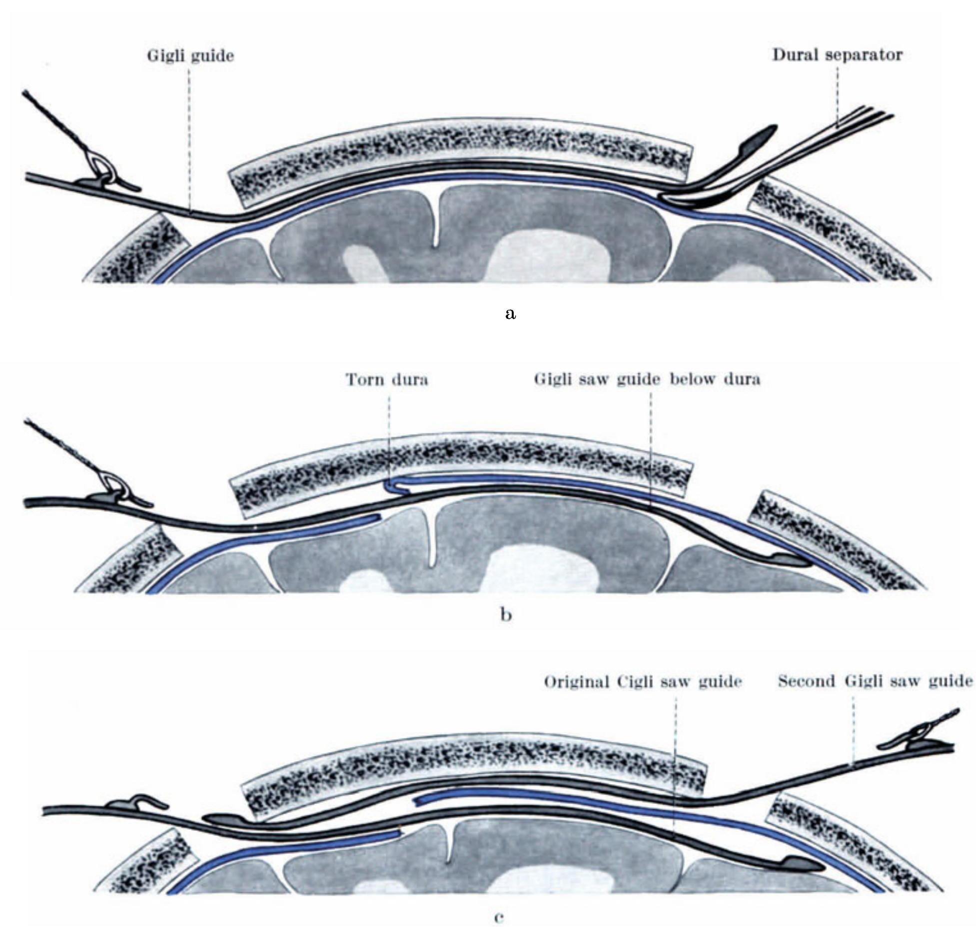


Fig. 13a—c. Steps to be taken if Gigli saw guide tears dura (b, c).
Observe: If Gigli saw guide penetrated dura (Fig. 13b) it should be left in place while second Gigli saw guide is introduced from the opposite side (Fig. 13c).

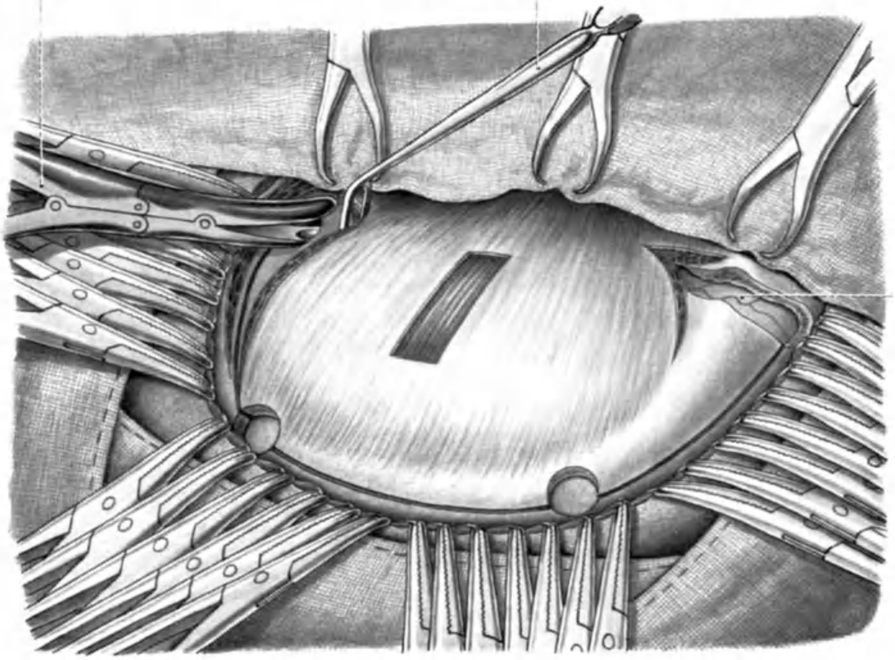


Fig. 14. Rongeuring base of bone flap.

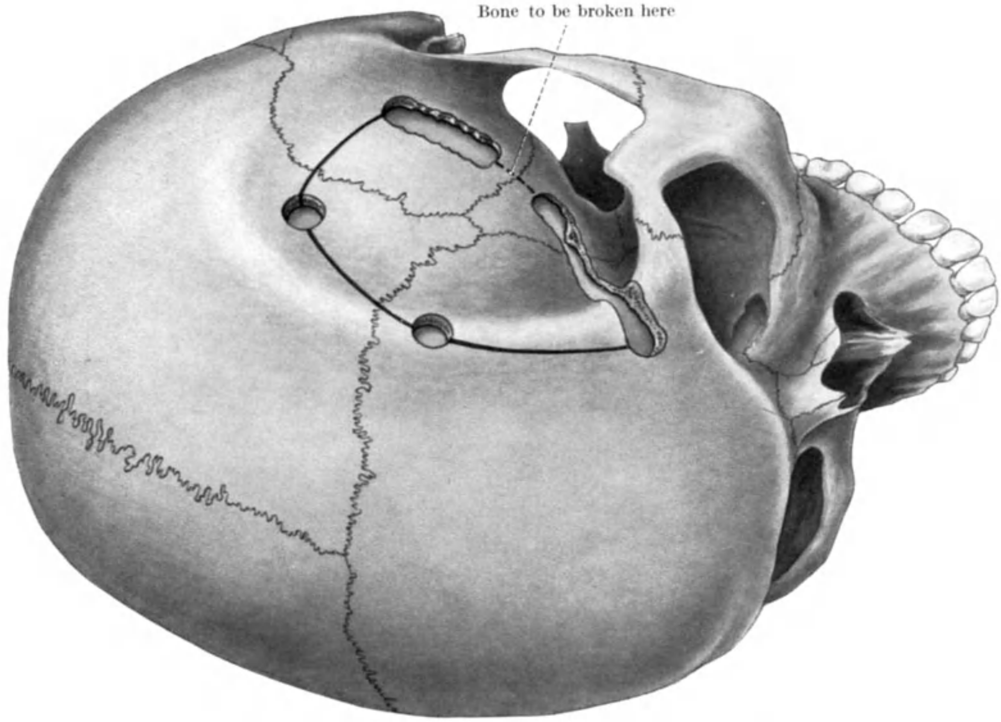


Fig. 15. Anatomical relationship of the bone flap.

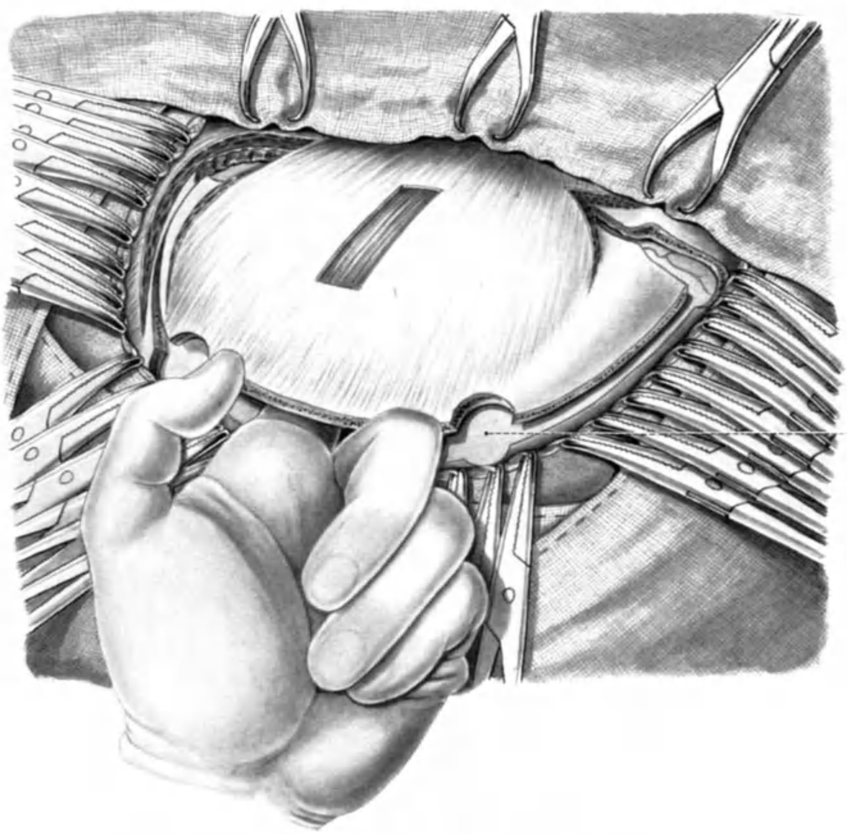


Fig. 16. Elevation of bone flap.
Observe: Index finger lifting bone flap and protecting dura.

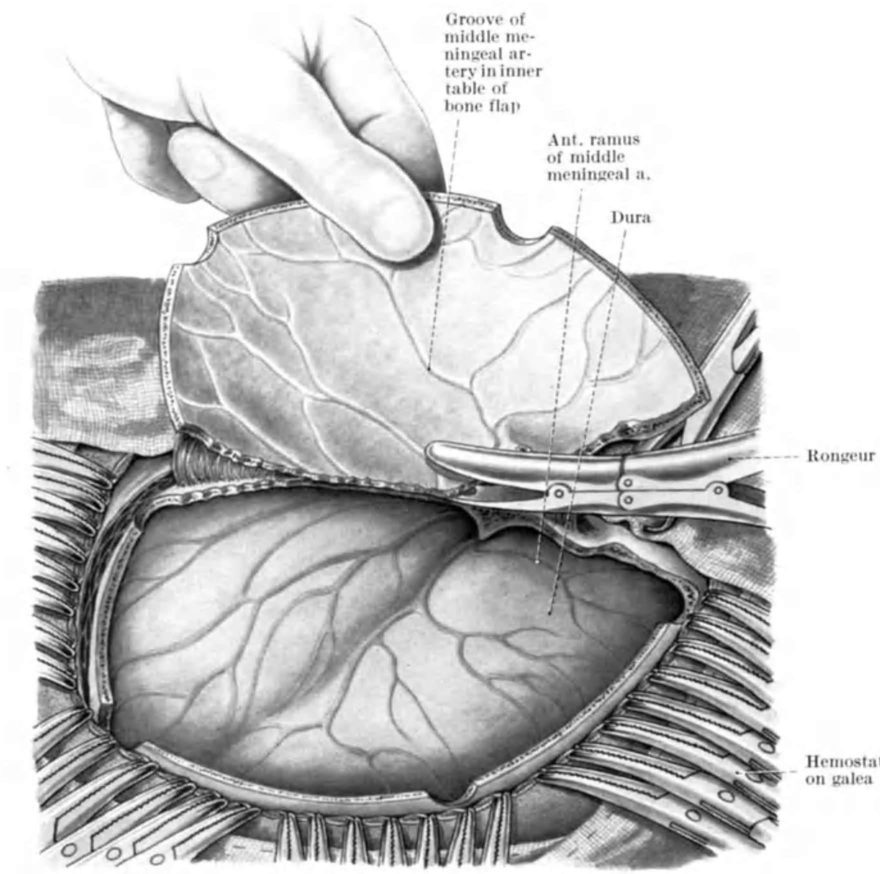


Fig. 17. Removal of the rough bone edge from the fracture site.

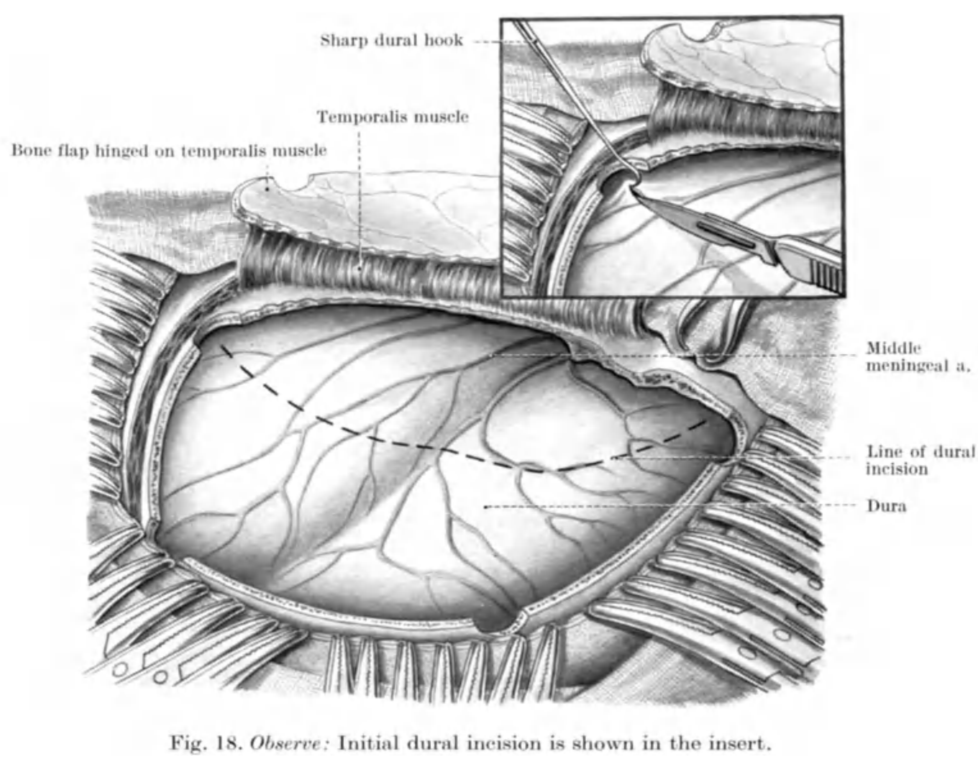


Fig. 18. *Observe:* Initial dural incision is shown in the insert.

a dry field and this is accomplished by suctioning through a cotton pledget close to the spot to be coagulated. Bleeding from the cut edge of the middle meningeal artery is often better clipped. The reflected dura is fastened to the temporalis muscle by stay sutures which are applied below and on the inside of the dural flap and sutured to the reflected temporalis muscle (Fig. 19). More stay sutures are used to pull the remaining dura to the inner table of the skull. Every time a needle is placed through the dura the underlying brain is protected by a spatula (Fig. 19).

We have come to use exclusively this frontotemporal craniotomy just described for all aneurysms, including the treatment of aneurysms of the middle cerebral artery. The same frontotemporal craniotomy is used in the pituitary tumors, craniopharyngiomas, and other sellar and immediate parasellar lesions. Over the past five years we have approached this area nearly exclusively from the right, non-dominant side, in order to protect the patient's dominant hemisphere. This relatively small craniotomy with the patient under controlled hyperventilation anesthesia, as described by HAYES and SLOCUM*, has been used since 1958 for the above-mentioned indications and given in every case a relaxed brain with ample room for the desired operative procedure.

Prior to closure of the dura the stay sutures on the inner surface of the reflected dura (Fig. 19) are removed and replaced by tack-up sutures which now are placed from the external surface of the dura (Fig. 20). The same figure also shows a dural stay suture placed in the center of the craniotomy opening which will later be brought through a drill hole in the center of the bone flap. Depending on the size of the craniotomy more than one central stay suture may be needed to prevent the formation of any extensive epidural accumulation of blood. The dural opening is closed using interrupted 0000 black silk sutures placed 2 mm apart. This will give a water-tight closure. Great care has to be exercised to accomplish this closure. Small openings left in the dura are prone to act as a valve and to allow the escape of cerebrospinal fluid which may lead to a persistent subgaleal accumulation. This is observed especially in infants. The same problem exists with small defects over the spinal dura. Because of this potential complication no catheter drainage of the intrathecal space is ever used. Admittedly it may be impossible to obtain a water-tight dural closure and in these instances a wider opening will not lead to this valve-like action and to the formation of a persistent pocket of cerebrospinal fluid. In every instance where the dura is intentionally left open a wide sheet of gelfoam or similar substitute is placed over the exposed area. The gelfoam is placed intrathecally at the margin of the dura.

The dural stay sutures are either brought through the same drill holes used for the wire to fasten the bone flap (Fig. 21) or sutured to the pericranium. The stay sutures should not be sutured to the galea. Over the inferior margin the stay sutures are tied to the temporalis muscle (Fig. 22) or brought through and tied over the temporalis muscle and fascia. In the latter case the sutures should only be tied when the bone flap is secured in place by wire sutures and the temporalis muscle and fascia incisions closed. Early tying of these stay sutures may result in breaking of the same in closing the temporalis muscle and fascia. The wire is fastened by twisting instead of tying a knot. This will permit additional tightening and readjusting of the firmness and the position of the bone flap. All burr holes are filled with cranioplasty, especially the important burr hole anterior to the inferior aspect of the superior temporal line of the frontal bone (Figs. 11, 12, 23 and 24). Over the anteroinferior aspect of the craniotomy the bony defect is also filled with cranioplasty material (methyl methacrylate) which will reestablish the previous osseous contour (Fig. 24). The temporalis muscle and fascia are each closed separately with the stitches in the temporalis fascia placed alternately in different distances from the cut edge to prevent splitting of the fascia. The galea is closed separately with interrupted sutures (Fig. 25). In infants inverted galeal stitches may be applied. At the time of closure of the scalp the assistant will again use the volar aspect

* Journal of N. S. 1962.

of the fingertips to control bleeding (Fig. 5) and push the skin edges together when the surgeon himself ties the galeal suture. The suction tip is held constantly at the most dependent part of the wound assuring good visualization of the tissue layers. Care should be taken to cut the galeal sutures short and this should therefore be done not blindly but under full visualization of the suture by suctioning and with slight separation of the skin margins. If a perfect galeal closure is obtained the skin sutures are necessary only to appose the edges without blanching of the skin thereby guaranteeing better healing. The skin sutures are placed about 1 cm apart (Fig. 26).

If all these steps as outlined in the closure of the craniotomy are strictly adhered to the use of epidural or subgaleal drains should not be necessary. Fine mesh gauze strips are placed over the incision which reduces the adherence of the coarser gauze to the incision which is advantageous when changing the dressing. Gauze fluffs are placed evenly over most of the entire hemicranium and an elastic gauze bandage is applied smoothly over the entire cranium. If the bandage is brought down below the suboccipital area it should be secure enough so that no adhesive tape is necessary to hold the bandage down. The surgeon stays with the patient until the endotracheal tube has been removed and the patient is placed in bed. He watches to prevent the patient from gagging on the endotracheal tube. The same holds true at the time of intubation. Straining should and can be prevented for it is markedly deleterious to the patient with increased intracranial pressure or with a tumor bed, and it may be disastrous when happening prior to closure of the dura. Postoperatively the position of the head and body of the patient in bed is in the same way handled by the surgeon and is analogous to the position on the operating table.

It is important to have constantly in mind the topographic three dimensional relationship of the patient's cranial, intracranial anatomy. The pertinent diagnostic x-ray pictures must be available and placed in full view on a lighted view box. Certain crucial instruments in aneurysmal surgery, for instance, the different clips, clip applier, ligature carrier, etc., are looked at and their presence verified by the surgeon himself. The same goes for the suction set-up. There should be two suctions working all the time and the whole length of the tubes to the collecting bottles and to the wall apparatus should be short and visible with one glance. Who does not know the frustration if the suction does not work at a crucial time and everyone is looking, pulling and plugging at endless tubes seeming to come and go from everyplace! The need of the correct position of the adjustable lighting during the operation is important. Getting used to a headlight will help immensely. The estimation of the blood loss is the surgeon's obligation. He knows how much irrigation fluid is mixed with the actual blood in the bottles. No blood is started without the surgeon's knowledge and there should be a regular exchange of information between the anesthetist and the surgeon regarding the patient's status during the operation. Where a change of personnel is unavoidable from time to time and the reliance on a constant crew is not possible, it teaches the surgeon to adhere strictly to all the above-mentioned facets.

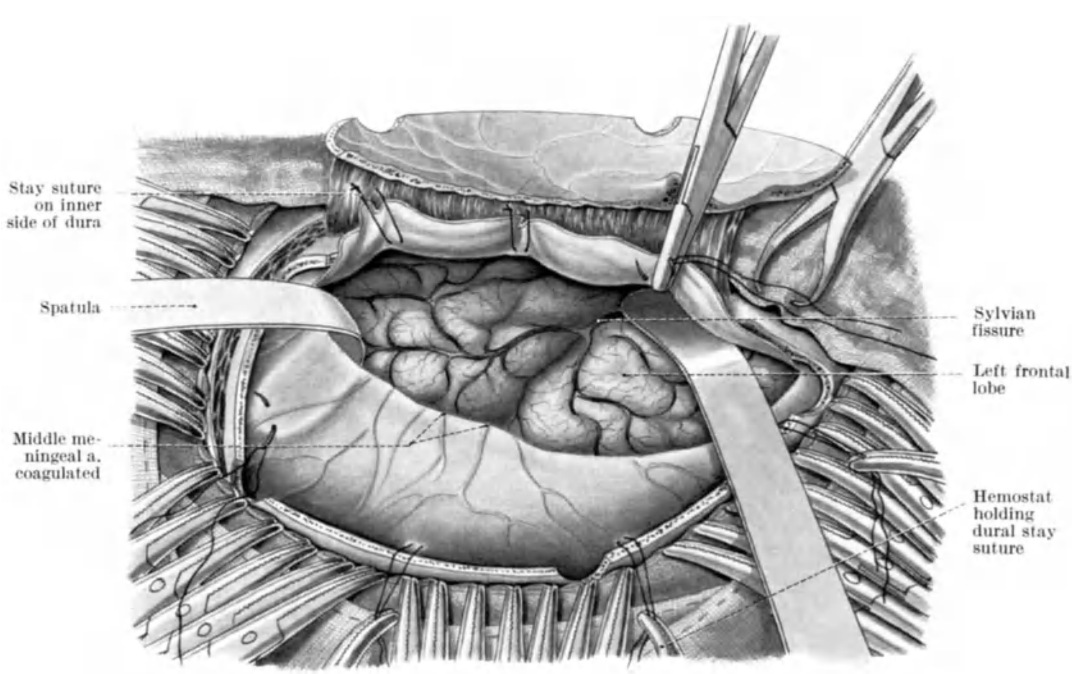


Fig. 19. Placement of initial stay sutures on dura to maintain exposure.
Observe: Spatula protecting brain while tenting dura.

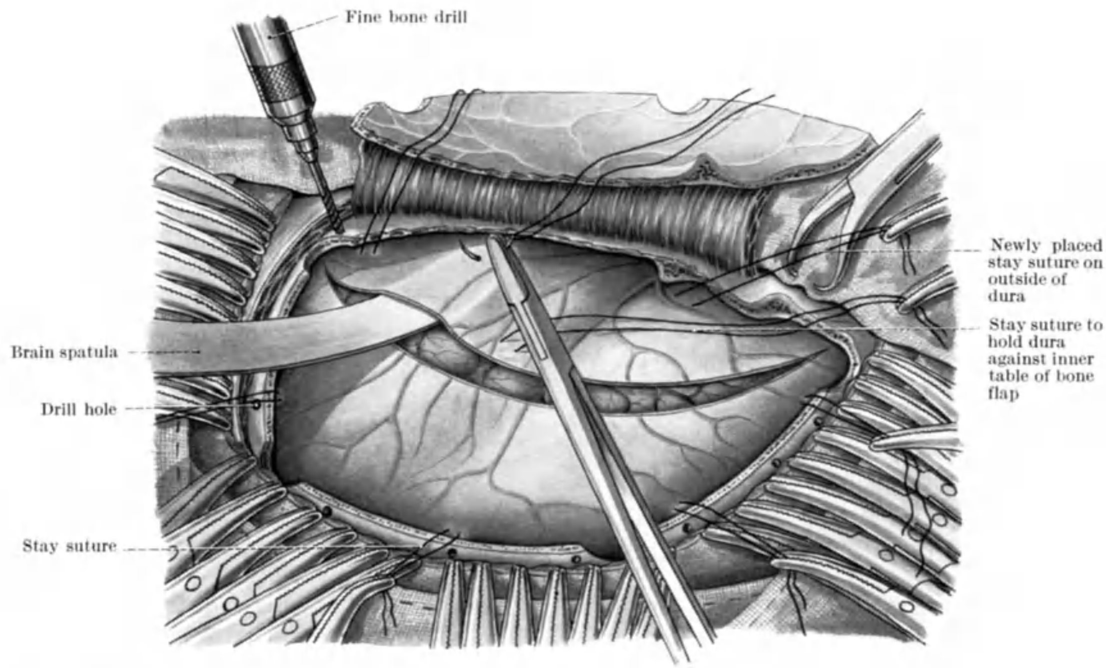


Fig. 20. First step in the closure of craniotomy.
Observe: Stay sutures on the inner side of the dura at the base of the dural flap were removed (compare with Fig. 19) and replaced by external stay sutures.

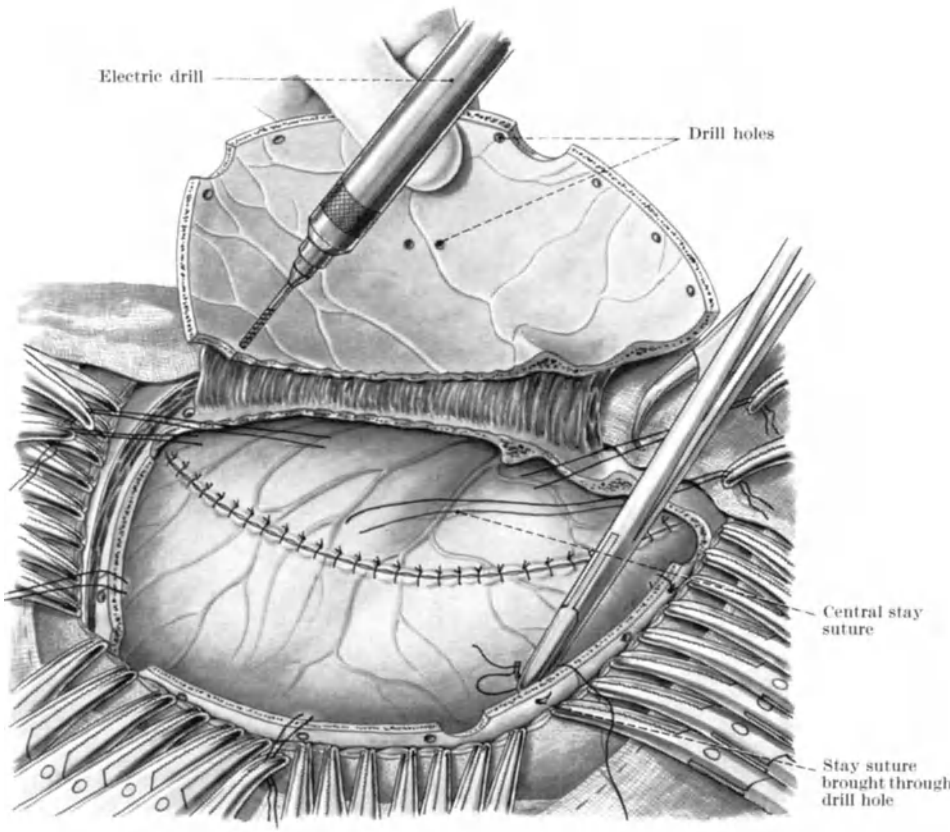


Fig. 21. Dural closure and final placement of stay sutures.

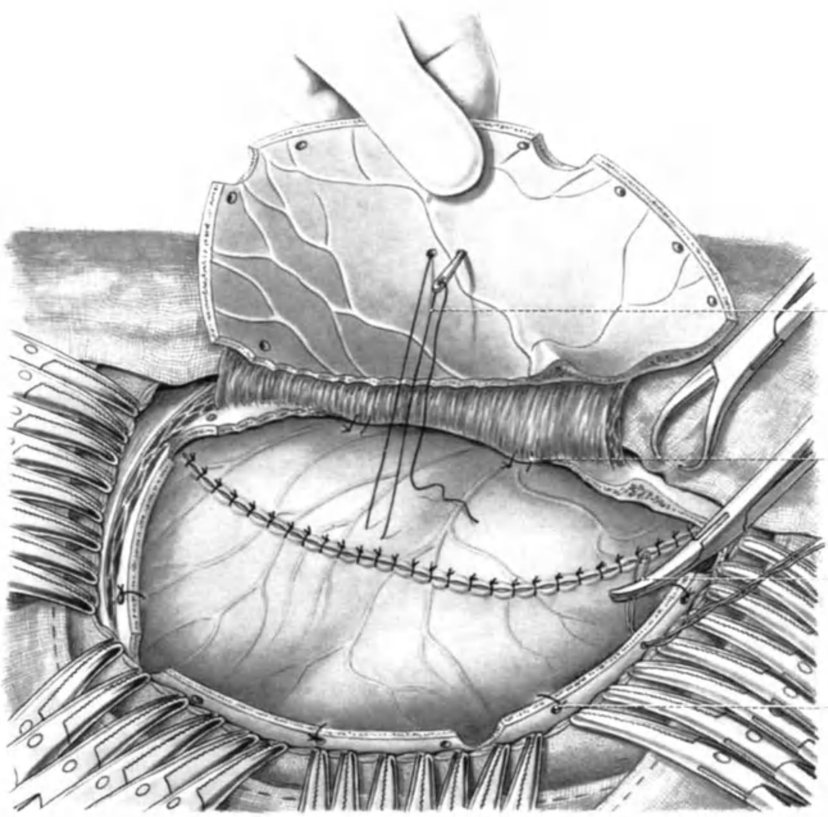


Fig. 22. *Observe:* As well as the peripheral stay sutures there is a stay suture brought through drill holes in the center of the bone flap.

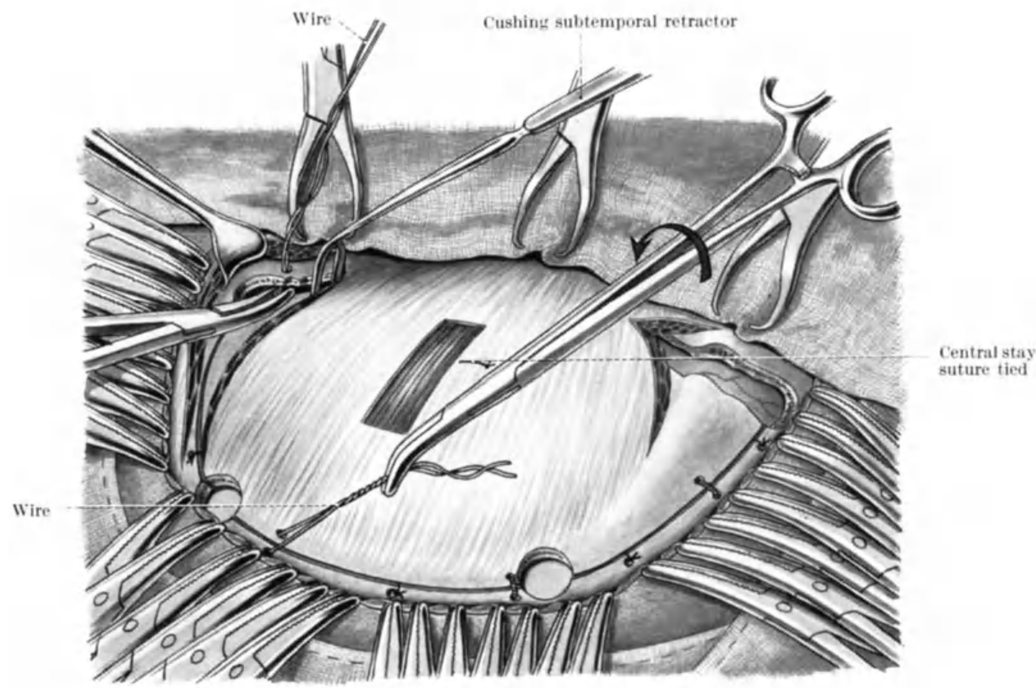


Fig. 23. Replacement of bone flap. *Observe:* Wire tightened by twisting.

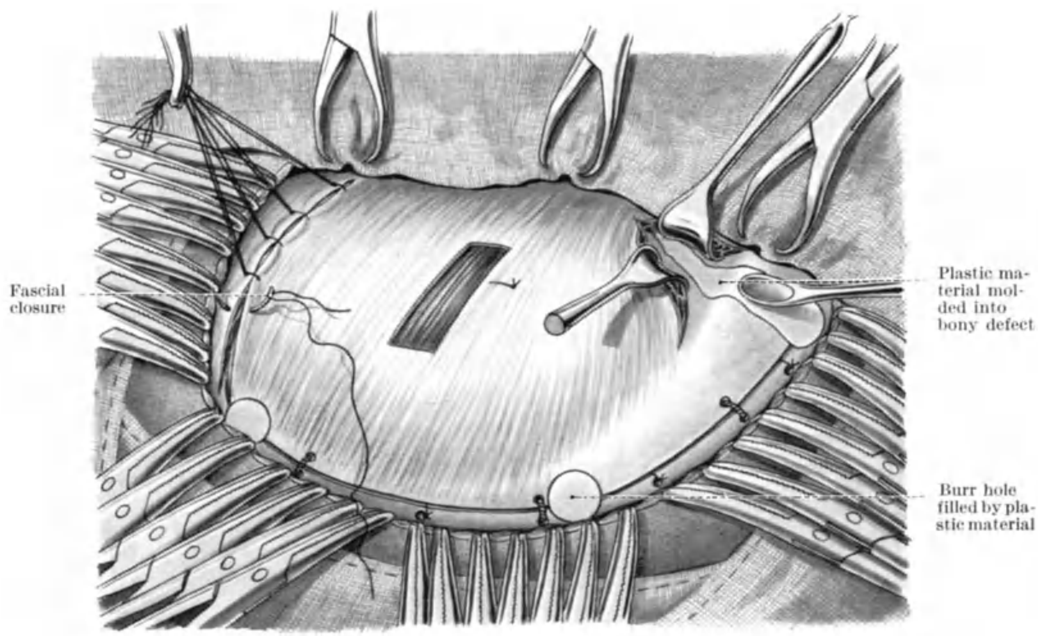


Fig. 24. *Observe:* Plastic material used here is methylmethacrylate.

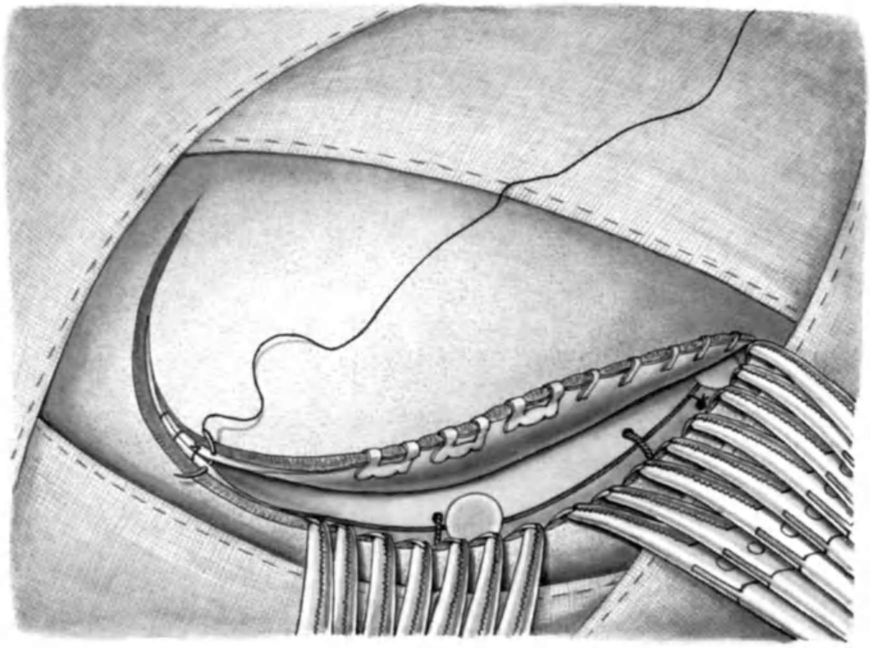


Fig. 25. Galeal closure.

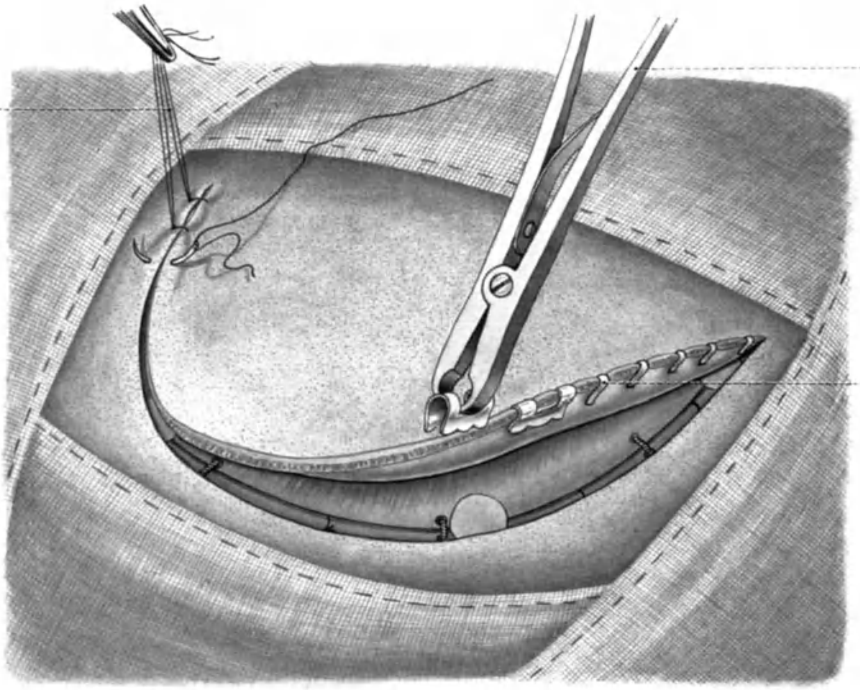


Fig. 26. Skin closure.
Observe: 1. For clarity gauze strips between skin and clips are not shown. 2. Michel clips over anterior part of incision.

Chapter II

Aneurysm, Anterior Part of Circle of Willis

1. Aneurysm of the Internal Carotid Artery

This chapter discusses aneurysms originating from the intracranial portion of the internal carotid artery where it emerges from the cavernous sinus below the anterior clinoid process to its bifurcation into the anterior and middle cerebral arteries. Cavernous sinus fistulae or aneurysms of the intracavernous sinus portion of the internal carotid artery are not described. These latter lesions are nearly always treated by trapping or embolization procedures and present no technical operative difficulties. The ligation of the ophthalmic artery which is indicated in the treatment of cavernous sinus fistulae will be presented in a separate section.

From the operative point of view we classify the aneurysms of the internal carotid artery in two important groups. In group one the aneurysm remains medial to the tentorial edge and in group two the dome of the aneurysm reaches lateral over the tentorial edge (Fig. 27). The operative approach to these two types of aneurysms is of fundamental difference. In Fig. 27 both types of aneurysms of the internal carotid artery are to be seen in a coronal section. The lateral extension of the aneurysm over the tentorial edge is of importance since, as the picture shows, the dome of the aneurysm is covered by the temporal lobe and the temporal lobe should therefore not be mobilized during the operative approach to prevent inadvertent bleeding. The preoperative angiogram in the straight anterior posterior view will give the exact position of the aneurysm and will clearly show to which of the two groups the aneurysm belongs. It is more important to know preoperatively whether or not the aneurysm reaches into the medial aspect of the temporal lobe than to know its relation to the origin of the posterior communicating artery.

Aneurysm of the Internal Carotid Artery Medial to the Edge of the Tentorium (Fig. 27, insert b). The example illustrated is a left-sided aneurysm and the patient's operative position is presented in Fig. 28a and b. A small frontal temporal craniotomy incision is made as shown in Chapter I, Figs. 2 to 19 and it is in aneurysmal surgery that we prepare the fascial sling from the temporal muscle fascia shown in Fig. 8. The brain spatula is introduced over the orbital surface of the left frontal lobe so that the left optic nerve and the arachnoid over the prechiasmatic cistern are visualized. This arachnoid is torn permitting the escape of cerebrospinal fluid (Fig. 29). The fluid is suctioned for several minutes providing additional visualization. Since the aneurysm we are to explore in this case is lying medial to the tentorial edge (Fig. 27, insert b), we are permitted to mobilize the tip of the temporal lobe without fear of causing renewed bleeding.

Mobilization of the temporal lobe is accomplished by carefully retracting the temporal lobe along the contour of the lesser sphenoid wing. The bridging veins are grasped by the smooth coagulation forceps (Fig. 30), coagulated and cut. The sectioning of the coagulated veins should be done closer to the brain than the dura. In the event the vein is cut without having completed the coagulation, it is always easier to coagulate a remaining venous stump than to coagulate the dura directly over a sinus (here the sphenoparietal sinus). Direct coagulation over the sinus can easily result in a dural defect into the sinus and bleeding. Furthermore, it is easier to control bleeding from the brain side. Fairly constantly a bridging vein goes from the temporal lobe to the cavernous sinus (Fig. 31). This vein should be located, coagulated and cut. Unintentional tearing of this vein may cause

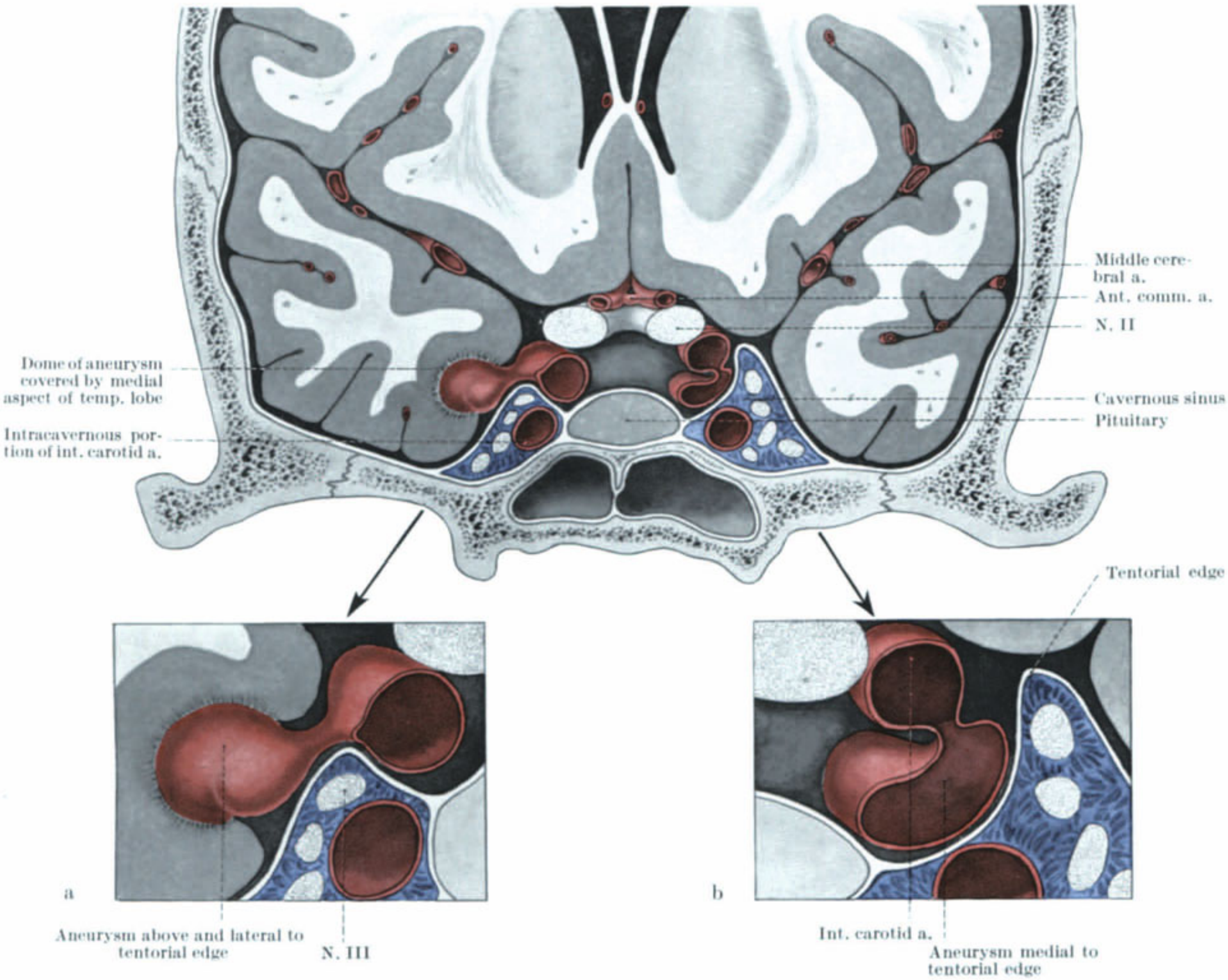


Fig. 27a and b. Schematic drawing showing the two important types of aneurysm of the supraclinoid portion of the internal carotid artery:

a The aneurysm reaching above and lateral to the tentorial edge.

b The aneurysm medial to and beneath the edge of the tentorium.

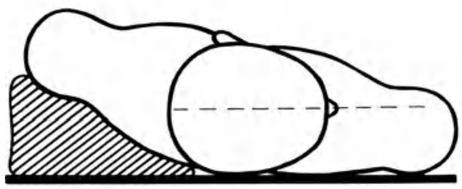


Fig. 28a.

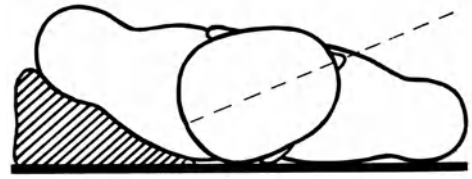


Fig. 28b.

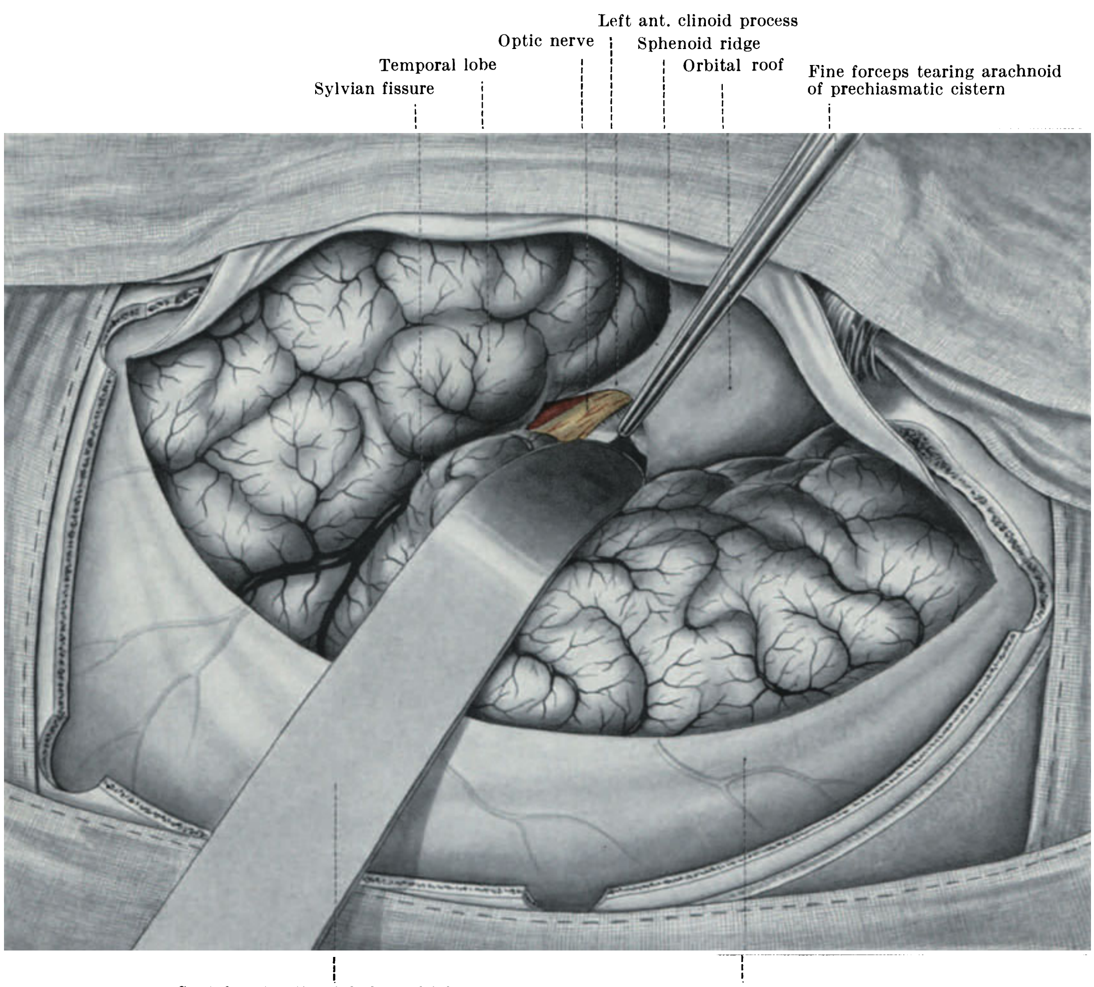


Fig. 29. Opening of prechiasmatic cistern permitting escape of cerebral spinal fluid and obtaining additional operative exposure.

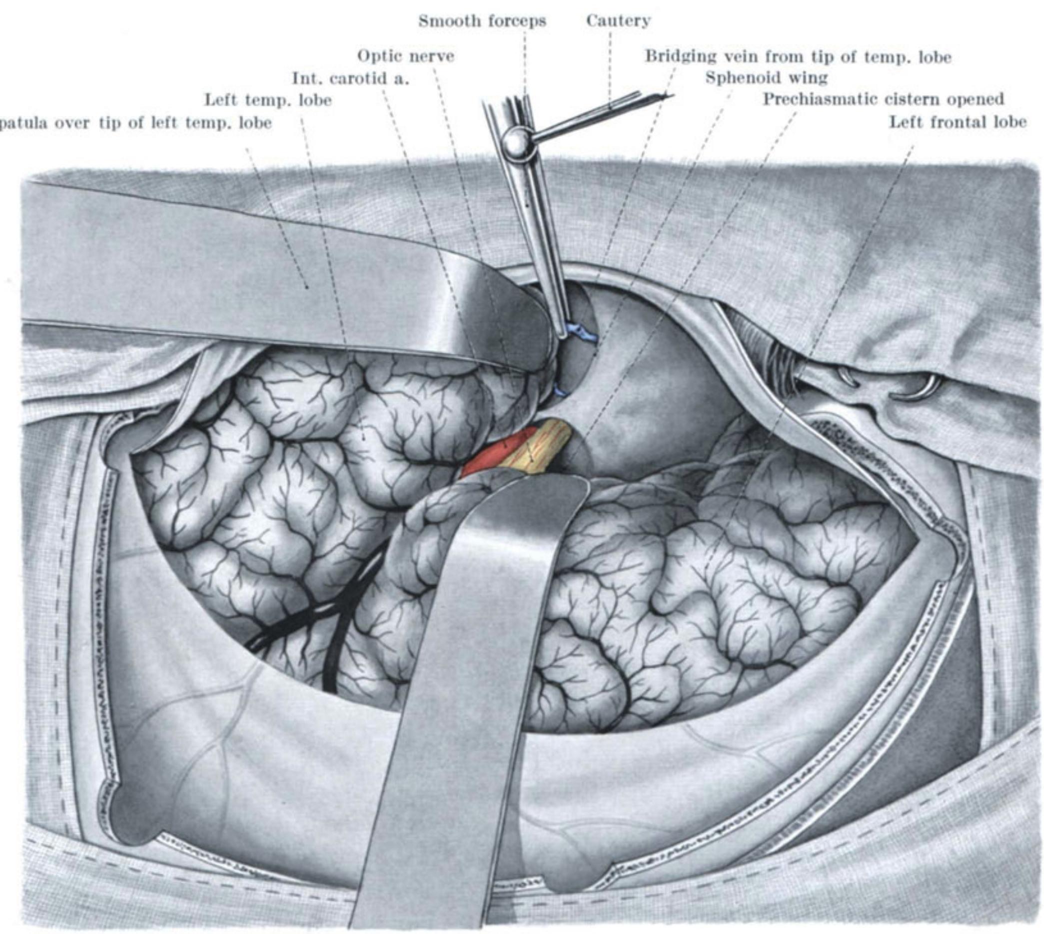


Fig. 30. Coagulation and cutting of bridging veins from temporal lobe tip to spheno-parietal sinus to mobilize the temporal lobe.

troublesome bleeding. If this vein had been coagulated flush at the dural side we have seen temporary third nerve paralysis since this nerve runs nearby in the cavernous sinus and, therefore, this is another reason for coagulation and sectioning of the bridging veins on the brain side. If a bridging vein, as seen in Fig. 32, continues to bleed on the dural side it is helpful to compress the dura lightly with a dural separator and coagulate (Fig. 33).

With retraction of the lobe and the temporal lobe tip, the internal carotid with the origin of the aneurysm can be seen covered by arachnoid (Fig. 34). At this stage of the operation, only the arachnoid of the prechiasmatic cistern had been opened. It is most important to leave the arachnoid over the aneurysm intact and to concentrate first on freeing the arachnoid over the internal carotid artery away from the aneurysm. In our presentation with the aneurysm having its origin at the inferior lateral aspect of the internal carotid artery, but not reaching over the tentorial edge, the arachnoid is freed from the medial side of the internal carotid artery between this artery and the optic nerve (Fig. 35). This figure also shows the beginning of the anterior and middle cerebral arteries freed of arachnoid. As a last step the arachnoid is freed from the base of the aneurysm being careful not to disturb any arachnoidal adhesions over the dome of the aneurysm (Fig. 36). If the size, configuration and position of the neck of the aneurysm has been verified by most careful probing with a fine blunt mastoid seeker or blunt nerve hook, the proper clip and clip applier can be chosen (Fig. 37). In the event the fine blunt nerve hook should ever get stuck while ascertaining the configuration of the base or neck of the aneurysm, it is better to release the instrument. After a few moments the instrument may be grasped again and usually the hold is then less forceful and the instrument may loosen. Repeating this maneuver will usually help in removing the instrument without tearing the neck of the aneurysm.

In Fig. 38 a rather large aneurysm of the left internal carotid artery is seen which has its base posteriorly and inferiorly and, as we will see later, the base or neck of this type aneurysm will not be amenable to simple clipping. In such cases the arachnoid is first removed on the middle and anterior cerebral arteries. Again the arachnoid is first removed away from the section of the internal carotid artery with the origin of the aneurysm. Figs. 38 and 39 show these steps — first the freeing of the arachnoid from the beginning of the middle and anterior cerebral arteries, then the freeing of the arachnoid from the internal carotid artery where it emerges medial to the anterior clinoid process. The last step is the removal of any arachnoidal coverings closest to the neck of the aneurysm. Always leave any adhesions leading to the lateral extent and fundus of the aneurysm undisturbed (Figs. 39 and 40)! A fine blunt hook (mastoid seeker) is used to outline the size and configuration of the base of the aneurysm (Fig. 40 and 41). The aneurysm presented here has a broad neck with its largest diameter in the longitudinal axis of the carotid artery. This neck cannot be clipped to obtain complete obliteration without using a special long clip. The danger of tearing into the neck is quite obvious if the clip is not applied approaching the neck in the longitudinal axis of the internal carotid artery. However, such an approach, inferiorly and posteriorly to the internal carotid artery, is nearly impossible without lifting the internal carotid artery thereby disturbing the fundus of the aneurysm causing rebleeding. This aneurysm should be ligated by a heavy silk ligature. Figs. 42 and 43 show the application of such a ligature using a simple ligature carrier. Fig. 44a, b, c, and d, show an alternate method. The important steps are that two ligatures are used around the internal carotid artery above and below the neck of the aneurysm. The two ligatures are tied together outside the cranial cavity. Only in the last step (Fig. 44d) is the ligature brought towards the neck of the aneurysm and tied, leaving any disturbance of the aneurysm, which may cause bleeding, to a time when we are ready and able to control the bleeding.

In the event the aneurysm is bleeding and the above-described operative maneuver is not successful, the use of the temporalis muscle fascial sling has proven most satisfactory. Preparation of this sling was given in Chapter I, Figs. 7 and 8. During the application of the fascial sling the sucker tip is constantly held over the bleeding site (Figs. 45 and 46).

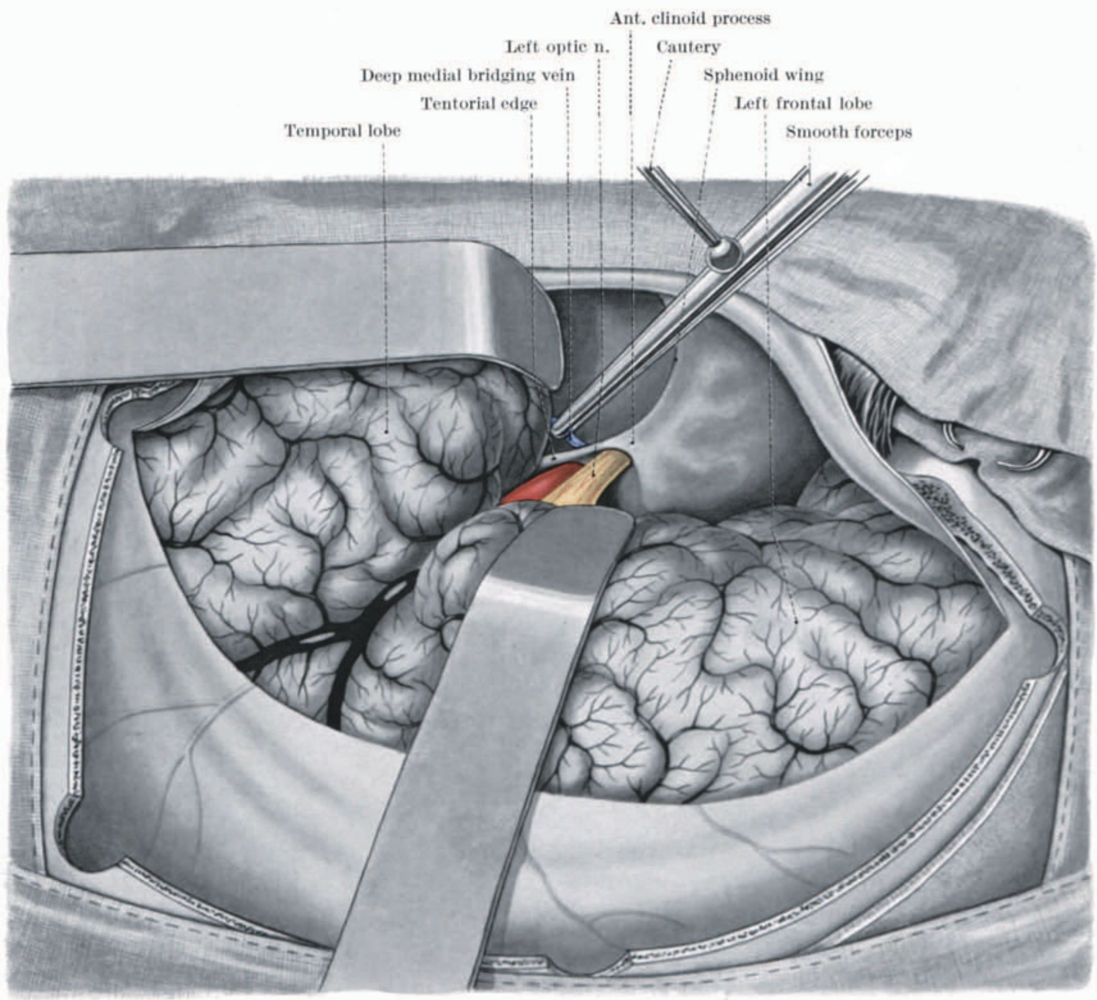


Fig. 31. Coagulation of deeper bridging vein from temporal lobe to sphenoparietal and cavernous sinus.

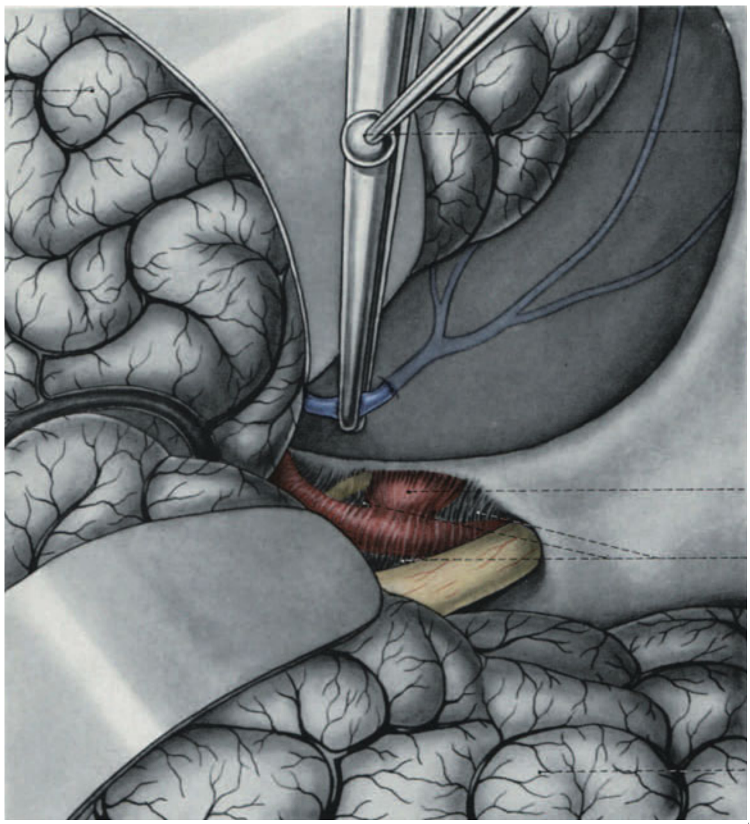


Fig. 32. Operative exposure of aneurysm medial and inside to the tentorial edge.
Observe: Aneurysm covered by arachnoid.

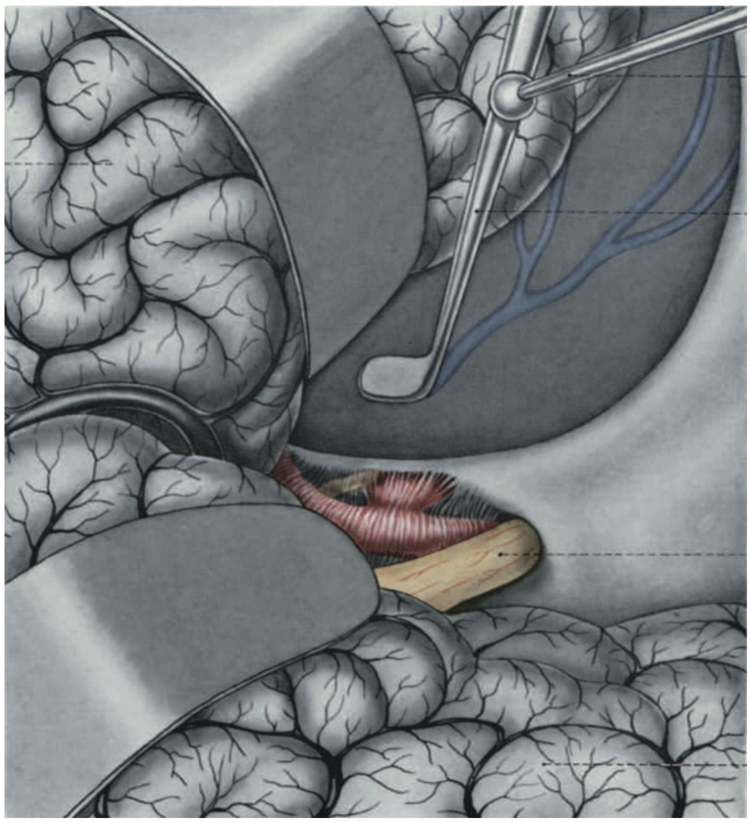


Fig. 33. Control of persisting bleeding from dura in middle fossa by *compressing* and coagulating within the middle fossa.

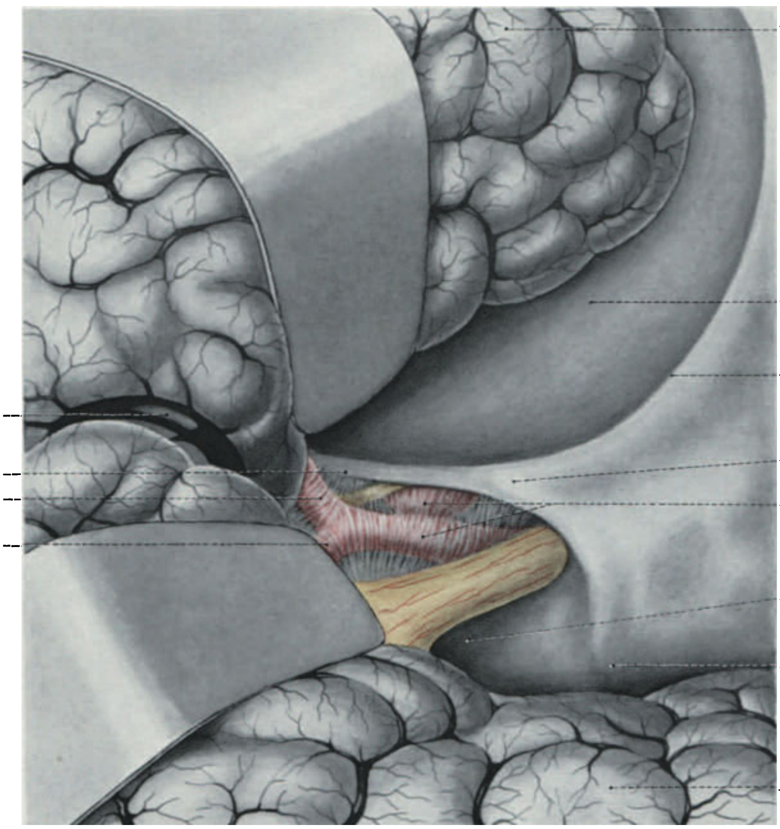


Fig. 34. *Observe:* Only the arachnoid of the prechiasmatic cistern has been opened at this stage of the operation.

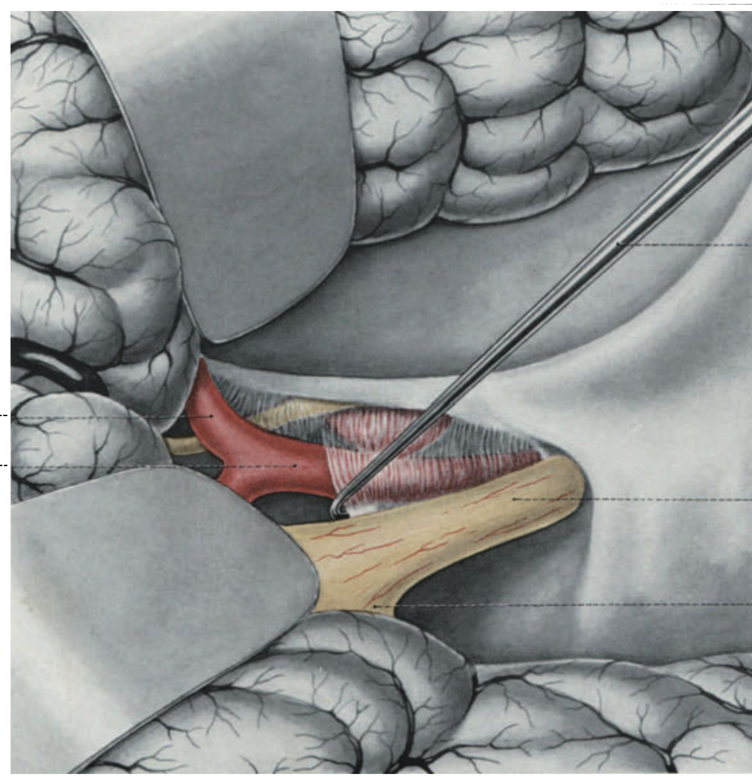


Fig. 35. Removal of the arachnoid between int. carotid a. and optic nerve. *Observe:* The arachnoid removed here is away from the neck of the aneurysm.

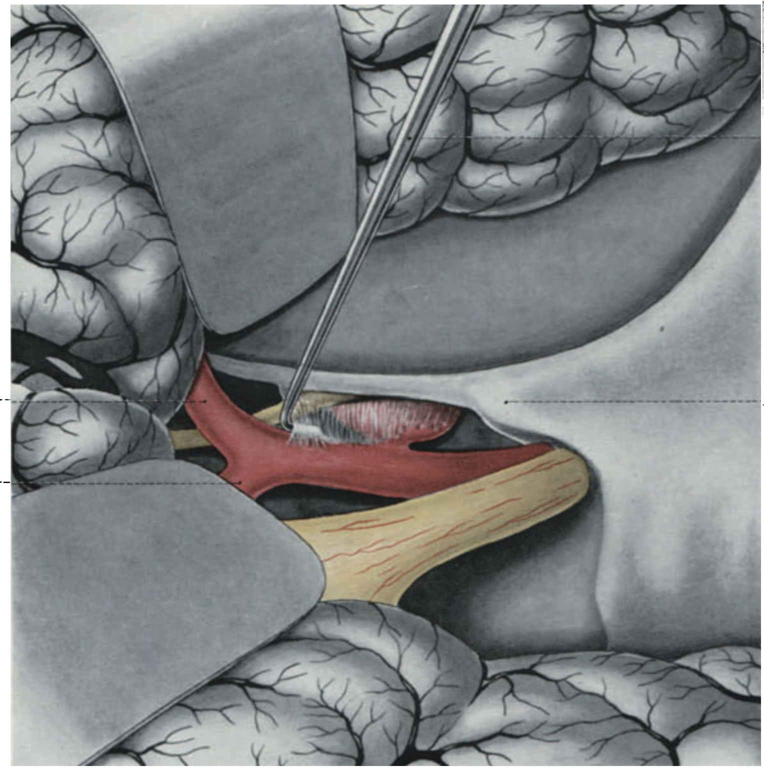


Fig. 36. Exposing neck of aneurysm.
Observe: 1. Arachnoidal adhesions closest to neck of aneurysm are removed as the last step in the exposure.
2. Dome or fundus of aneurysm is left undisturbed.

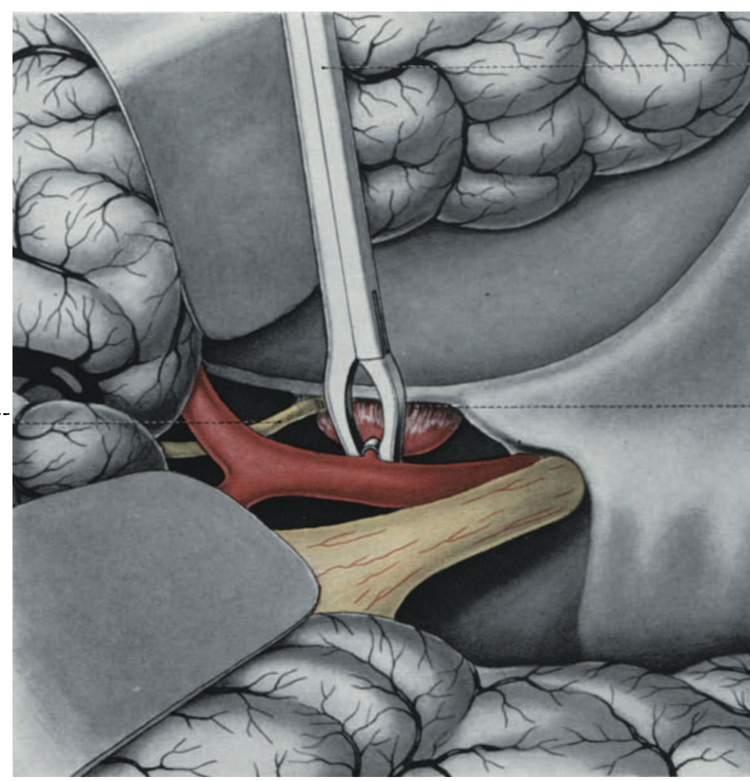


Fig. 37. Clipping of aneurysm.

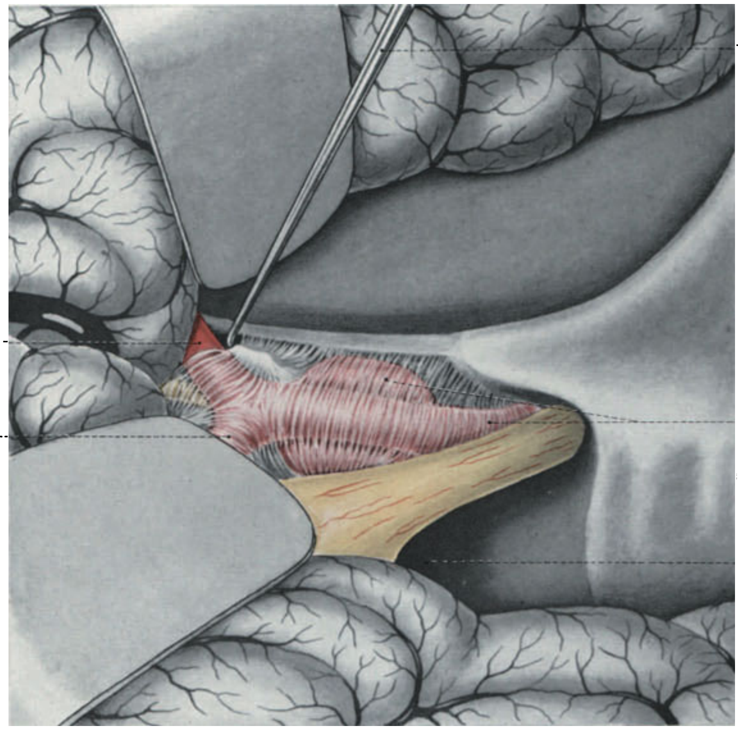


Fig. 38. Aneurysm of int. carotid artery medial to tentorial edge pointing posteriorly and inferiorly.

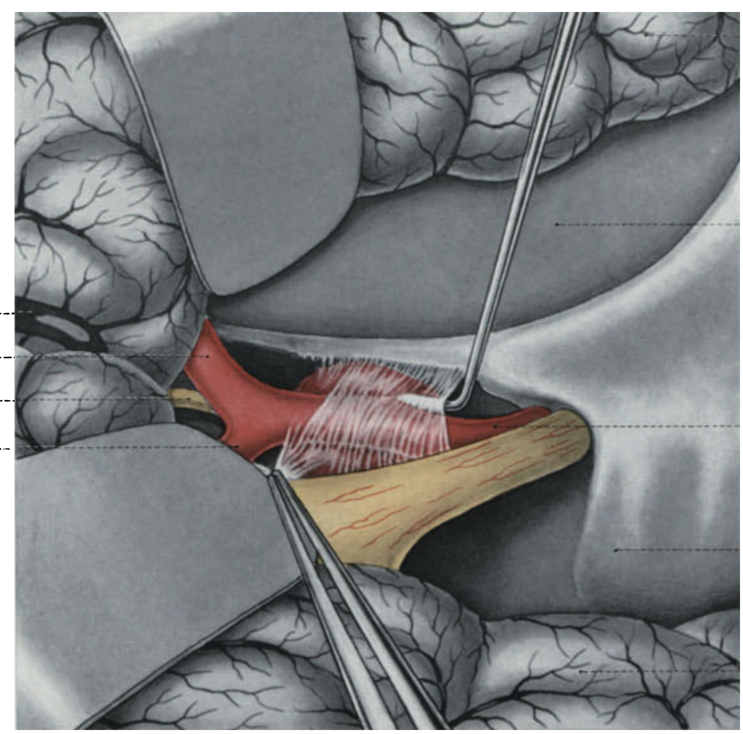


Fig. 39. Freeing of arachnoid directly over superior aspect of the internal carotid artery.
Observe: Origin of aneurysm is on the posterior inferior side of the artery.

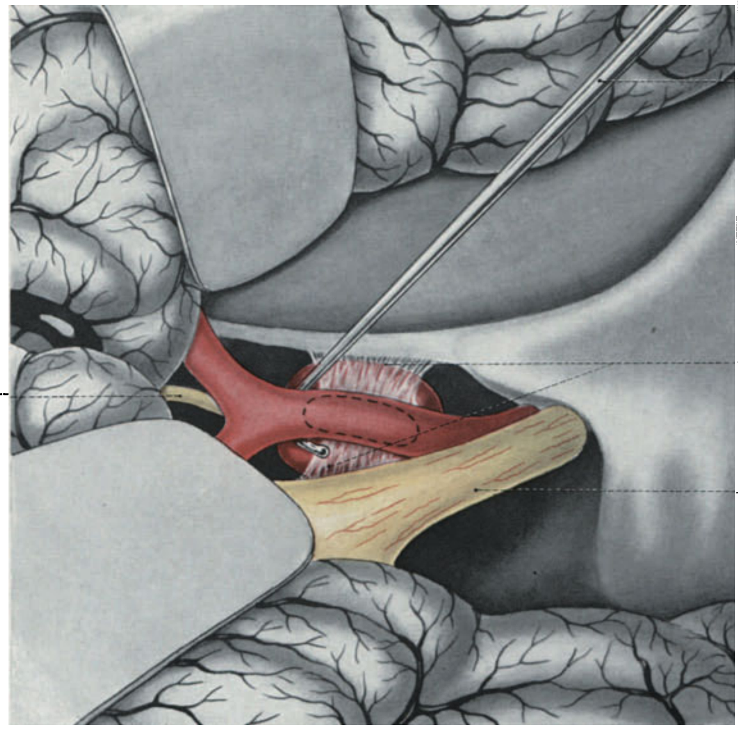


Fig. 40. *Observe:* 1. Arachnoidal adhesions are freed from the origin of the aneurysm but left intact over lateral extensions and fundus of the aneurysm. 2. Size and configuration of "neck" of aneurysm is obtained by probing with fine blunt hook. 3. Interrupted line outlines "neck" (origin) of aneurysm of internal carotid artery.

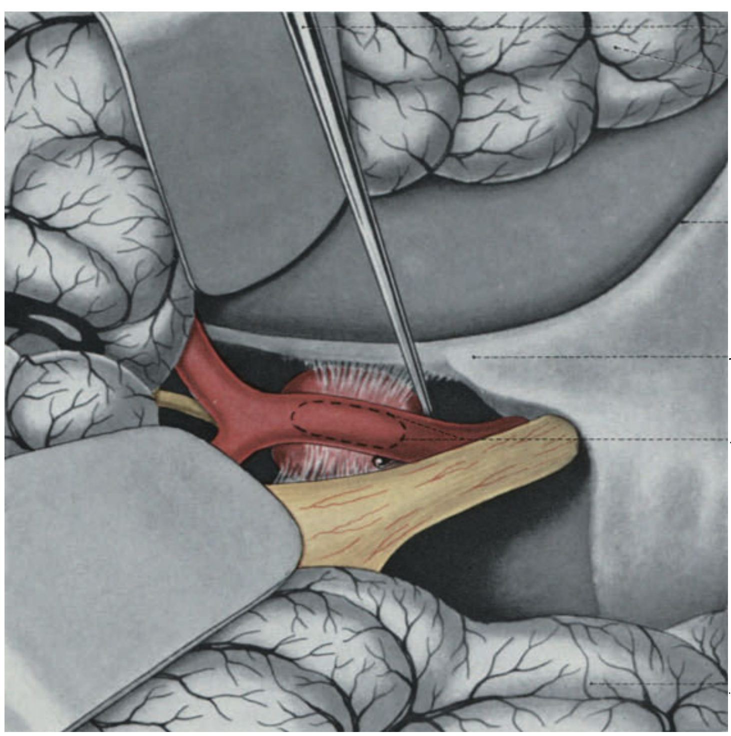


Fig. 41. Aneurysm of internal left carotid artery with dome of aneurysm directed posteriorly and inferiorly. *Observe:* 1. Aneurysm medial to tentorial edge. 2. Size and configuration of aneurysmal "neck" does not permit simple clipping in this case.

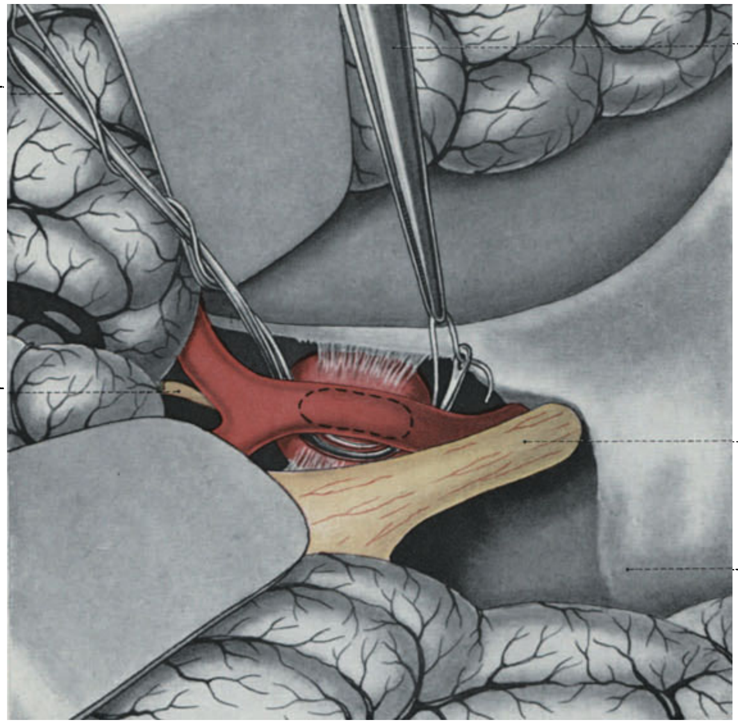


Fig. 42. Application of heavy silk ligature to aneurysm of internal carotid artery.

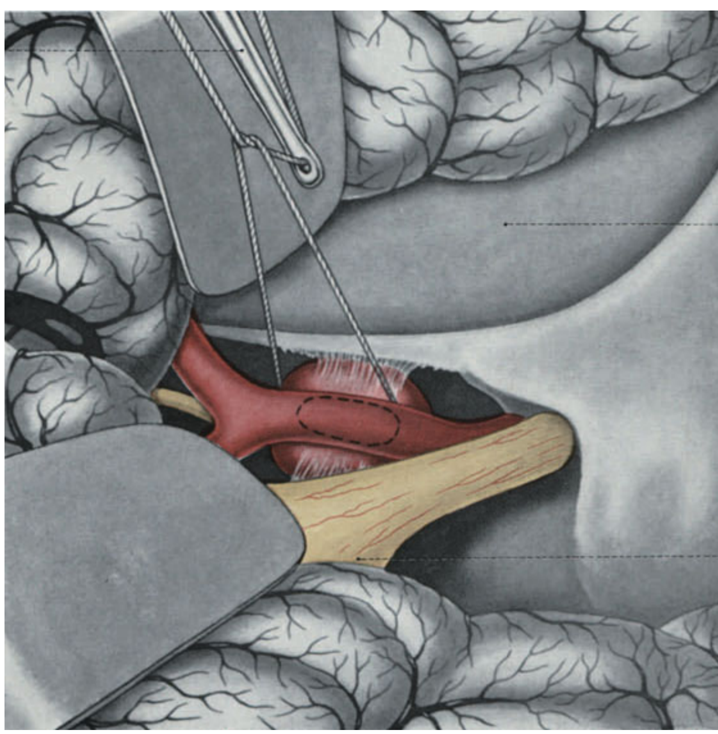


Fig. 43. *Observe:* First a single overhand knot is made high outside the cranial cavity and carried down by the knot tier.

The suction should be strong enough to keep the operative field clear but not too strong to cause unwanted tearing of the remaining aneurysmal walls. It is the tendency of the inexperienced surgeon in the event of sudden rupture with its vigorous bleeding to want to ligate the internal carotid artery. There is still time to do this but not yet. Patience and experience will show that if the sucker tip is gently moved around, the aneurysm will move partly into the sucker. It is often possible by gently guiding the sucker tip to position the aneurysm folded against the internal carotid artery and to arrest or slow down the bleeding. Leading the fascial sling around the aneurysm and internal carotid adds to enfolding and compressing the aneurysmal wall. Every step is done slowly and without force. Depending on the position of the aneurysm of the internal carotid artery and the position of the sucker to keep the field fairly clean, the fascial sling is brought around either from lateral or medial or from distal or proximal part of the internal carotid artery. The sling is clipped to itself only after the sucker has been removed and it is ascertained how strong, tight and in which direction the sling has to be pulled to assure hemostasis without obliterating the carotid artery itself (Fig. 47 and 48). It shall be remembered that the sling is always guided deep enough at the beginning of its insertion around the aneurysm to include the posterior communicating artery wrapped up within the sling. This deep insertion is important when bringing the fascial sling from the distal part or bifurcation end of the internal carotid artery. After application of the sling the entire structure can be encased in fast setting methyl methacrylate as will be described later on.

Aneurysm of the Internal Carotid Artery with the Aneurysm Extending Lateral to the Tentorial Edge. As stated previously it is this type of aneurysm where one does not mobilize the tip of the temporal lobe nor are the bridging veins coagulated and sectioned. Fig. 49, insert a, shows the aneurysm extending laterally and the dome of the aneurysm embedded into the medial aspect of the temporal lobe. Because of its importance, the same relationship is demonstrated in a view from above (Fig. 50) and another view (Fig. 51) is given showing the base of the brain and the Circle of Willis with an aneurysm of the left internal carotid artery, the dome of which is adherent to the uncus of the temporal lobe. Figs. 49, 50 and 51 reveal clearly the hazard of causing rebleeding of the aneurysm if the temporal lobe is mobilized.

An operative view of the left internal carotid artery aneurysm extending just slightly over the tentorial edge is seen in Fig. 52. In this picture the relationship of the aneurysm to the third nerve is of interest, explaining the frequent oculomotor deficits prior to rupture. Another similar aneurysm is seen in Fig. 53. Here, a spatula is placed over the temporal tip just to show how any further retraction would certainly cause breakage of the adhesions formed over the dome and, most likely, unwanted bleeding. Besides the difference of not touching the temporal lobe in this operative maneuver the exposure and obliteration of the neck of the aneurysm extending over the tentorial edge is the same as given in the preceding paragraphs.

2. Aneurysm at the Bifurcation of the Internal Carotid Artery

The aneurysm at the bifurcation of the internal carotid artery in our experience is amenable by clipping in about 60 per cent of cases. The remaining have been wrapped with fine gauze soaked in fast setting methyl methacrylate or encased by the fascial sling.

The position of the patient for craniotomy is the same as shown in Chapter I. The prechiasmatic cistern is exposed and opened to gain more space while aspirating cerebrospinal fluid (Fig. 29). Since the dome of the aneurysm is either covered by the frontal or temporal lobe or not infrequently by both lobes where the two meet in the Sylvian fissure, we are most careful with retraction of the lobes. Again the angiographic study with perfect positioning will give the relationship of the aneurysm to its surrounding structures. In the case presented the aneurysm points towards the left frontal lobe (Fig. 54) and leans in the

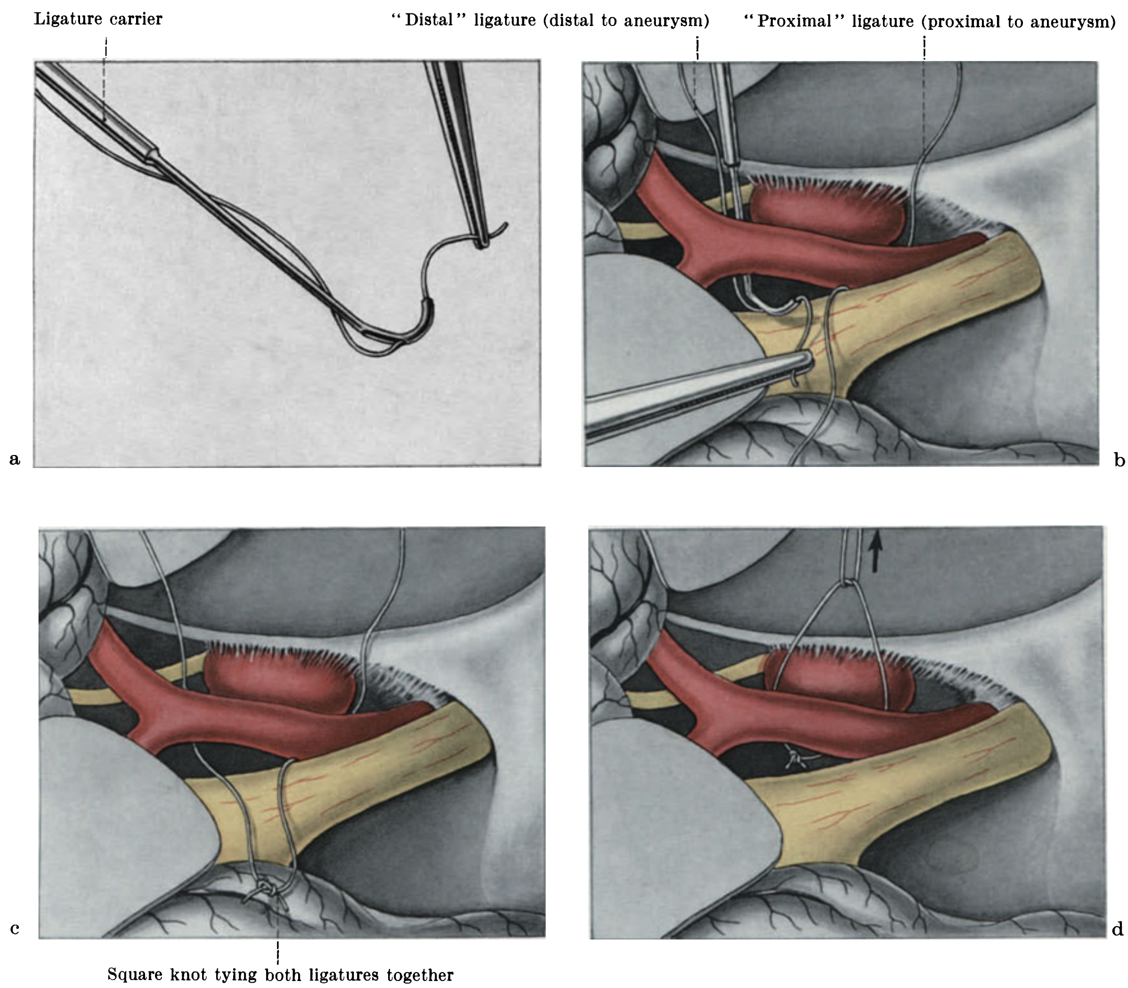


Fig. 44a—d. Alternate method of ligature placement.
Observe: Fig. b both ends of each ligature are long enough to be brought outside the cranial cavity to facilitate tying.

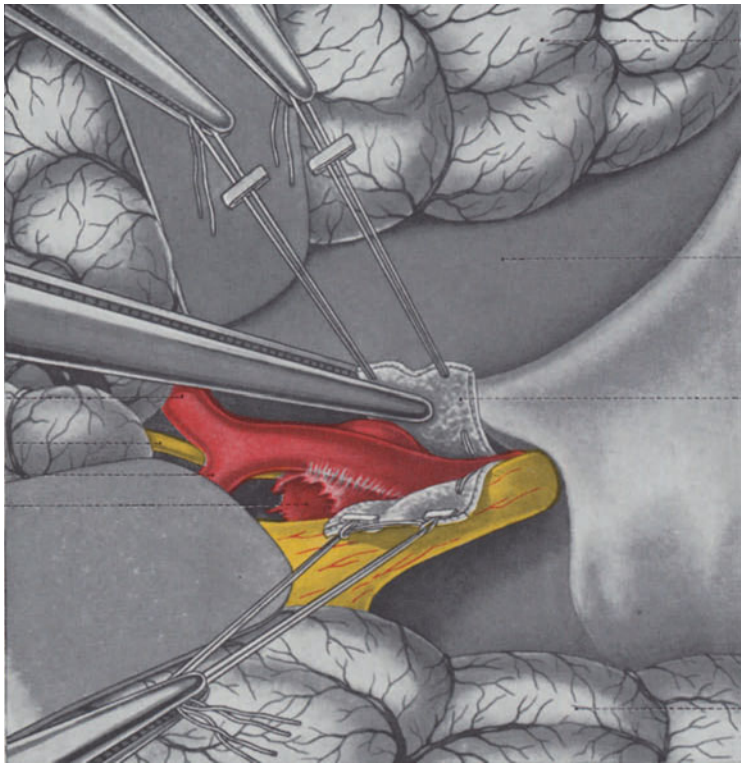


Fig. 45. Application of fascial sling in ruptured bleeding aneurysm of internal carotid ar without obvious clippable neck.
The preparation of the fascial sling is shown in Fig. 7 and Fig. 8.

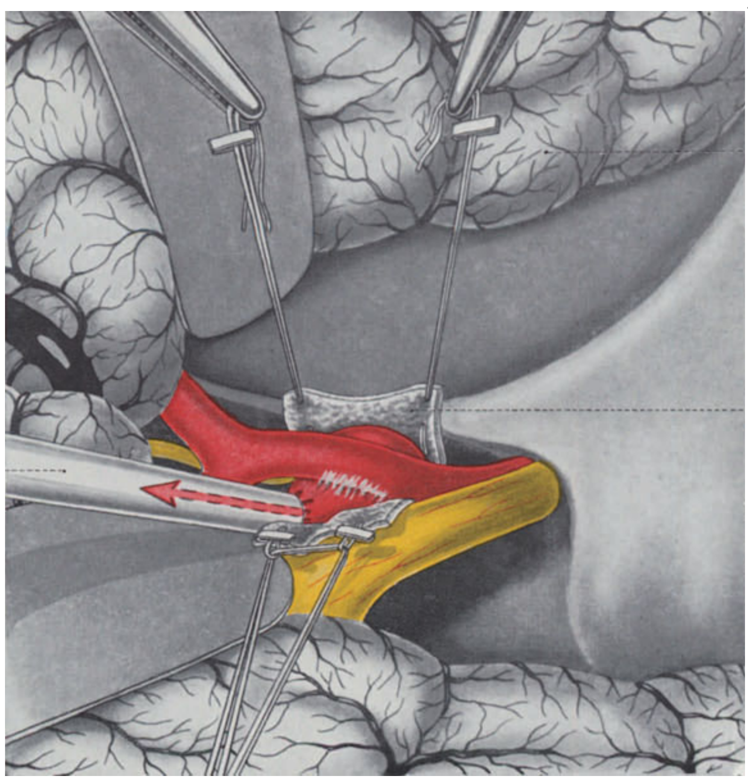


Fig. 46. Clearing of operative field during application of fascial sling to bleeding aneurysm of internal carotid artery.

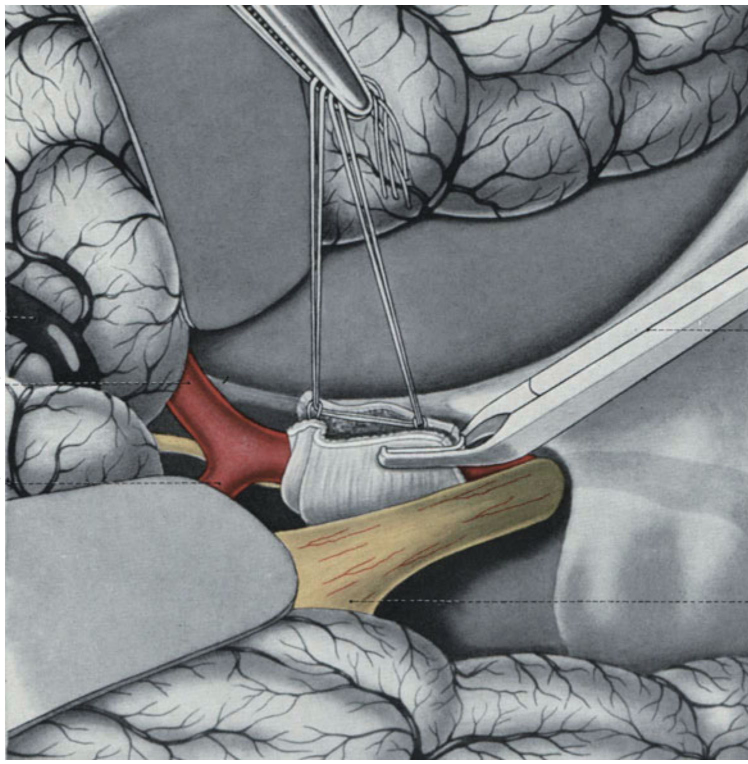


Fig. 47. *Observe:* Circumferential fascial sling is held and clipped firm enough to control the hemorrhage without obliterating the internal carotid artery.

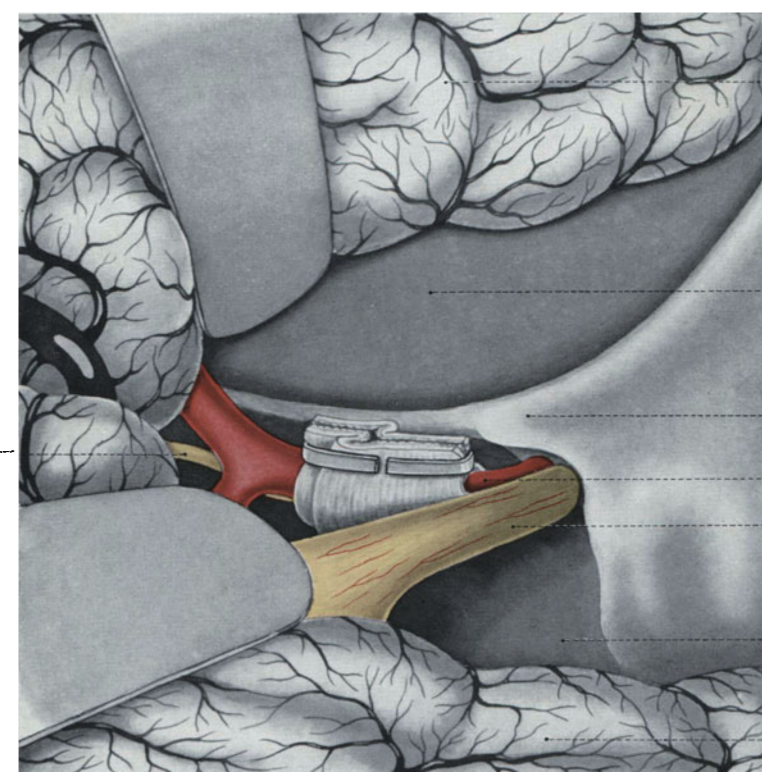


Fig. 48. Obliteration of aneurysm of internal carotid artery by fascial sling.

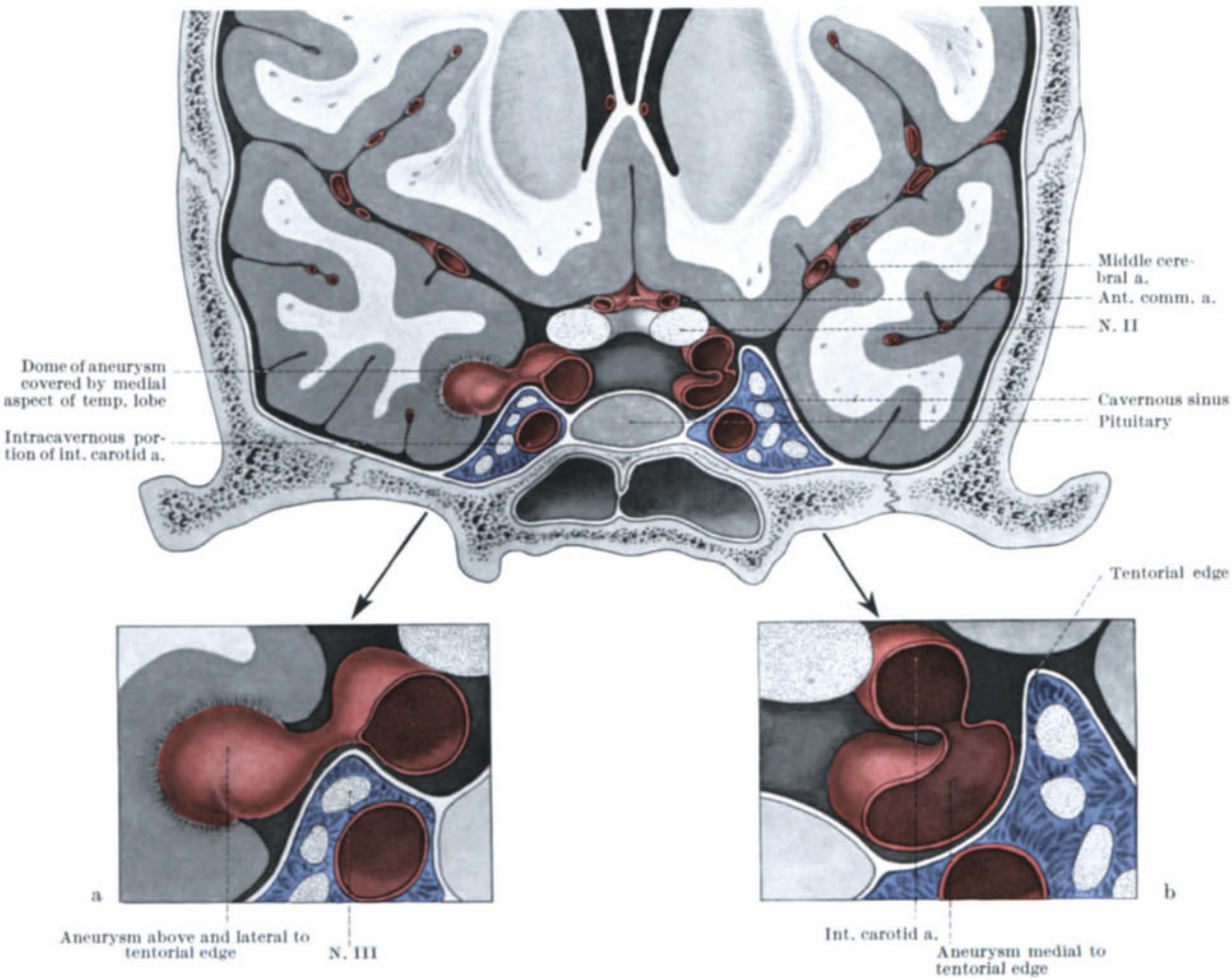


Fig. 49a and b. Schematic drawing showing the two important types aneurysm of the supraclinoid portion of the internal corotid artery:

a The aneurysm reaching above and lateral to the tentorial edge.

b The aneurysm medial to and beneath the edge of the tentorium.

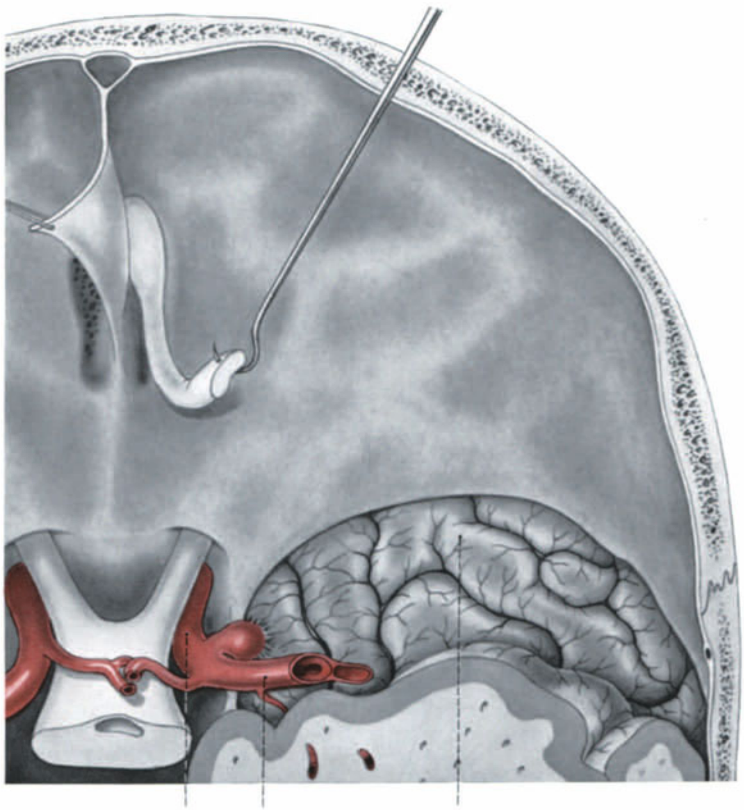


Fig. 50. Aneurysm of right internal carotid artery.
Observe: 1. Aneurysm extending over tentorial edge. 2. Dome of aneurysm adherent to temporal lobe. 3. Right frontal lobe removed.

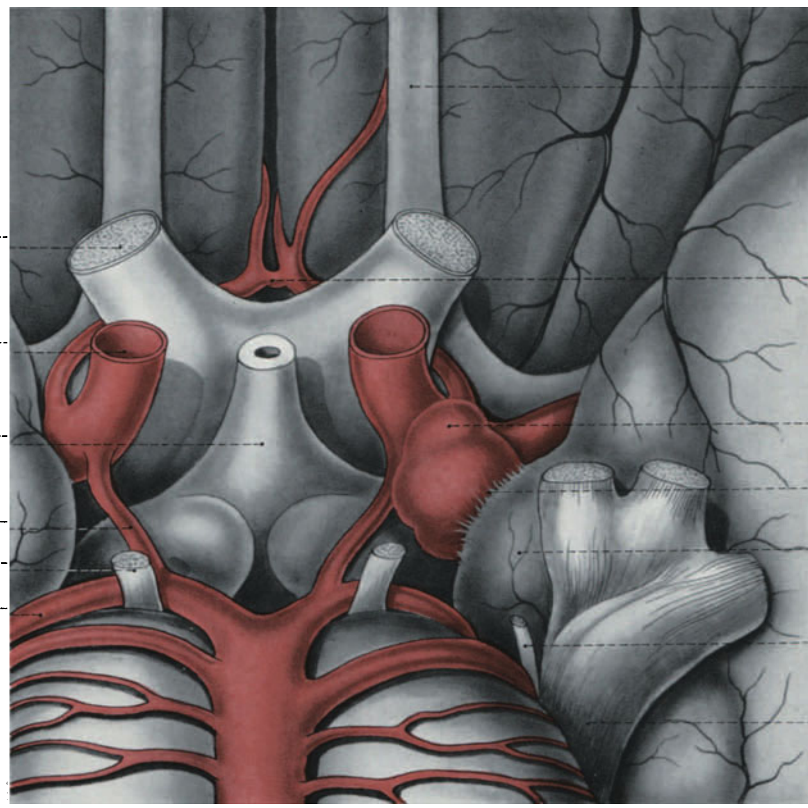


Fig. 51. View of base of brain with aneurysm of left internal carotid a. situated lateral to the tentorial edge and the dome of the aneurysm adherent to medial aspect of the temporal lobe.

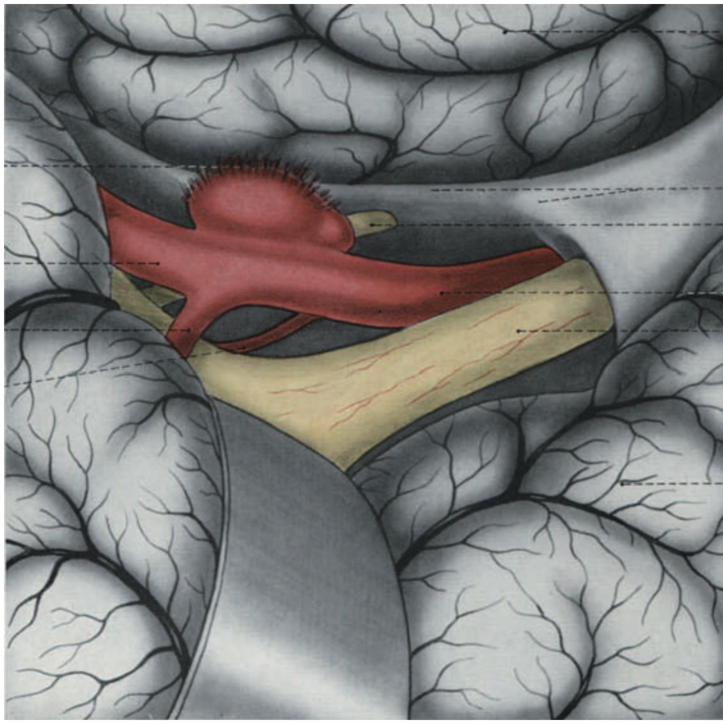


Fig. 52. Operative view of internal carotid artery aneurysm pointing laterally.
Observe: Arachnoidal adhesions over dome of aneurysm are left undisturbed.

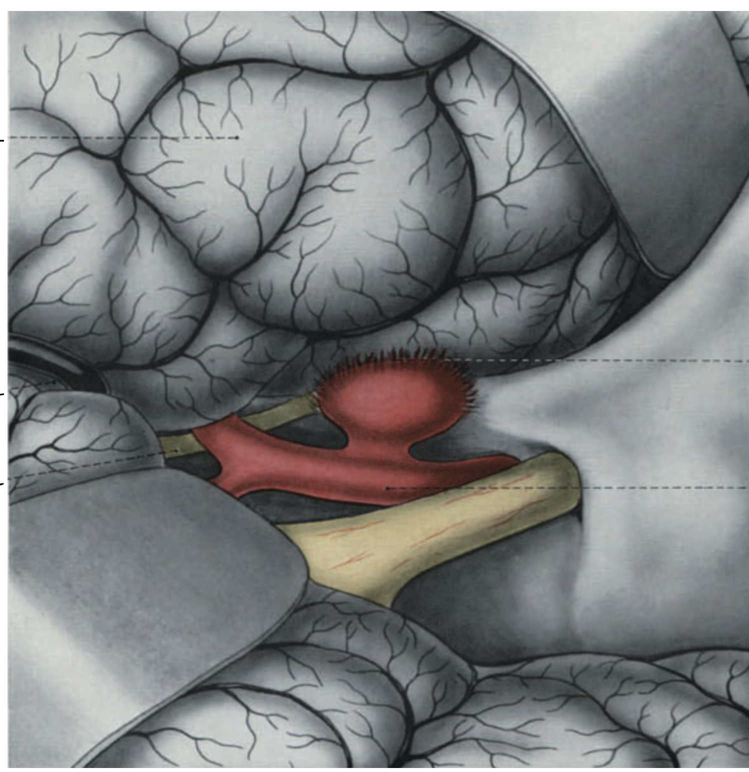


Fig. 53. Aneurysm of int. carotid artery pointing laterally and above the tentorial edge.
Observe: Traction on temp. lobe would break adhesions over dome of aneurysm causing unwanted rupture.

direction of the anterior cerebral artery. We, therefore, have to be most careful with the retractor over the frontal lobe. Freeing of the arachnoid starts from where the internal carotid artery comes into view medial to the anterior clinoid process and lateral to the optic nerve. In Fig. 55 all the arachnoid covering has been removed except around the neck and all coverings are left intact between the dome of the aneurysm and the frontal lobe. The surgeon should hold the important retractor over the frontal lobe himself while he frees the neck of the aneurysm with a fine blunt nerve hook. In this way he can feel the strength of the adhesiveness between the aneurysm and the covering brain and can immediately relax the spatula if freeing of the adhesions about the neck causes on occasion unwanted forceful tearing. Here it may be mentioned that the arachnoid is not torn by lifting it alone but by lifting slightly and then rotating the nerve hook until the separating is accomplished. While turning the nerve hook it is guided in the direction of the dome of the aneurysm to prevent pulling the aneurysm away from its protective covering. If the surgeon needs both his hands to free the aneurysmal base it has been found helpful to use a self-retracting retractor over the crucial frontal lobe, as in the case presented. The assistant usually cannot see and the tendency to move the spatula is great. This is especially true of the inexperienced assistant who can hardly imagine how important he can be in helping or contributing to a disaster.

In Fig. 57 a large aneurysm at the bifurcation of the left internal carotid artery can be seen. The anterior cerebral artery appears to come right out of the aneurysm itself. No clipping could possibly be done in this case as seen in Fig. 56. This type of aneurysm is handled by encasement which will be discussed in the next section, p. 48.

Over the last years it appeared advisable to encase the aneurysm as seen in Fig. 56 even after successful clipping or tying has been accomplished. Especially of the aneurysm at the bifurcation of the internal carotid artery where the aneurysm sits directly over the main force of the blood stream has it been observed that a continuous enlargement below the clip has developed some time later. A clip having been applied over the neck appeared then to sit on the fundus of a newly formed aneurysm. Encasement in fast setting methyl methacrylate will prevent this from occurring.

3. Aneurysm of the Middle Cerebral Artery

Most of the aneurysms of the middle cerebral artery are to be found at the first major division of the middle cerebral artery which is distal to the small perforating arteries. These small perforators (also called lenticulostriate, thalamostriate or thalamolenticular arteries) leave the middle cerebral artery over the posterior superior surface of the pars sphenoidalis. These small important vessels emerge from the middle cerebral artery either in bundles or separately and may, before entering the lateral part of the anterior perforate substance, form a loop which hangs anteriorly over the pars sphenoidalis of the middle cerebral artery. The loop formation occasionally comes forward and extends quite anteriorly where the Sylvian fissure opens and therefore is in danger of injury. It is important to avoid tearing these fine vessels while exposing the middle cerebral artery.

The example given is a left-sided aneurysm of the middle cerebral artery situated distally to the pars sphenoidalis of the middle cerebral artery. The exact anatomical position is at the limen insulae. The position of the patient for the craniotomy is the same as shown in Chapter I. After opening the dura the next steps are the same as seen in Figs. 29 to 31. The internal carotid artery is freed from its leptomeningeal covering, starting where it emerges medial to the anterior clinoid process, and exposed distally to the bifurcation. One spatula lifts the frontal lobe and the other the temporal lobe whose bridging veins had been coagulated and sectioned (see p. 25). In Fig. 58 the left Sylvian fissure is partially opened and most of the pars sphenoidalis of the middle cerebral artery is freed from the leptomeningeal covering. A fine blunt nerve hook or mastoid seeker is always kept anteriorly and inferiorly to the middle cerebral artery while removing the arachnoid

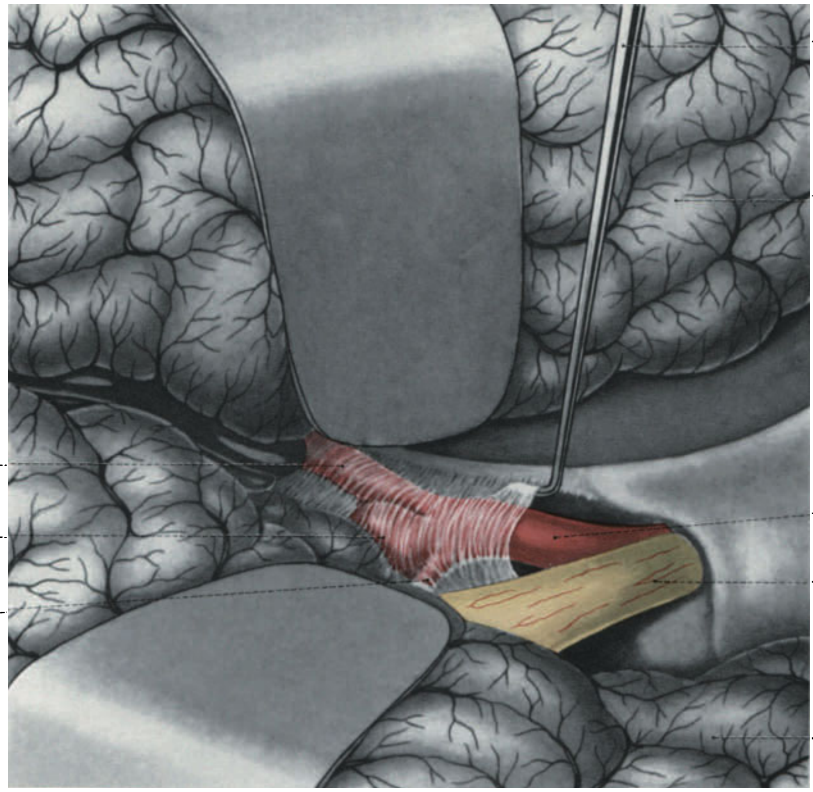


Fig. 54. Operative view of aneurysm at bifurcation of left internal carotid artery.

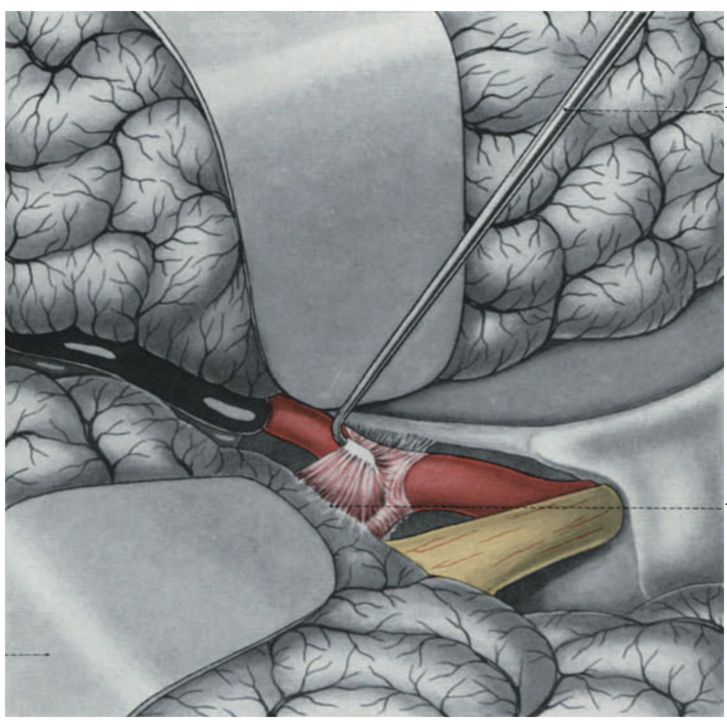


Fig. 55. Exposure of the neck of aneurysm at bifurcation of internal carotid artery.
Observe: Avoidance of exposure of dome of aneurysm.

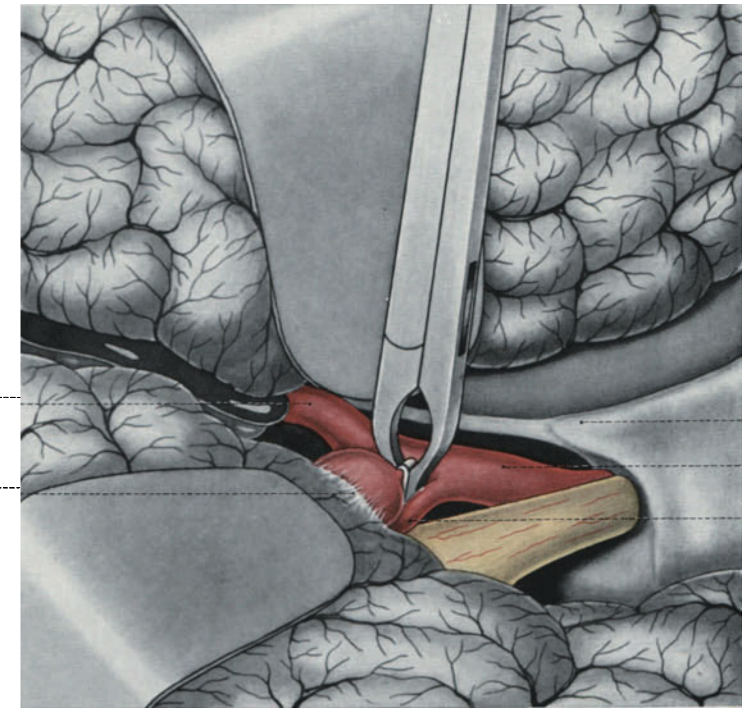


Fig. 56. Clipping of aneurysm at bifurcation of internal carotid artery.

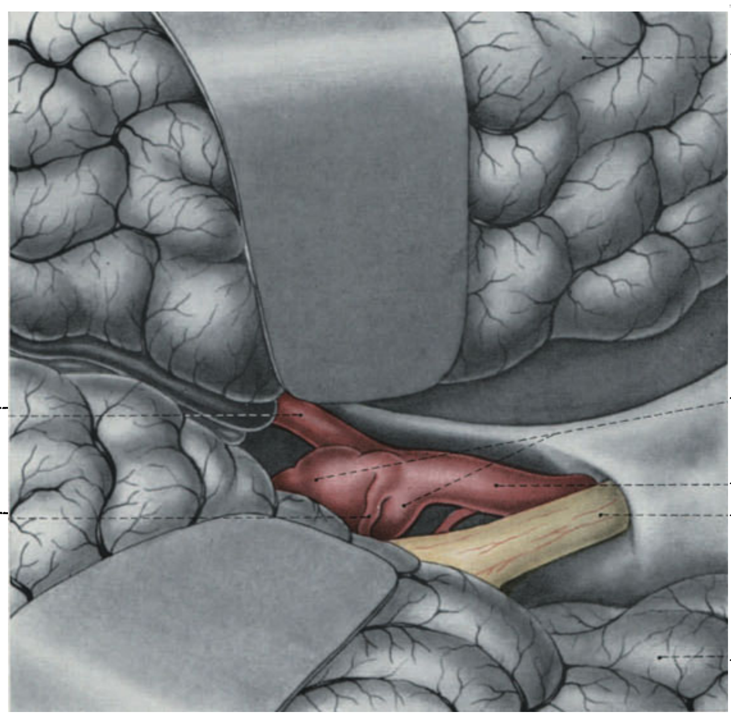


Fig. 57. Large aneurysm at bifurcation of internal carotid artery not amenable to ligation.
Observe: Fig. 62—66 for treatment by encasement.

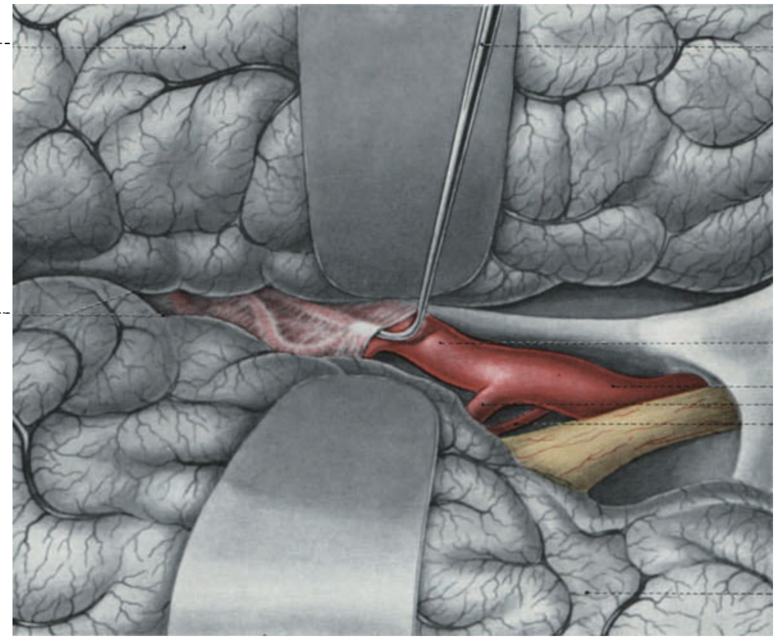


Fig. 58. Operative view of aneurysm of left middle cerebral artery.
Observe: Arachnoid has been removed starting from internal carotid artery.

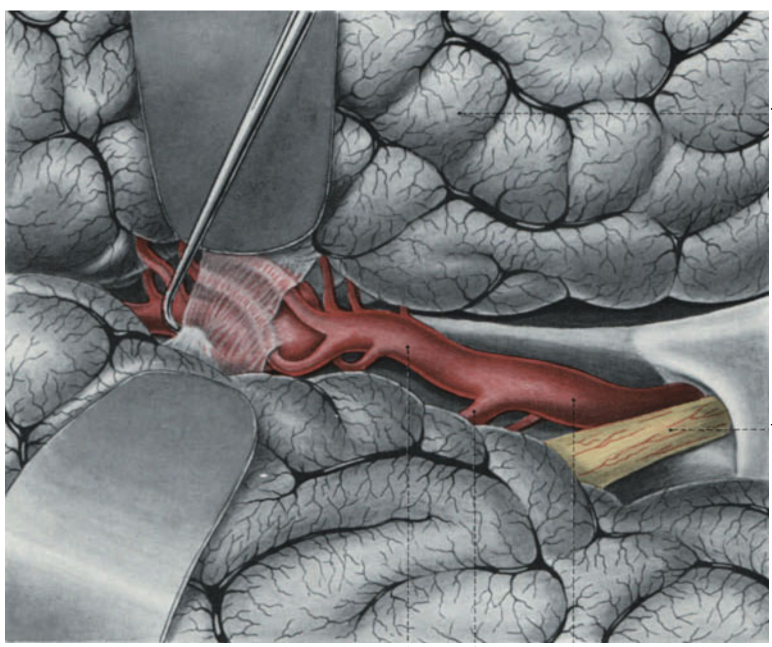


Fig. 59. Aneurysm of left middle cerebral artery.
Observe: All small branches of the middle cerebral artery are left intact.

to avoid injury to the small perforating vessels. In the majority of the aneurysms of the middle cerebral artery we expose the neck first while approaching it from the medial side. It is important to expose the aneurysm in its entirety to ascertain the major branches of the middle cerebral artery.

After the aneurysm has been partially exposed as is seen in Fig. 59 we start to remove some of the arachnoid distal to the fundus of the aneurysm. This is done when we see a rather thin-walled aneurysm looking angry enough to rupture any moment. We like to free as much as possible the branches of the middle cerebral artery before unwanted ruptures occur to ascertain the definite relationship of this aneurysm to the middle cerebral artery and its branches. It is important to ascertain whether the aneurysm can be eliminated by clipping the neck or if another procedure has to be used. Fig. 60 reveals the aneurysm completely exposed and amenable to clipping of its neck. Since this aneurysm is sitting in a nest of major branches of the middle cerebral artery, these branches are held away (Fig. 61) while the clip is applied to ensure that none of these branches are caught within the clip.

At least half of the aneurysms of the middle cerebral artery cannot be eliminated by clipping without obliterating a major branch or even the main continuation of the middle cerebral artery. The fast setting methyl methacrylate has been our method of choice for embedding these aneurysms together with the parent vessels. This plastic material is prepared and when it has attained the consistency of toothpaste it is put into a glass eyedropper and immediately applied to the base of the exposed vessel. In this case (Fig 62) of a middle cerebral artery aneurysm the base is the limen insulae. It is most important to lift the parent vessel while pouring the plastic to ensure complete circumferential encasement (Fig. 62). Lifting of the vessel is done by either using a blunt hook or better a silk suture which can be left in place in the event it should be caught in the hardening plastic. The lifting of the whole vascular structure should be maintained long enough for the plastic to develop a consistency so that the vascular structures cannot push the material away and denude themselves of the plastic once resting on the brain. Once the posterior covering is well accomplished, the plastic is used until the entire complex is embedded (Fig. 63). When using materials like methyl methacrylate one of the assistants should hold in his hand a small quantity of plastic material and he will announce when the exothermic process of hardening has reached the point where continuous irrigation with saline solution should be started to prevent any local damage from the heat. The assistant should also report when the irrigation can be discontinued.

An alternate method to encase the aneurysm is to use a fine mesh gauze which has been covered with the plastic prior to wrapping the aneurysm. This assures circumferential embedding and usually requires using much less plastic material.

Often successful had been still another method which is especially helpful when the aneurysm is not clippable and furthermore is bleeding at the time of exposure. Here a piece of fine mesh gauze is put around the whole complex (Fig. 64). This gauze has not been covered by plastic material. Our picture shows no bleeding from the aneurysm, but if bleeding should occur, the problem is handled as described earlier in bleeding aneurysms of the internal carotid artery. The sucker tip is held over the bleeding point and by gentle movement the sucker tip will find the opening in the aneurysm. Further gentle pressure will most often permit enfolding of the dome of the aneurysm causing cessation of the bleeding. This maneuver is accomplished much easier with bleeding of the middle cerebral artery than with an aneurysm of the internal carotid artery. Here we work on the middle cerebral artery at the level of the limen insulae which is close to the surface. Measurements of the skull in the AP view from the inner table to the base of 122 aneurysms of the middle cerebral artery averaged 30 mm. The gauze is then wrapped around as shown in Fig. 65. One corner of the fine mesh gauze has to go over the bleeding point. The sucker can be immediately re-applied for suction through the gauze. Most of the corners of the gauze, if not all of them, have to be grasped in one instrument (Fig. 66) and it has to be twisted

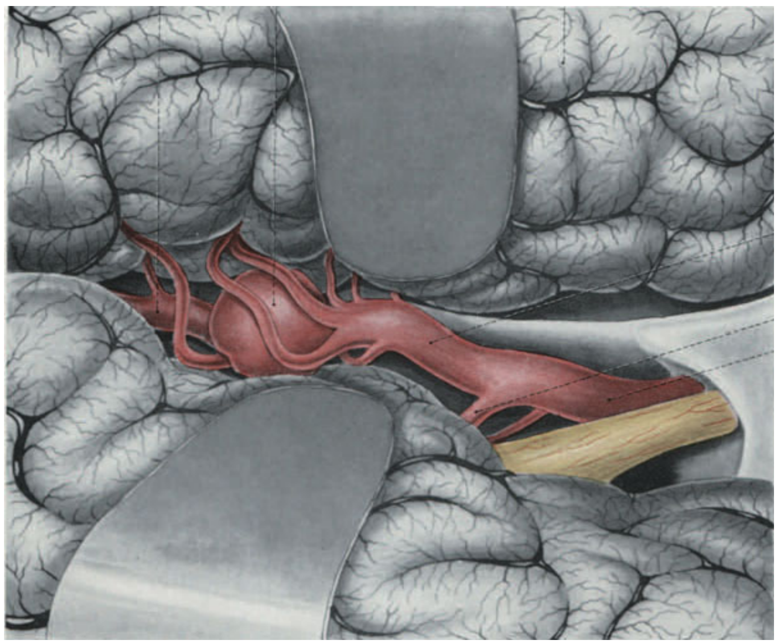


Fig. 60. Aneurysm of left middle cerebral artery completely exposed.

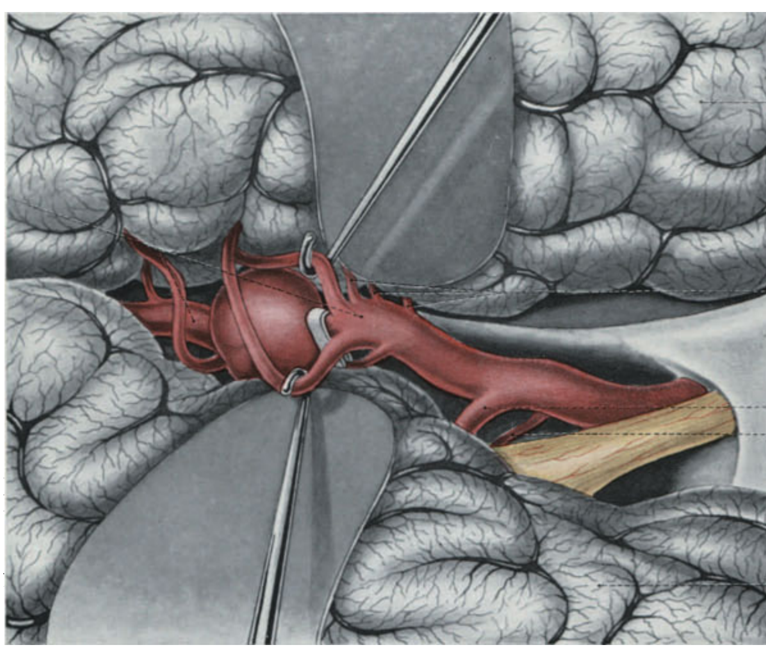


Fig. 61. Neck of aneurysm of middle cerebral artery clipped.
Observe: Avoidance of obliteration of middle cerebral artery and its branches by clipping only the aneurysm.

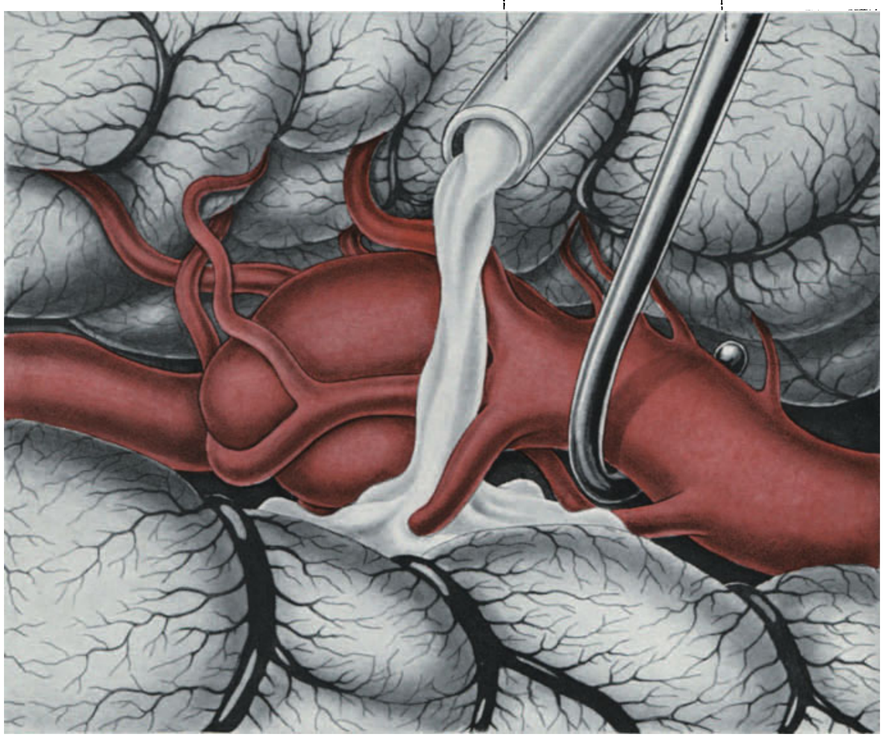


Fig. 62. Aneurysm of middle cerebral a. not amenable to simple clipping treated by encasement in plastic (methylmethacrylate).

Observe: Elevation of middle cerebral artery and aneurysmal complex while pouring plastic to assure complete circumferential encasement.

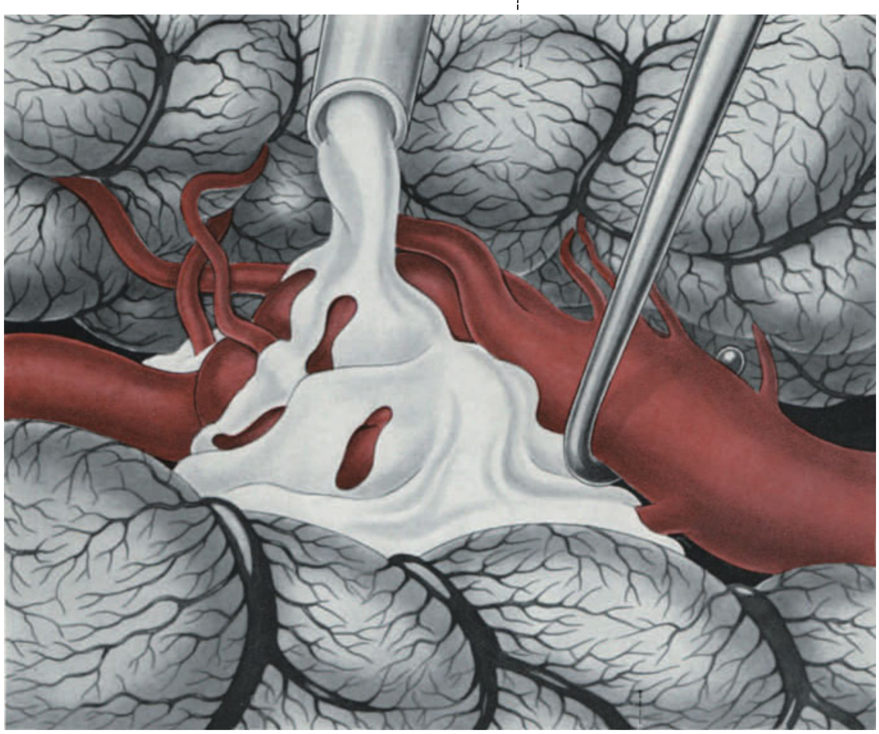


Fig. 63. Further step in embedding of middle cerebral artery aneurysmal complex in plastic.

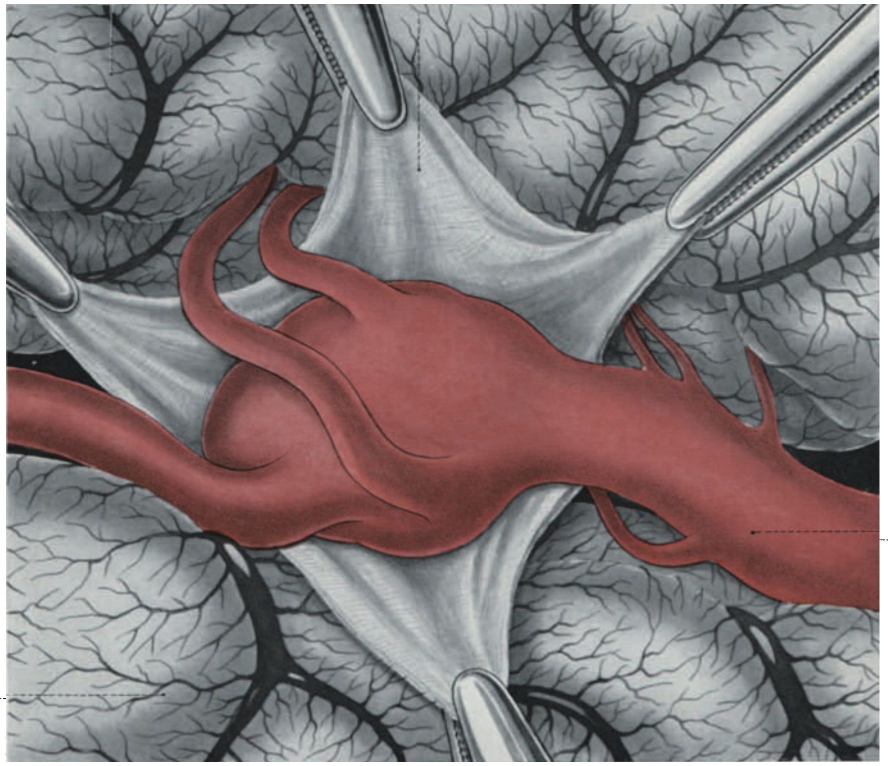


Fig. 64. Aneurysm of middle cerebral artery not amenable to clipping treated by wrapping in *fine* mesh gauze followed by encasement in plastic.

Fig. 65. Further step of wrapping aneurysmal complex of middle cerebral artery in *fine* mesh gauze.

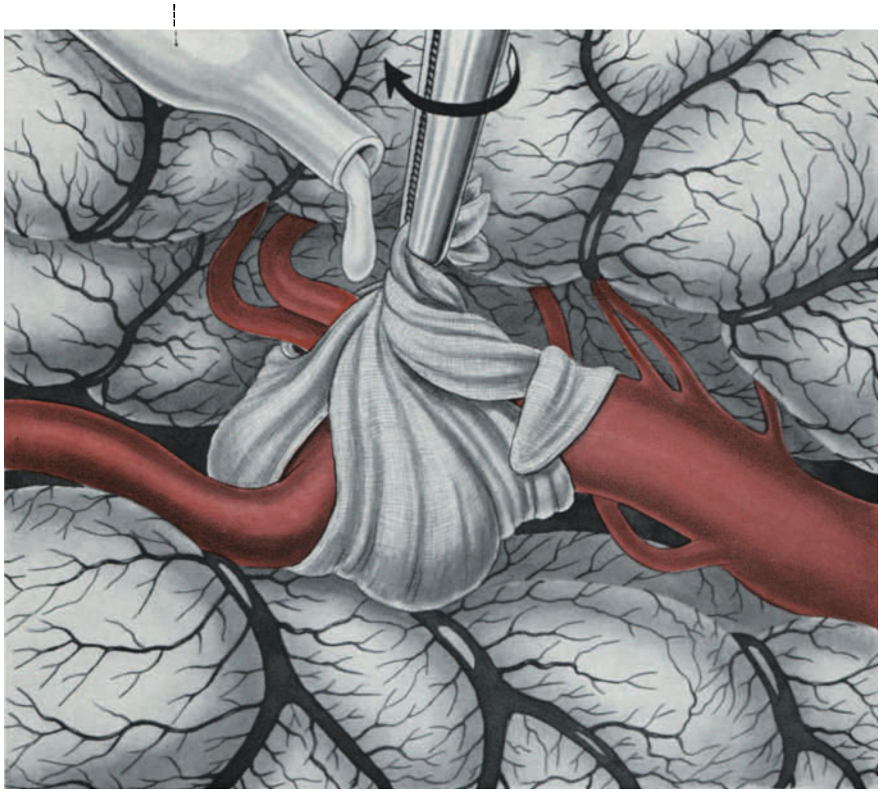


Fig. 66. Last step in the operative treatment of aneurysm of the middle cerebral artery not amenable to clipping. *Observe:* 1. Grasping and twisting of gauze wrapping to secure fitting and if necessary hemostasis from bleeding aneurysm. 2. Application of plastic (methylmethacrylate) to the entire structure.

and pulled in one direction until the bleeding ceases. We have been successful utilizing this method without obliterating the main branches of the middle cerebral artery. Only after holding the gauze until the field is dry can the whole complex, aneurysm, middle cerebral artery and its branches and the wrappings, be embedded in fast setting plastic (methyl methacrylate) (Fig. 66). Temporary clipping of the middle cerebral artery has not been used nor found necessary while doing this operative maneuver.

In Fig. 67 a giant aneurysm of the internal carotid artery is seen which had been removed by temporary clipping and suturing of the vessel wall. Hypothermia or temporary hypotension has not been used in surgery of any intracranial aneurysms for the past eleven years. With the technique here described and the ones to be shown in later chapters for aneurysms of the anterior cerebral artery, anterior communicating artery complex and vertebral basilar artery, the use of hypothermia or hypotension was found to be of little value. Also, ligation of the internal carotid artery in the neck for aneurysm of the intracranial portion of the internal carotid artery has been found to have a greater mortality and morbidity than the direct intracranial approach. In each of the patients, cross-filling or not, preoperative use of the Matas' test has not changed the value of the direct operative attack as outlined in this book.

The use of the headlight and the Zeiss 2× magnifying glass, fitted individually for the surgeon, is of great assistance (Fig. 68).

Middle Cerebral Artery Aneurysm with Intracerebral Hematoma. In Fig. 69a coronal section illustrates a left temporal intracerebral hematoma which was caused by a ruptured aneurysm of the middle cerebral artery situated at its most frequent location, the limen insulae. The preoperative angiographic study will reveal signs of an intracerebral hematoma by its upward and medial displacement of the middle cerebral artery. We see in our picture (Fig. 69) slight elevation of the pars sphenoidalis of the middle cerebral artery. The operative approach is through the same fronto-temporal craniotomy as depicted in Chapter I. After opening of the dura (Fig. 70) the widening of the temporal gyrus with its possible discoloration and the elevation of the Sylvian fissure will indicate the presence of a large intracerebral hematoma. Here we do not try to expose the prechiasmatic cistern as described previously. Instead, an incision of the cortex parallel to the axis of the gyrus is accomplished as seen in Fig. 70. The cortical incision is carried towards the hematoma by suction and coagulation. The moment the intracerebral hematoma has been evacuated there will be ample room and at the bottom of the excavated cavity the bleeding aneurysm will be found (Fig. 71). Obliteration of the aneurysm is done depending on its relationship to the middle cerebral artery and its major branches. The insert in Fig. 71 shows an aneurysm where a clip can be applied. Some of the maneuvers previously discussed in the care of aneurysms of the middle cerebral artery may be used. The principle of direct attack through an evacuated hematoma cavity is used in all aneurysms with large intracerebral hematomas. Occasionally we have operated on what was previously considered another type of space-occupying lesion and an intracerebral hematoma was encountered. After evacuation of the hematoma the aneurysm was found.

4. Aneurysm of the Anterior Cerebral Artery, Anterior Communicating Artery Complex

We classify the aneurysm of the anterior communicating artery complex in three basic categories depending on its position (Fig. 72). This classification is based on the important different operative approach underlying the same principle as we have done with the aneurysm of the internal carotid artery (see text, p. 22 and Fig. 27). Since the operative approach is based on the principle of leaving the fundus of the aneurysm alone, the direction from the base to the fundus of the aneurysm is the decisive factor in knowing how to plan the operative approach. Therefore, it will become obvious that if the aneurysm

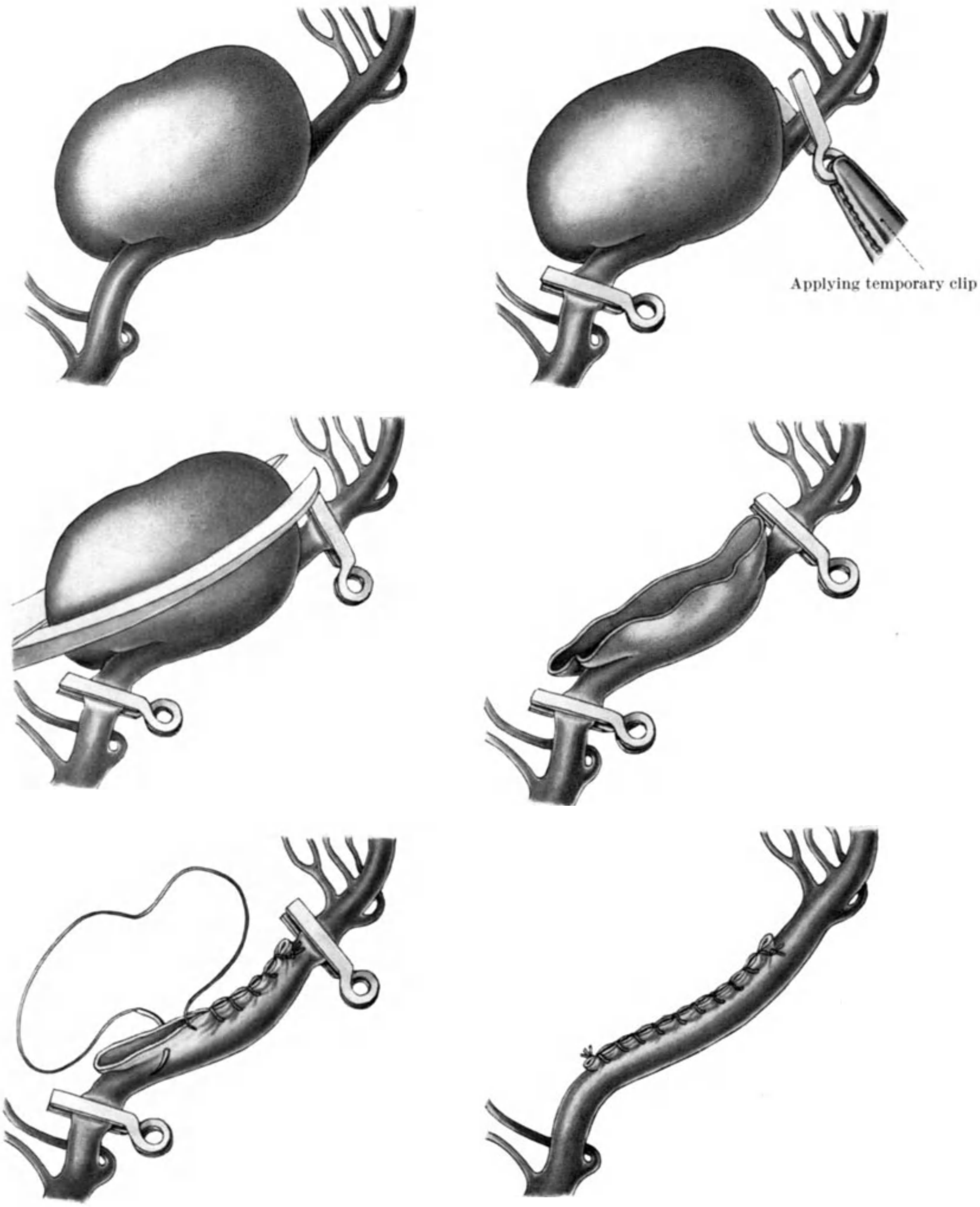


Fig. 67. Surgery of giant aneurysm by excision.

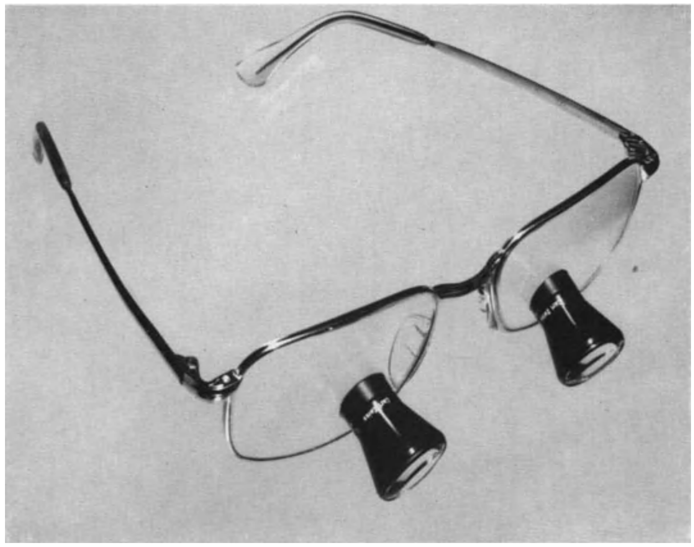


Fig. 68. Magnifying lenses (Zeiss) individually fixed to prescription eye glasses.

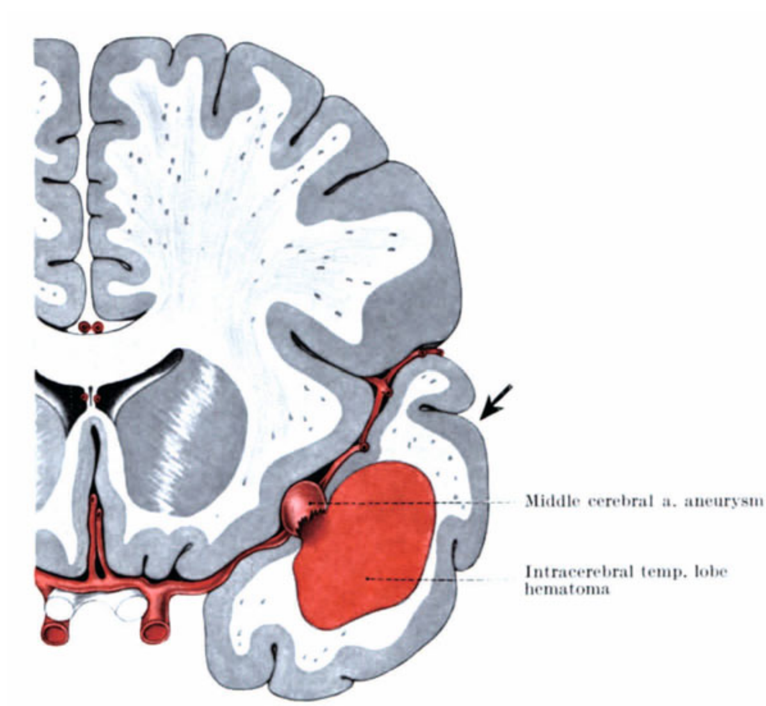


Fig. 69. Anatomical relationship of left middle cerebral artery aneurysm with intracerebral temporal lobe hematoma.

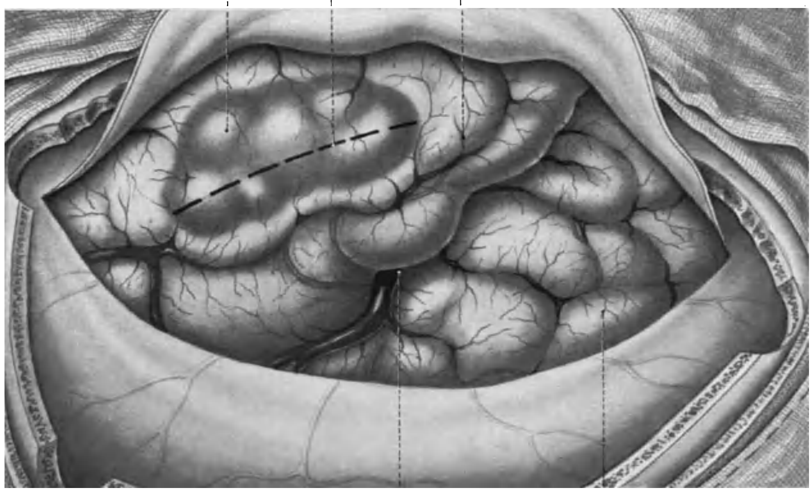


Fig. 70. Operative appearance of cortex with underlying hematoma.
Observe: Line of incision over area of discoloration and widened gyrus.

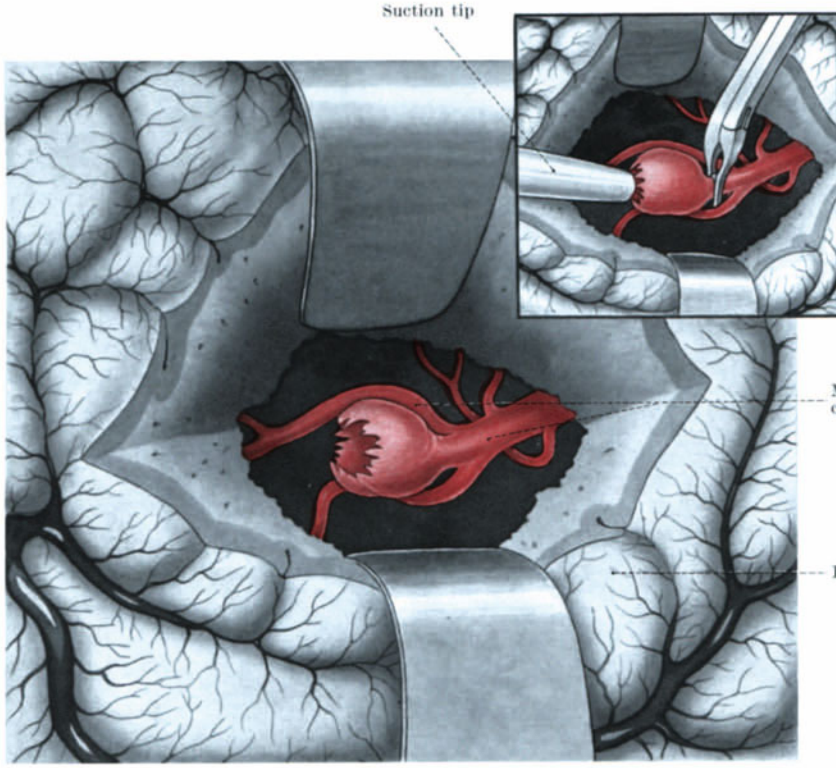


Fig. 71. Aneurysm of left middle cerebral artery with intracerebral hematoma removed.
Observe: 1. Surgical approach is directly through the evacuated cavity of the hematoma. 2. Insert shows control of bleeding from aneurysm while clip is applied.

is pointing downward the operative attack will be from above; if the aneurysm is pointing anteriorly the operative approach will be planned to come from behind and above; and finally, if the aneurysm is pointing superiorly or posteriorly the operative approach is from below. The word pointing as used above means the direction from the base of the aneurysm to the fundus. In Fig. 72 we see the three basic positions for which two important different operative approaches are to be made. To help visualize the position of the aneurysm in its true anatomical topographical relationship as seen by the surgeon it may be helpful to compare Fig. 72a with Fig. 86. In both of these pictures an aneurysm of the anterior communicating artery pointing inferiorly is depicted even though not completely identical. In Fig. 86 the surrounding brain is shown which is left out in Fig. 72.

It is advisable to approach the aneurysms of the anterior communicating artery complex from the right side to protect the dominant hemisphere. Only in few exceptions has it been necessary to approach the aneurysm from the left. Some marked lateral deviations of the aneurysm during the angiographic study with contralateral compression may reveal that the approach should be done from the left side to protect and visualize the anterior cerebral artery of this side first. In these cases the left side was chosen. In 203 aneurysms of the anterior communicating artery, the approach from the left side was felt necessary in only 9 per cent of the cases.

As the first example of the two basic different approaches to the aneurysm of the anterior communicating artery, an aneurysm pointing superiorly, similar to Fig. 72c, is chosen. Since we have presented all our preceding operative approaches in this book up to now from the left side, the same will be done in this case assuming the reader to be more familiar with the view from the left. The position of the patient is depicted in Fig. 73a and b and in Fig. 2, p. 3. The craniotomy is the same as in Chapter I. The frontal lobe is elevated, the arachnoid between the optic nerves visualized and torn, and cerebrospinal fluid aspirated from the chiasmatic cistern (Fig. 29). Mobilization of the temporal lobe tip is not indicated. The internal carotid artery is exposed removing the leptomeningeal covering (Fig. 74). This picture shows the arachnoid being removed over the anterior aspect of the left anterior cerebral artery near the bifurcation. Care is taken not to disturb the small perforating vessels emerging from the superior posterior aspect of the anterior cerebral artery. These important vessels may reach forward on their way to the medial aspect of the anterior perforated substance and can easily be torn while removing the arachnoid over the anterior rim of the anterior cerebral artery. After exposing approximately the lateral two-thirds of the anterior cerebral artery, the spatula over the orbital surface is moved to a new position bringing the right anterior cerebral artery into view where the vessel comes over the margin of the chiasm (Fig. 75). Whenever we move the brain spatula, it is either first completely removed or relaxed enough so that the spatula never glides over the surface of the brain while at the same time retracting. If this principle is not strictly adhered to in any handling of a brain spatula we will not only tear the brain but also in our case presented will cause rebleeding of an anterior communicating artery aneurysm. Forceful retraction and movement would squeeze or milk the coagulum from and over the ruptured fundus of the aneurysm to cause hemorrhage. If the insertion and change of position of the brain spatula is handled correctly, as above described, it will be seen that we can hold the spatula over the longitudinal fissure in which the aneurysm is situated, covering the aneurysm complex itself without causing rupture. A more obvious picture of the anatomical relationships with the spatula in place to expose the opposite anterior cerebral artery is seen in Fig. 85. Here in Fig. 85 the longitudinal fissure is clearly seen, and we know that the anterior communicating artery with the aneurysm itself is embedded in this longitudinal fissure. In our drawings the use of wet cotton pledgets below the spatula is rarely shown to reveal more of the anatomy. In practice, however, the use of the wet cotton pledgets to protect the brain surface is not to be forgotten.

Only after having removed the arachnoid from the lateral two-thirds of the left and right anterior cerebral arteries (Fig. 75) and after having ascertained their position and

Fig. 72a—c. Three basic positions of aneurysm of anterior communicating artery complex.
a aneurysm pointing inferiorly
b aneurysm pointing anteriorly } operative attack from above through gyrus rectus.
c aneurysm pointing superiorly and posteriorly, operative attack through longitudinal fissure.

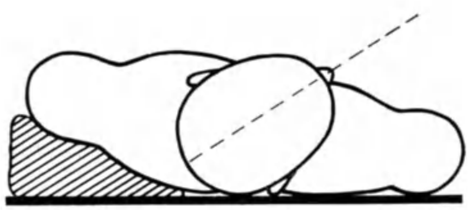


Fig. 73a.

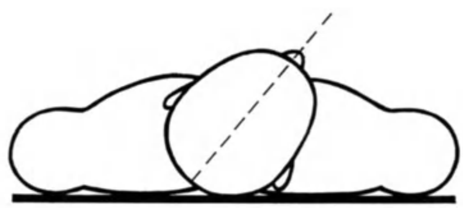


Fig. 73b.

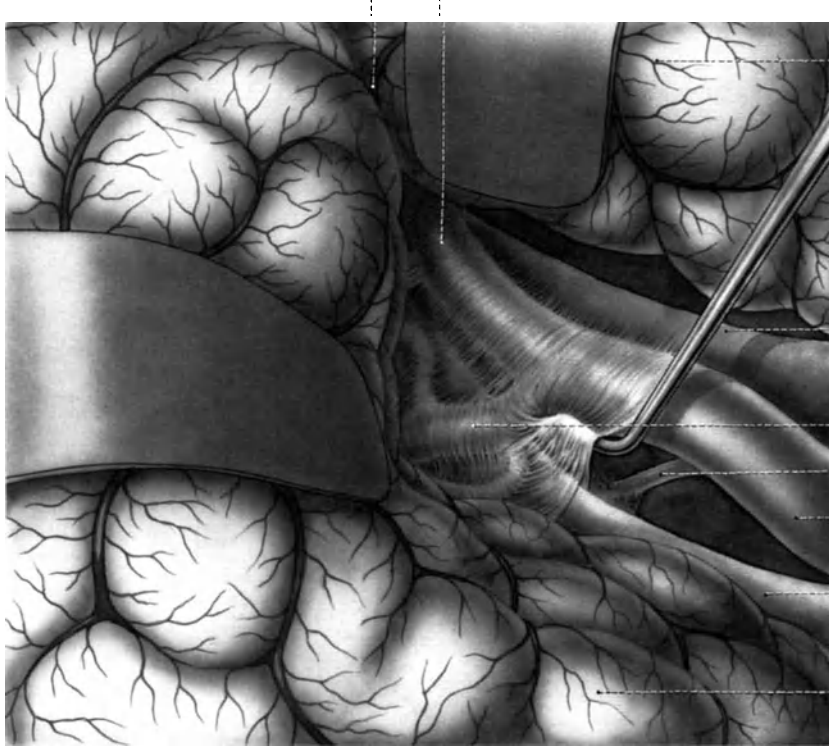


Fig. 74. Operative approach for exposure of aneurysm of anterior communicating artery with dome of aneurysm pointing superiorly.
Observe: 1. In this case the approach is through a left fronto-temporal craniotomy, see Fig. 15. 2. Free initially the arachnoid over *origin* of left anterior cerebral artery.

direction towards the midline, do we begin freeing the arachnoidal covering closer and closer to the base of the aneurysm (Fig. 76). In other words, we work towards the anterior communicating artery and great care is taken to leave the dome of the aneurysm undisturbed. When the relationship of the base of the aneurysm to the A-2 section of both anterior cerebral arteries is ascertained, we are able to judge in which way the aneurysm can best be obliterated (Fig. 76).

Valuable information about the aneurysm should be obtained from the angiographic studies. Oblique views with the anterior communicating artery projected into the center of the left and right orbits are essential preoperative studies. We should know prior to the operation from the angiographic study if the aneurysm belongs to one of the three basic positions as described in Fig. 72, and therefore know the two important different approaches to the base of the aneurysm. However, the true relationship to the parent vessels and the possibility of obliteration of the aneurysm without embarrassment of one or both anterior cerebral arteries will only be known at the time of the operative exposure. Only by truly verifying the anatomy can one decide the correct placement of the clip or ligature or the necessity of encasement. In Fig. 76 a broad gold clip is used. The clips are prepared from dental gold plates with scissors and file. They are often useful not only in large aneurysms but also in some forms of arteriovenous malformations. In Fig. 78a and b, the aneurysm could not be obliterated by the application of one clip since the A-2 section of one anterior cerebral artery emerged directly from part of the aneurysmal wall. The clip seen in Fig. 78b will take care of one section of the aneurysm and will stop the bleeding at the time but additional embedding in fine mesh gauze (Fig. 78c and d) and the use of fast setting methylmethacrylate is needed for this type of lesion. The use of several clips is seen in Fig. 79 and a ligature in Fig. 80. The application of ligature is described in greater detail on p. 26 and in Fig. 44. The handling of fast setting methylmethacrylate is described on p. 48.

The other example of the two basic different approaches to the aneurysm of the anterior communicating artery complex applies to the aneurysm pointing inferiorly and slightly posteriorly. The aneurysm's basic position is seen in Fig. 72a and is attacked from above through the gyrus rectus. In reviewing the aneurysm of the anterior communicating artery complex we found that close to 65 per cent belong to the basic position (Fig. 72a and b). As previously stated, the majority of the aneurysms of the anterior communicating artery are approached from the right side (see p. 58). The following is therefore a detailed description of an approach from the *right side.*

The position of the patient on the operating table is seen as in Fig. 81a or 81b. The craniotomy is of the same configuration as discussed in Chapter I and seen in Fig. 82. To recall the topographic situation (Fig. 83) an anatomical specimen of an anterior communicating artery aneurysm pointing anteriorly and inferiorly with the frontal lobe removed and with the entire specimen in the position of the patient at operation is depicted and labeled.

The first step after opening and reflecting the dura is the opening of the prechiasmatic cistern to aspirate cerebrospinal fluid. The tip of the temporal lobe may be mobilized. The arachnoidal covering of the right internal carotid artery is removed to the bifurcation showing clearly the anterior cerebral artery over the right lateral margin of the chiasm (Fig. 84). In this picture we clearly see the gyrus rectus on the right side and lateral to it the olfactory tract. The proximal third of the right anterior cerebral artery is freed of its arachnoidal covering and its position and direction are constantly kept in mind. The spatula is re-inserted as seen in Fig. 85 at which time it is placed forward and closer to the midline. Most frequently the spatula is placed over the midline, which covers the longitudinal fissure and the right and left gyrus recti. No harm is done placing the spatula directly over the area where we know the aneurysm is situated between the hemispheres in the longitudinal fissure. In Fig. 85 the spatula is placed more anteriorly to show the important structures; right olfactory tract, right gyrus rectus, longitudinal fissure, and

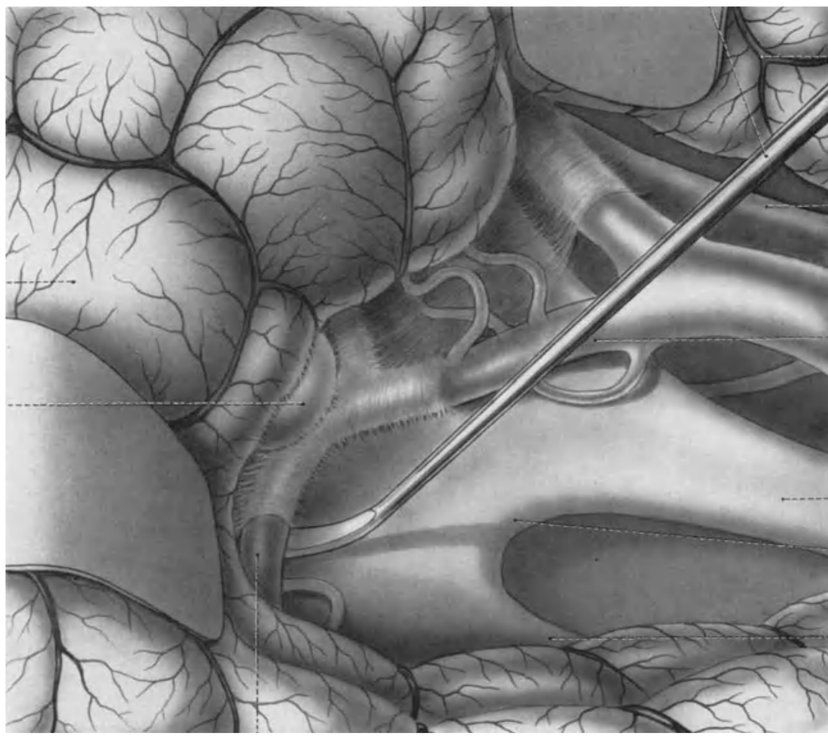


Fig. 75. Consecutive steps in the exposure of aneurysm of the anterior communicating artery with the aneurysm pointing superiorly.

Observe: 1. Only the arachnoid covering the most anterior aspect of the anterior cerebral arteries is removed to protect the small perforating arteries. 2. Prior to freeing any leptomeningeal adhesions close to the anterior communicating artery, the anterior cerebral artery on the *opposite* side is identified coming over the chiasm and freed from its leptomeningeal cover.

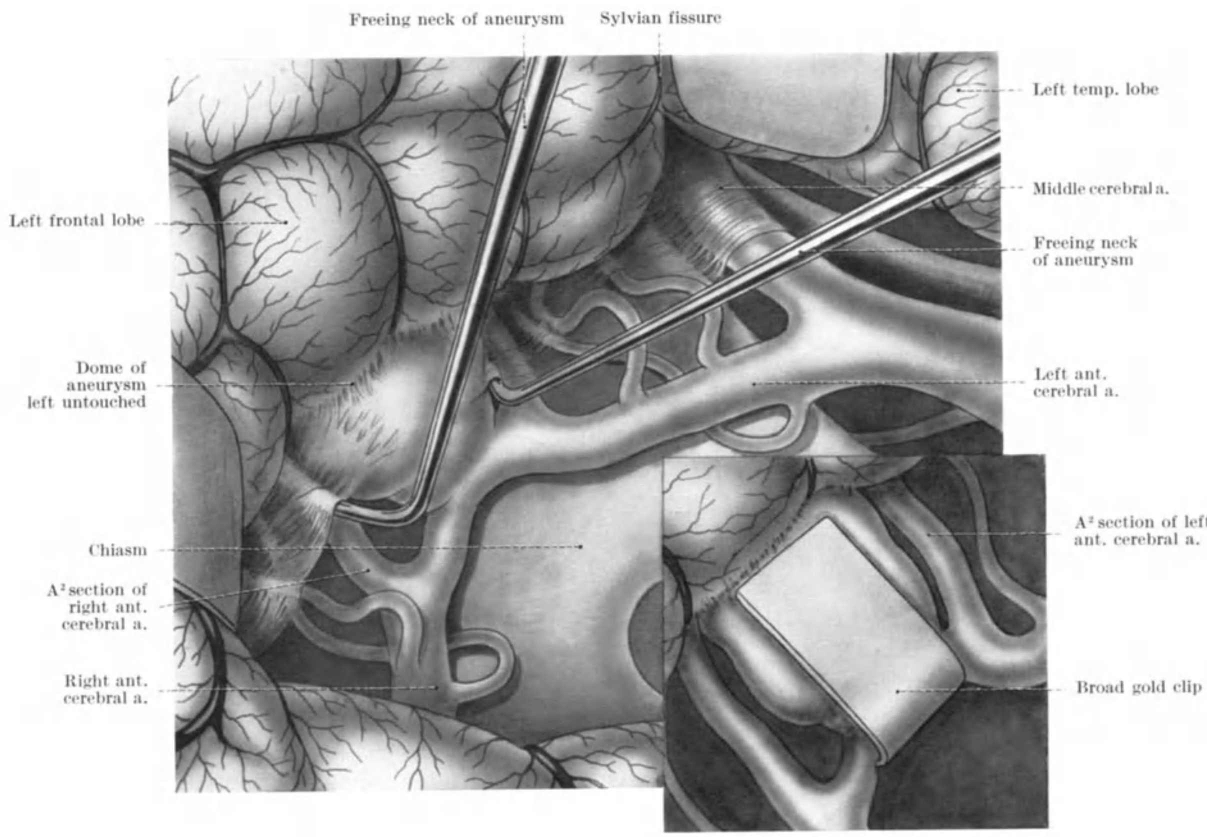


Fig. 76. Exposing the base of aneurysm of anterior communicating artery with dome of the aneurysm pointing superiorly.
Observe: 1. Dome of aneurysm is left covered by leptomeninges and brain tissue. 2. Insert shows broad (gold) clip obliterating base of aneurysm.

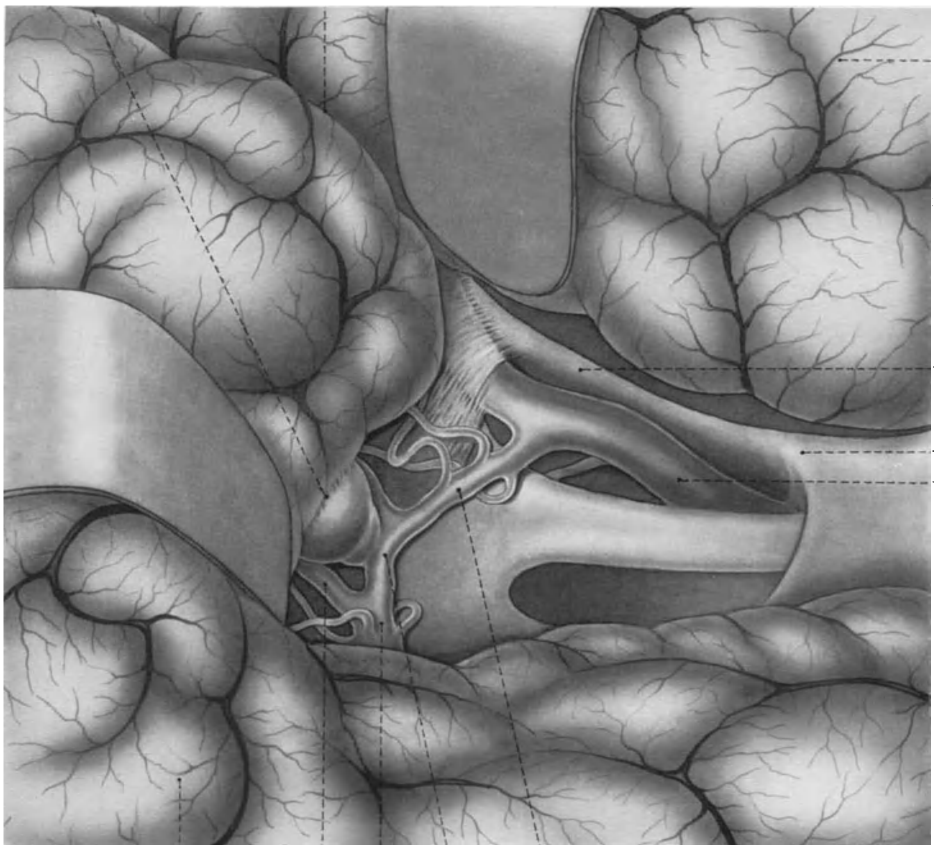


Fig. 77. Aneurysm of anterior communicating artery with dome of aneurysm pointing superiorly.

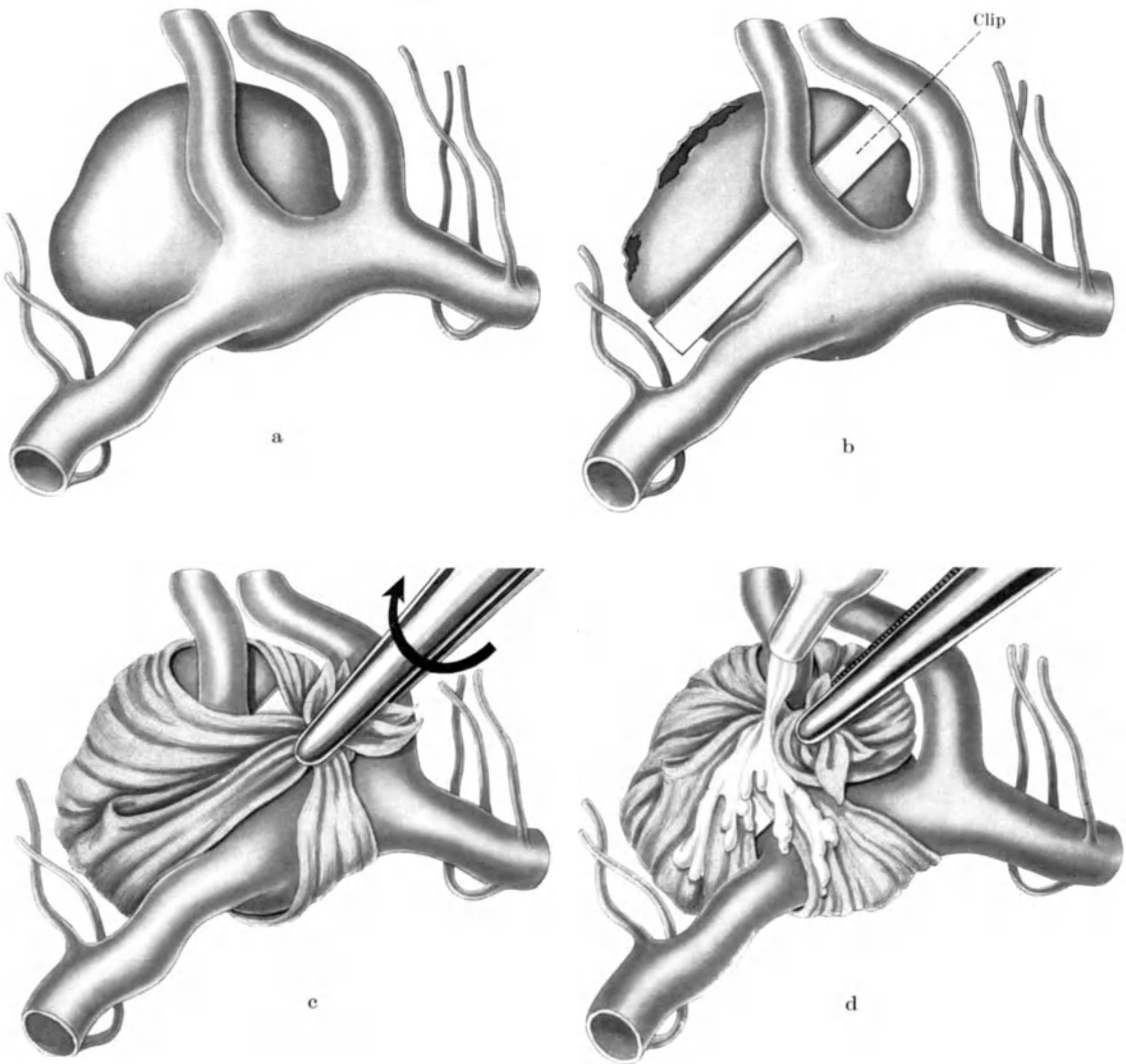


Fig. 78a—d. Example of anterior communicating artery complex not amenable to simple clipping. *Observe:* 1. In figure b the clip does not accomplish the obliteration of entire aneurysm from the circulation. 2. Figures c and d show the use of fine mesh gauze and plastic to encase the entire anterior cerebral-anterior communicating artery aneurysm complex.

Fig. 79. Use of several clips to obliterate anterior communicating artery aneurysm.

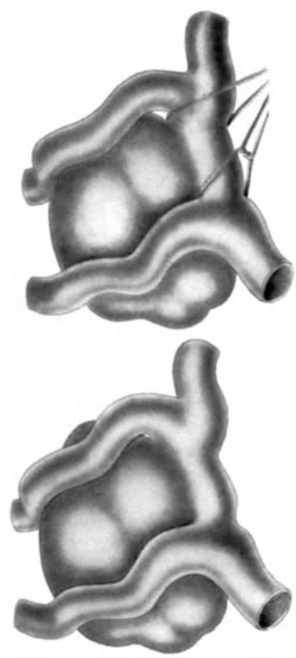


Fig. 80. Use of silk ligature in the treatment of certain aneurysms of the anterior communicating artery. For the technique applying the ligatures, compare Fig. 44.

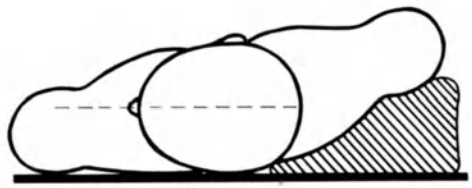


Fig. 81a.

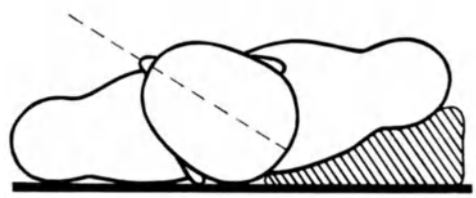


Fig. 81b.

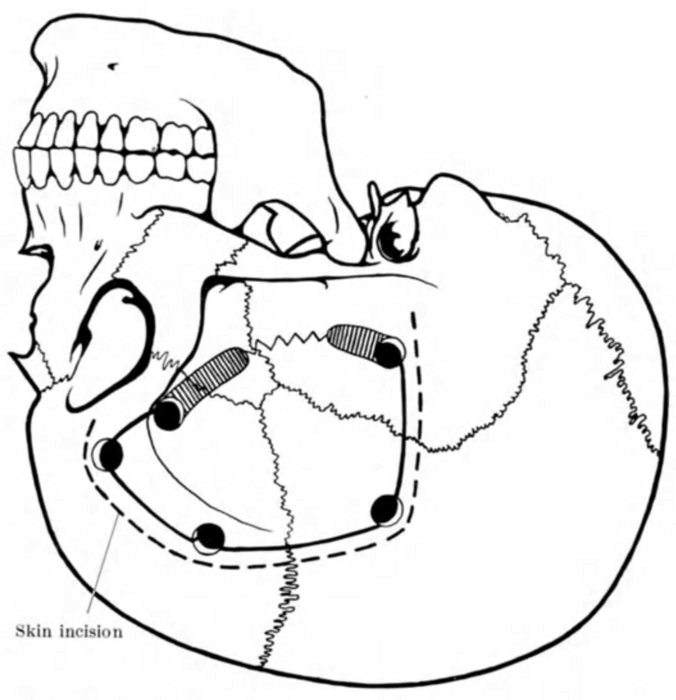


Fig. 82. Right sided craniotomy for aneurysm of the ant. communicating artery.

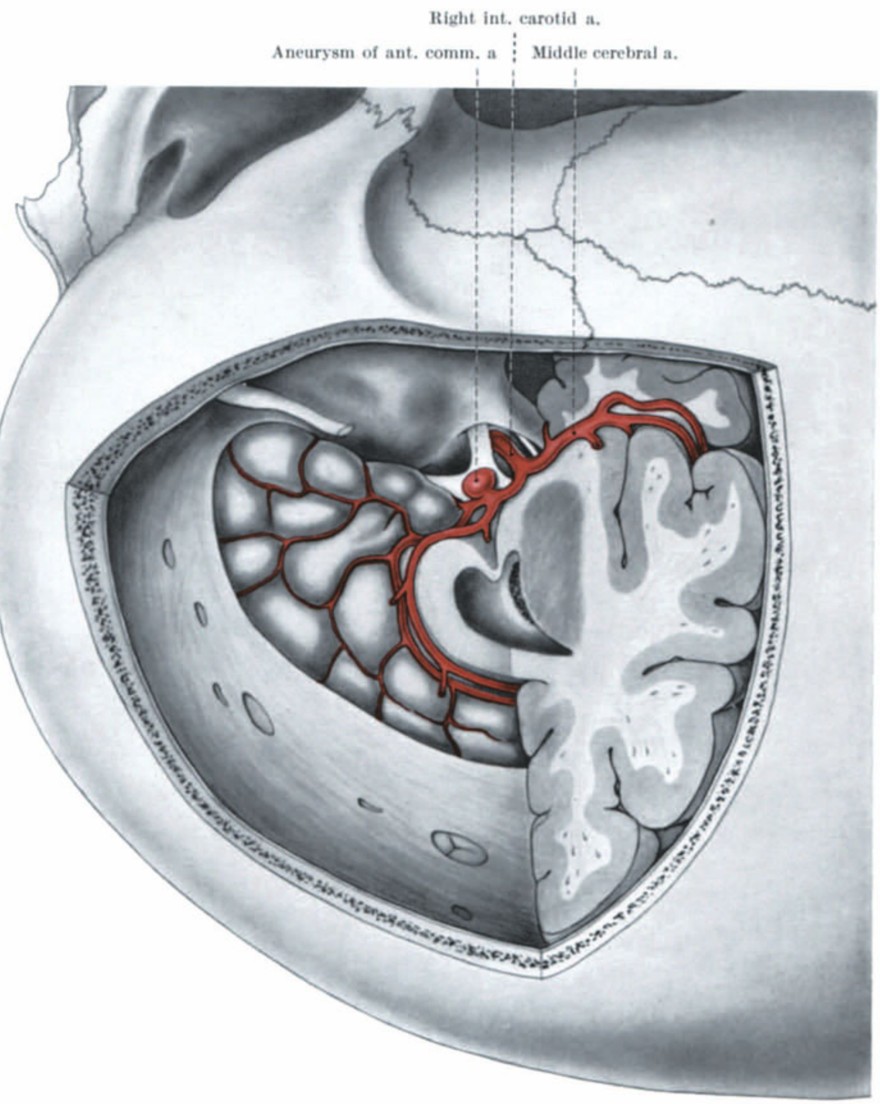


Fig. 83. Anatomical demonstration of aneurysm of ant. communicating artery with dome of aneurysm pointing inferiorly and anteriorly.

Observe: The anatomical exposure is shown from the right side, since over 90% of the operative approach in recent years is done from the nondominant side.

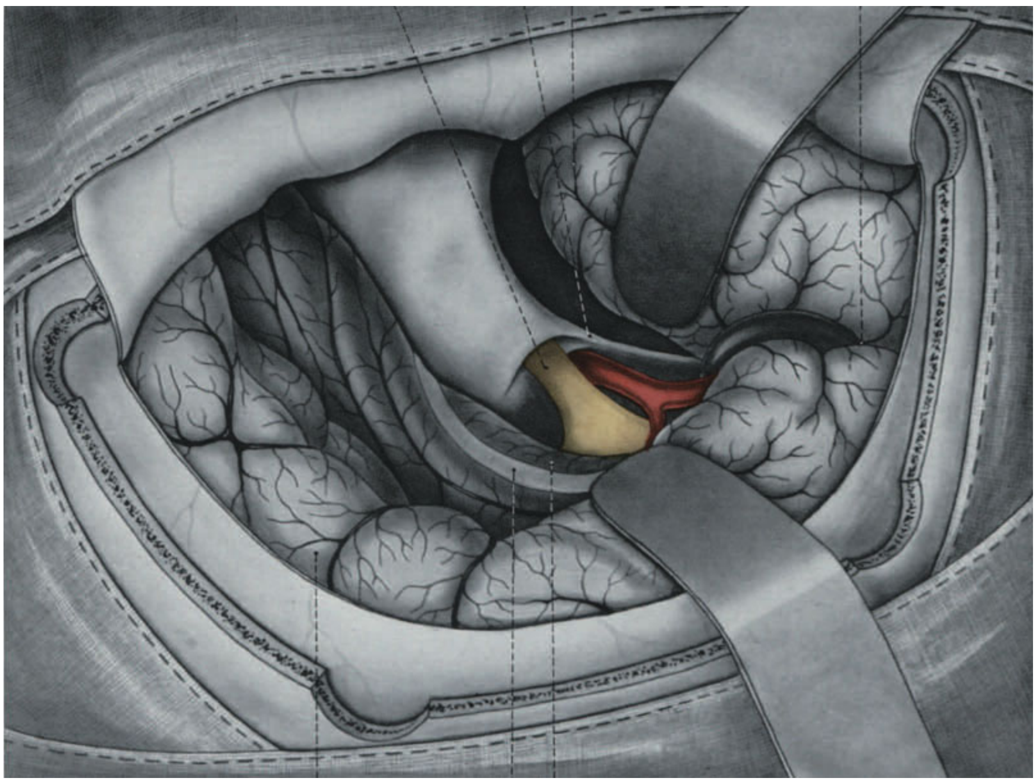


Fig. 84. Operative approach of anterior communicating artery aneurysm with dome of aneurysm pointing inferiorly and anteriorly.
Observe: Exposure of origin of right anterior cerebral artery.

the opposite left gyrus rectus. It is important to identify the left anterior cerebral artery coming over the chiasm. After the proximal sections of both anterior cerebral arteries have been identified by freeing them from the overhanging brain and leptomeningeal covering, we are now able to visualize and project in our mind the position of the aneurysm which sits deep in the longitudinal fissure surrounded by the medial aspect of the right and left gyrus recti and is covered by brain. In Fig. 86 we have projected the position of the aneurysm on the same structures as seen in Fig. 85. The surgeon, with the knowledge gained from studying the angiographic films and having exposed the proximal part of both anterior cerebral arteries, should now be able to project the configuration and position of the aneurysmal complex which is hidden in the depths of the longitudinal fissure. Its depth may be minimal and the fundus of the aneurysm may be covered by a leptomeningeal layer only. Repeated comparison of Fig. 85 with Fig. 86 will be useful and helpful in clarifying what is here discussed. Since the fundus is to be left undisturbed the right-gyrus rectus is now incised after having coagulated the pia-arachnoid (Fig. 87). With practice it will be possible to incise the correct area with removal of not more than 10 cubic millimeters of brain tissue, to reach the longitudinal fissure, to expose the A-2 sections of both anterior cerebral arteries and to visualize the base of the aneurysm (Fig. 88). It may be remembered that we again encounter the leptomeningeal covering over the right gyrus rectus but now over its medial or subcortical surface. It is this pia-arachnoidal covering which has to be opened to free the A-2 sections of the anterior cerebral arteries and the base of the aneurysm. It should also be remembered that the pia is quite a strong membrane and we should not open it by coagulation and incision, as we have done over the orbital surface of the gyrus rectus. The pia is carefully broken and widened by grasping small bites with a fine tooth forceps. After this is done the identification of the base of the aneurysm with its relationship (Fig. 89) to the anterior cerebral arteries is accomplished. The last picture (Fig. 90) reveals clearly that the fundus of the aneurysm is left covered. Note the relationship of the fundus of the aneurysm, which is pointing inferiorly and posteriorly, to the longitudinal fissure. In this case clipping of the aneurysm is the treatment of choice (Fig. 90). The use of two heavy silk ligatures as seen in Fig. 44, p. 37 and in Fig. 80 would also be feasible.

5. Ligation of the Ophthalmic Artery

In the treatment of cavernous sinus fistula the ligation of the ophthalmic artery is essential. Anatomical dissections on 50 cadavers revealed the ophthalmic artery to be, in 10 per cent, on the inferior lateral side of the optic nerve prior to entering the optic foramen and quite symmetric in its relationship to the optic nerves of both sides. The remaining 90 per cent revealed the position of the ophthalmic artery to be on the inferior medial side of the optic nerve prior to entering into the optic foramen. No difficulties are encountered in exposing and clipping of the ophthalmic artery if the same is in the lateral position (Fig. 93a and b). The inferior medial position of the ophthalmic artery to the optic nerve occasionally requires retraction of the optic nerve to a greater extent than the dural and bony covering would permit without angulating the nerves too acutely against the dura and thereby damaging the nerves. To permit adequate retraction of the nerve the entrance to the optic foramen is unroofed, incising first the dura and stripping the same away over a small area slightly lateral to the entrance to the optic foramen (Fig. 94b and c). In Fig. 94d the optic nerve is retracted laterally exposing the medially located ophthalmic artery.

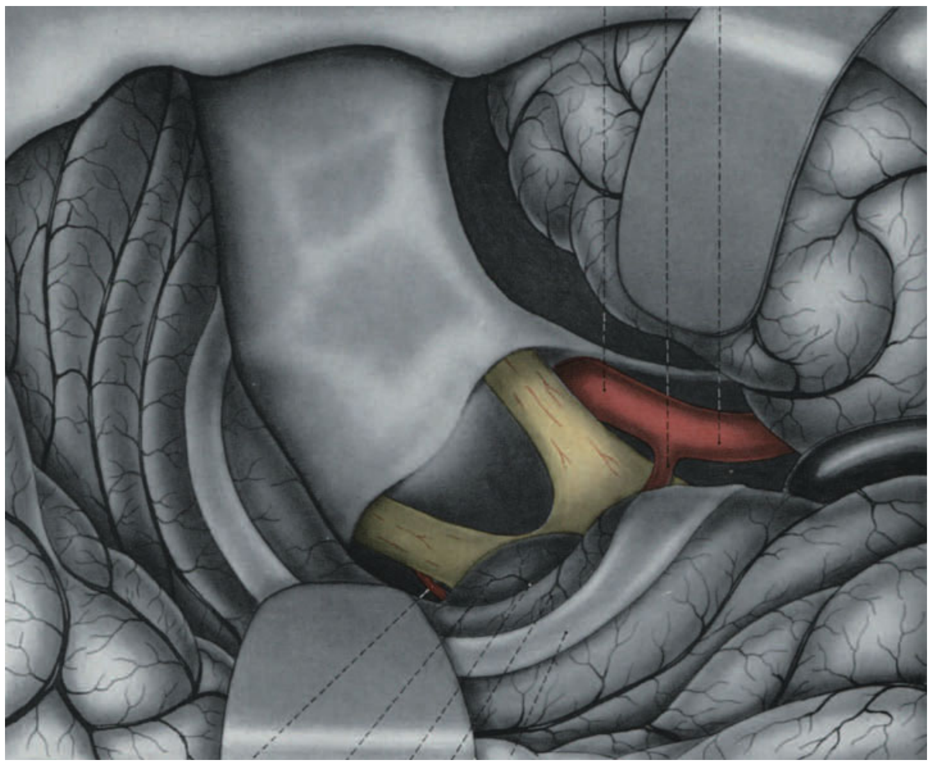


Fig. 85. Exposure of left anterior cerebral artery on the opposite side running over lateral border of optic nerve or chiasm.

Observe: 1. Shifting of spatula from the position as seen in Fig. 84 to the position presented here, will help to find and expose the opposite left anterior cerebral artery (A^1 section). 2. This operative maneuver will also bring into view the longitudinal fissure and opposite gyrus rectus.

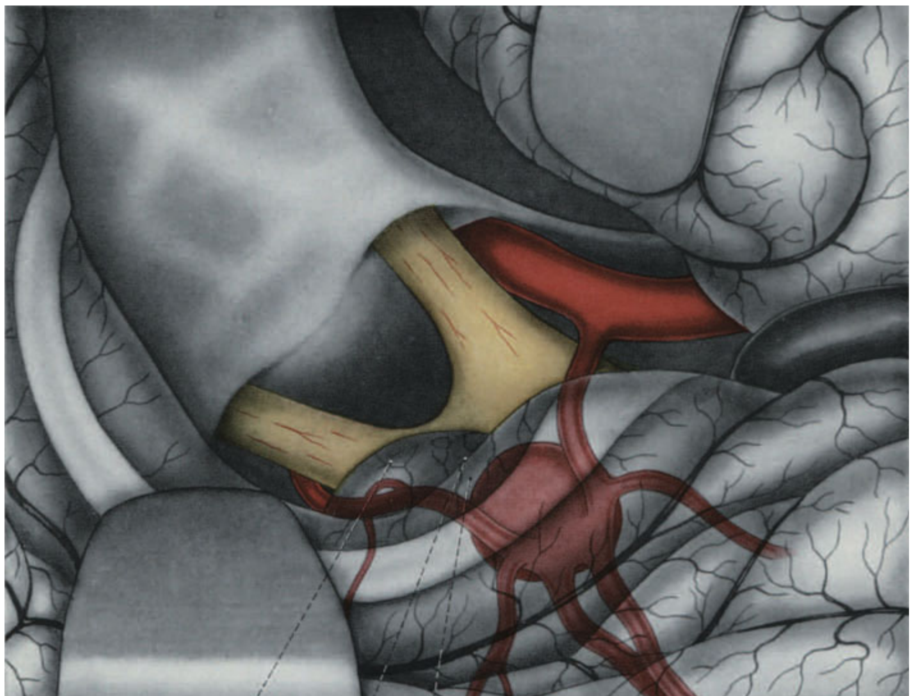


Fig. 86. Schematic drawing showing topographic relationship of aneurysm of anterior communicating artery complex to the longitudinal fissure and gyrus rectus.

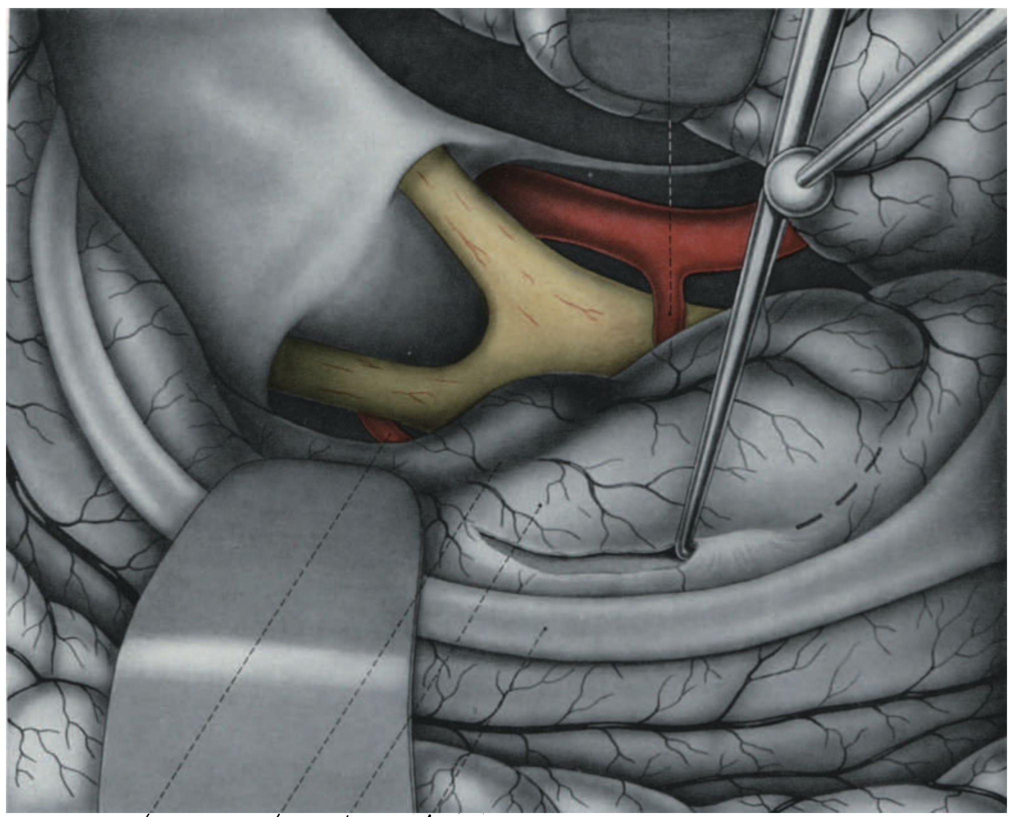


Fig. 87. Operative approach of aneurysm of anterior communicating artery with dome of aneurysm pointing inferiorly or anteriorly.
Observe: 1. Aneurysm is left undisturbed in longitudinal fissure. 2. Approach to aneurysm is through gyrus rectus from lateral and above the neck of the aneurysm.

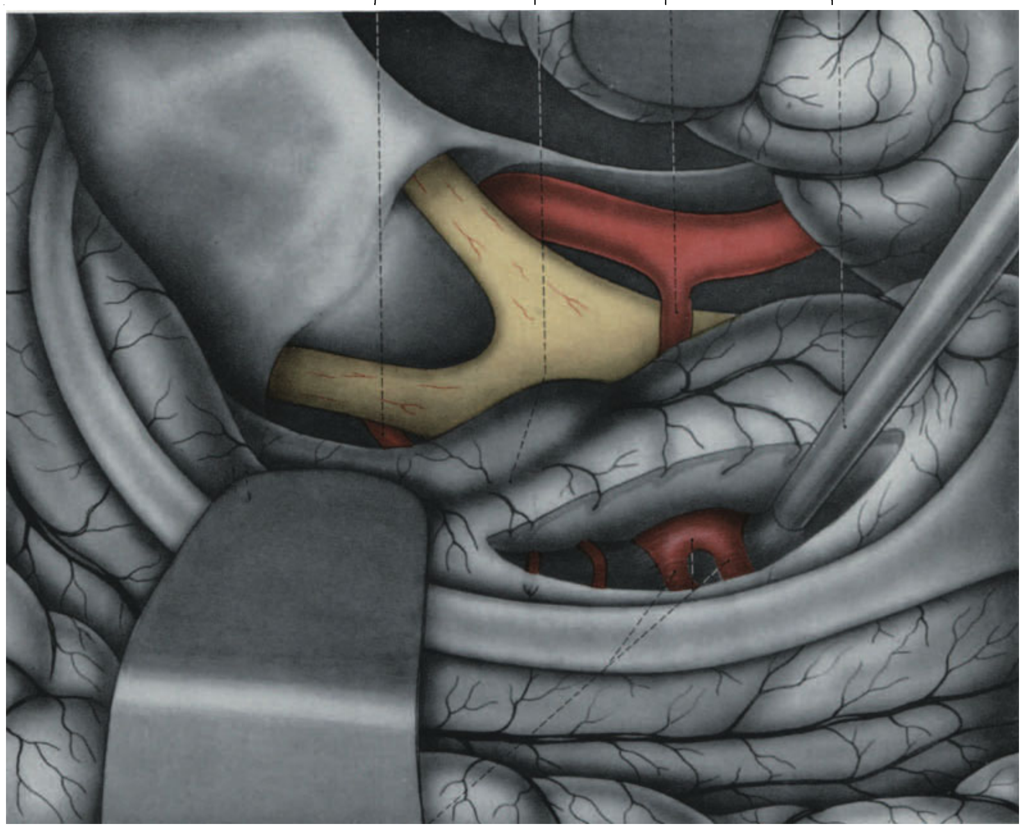


Fig. 88. Operative approach to aneurysm of ant. communicating artery with dome of aneurysm pointing inferiorly or anteriorly.

Observe: 1. Vascular structures in this approach are covered by pia arachnoid which overlies the medial interhemispheric surface of the right gyrus rectus and gives additional protection against unwanted rupture of aneurysm. 2. Dome of aneurysm is left undisturbed.

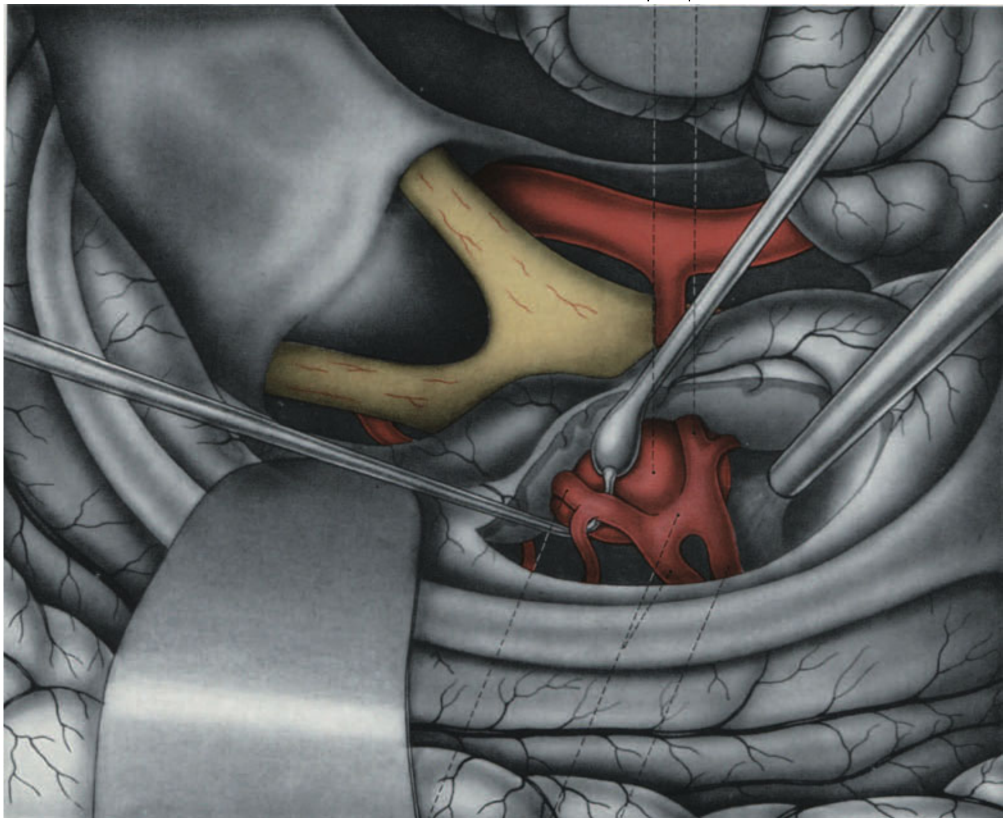


Fig. 89. Exposure through right gyrus rectus of anterior communicating artery aneurysm pointing inferiorly. *Observe:* 1. Leptomeningeal coverings are removed. 2. Dome of aneurysm is left undisturbed. 3. If correctly placed the incision into the gyrus rectus is not longer than 10—15 mm.

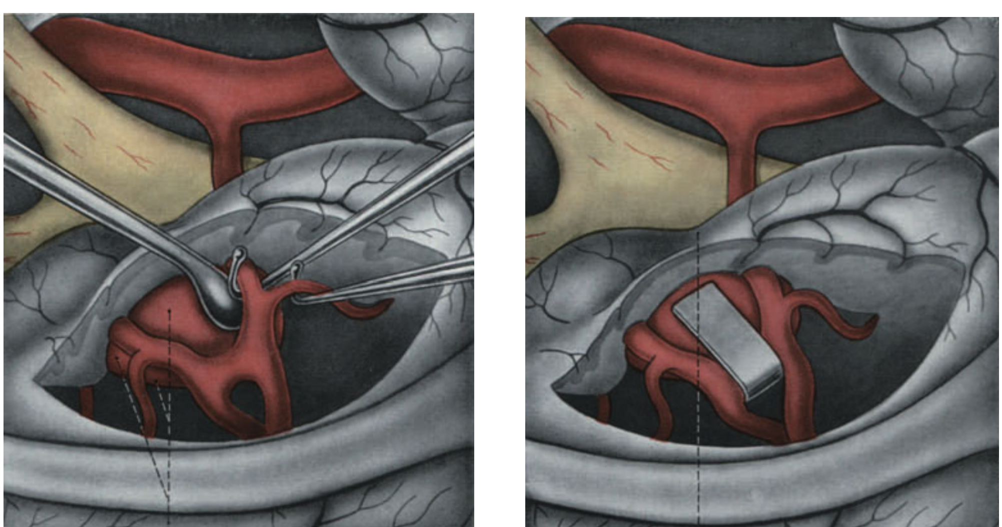


Fig. 90. Identification and clipping of base or neck of aneurysm of anterior communicating artery with dome of aneurysm pointing inferiorly.

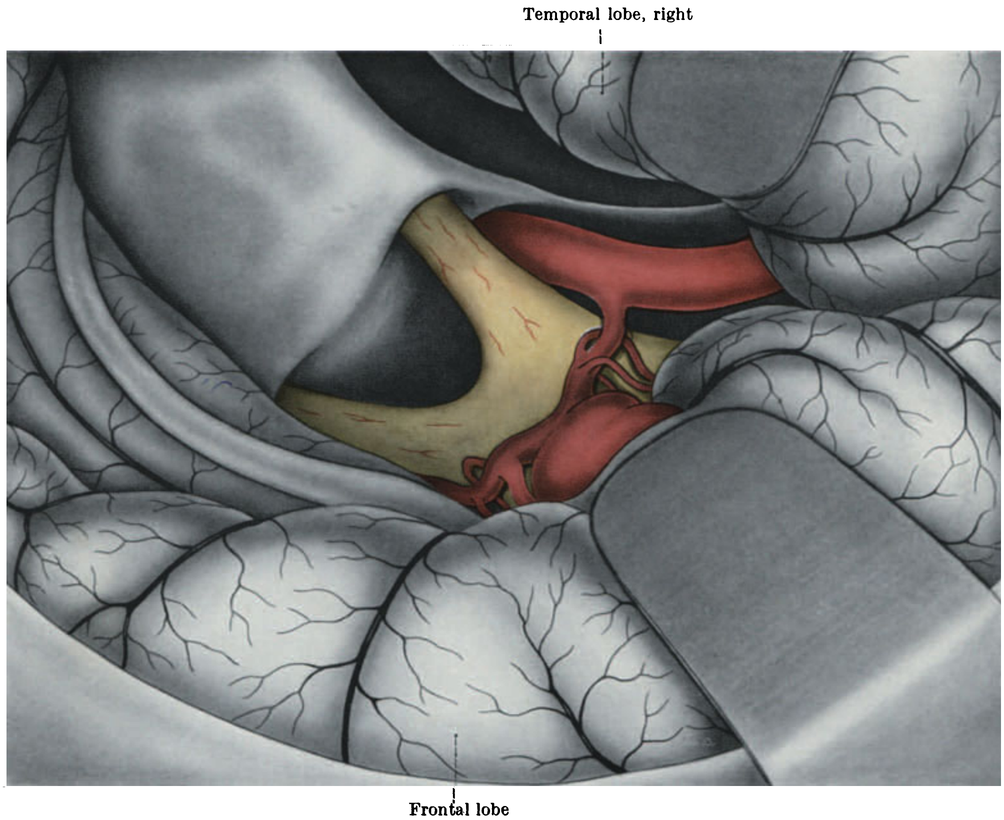


Fig. 91. Operative exposure of aneurysm of anterior communicating artery through right frontotemporal craniotomy.
Observe: 1. Dome of aneurysm is left unexposed. 2. Dome of aneurysm pointing superiorly and posteriorly.

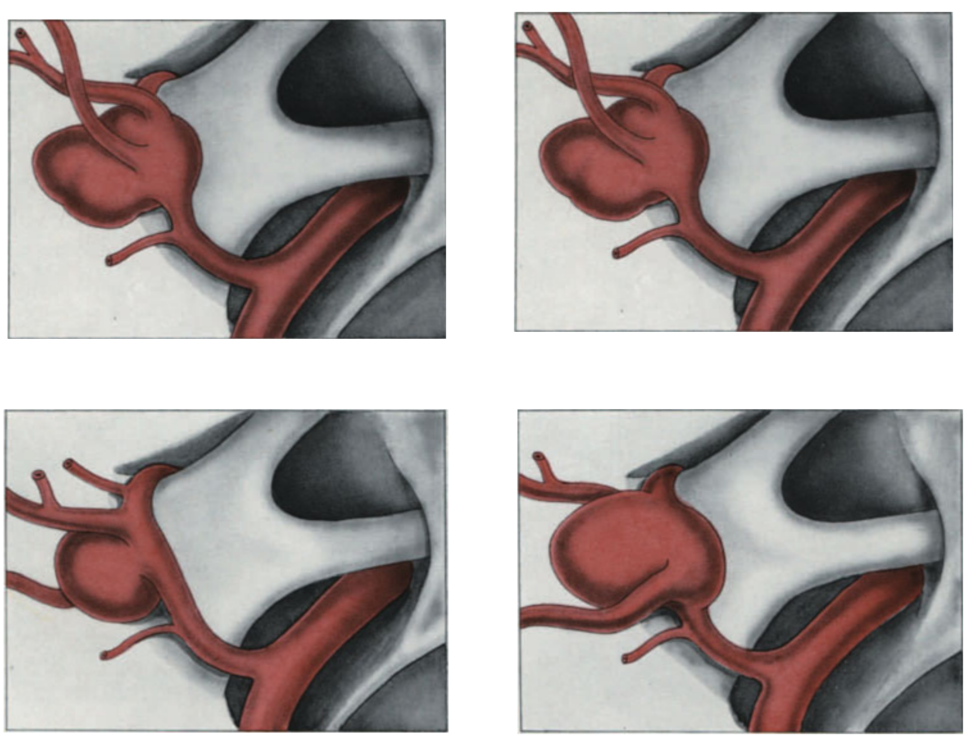


Fig. 92. Four examples of aneurysm of anterior communicating artery complex which are not clippable but were successfully encased in fine mesh gauze and methylmethacrylate as seen in Fig. 62 to 66, and Fig. 78.

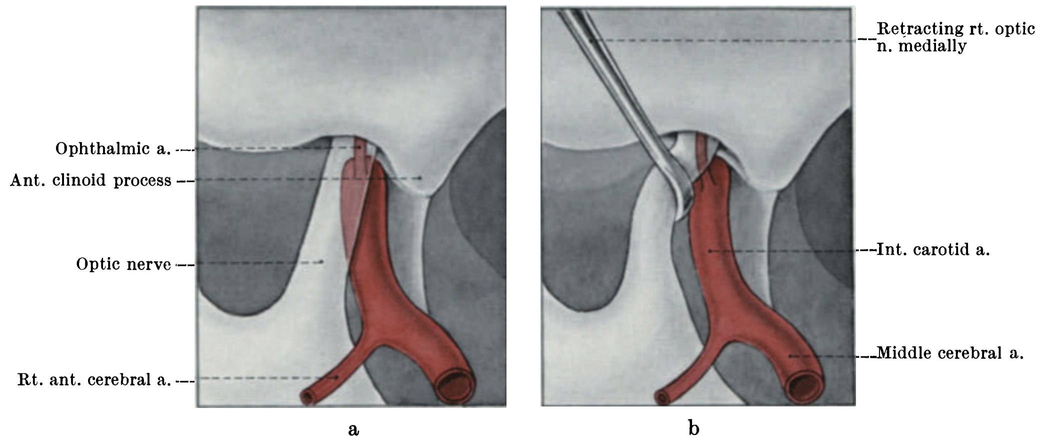


Fig. 93a and b. Exposure for ligation of rt. ophthalmic a.

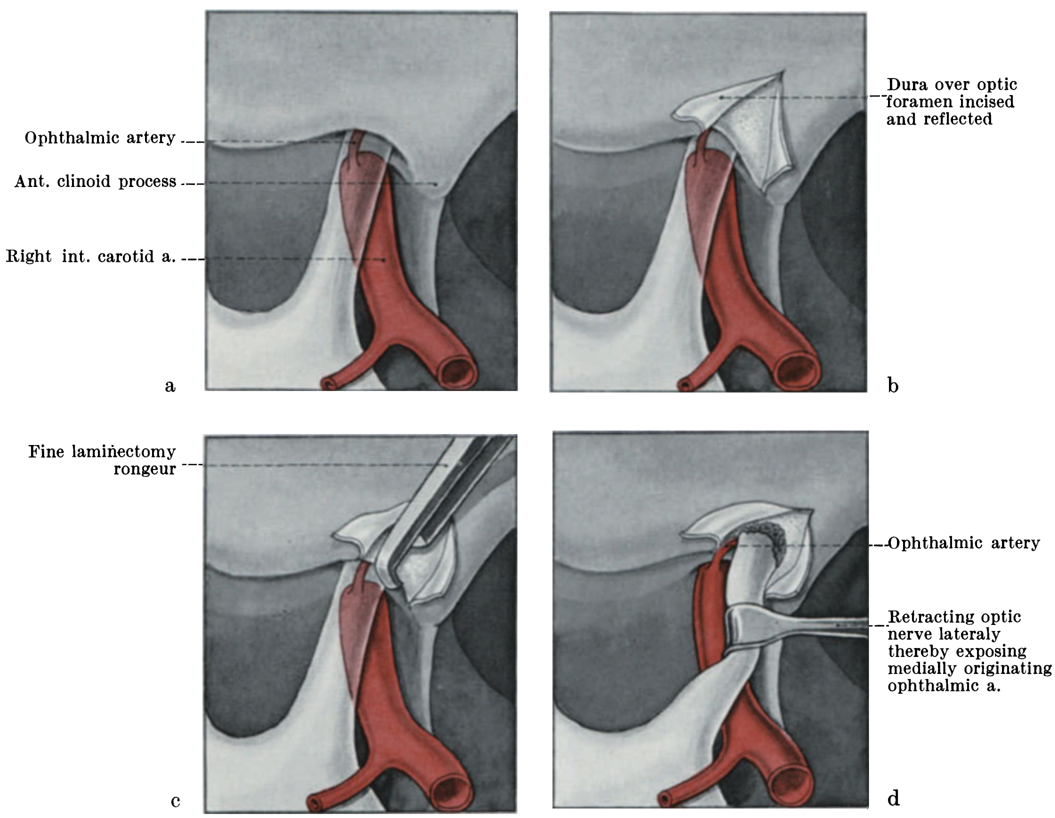


Fig. 94a—d. Exposure for ligation of ophthalmic a. which originates medially. *Observe:* Fig. 94d. Retraction of optic nerve into bony defect.

Chapter III

Retrobulbar Intraorbital Tumors (Optic Nerve Glioma)

In mass lesions situated behind the optic globe the intracranial approach remains the method of choice. In tumors of the optic nerve, the transcranial approach is the only way to manage the possible intracranial extension of the tumor. Lesions situated anteriorly, laterally and inferiorly to the globe are in the domain of the ophthalmologists. The case presented is a dumbbell-shaped, right-sided optic nerve glioma. On occasion a patient with this type of tumor will still have fairly adequate vision. Since the response to radiation and repeated radiotherapy can be quite dramatic and can, on occasion, maintain vision over years, the pros and cons of total extirpation of this lesion have to be discussed with the patient or his guardian. If the tumor involves the optic chiasm and the patient's vision is satisfactory, biopsy and radiation therapy are to be recommended.

The patient is placed on the operating table as seen in Fig. 95a and b and a fronto-temporal craniotomy, as described in Chapter I, is used. Fig. 96 shows the outline of the bone of the orbital roof which will be removed for exposure. The dura of the orbital roof is incised in the longitudinal axis and stripped sideways. The uneven surface of the orbital roof frequently will cause one to tear the dura. Should one of the paranasal sinuses be inadvertently entered, it is advisable to have some remaining dura, especially over the medial side. This redundant dura can be sutured to the orbital fascia and thereby cover the sinus.

After removal of the bone the orbital capsule or fascia will bulge into the defect. The fascia is opened longitudinally to the axis of the optic nerve. The orbital fascia forms the periosteum of the orbit and fuses with the dura mater at the optic foramen. In a dumbbell-shaped glioma the optic foramen has to be unroofed, exposing the tendinous annulus of Zinn which gives origin to external ocular muscles. The annulus is incised and opened to permit lifting of the optic nerve (Fig. 97). The ophthalmic artery is clipped and divided. Muscles and nerves are retracted exposing the tumor (Fig. 98), taking care not to injure the levator palpebrae muscle and the supraorbital branch of the ophthalmic nerve. The tumor is excised leaving the optic globe in place to prevent contamination and infection and for cosmetic reasons. If the tumor is of such size as depicted here, a large cavity will result after the tumor is removed and the frontal lobe will herniate into the orbit. A fine mesh stainless steel wire plate is cut to proper size and filled over this bony defect. Pericranial fascia is fastened to the redundant dura, and muscle tissue and gelfoam are placed into the remaining optic foramen. Free transplant of fatty tissue may be placed into the orbit prior to reconstructing the orbital roof. Such transplants have been found to form very good scars in creating a barrier between the optic globe and the retro-orbital wall. At the end of the operation a temporal canthorrhaphy is performed to protect the cornea.

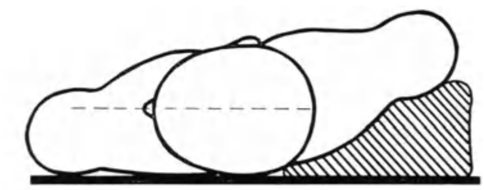


Fig. 95a.

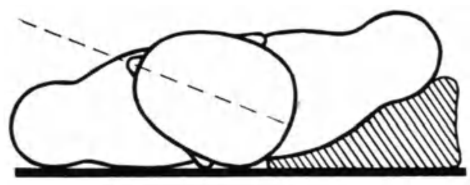


Fig. 95b.

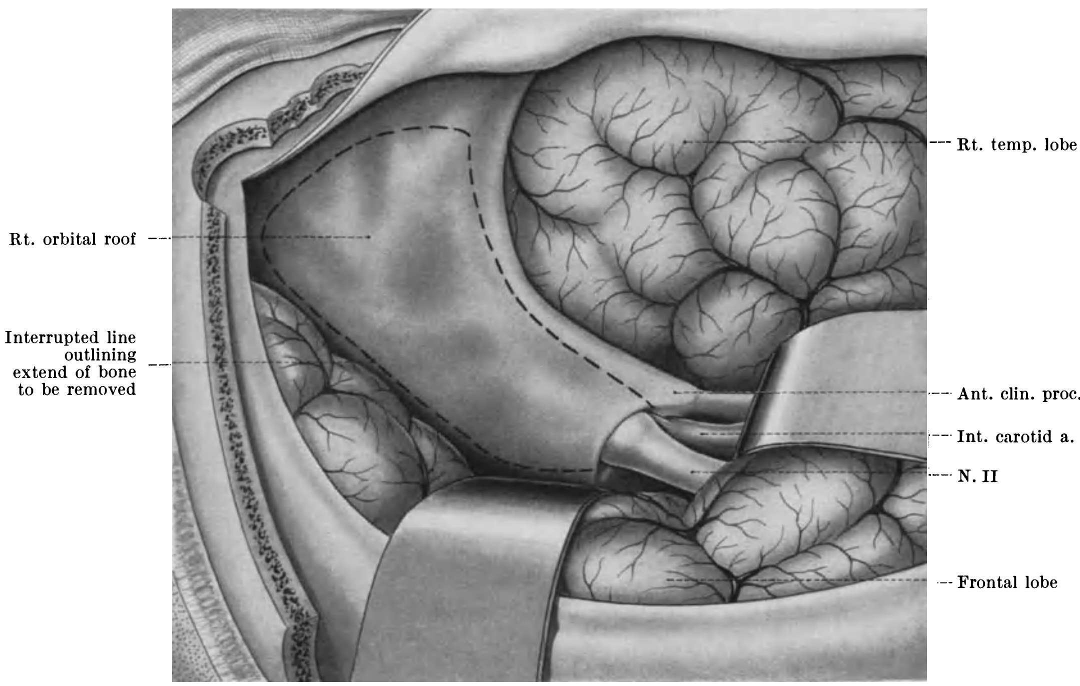


Fig. 96. Operative approach to right intraorbital tumor.
Observe: Abnormal enlargement of optic nerve close to the optic foramen.

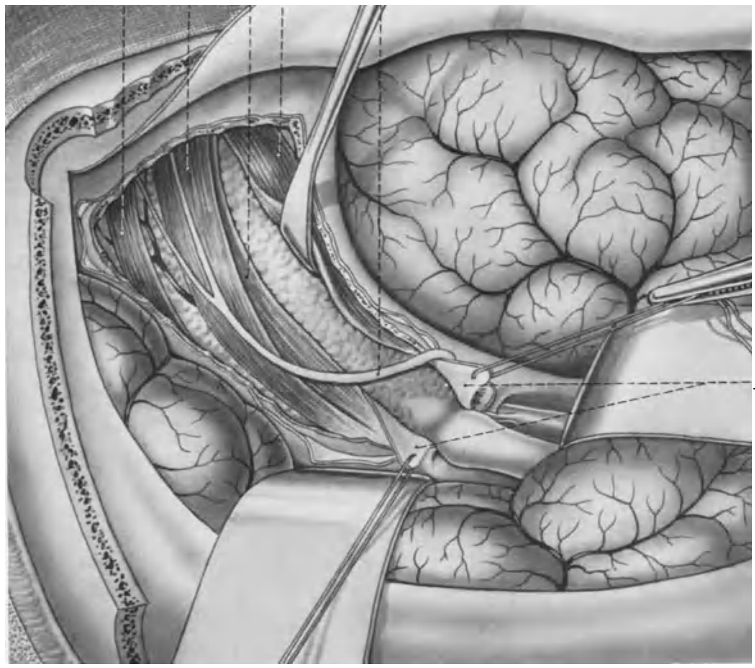


Fig. 97. Operative approach to right intraorbital tumor.
Observe: For clarity N. IV and venous channels are not shown.

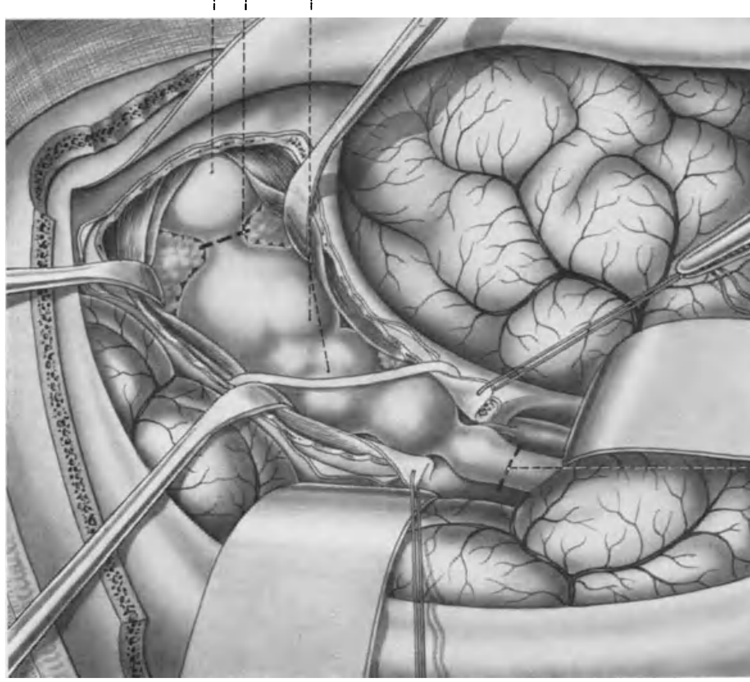


Fig. 98. Right optic nerve glioma exposed.

Chapter IV

Pituitary Tumor (Adenoma)

The patient with pituitary adenoma presents himself initially because of endocrine manifestations and later, when the tumor extends beyond the sella turcica, because of pressure symptoms on the neighboring structures, foremost of which is the optic chiasm. The goal of any operative intervention is to relieve the pressure on the optic nerves and chiasm and the remaining functioning pituitary tissue. The patient in the case illustrated presented with an unusually large tumor causing indentation into the floor of the third ventricle which could lead to obstruction of the intraventricular pathways (Figs. 99 and 100). Surgery is, in addition, intended to open these pathways. Such large suprasellar extensions are more frequently seen in craniopharyngiomas (see Chapter V).

Immediate preoperative studies include angiography to rule out a possible large aneurysm and pneumoencephalography to obtain additional information as to the size of the suprasellar extension of the lesion. Most often the operative approach is from the right, nondominant, side. Rarely is it necessary to approach the lesion from the opposite side to protect a sole remaining left optic nerve. In pituitary adenomas a decompression of the optic nerves is usually not difficult. In craniopharyngiomas this situation is different since the tumor may be quite adherent to optic nerve and internal carotid artery. If the tumor capsule in a pituitary adenoma or craniopharyngioma cannot be easily removed from the nerve and artery, it is unquestionably best to leave the capsule in place.

The position of the patient is shown in Fig. 101a and b. The craniotomy (Fig. 102) is the same as presented in Chapter I. Instead of the skin incision as seen in Fig. 102 a transcoronal approach may be chosen to have the scar behind the hairline. The frontal lobe is elevated to expose the chiasmatic cistern, which is opened to gain further exposure (compare Fig. 29, p. 24). Usually the cistern is filled by the tumor (Fig. 103). The bridging veins over the temporal lobe are coagulated and sectioned as described previously. A 20-gauge spinal needle is inserted into the tumor (Fig. 104) presenting between the optic nerves to ascertain whether it could be a large aneurysm that did not fill in the preoperative angiogram because of partial thrombosis. A partially cystic degenerated tumor may be encountered and aspirated. The needle is held by hemostat to prevent any slipping while aspirating. The needle is inserted not deeper than 4 to 5 mm and kept in the midline to prevent any injury to the opposite internal carotid artery. We coagulate and then incise the tumor capsule which, in this case, consists partly of thinned out diaphragma sellae bulging anteriorly to the chiasm (Figs. 105 and 106). A bone curet or a malleable gallbladder spoon is used to remove tumor tissue (Fig. 107). The objective is to decompress the optic nerve and chiasm and, in our case, the intraventricular pathways. A radical removal, even though technically feasible, is not to be done since the removal of the tumor capsule may disrupt the blood supply to the hypothalamus. By careful curetting and suctioning, avoiding the base and the extreme lateral extension of the sella turcica, we avoid opening the cavernous sinus whose dural wall is extremely thinned out. By removing the tumor tissue extending upwards, without removing the tumor capsule from the base of the brain, about 75 per cent of the tumor is removed. Some of the tumor capsule presenting between the optic nerves is removed (Fig. 108). Bleeding from the tumor bed is controlled by temporary tamponade with gelfoam or muscle tissue.

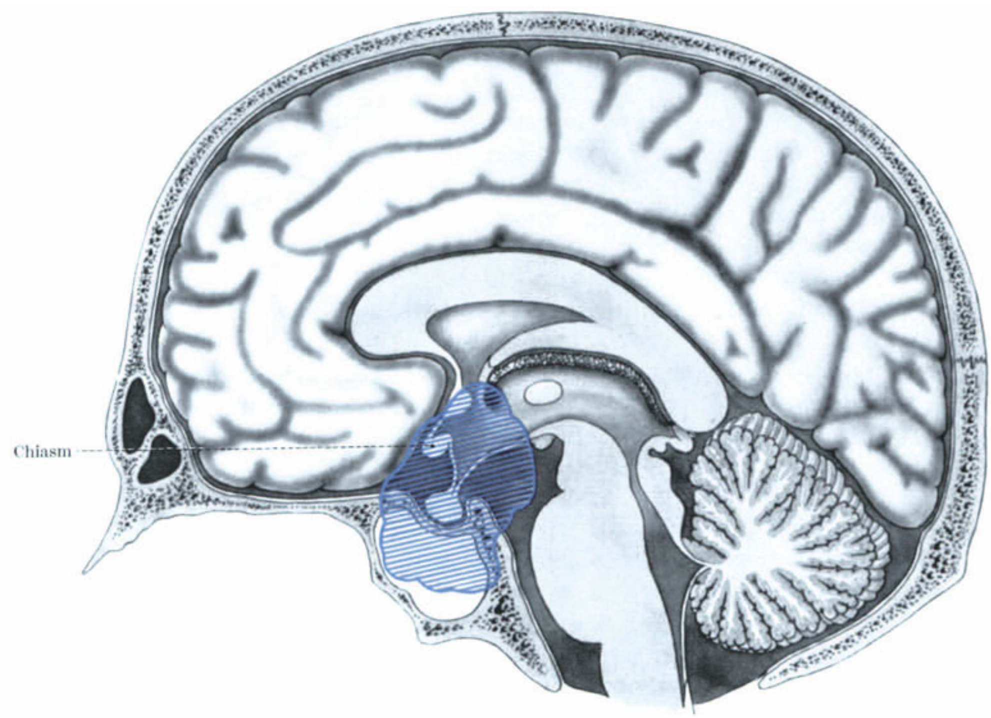


Fig. 99. Schematic drawing projecting pituitary tumor on normal midline craniocerebral structures.

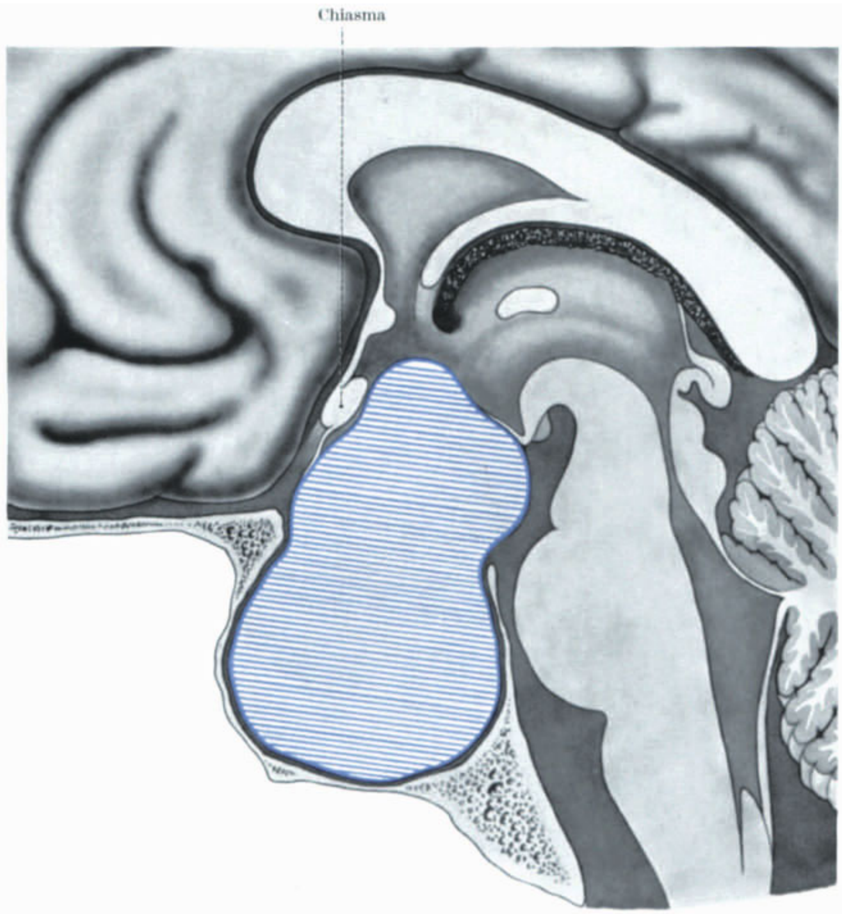


Fig. 100. Pituitary adenoma, midline sagittal section.
Observe: Nodules of tumor situated behind and above chiasma.

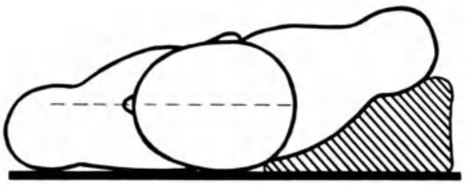


Fig. 101 a.

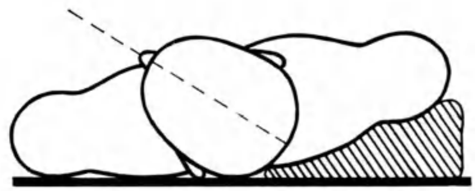


Fig. 101 b.

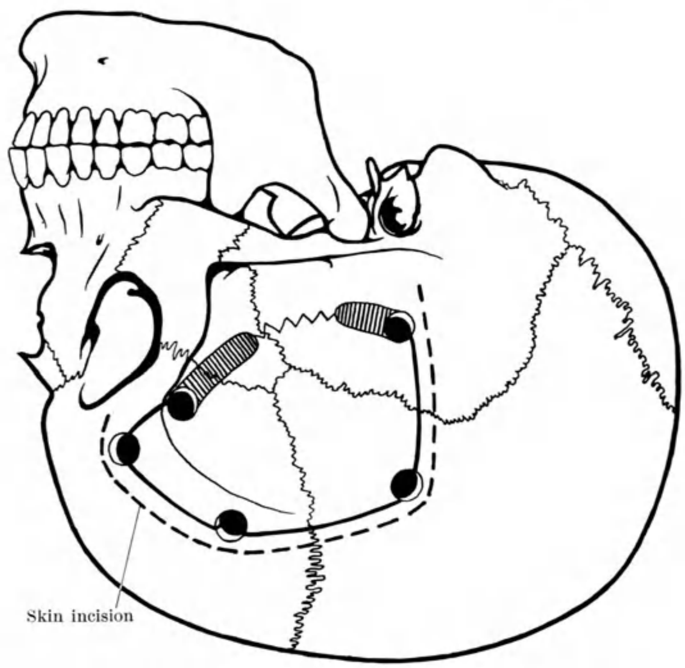


Fig. 102. Skin incision and craniotomy for pituitary tumor.

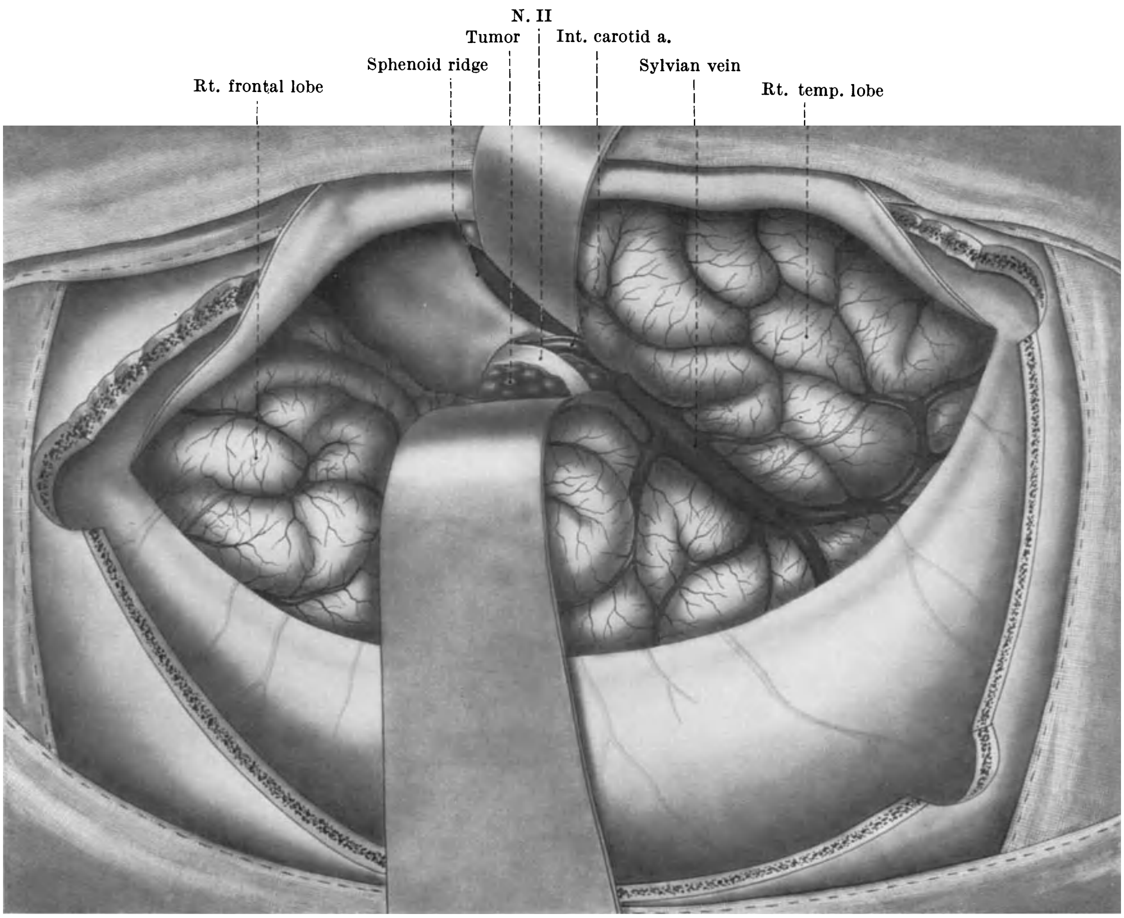


Fig. 103. Operative exposure of pituitary tumor through right fronto-temporal craniotomy.

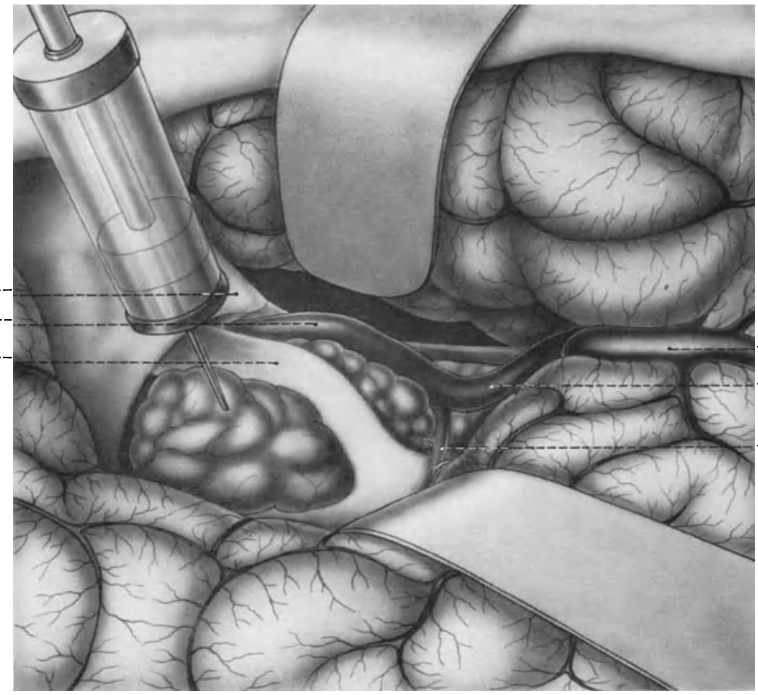


Fig. 104. Close up view of operative exposure of pituitary tumor.
Observe: 1. Insertion of aspirating needle into center of tumor. 2. Elevation and flattening of optic nerve. 3. Lateral displacement of int. carotid artery.

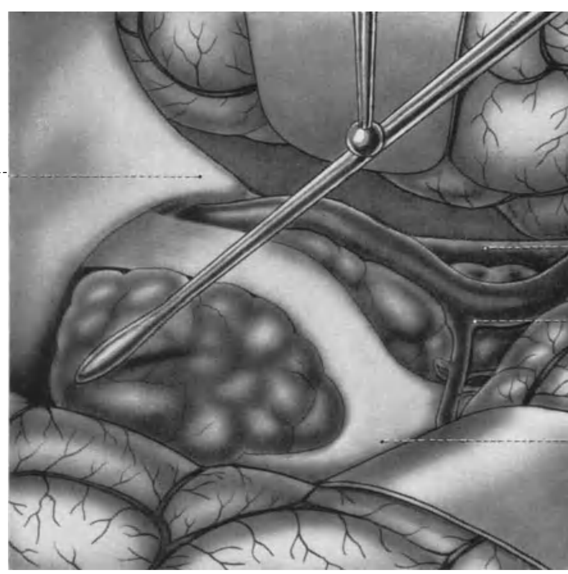


Fig. 105. Coagulation of tumor capsule in preparation for incision.

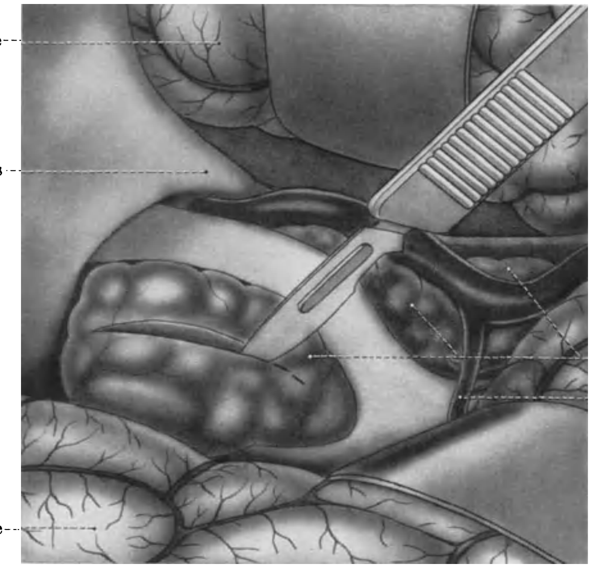


Fig. 106. Incision into tumor capsule.

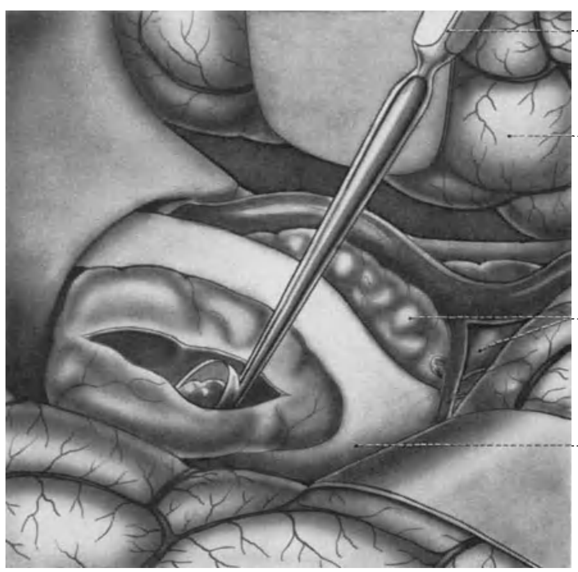


Fig. 107. Intracapsular removal of tumor tissue.

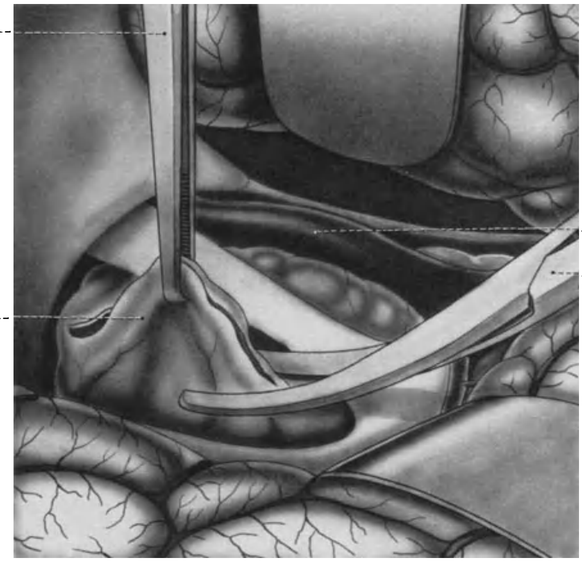


Fig. 108. Partial removal of capsule

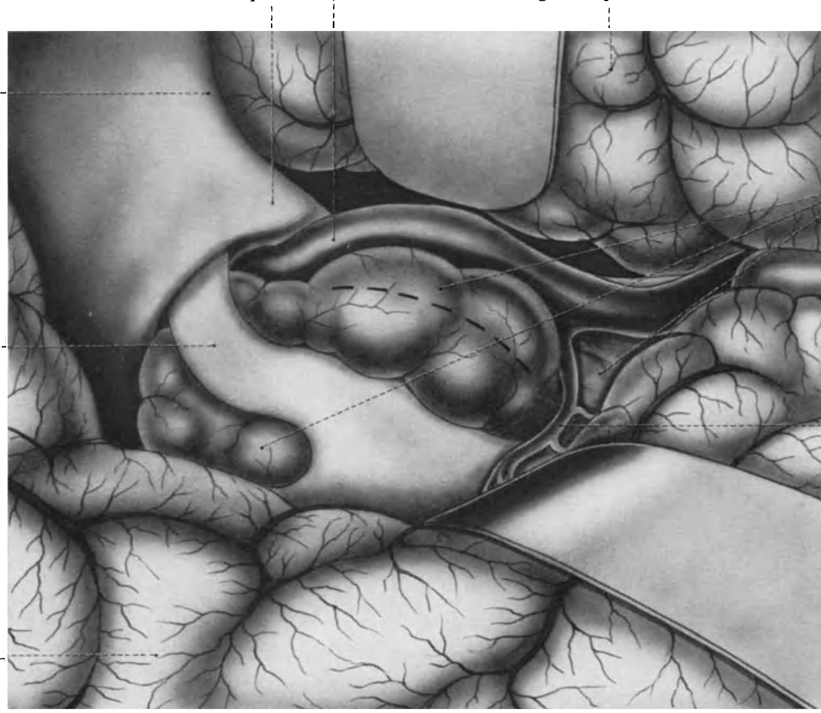


Fig. 109. Anteriorly fixed chiasm with tumor bulging lateral to optic nerve and chiasm.
Observe: Line of incision over tumor between int. carotid a. on one side and optic nerve and chiasm on the other.

Occasionally we find a prefixed chiasm and the tumor cannot be approached from the midline between the optic nerves. A lateral approach between optic nerve and chiasm medially and internal carotid artery laterally is shown in Fig. 109. In Fig. 109 the tumor not only has displaced the optic nerve, chiasm, and internal carotid artery but also has nearly enveloped the anterior cerebral artery close to the bifurcation. After decompressive surgery it is preferable to leave the tumor capsule alone so as to prevent injury to the vascular structures.

Hypophysectomy

Knowledge of the anatomical relationship of the pituitary to the arachnoid and dura is essential in doing a complete hypophysectomy. The hypophysis is surrounded by a true mesenchymal organ capsule and external to it is a fine venous network embedded in loose connective tissue. It hangs in a true subarachnoidal space called the hypophysial cistern. This cistern is in free communication with the chiasmatic cistern. The relationship of the arachnoid to the dura at the opening of the diaphragma sellae is fundamentally different. Here, the arachnoid is fused with the dura or, in other words, the subdural space is interrupted in a circular fashion at the opening of the diaphragma sellae. The line of cleavage in hypophysectomy is the hypophysial cistern. However, is most cases there are some areas of fusion with the arachnoid over the lateral aspect of the pituitary and several strong trabeculations directly below the diaphragma sellae. Accordingly, during hypophysectomy it is likely to have some tissue remaining over these areas. The danger of breaking through the dura and of entering the cavernous sinus is less in hypophysectomy than in the removal of a pituitary adenoma where the dura may be extremely thinned out. In both cases, one should avoid scraping the wall and bottom of the sella.

The operative approach for hypophysectomy is from the nondominant side. The position of the patient on the operating table is seen in Fig. 110a and b. The skin incision and craniotomy are identical with the ones described in Chapter I (see also Fig. 102, p. 82). The frontal lobe is elevated, the right optic nerve visualized and the cisterna chiasmatica is opened (compare Fig. 29, p. 24). After the chiasm is gently lifted, the pinkish pituitary stalk will be seen (Fig. 111). The stalk is pulled slightly forward with the help of a blunt nerve hook and then either clipped and divided or coagulated and divided. A blunt nerve hook is introduced into the opening of the diaphragma sellae to tent and coagulate it. Cutting current or a knife may be used to widen the opening of the diaphragma sellae. It is important not to extend this opening too far forward to avoid the anterior superior circular extension of the cavernous sinus (Figs. 112 and 113). A ring curette will break the pituitary tissue and the fragments are removed by irrigation and suction (Fig. 114). Because of the anatomical relationship, fragments of tissue are more likely to be found remaining directly below the diaphragma sellae and parts of the true mesenchymal capsule of the pituitary should be looked for using a fine spatula under constant irrigation.

Fig. 110a.

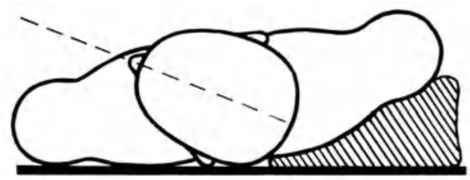


Fig. 110b.

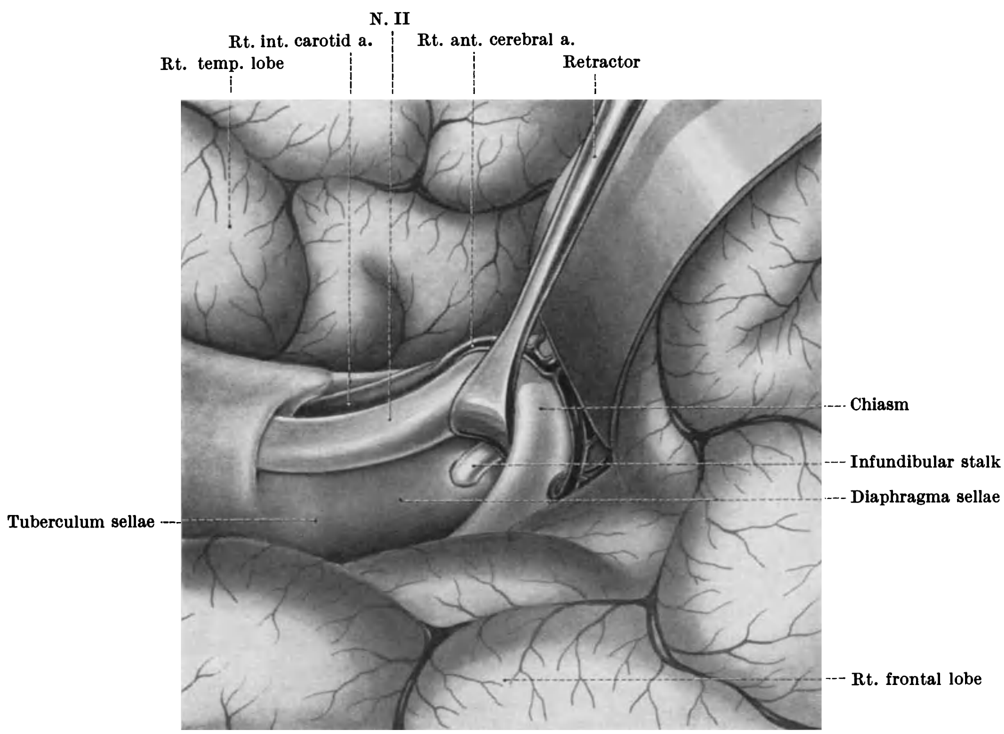


Fig. 111. Operative approach in hypophysectomy through right fronto-temporal craniotomy. *Observe:* Steady but gentle elevation of optic chiasm.

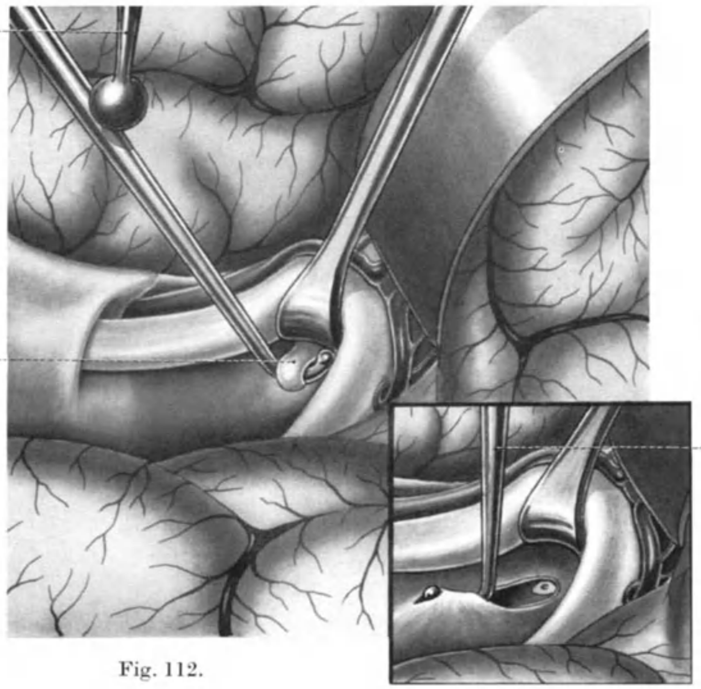


Fig. 112. Fig. 113.

Fig. 112 and 113. Division of infundibular stalk and opening of diaphragma sellae in hypophysectomy.

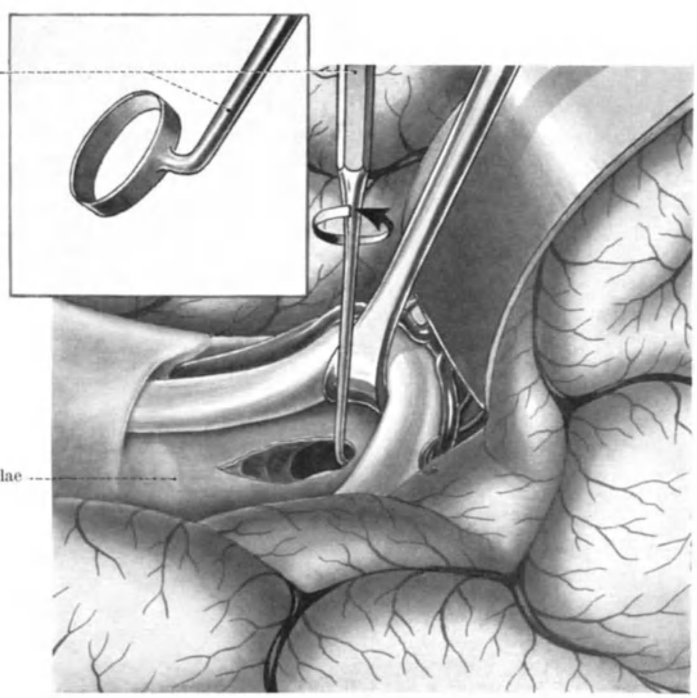


Fig. 114. Hypophysectomy.

Observe: 1. Diaphragma sellae opening does not extend to the tuberculum sellae in order to prevent entering sup. recess of cavernous sinus. 2. Ring curette is used to break up the pituitary and the fragments are then removed by suction and irrigation. 3. Ring curette is not used to scrape the wall of the sellae to avoid entering the cavernous sinus.

Chapter V

Craniopharyngioma

The size and configuration of craniopharyngiomas varies a great deal. Nearly every tumor is partially cystic. The relation of the cyst to the more solid part of the tumor is rather constant with the cyst anterior and the solid tumor inferior, close to the pituitary and the pituitary stalk. The tumor presented in Fig. 115 and 116 is lying completely outside the sella turcica, bulging into the third ventricle and into the interpeduncular fossa. Contrary to pituitary adenomas the strong connective tissue capsule of the craniopharyngioma adheres to the surrounding tissue; i.e., optic nerves, optic chiasm, internal carotid arteries and branches, infundibular stalk, and hypothalamus. It is this close attachment of the tumor capsule which prevents the total removal of the tumor and the capsule. Nothing is gained by leaving the patient with an infarcted hypothalamus after "successful" total removal of the tumor. Occasionally the capsule appears to come off the surrounding structures without any difficulty but it should be remembered that, especially over the hypothalamus, the fine vessels leaving the posterior communicating arteries which supply the hypothalamus are usually injured and result in infarction of the hypothalamus. We, therefore, do not attempt to remove the tumor capsule over the posterior superior aspect. Also, any part which adheres closely to optic nerve, chiasm, and artery is left alone. The objective of the operation is reduction of tumor mass, decompression of surrounding structures and patency of the intraventricular pathways. The immediate preoperative studies are the same as for pituitary adenoma. Angiography is important to establish the relationship of the blood vessels of the anterior part of the Circle of Willis. Also, bowing of the A-2 section of the anterior cerebral arteries may point to enlarged lateral ventricles, obstruction at the foramen of Monro, and/or a tumor bulging into the interpeduncular fossa. The vertebral angiogram will give additional information as to the extent of the tumor and displacement of the posterior part of the Circle of Willis. Pneumoencephalography gives information as to the size of the tumor. Plain skull films and laminography often show the widespread calcification and will give a clue to the tumor size.

The operative approach is from the right, nondominant, side as described in pituitary adenoma, Chapter IV. The position of the patient is seen in Fig. 117a and b. Configuration of the craniotomy is the same as described in Chapter I. Again, it does not appear to be necessary to approach the lesion from the side with the optic nerve that we want to preserve because the optic nerve on the opposite side with intracapsular reduction of the tumor mass will come into view and can be protected. It is not wise to remove the capsule from the hypothalamus but only to remove the capsule from optic nerve and carotid artery if it is not too closely adherent.

A needle is first introduced into the anterior aspect of the presenting tumor tissue (compare Fig. 104). This part of the tumor, as stated earlier, is invariably cystic. Care is taken not to spill the cholesterol-containing fluid for it causes a chemical leptomeningitis. Figs. 118, 119 and 120 reveal the operative steps. The tumor capsule, after aspiration, is opened. These pictures should be compared with Fig. 116 to re-emphasize the extension of this tumor behind the chiasm and into the third ventricle. A large, round, flexible, copper curette is most suitable for removal of the solid part of the tumor. Not shown in these pictures is the use of wet cotton pledgets to protect the surrounding tissue from any spillage of the cystic contents.

It is not in the scope of this book to discuss preoperative and postoperative corticosteroid medication which is the single most important adjunct in surgery of the sellar and parasellar areas during the past two decades.

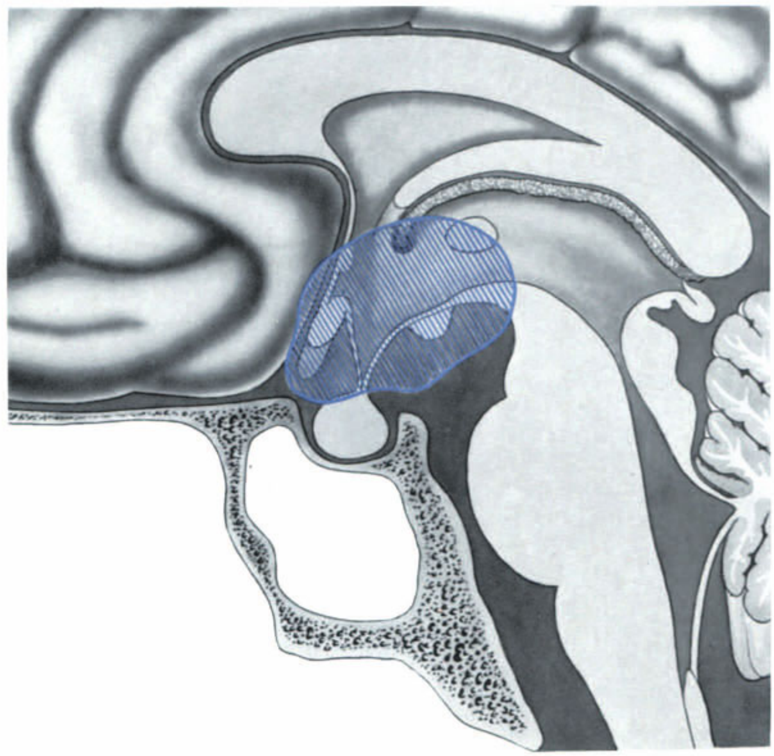


Fig. 115. Schematic drawing of typical craniopharyngioma projected on normal midline craniocerebral structures.

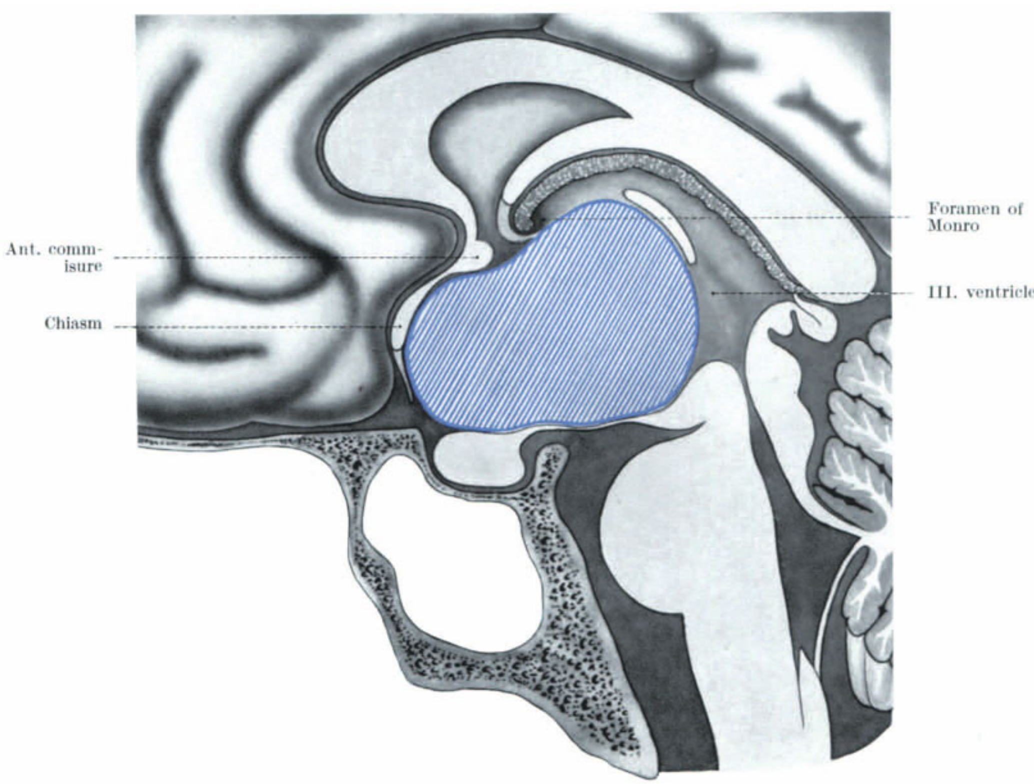


Fig. 116. Midline sagittal section of craniocerebral structures displaced by craniopharyngioma.
Observe: 1. Displacement of chiasm. 2. Relation of tumor to III. ventricle.

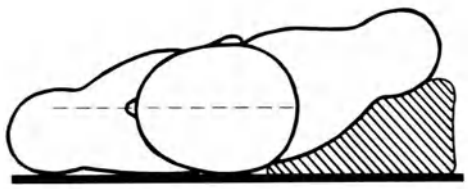


Fig. 117a.

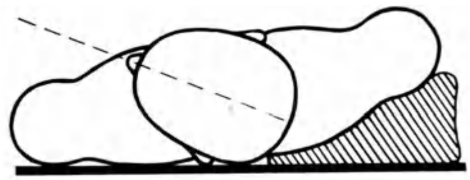


Fig 117b.

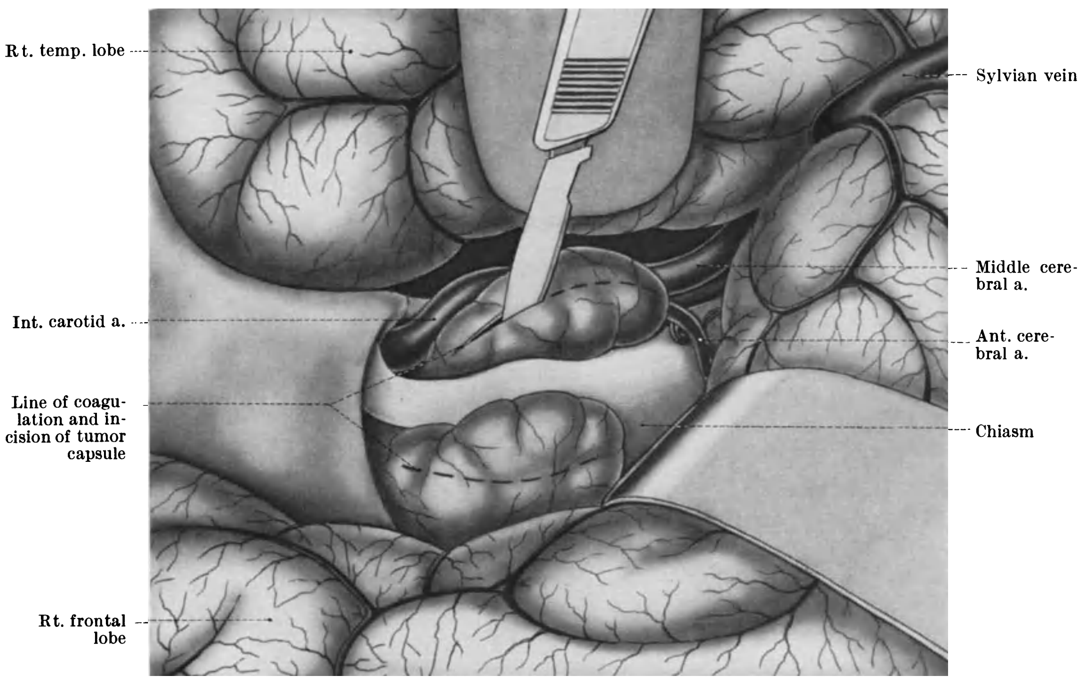


Fig. 118. Operative exposure of craniopharyngioma through right fronto-temporal craniotomy.

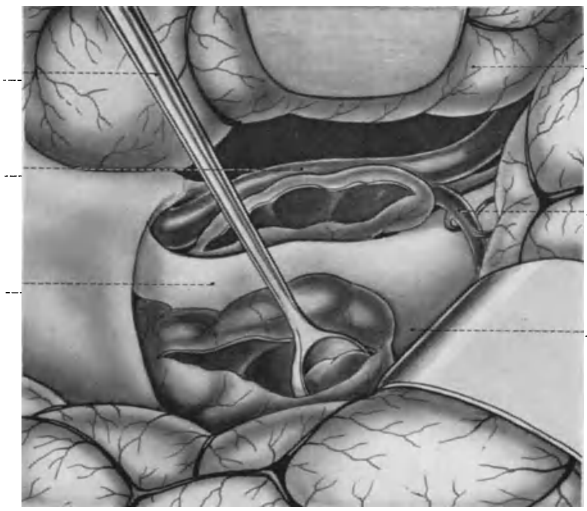


Fig. 119. Intracapsular removal of tumor.

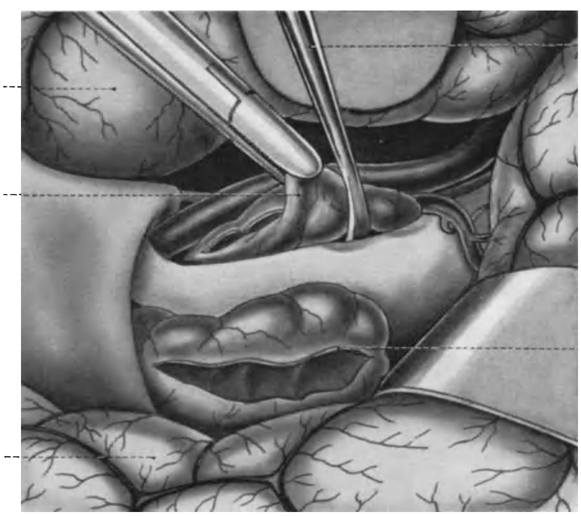


Fig. 120. Removal of tumor capsule of craniopharyngioma.

Chapter VI

Tuberculum Sellae Meningioma

The first clinical sign and symptom of the meningioma located over the tuberculum sellae is a defect in the field of vision. Invasion of the cavernous sinus will lead to extraocular muscle paralysis and fifth nerve involvement. Larger and more extensive lesions impair pituitary and hypothalamic function.

Angiography is the most helpful study which shows displacement of the anterior cerebral arteries and outlines the vascular supply to the tumor from the ophthalmic artery via the posterior ethmoidal arteries and from the middle meningeal artery. In twelve tuberculum sellae meningiomas, bilateral carotid arteriography revealed the middle meningeal artery to have definite branches going to the tumor in only two cases. The venous phase of the angiogram gives a most homogenous staining in meningioma and thereby gives the best indication as to the size of the tumor.

In Fig. 121 a typical tuberculum sellae meningioma is depicted, which shows displacement of the optic chiasm posteriorly and the optic nerves laterally. In olfactory groove meningioma the displacement of these structures is downward (see Fig. 142). The operative approach is from the right, or nondominant hemisphere, and the position of the patient is depicted as shown in Fig. 122. The same frontotemporal craniotomy is used as discussed in Chapter I. A larger craniotomy is not desirable. The tip of the temporal lobe is mobilized as seen in Figs. 30 to 33. Only thereafter is the frontal lobe gently retracted. Moist cotton strips are placed directly to the tumor wall as soon as a part of the tumor is seen. The retractor is re-applied over the cotton strips to help expose a smooth line of cleavage between brain and tumor. Hyperventilation anesthesia will permit definite reduction of brain mass and help to bring the tumor into view as seen in Fig. 123. A small tumor may be dislodged from its base; however, great care is to be taken to ascertain the relationship of the tumor to the optic nerves and carotid arteries. In moderate to large tuberculum sellae meningiomas these structures may be adherent to the tumor capsule or even completely surrounded by the tumor. (This problem is more often seen in medially located sphenoid ridge meningiomas as will be discussed in Chapter IX, p. 109.) It may be necessary to leave a shell of tumor tissue around the optic nerve and vascular structures. If the tumor is of such size as to prevent a full view of its relationship to the opposite optic nerve, the tumor is reduced in size using the wire loop electrode (Fig. 124). Continuous suction to remove the smoke and blood is needed. The capsule with a shell of tumor is then separated from optic nerves, chiasm, carotid arteries, tuberculum, and diaphragma sellae by gentle traction and by the use of the Sachs separator (Fig. 125). The tumor bed will show brisk bleeding from the feeding arteries. To protect the optic nerves from the heat generated by unipolar coagulation, the bipolar coagulation under continuous saline irrigation is employed (Fig. 126). Bipolar coagulation will also lessen the possibility of entering the cavernous sinus when coagulation over the lateral extent of the diaphragma sellae is needed.

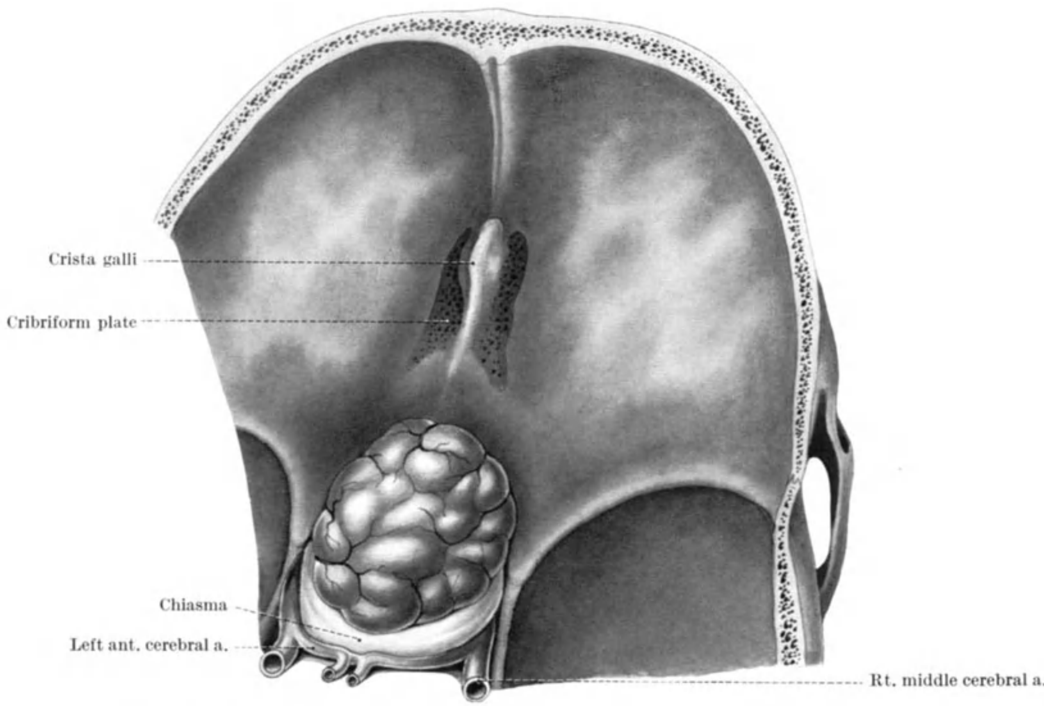


Fig. 121. Anatomical demonstration of tuberculum sellae meningioma.
Observe: Displacement of optic nerve and chiasm.

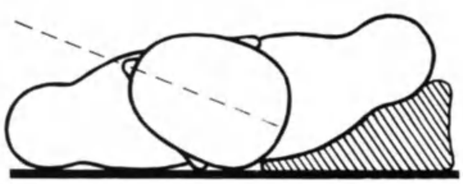


Fig. 122.

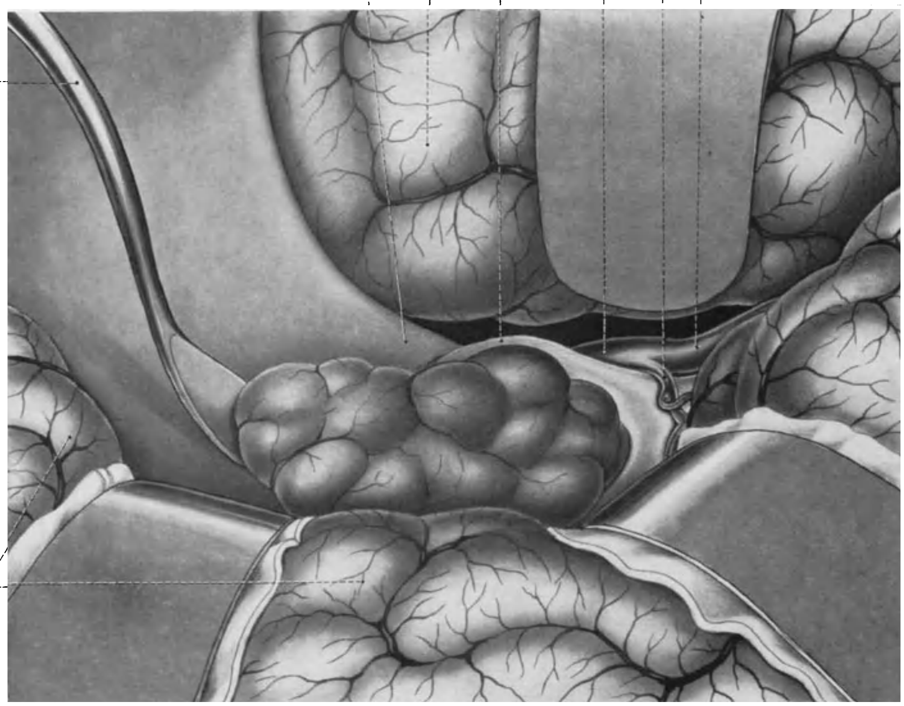


Fig. 123. Operative approach for tuberculum sellae meningioma through right fronto-temporal craniotomy.

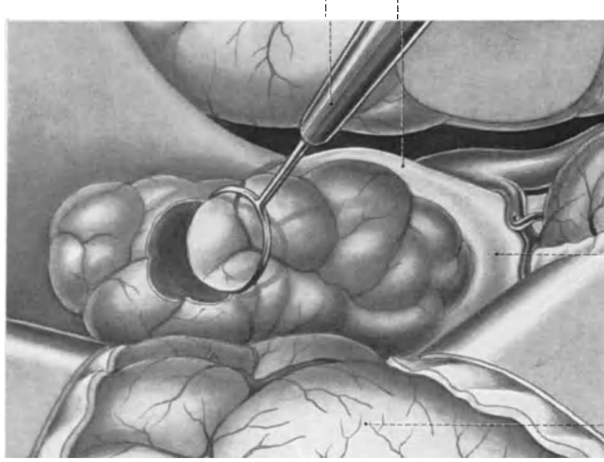


Fig. 124. Use of loop cautery to reduce size of tumor.

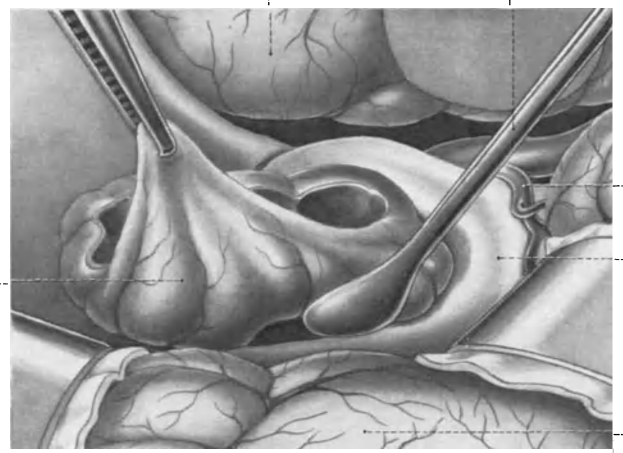


Fig. 125. Tuberculum sellae meningioma

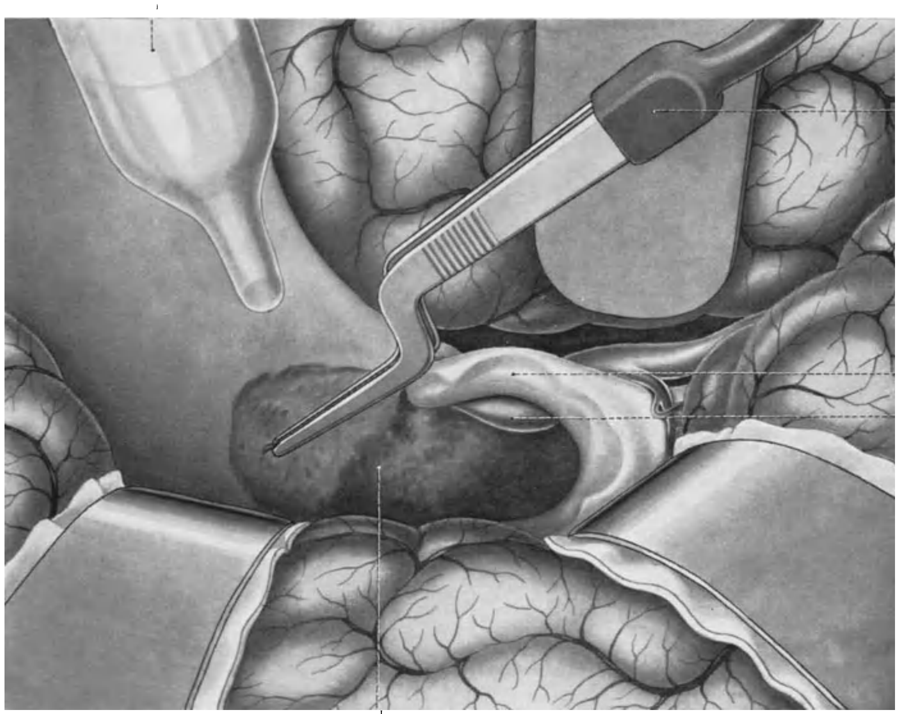


Fig. 126. Hemostasis of tumor bed.
Observe: 1. *Bipolar* coagulation over the tumor bed keeps dissipation of heat to a minimum to protect the optic nerves. 2. Constant irrigation will aid in heat dissipation.

Chapter VII

Frontal Lobectomy

Frontal lobectomy may be indicated in several circumstances. With olfactory groove meningiomas in which the frontal lobe forms a shell around the tumor, it is not possible to remove the lesion without destruction of part of the frontal lobe. The same holds true with large meningiomas of the sphenoid ridge and planum sphenoidale. Thus, with these tumors, a limited lobectomy is needed. In trauma, the contused lacerated lobe may have to be removed in performing a good debridement. Arteriovenous malformation may require removal of the lobe, but the most frequent reason for removal of the prefrontal part of the frontal lobe is internal decompression in gliomas which otherwise occupy most of the frontal lobe.

In the description of the removal of parts of the cerebral hemisphere (prefrontal part of the frontal lobe, temporal lobe and occipital lobe) the dominant hemisphere will be presented to illustrate which part of the hemisphere should be left behind in order to prevent profound neurological deficits. It is also believed that with a detailed description of a cerebral lobectomy the operative maneuvers for the removal of a more localized, circumscript glioma or metastatic intrahemispheric lesion can be handled and do not deserve separate descriptions. The same basic principles apply to the cortical incision, the exposure and removal of the tumor, the use of a spatula, soft cotton pledget, and suction, and the surgeon's "trained" finger. Hemostasis by clipping and coagulation with the aid of suction and dripping wet cotton fluff is analogous in the operative technique used in the here-to-be described lobectomy.

The patient is positioned for a left frontal lobectomy as seen in Fig. 127a and b. For all operative procedures described in this book to this point we have used the same frontotemporal craniotomy. Now a larger craniotomy is needed and is shown in Fig. 128. The craniotomy extends $1^1/_2$ cm lateral from the midline. If a lobectomy is needed for an arteriovenous malformation the craniotomy should come to the midline since it will then be easier to handle the bridging, draining veins. The skin incision is preferably transcoronal behind the hairline. In Fig. 129 the line of the cortical incision on a left hemisphere is presented for the prefrontal lobectomy. This Figure should be compared with the operative exposure in Fig. 130. BRODMANN's area 44 (BROCA's area) must be preserved. To find this area we usually can discover a sulcus ascending at a right angle from the Sylvian fissure and interrupting the large inferior frontal gyrus. Cortical structures lying posterior to this sulcus, also called pars opercularis of the inferior frontal gyrus, are to be spared.

After opening and reflecting the dura, the pia arachnoid along the line of intended excision is coagulated using the tip of a smooth coagulation forceps (Fig. 131). Thereafter a small opening is made into the pia arachnoid by grasping and coagulating it along with the superficial layer of cortical tissue with a smooth forceps (Fig. 132). It is helpful to have adjacent to the area to be coagulated a small cotton pledget attached to the tip of the suction. Keeping the field dry in this way will give better coagulation. The coagulated pia-arachnoid is incised (Fig. 133) and the coagulated cortex is removed by suction (Fig. 134). Larger vessels are first clipped, then coagulated and cut (Figs. 135 and 136). The white matter may be divided by suction or a blunt instrument. The cortex along the midline and at the base is handled in the just described manner before extending the incision too deep into the lobe. With each advance or move to another area a wet cotton strip is placed into the incision so that the remaining surface of the frontal lobe is covered and kept

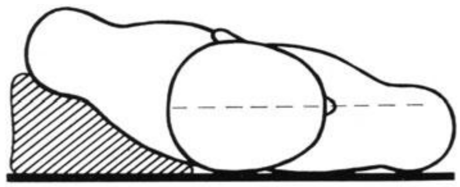


Fig. 127a.

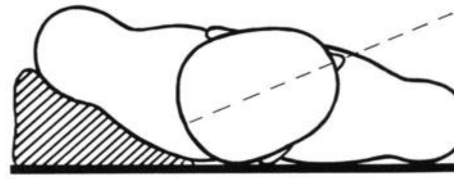


Fig. 127b.

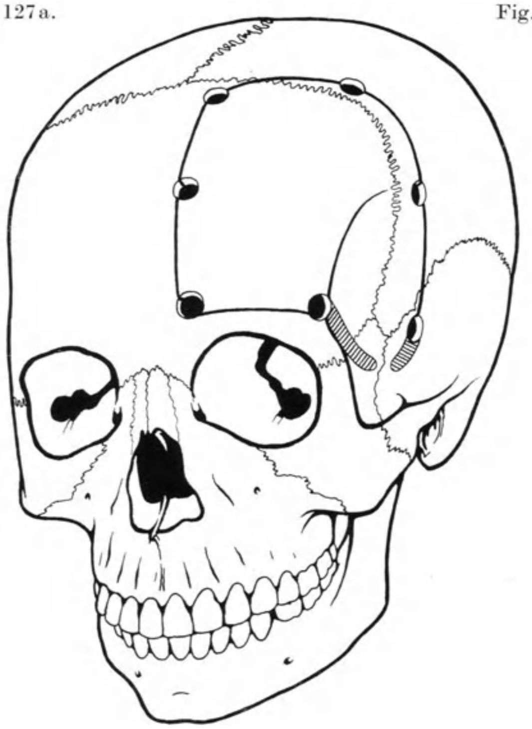


Fig. 128. Craniotomy for left frontal lobectomy.
Observe: **Skin incision is not shown. Transcoronal incision may be used as in Fig. 331.**

moist. The retraction is primarily done on the part of the lobe to be removed (Fig. 137). The veins leading to the superior sagittal sinus can be divided early since there is adequate drainage left over the medial orbital surface and the tip of the frontal lobe. Coagulation and cutting of these veins are always done close to the brain and not close to the dura and/or sinus. The excision of the lobe here depicted opens the frontal horn of the lateral ventricle. As soon as the ventricle is opened it is covered by cotton strips to prevent blood from entering the ventricles. The major vessels, which must be looked for and protected, are the anterior cerebral arteries. The artery we will have to divide is the frontal polar artery. Care should be taken not to divide the frontal polar artery of the opposite anterior cerebral artery which can easily happen since all these structures lie close together in the midline (Fig. 138). The last phase of the operation centers on the venous drainage over the medial orbital area and along the tip of the frontal lobe. By this time the surgeon holds the already separated lobe in his one hand, and by elevation and retraction these draining veins are exposed. The olfactory bulb is to be left in place to prevent any unnecessary tearing of the olfactory nerves and any possible opening in the cribiform plate. Hemostasis of the small vessels is obtained by filling the remaining cavity with dripping wet cotton balls which will enter every corner and crevice (Fig. 139). After placement of the wet cotton balls they are suctioned dry and left in place for about ten minutes. Before removing the cotton balls or any cotton strips they should be first irrigated with saline; otherwise, the fine vessels will adhere to the cotton fibers and will be pulled with the cotton when it is removed, resulting in rebleeding.

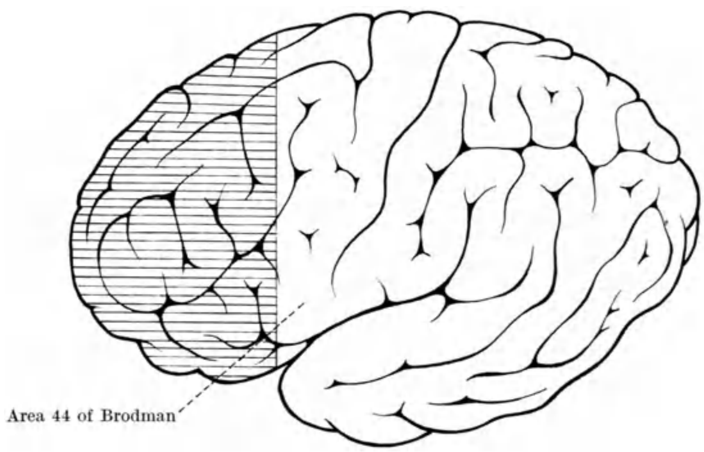


Fig. 129. Left frontal lobectomy.
Observe: 1. Shaded area shows part to be removed. 2. Line of excision is anterior to area 44 of Brodman (Broca's area).

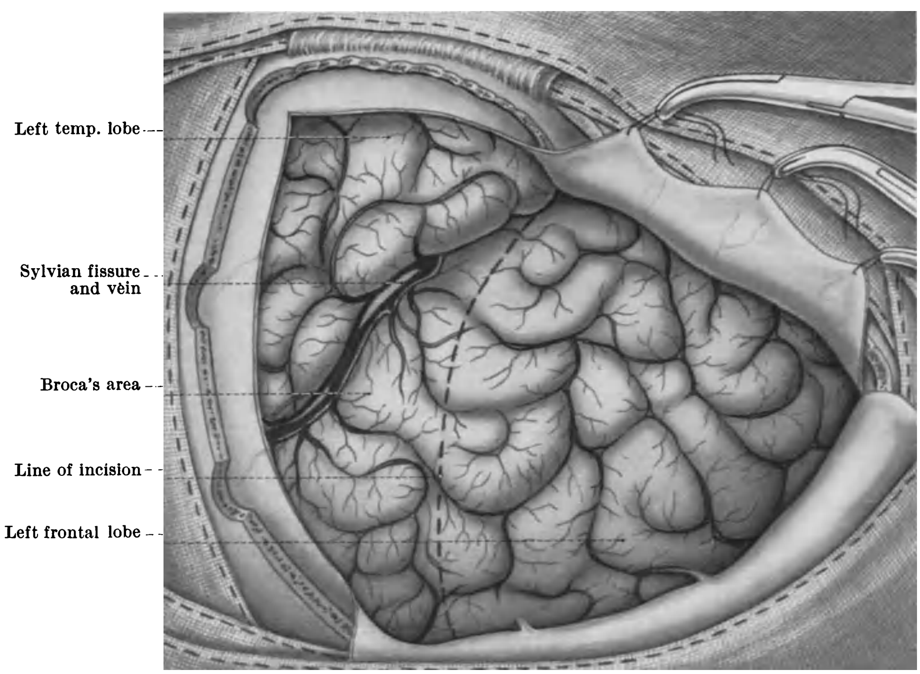


Fig. 130. Operative view of left frontal lobe.

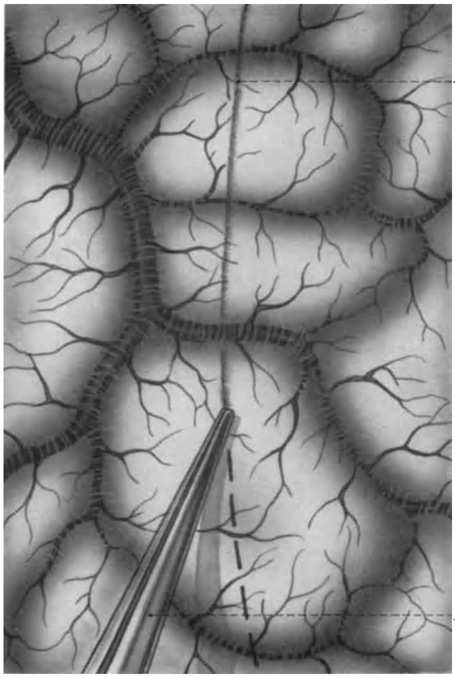


Fig. 131.

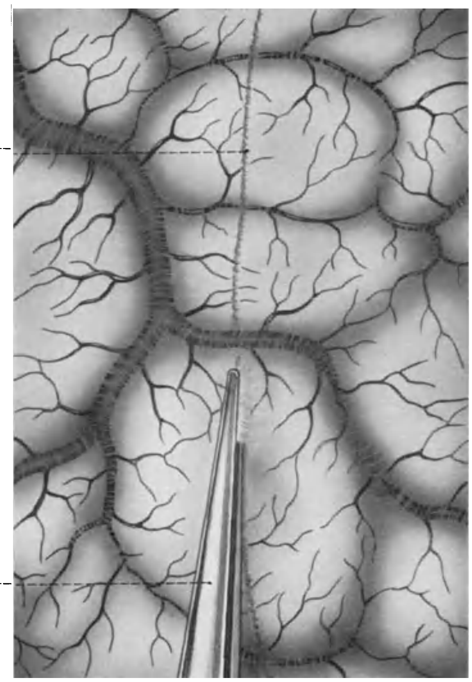


Fig. 132.

Fig. 131. Left frontal lobectomy.

Fig. 132. Coagulation of leptomeninges and superficial layer of cortex.

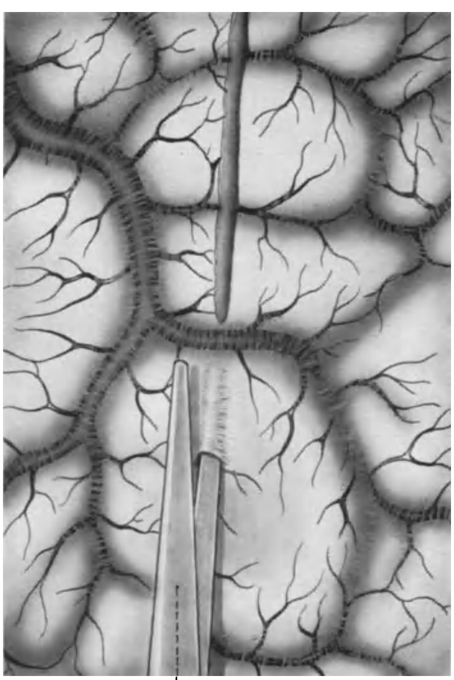


Fig. 133.

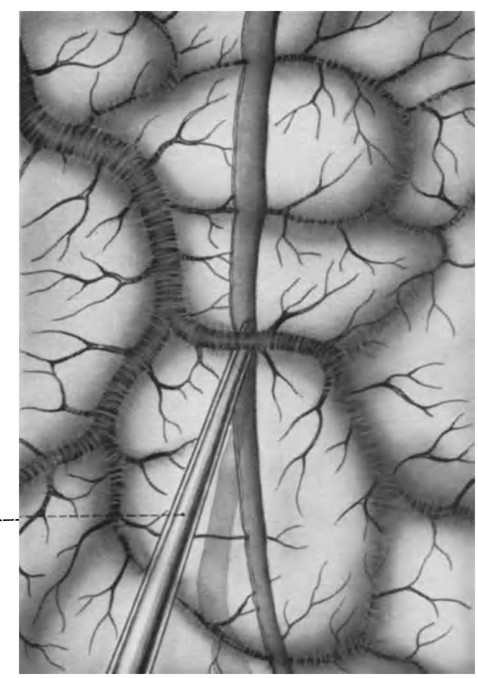


Fig. 134.

Fig. 133. Left frontal lobectomy.

Fig. 134. *Observe:* Larger vessels are not coagulated but clipped and then divided.

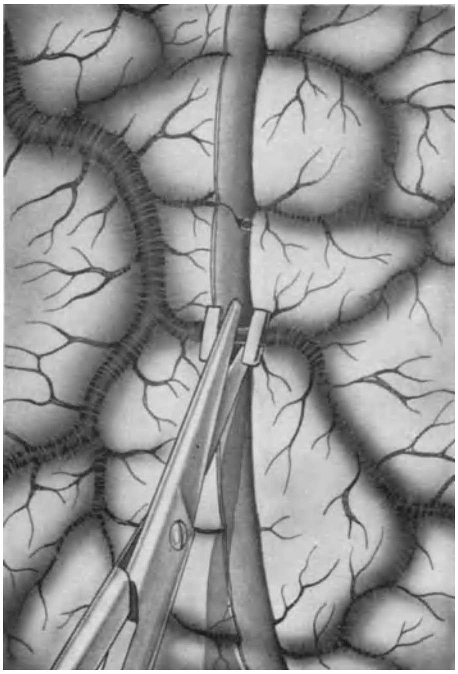


Fig. 135.

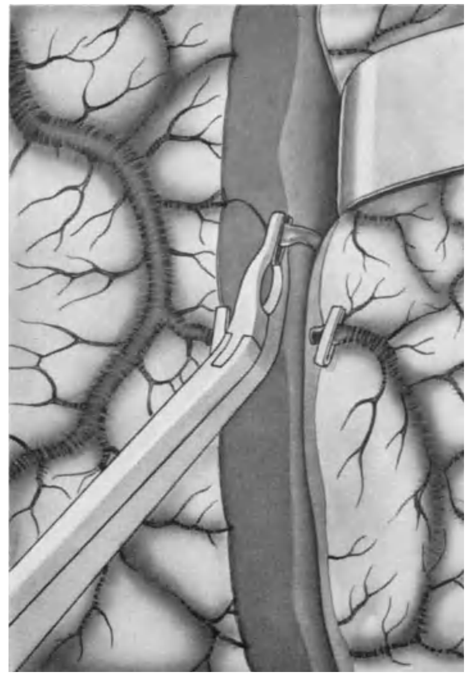


Fig. 136.

Fig. 135. Division of larger vessels by clipping and then sectioning.

Fig. 136. Clipping of deeper vessels.

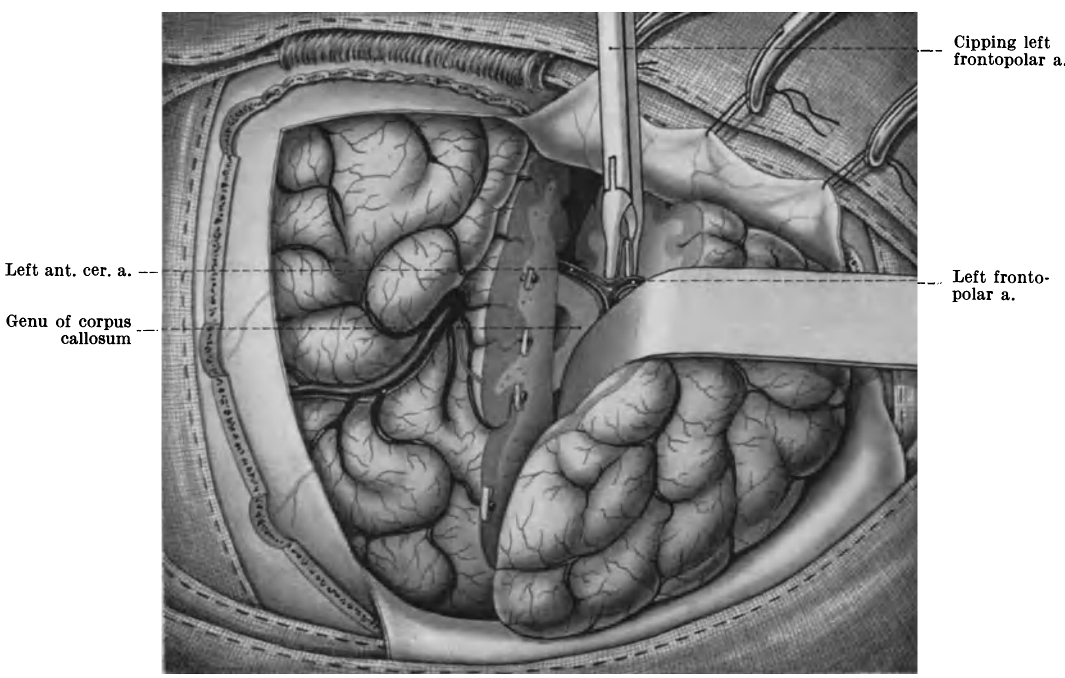


Fig. 137. Left prefrontal lobectomy.

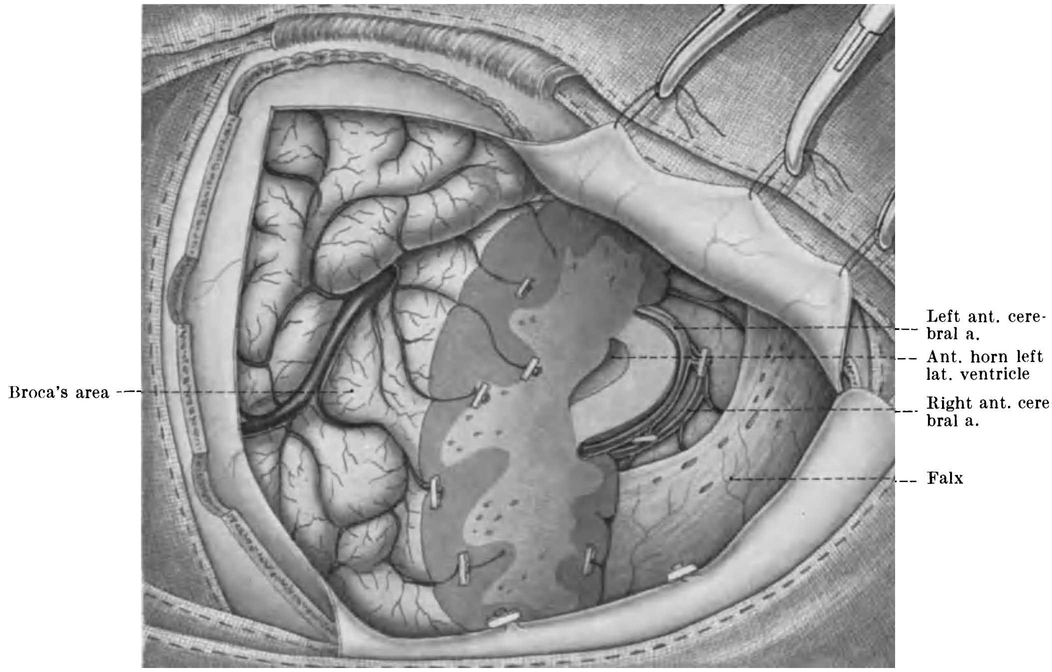


Fig. 138. Operative view after removal of anterior part of left frontal lobe.

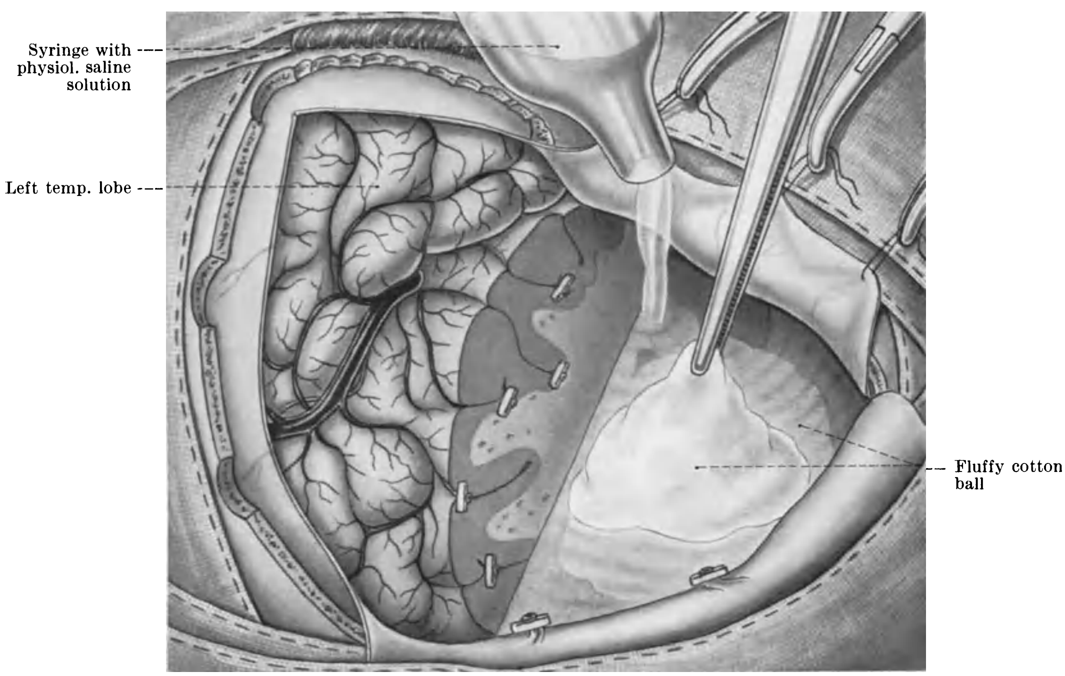


Fig. 139. Bleeding from small vessels is controlled by applying dripping wet, fluffy, cotton balls which will enter and cover every minute crevice.

Chapter VIII

Olfactory Groove Meningioma

Anosmia is the initial clinical sign of an olfactory groove meningioma. Later on, as the tumor reaches a larger size, visual field defects and personality changes are observed. In the diagnostic studies angiography will reveal elevation and stretching of the anterior cerebral and frontal polar arteries (Figs. 140 and 141). The vascular supply comes from the anterior ramus of the middle meningeal artery and the anterior ethmoidal artery which is a branch from the usually widened ophthalmic artery. The venous phase indicates the size of the meningioma by its diffuse staining. A combined angiographic-pneumoencephalographic study will give additional information as to the side on which the larger mass of the tumor is situated. The attachment to the floor of the anterior fossa is over the posterior cribiform plate and planum sphenoidale. Fig. 142 shows a predominantly left-sided olfactory groove meningioma extending back, depressing the optic nerve and chiasm. Its relationship to the optic nerve and chiasm is different from that of a tuberculum sellae meningioma (see p. 94, Chapter VI). The operative removal of the olfactory groove meningioma in Fig. 142 will be discussed.

The side on which the larger tumor mass exists is the side to perform the craniotomy. A bilateral frontal craniotomy is not necessary nor indicated. If a larger tumor demands a prefrontal lobectomy, a craniotomy as seen in Fig. 128, p. 99 is chosen; otherwise, we prefer the craniotomy seen in Fig. 143. It will be seen that the craniotomy reaches to the midline. The dura is opened as in Fig. 130, p. 100 and the frontal lobe is elevated which will bring the tumor readily into view. In an elongated tumor, as the one presented here, the total length of the lesion will be exposed to ascertain its relationship to the optic nerves (Fig. 145). To show more clearly the anatomical situation our pictures omit the wet cotton strips which are used in separating the frontal lobe from the tumor capsule. However, nothing is more gentle than is the use of wet cotton strips in finding and maintaining a plane of cleavage between the brain and the tumor. This also will prevent any injury to the anterior cerebral and frontal polar arteries which are stretched tightly over the superior surface of the tumor (Fig. 141). The tumor is reduced in size using a wire loop electrode (Fig. 146). Constant suction removes smoke and blood. After the meningioma has been sufficiently reduced in size, the tumor which extends to the opposite side can now be evaluated. The falx will be incised (Fig. 146) for total removal. The posterior extension of the meningioma towards the planum sphenoidale and the optic nerves are now attacked by using a small separator and by starting from the optic nerves and moving anteriorly (Fig. 147). The electric loop is not used close to the optic nerves and chiasm. As emphasized in the chapter on tuberculum sellae meningiomas any part of the tumor not easily freed from the optic nerves or associated arteries should be left behind. In elevating the tumor from the planum sphenoidale and cribiform plate the feeding vessels are encountered and cauterized with bipolar electrode under constant irrigation. This will reduce transmission of heat and will prevent damage to optic nerves as they pass through the optic foramen. The entire tumor bed is now carefully coagulated (Fig. 148). The anterior branch of the middle meningeal artery reaches the tumor frequently at the base of the anterior pole of the tumor. Meningiomas being supplied by branches from the external carotid artery have a most vascular dura. After hemostasis has been obtained, the cribiform plate is covered by muscle tissue taken from the temporal muscles and by a layer of gelfoam placed above the muscle. Closure is as described in Chapter I. To prevent postoperative epidural hematoma many stay sutures are used as illustrated in Figs. 20, 21 and 22 on p. 17.

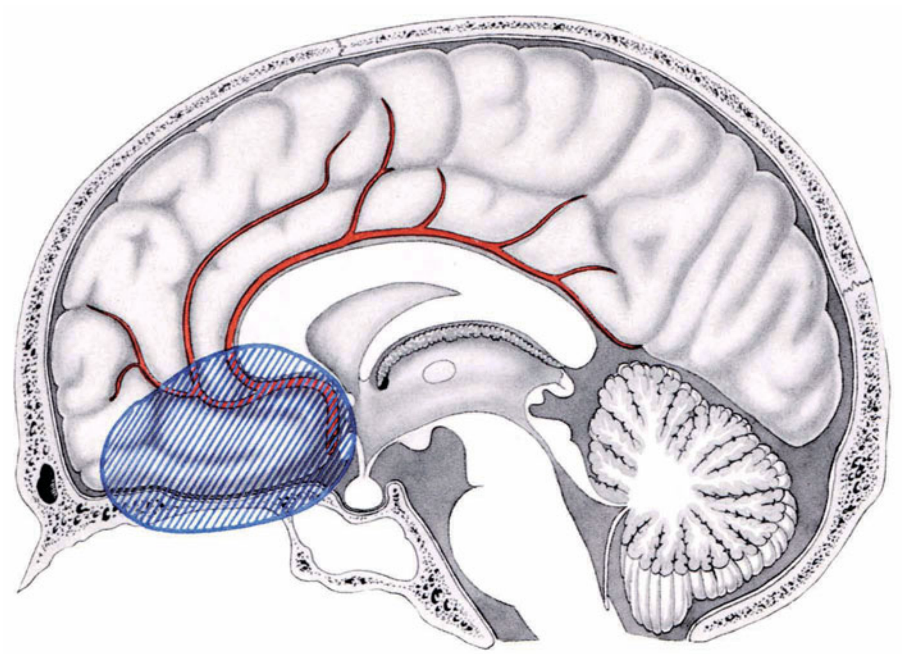


Fig. 140. Olfactory groove meningioma projected on normal midline cerebral structures.

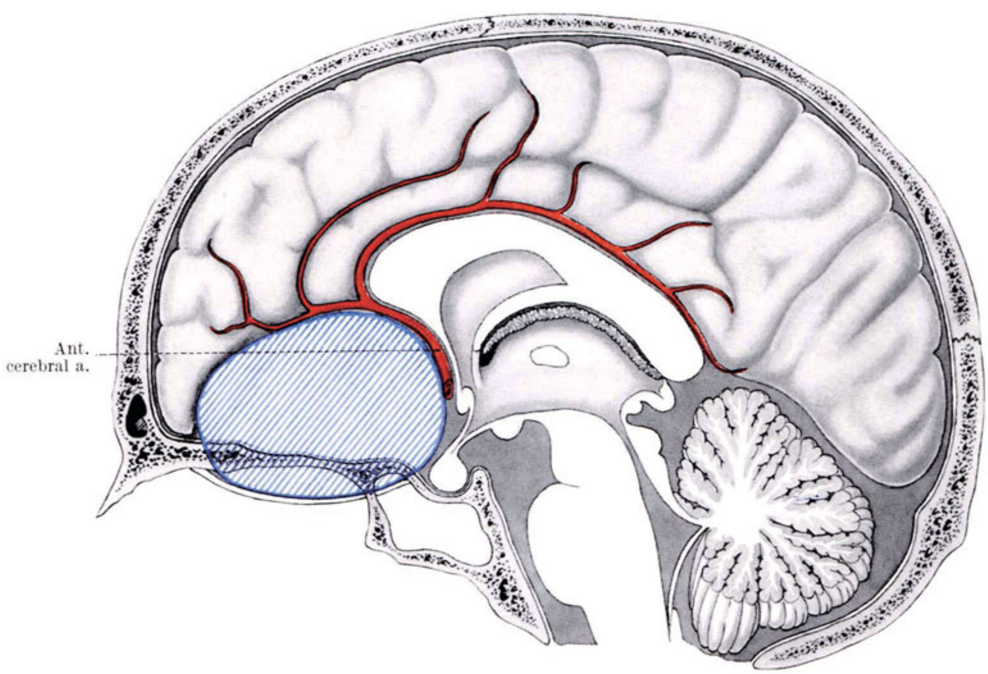


Fig. 141. Schematic drawing of midline cerebral structures displaced by olfactory groove meningioma. *Observe:* The relationship of the tumor to the anterior cerebral artery and its branches.

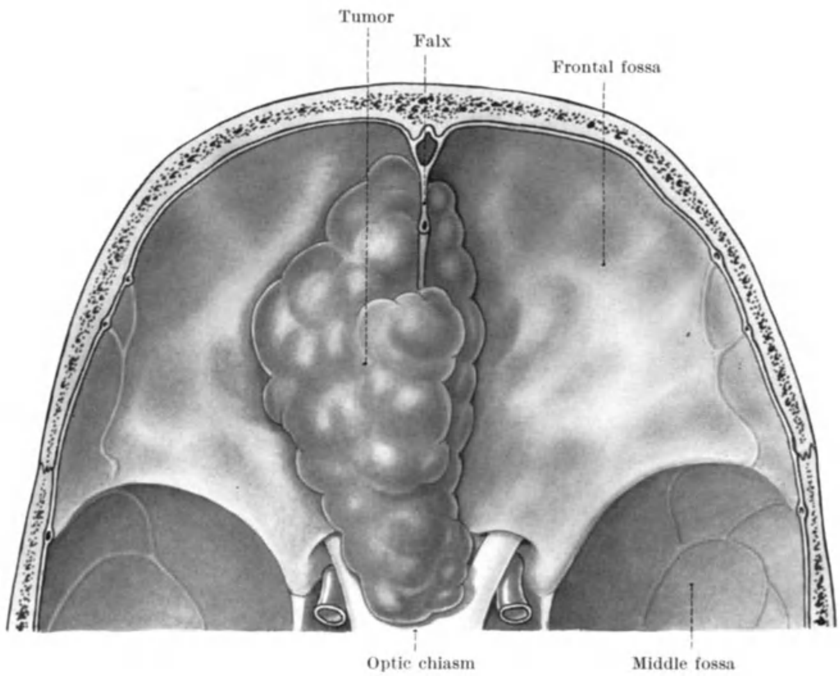


Fig. 142. Anatomical demonstration of olfactory groove meningioma.
Observe: The tumor presented is predominantly on the left side and involves the tuberculum sellae.

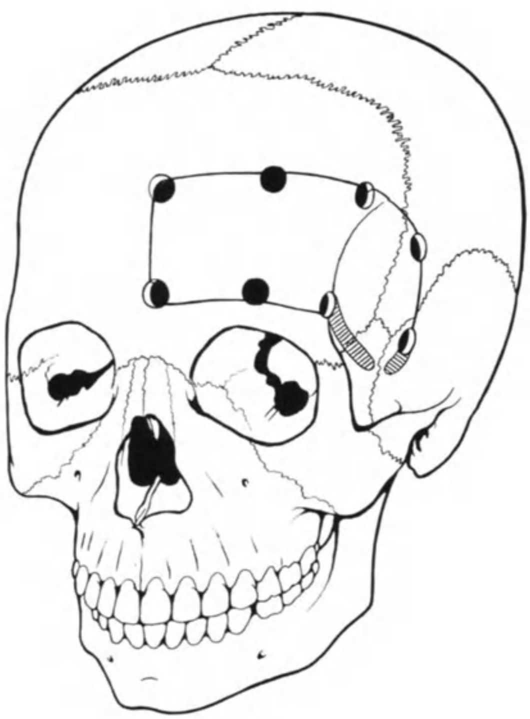


Fig. 143.

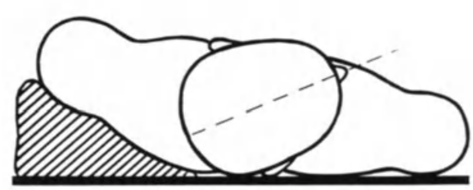


Fig. 144.

Fig. 143. Craniotomy for olfactory groove meningioma.
Observe: 1. Skin incision is not shown, see Fig. 331 for transcoronal incision. 2. Craniotomy extends to midline

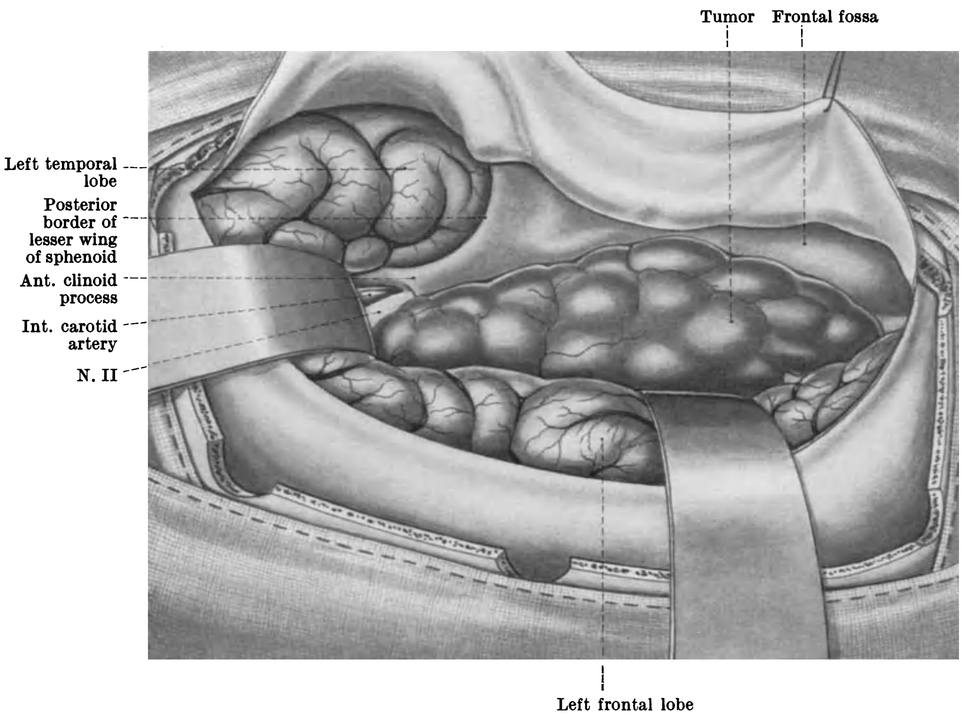


Fig. 145. Operative view of olfactory groove meningioma.

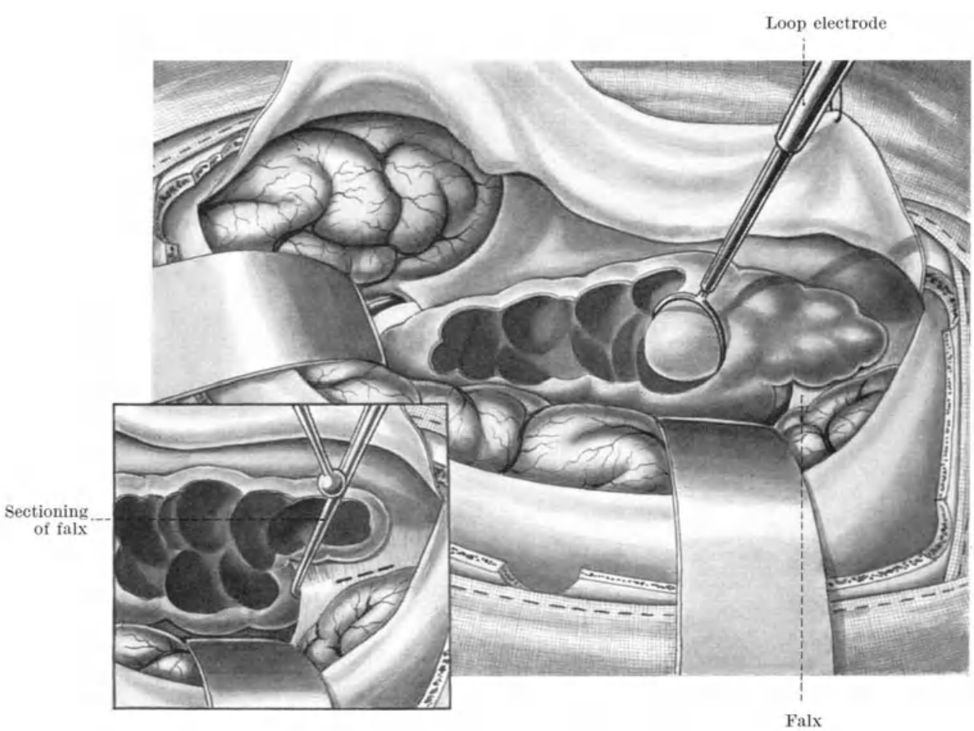


Fig. 146. *Observe:* 1. Reduce bulk of tumor with loop electrode using coagulation and cutting current. 2. Insert shows sectioning of falx cerebri to gain necessary exposure.

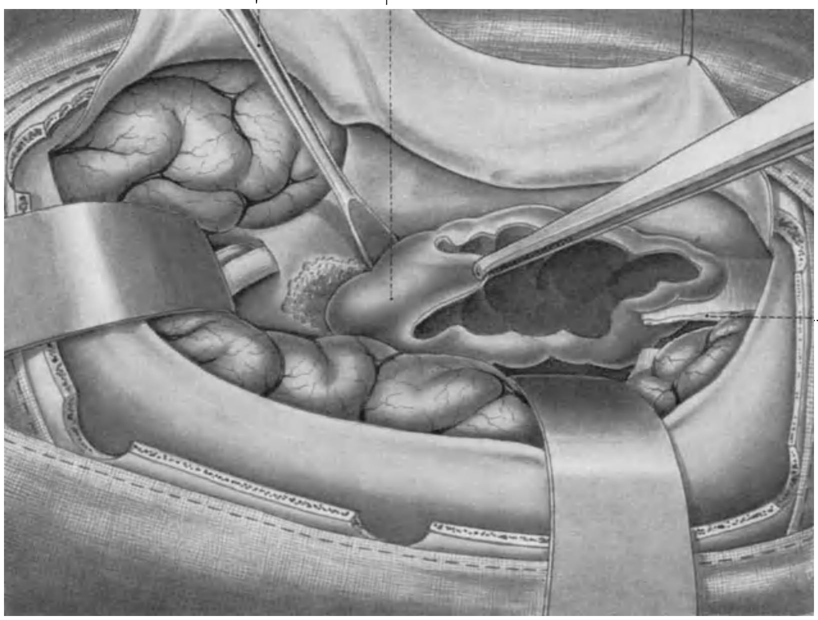


Fig. 147. Olfactory groove meningioma.

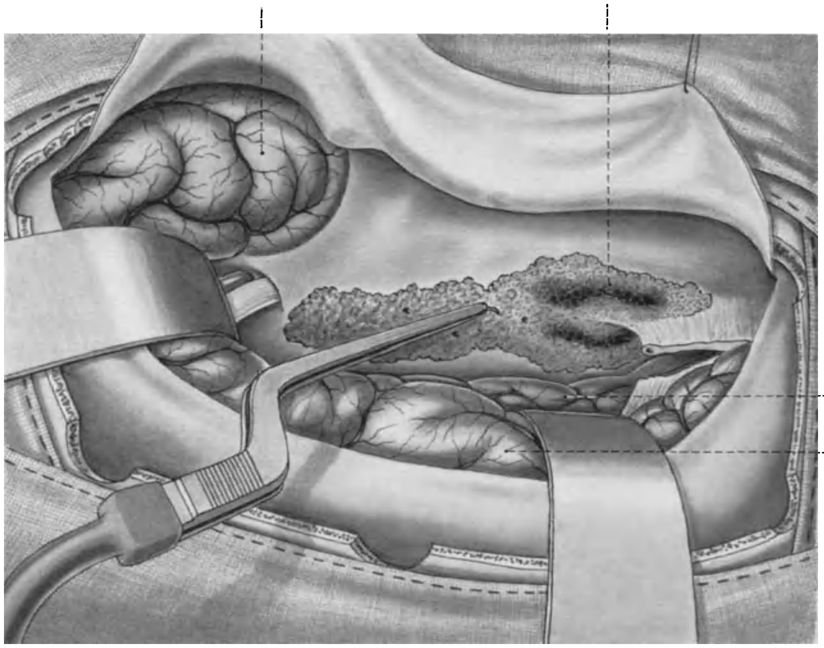


Fig. 148. Cauterization of tumor bed with the *bipolar* coagulation forceps.

Chapter IX

Sphenoid Ridge Meningioma

Nearly all extracerebral, intracranial meningiomas have a common relationship in regard to their blood supply, vascularity, and relationship to neighboring structures. To prevent repetition, only the pertinent operative maneuvers of the specific lesion at hand are shown; but, if they are taken together with the other chapters dealing with meningiomas, we believe that an exhaustive description is given. Beginning with the tuberculum sellae meningioma, the reader and student should review all chapters presenting the operative handling of meningiomas.

1. Medial Sphenoid Ridge Meningioma

The operative removal of the medially located sphenoid ridge meningioma is dependent on the tumor's relationship to the optic nerves, the internal carotid artery and its branches, and the extension of the tumor into the cavernous sinus and ventral part of the diencephalon. In Fig. 149, a right-sided tumor has completely encased the optic nerve and internal carotid artery with the latter being displaced laterally and superiorly. It is obvious that the total extirpation of this tumor will not be possible. The topographic relationship of such a tumor seen in Fig. 149 and in a coronal section in Fig. 150 is presented. The middle meningeal artery provides most of the blood supply. This artery and its branches can occasionally be tremendous in size which may make it advisable to ligate the external carotid artery prior to craniotomy.

The patient is placed on the operating table as seen in Fig. 151a and b and the craniotomy is outlined in Figs. 152 and 153. The opening is slightly larger than the craniotomy discussed in Chapter I, for it reaches more forward and higher. After one opens and reflects the dura, the frontal lobe is elevated. With smaller tumors we are permitted to expose the prechiasmatic cistern, open it, and aspirate cerebrospinal fluid as seen in Fig. 29, p. 24; but, more commonly, the tumor mass will block the exposure of the prechiasmatic cistern. Wet cotton strips are placed between tumor wall and frontal lobe and these are left in place. Turning to the temporal lobe, its tip is mobilized by coagulating and cutting the veins going to the sphenoparietal sinus. This mobilization permits retraction with opening of the medial aspect of the Sylvian fissure (Fig. 154). As soon as the tumor comes into view wet cotton strips are placed against its capsule. It will be necessary to split the arachnoid over the Sylvian groove for wider separation of frontal and temporal lobes to give the needed view of the tumor. The spatula is re-applied and cotton strips help in retracting the cortex of temporal and frontal lobes from the tumor.

The middle cerebral artery, especially the lenticulostriate branches, may be stretched over the medial dorsal part of the tumor. These vessels are carefully freed and covered by cotton strips. If the size of the tumor does not permit a wide exposure without excessive retraction, the electric loop is used to remove the lateral part of the meningioma (Fig. 155). The electric loop should not be used over the medial and posterior dorsal extent of the tumor to avoid injury to the internal carotid artery, the middle cerebral artery and the penetrating arterial vessels. After sufficient tumor mass has been so removed, we may enfold the tumor capsule and have more success in freeing those vessels which were previously stretched over the meningioma.

The most medial extent of this sphenoid ridge meningioma is carefully removed in very small fragments with a sharp round curette (Fig. 156). The curette must be sharp as a dull curette will easily tear and break into tissue and vessels. In the example case tumor tissue over the anterior clinoid process area has to be left behind to avoid damage to the internal carotid artery. The preoperative angiogram will give the information about displacement of the internal carotid artery and its branches (compare Fig. 149). While one removes most of the medial extent of the tumor, it is advisable to look for the middle cerebral artery which will guide us either towards the bifurcation and internal carotid artery or to the exit of these structures from the tumor. Following the vessels from lateral to medial will aid in preventing vascular injury. Bleeding from the middle fossa, the middle meningeal artery and its branches may be quite profuse if the external carotid artery was not ligated at the start of this operation, and the foramen spinosum may have to be filled with a cotton plug after one coagulates and sections the middle meningeal artery. Thereafter, the tumor bed, devoid of the dura, requires thorough coagulation.

In some cases the tumor lays around the vessels and optic nerves without being adherent to them as seen in Fig. 157, and complete removal of the meningioma is possible.

As mentioned repeatedly we show the anatomical structures over the exposed field to emphasize the topographic relationship. The cotton strips are not depicted in the pictures but their use is important in the actual operation.

2. Lateral Sphenoid Wing Meningioma (Pterion Meningioma)

The lateral sphenoid wing meningioma receives its blood supply from the middle meningeal artery and the superficial temporal artery. The latter especially feeds the tumor if it has invaded the bone and temporal muscle. Angiography will give indication as to whether or not it is advisable to ligate the external carotid artery prior to turning the bone flap.

A right-sided tumor is chosen and its size and anatomical position are seen in Fig. 158. For this lesion the craniotomy necessary is of the same configuration as in the medially placed sphenoid wing meningioma (Figs. 152 and 153). The tumor here has invaded the inner table of the bone flap (Fig. 159). Profuse bleeding from the bone diploe will require the generous use of bone wax. Bleeding should be reduced with the bone wax even though we may have to rongeur or use the dural separator, Gigli saw, etc., in the same area again. With each renewal of bleeding it is controlled by repeated application of bone wax. If the tumor has invaded the bone extensively so that the elevation of the bone flap is not possible without undue pull, the bone which is immediately adherent to the tumor is left in place. The remaining part of the bone flap is removed by using a rongeur or by the method as described in Chapter XI, Fig. 191, p. 136. Any forceful rocking of a bone flap with attached tumor will lead to severe neurological deficit, especially if the tumor is situated over the dominant side.

In many lateral sphenoid wing meningiomas a circumferential piece of dura is excised (Fig. 159). Later the dural attachment to the tumor furnishes a hold on the tumor (Fig. 160). The cortex is freed from the tumor using the small separator, wet cotton strips and the brain spatula. The tumor is then dislodged from its attachment to the sphenoid wing. If the tumor is excessively large, it should be reduced first with the wire loop electrode. If the sphenoid ridge is invaded by tumor, manifested by thickening of the bone, it needs to be removed. Hemostasis is best obtained with bipolar coagulation. The excised dura is replaced by a free pericranial graft or a dural substitute (see Fig. 201, p. 141). Any part of the bone flap invaded by tumor is removed (Fig. 162) with a rongeur. If there is undue brain swelling, especially in the dominant hemisphere, do not hesitate to leave the bone flap out and perform a cranioplasty a few weeks later.

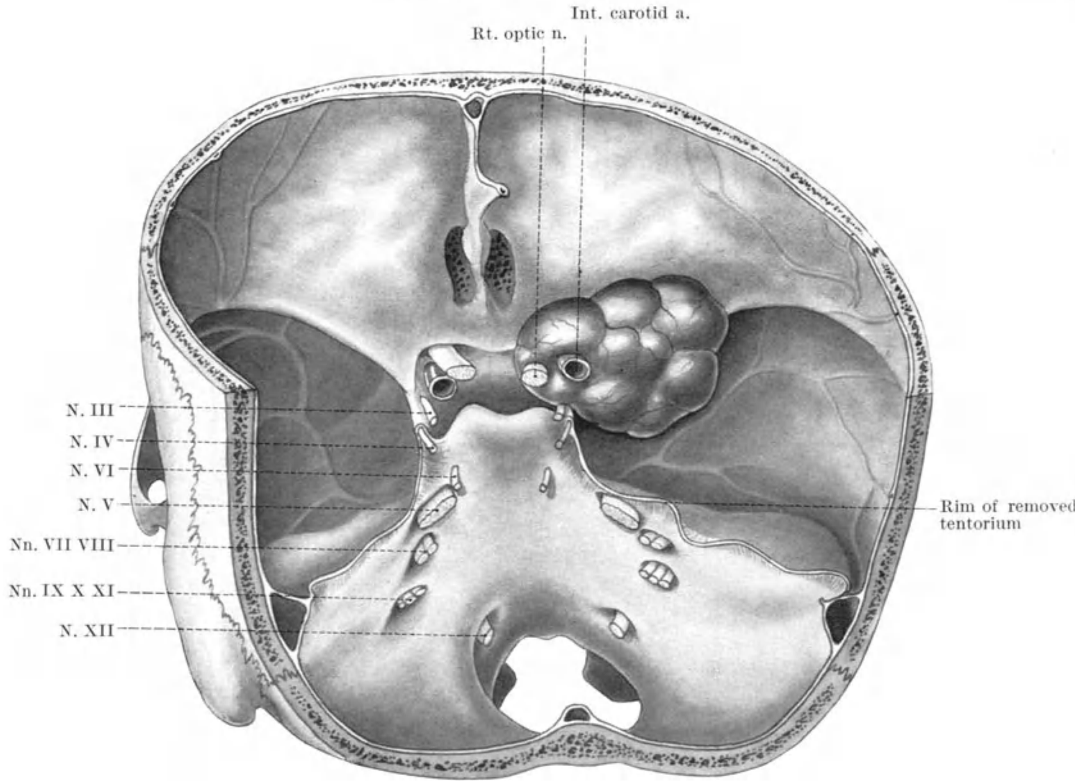


Fig. 149. Anatomical demonstration of medially placed right sphenoid wing meningioma.
Observe: 1. Displacement of internal carotid artery. 2. Envelopment of optic nerve and int. carotid a. by tumor.

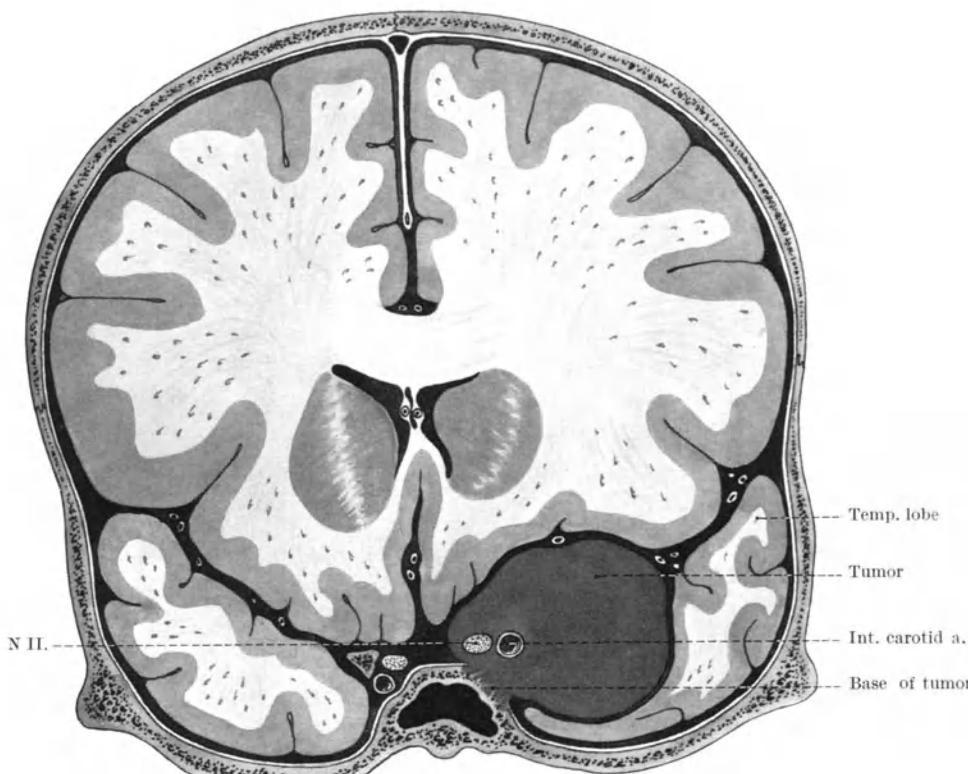


Fig. 150. Coronal section of medially placed right sphenoid wing meningioma.

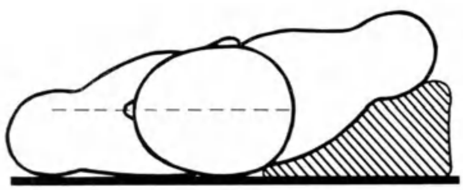


Fig. 151 a.

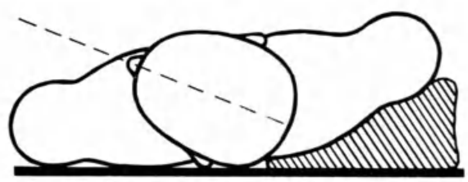


Fig. 151 b.

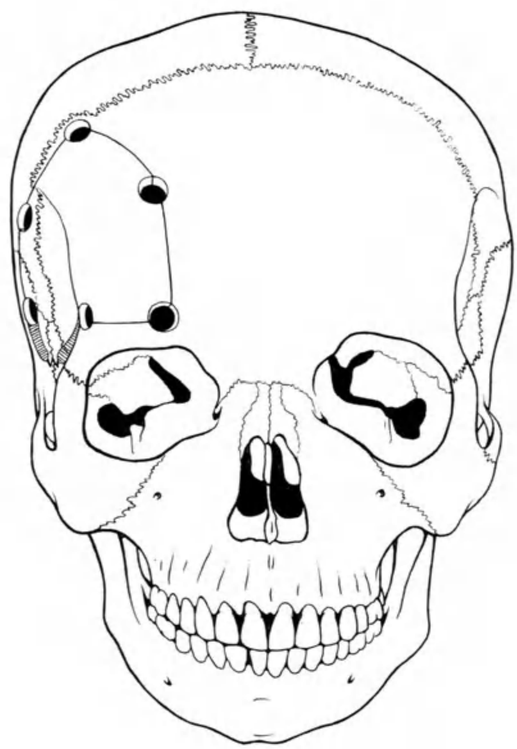


Fig. 152. Craniotomy for right medial sphenoid wing meningioma. *Observe:* Inferior frontal burr hole is placed about 2 cm from midline.

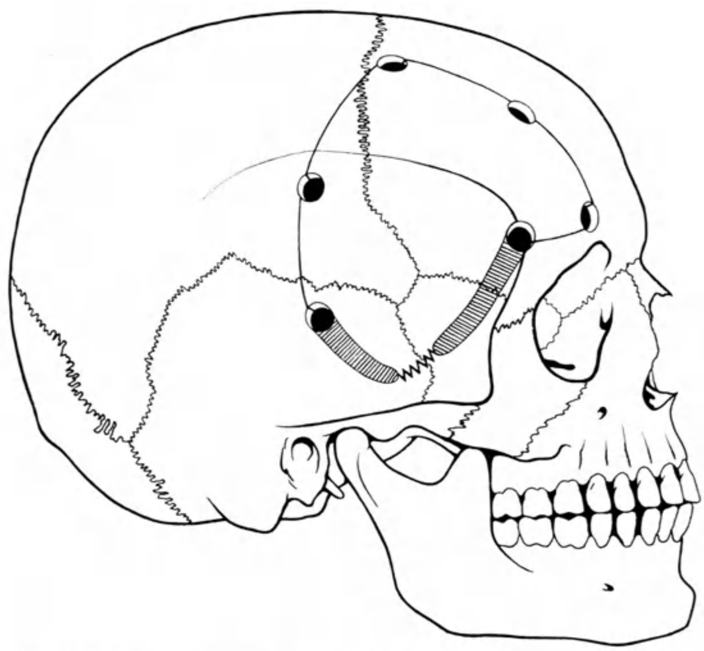


Fig. 153. Craniotomy for right medial sphenoid wing meningioma.

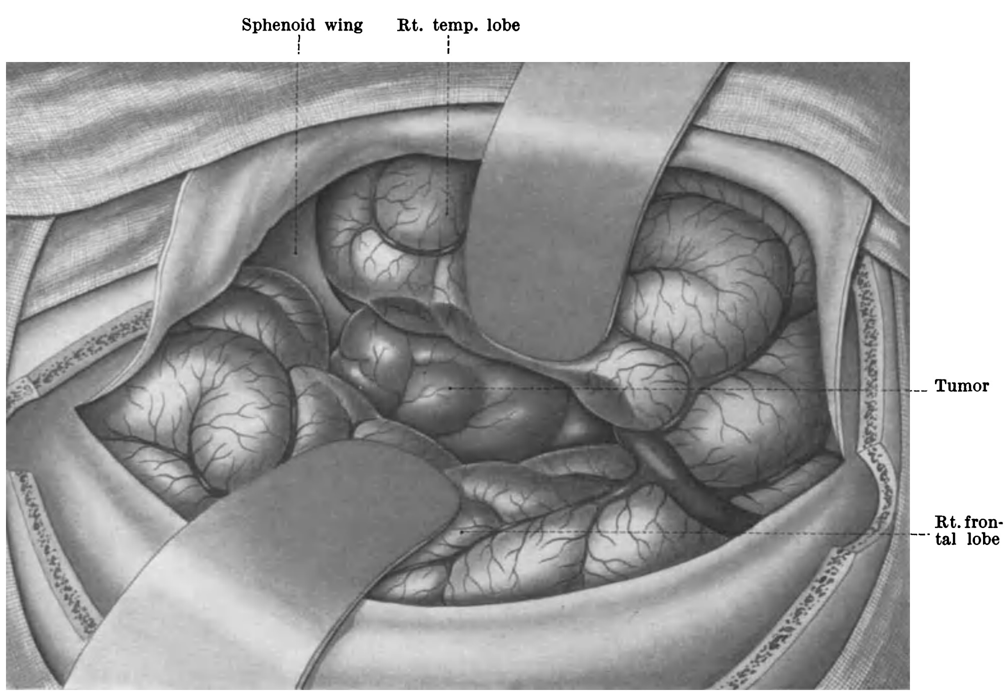


Fig. 154. Operative view of medially placed right sphenoid wing meningioma.

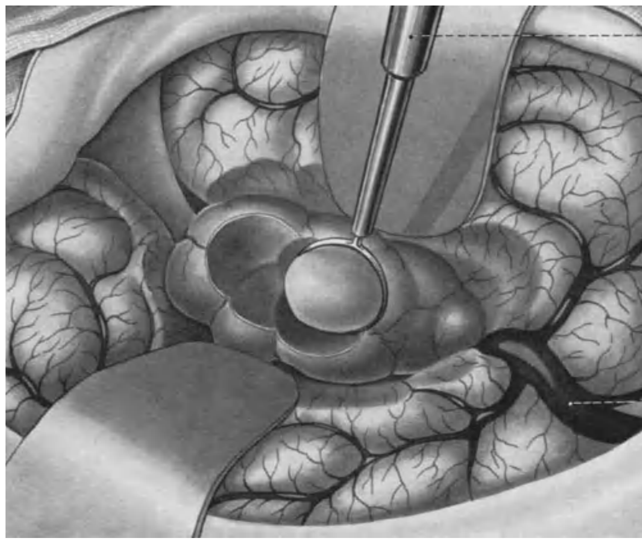


Fig. 155. Removal of the *lateral* extent of tumor with loop electrode.

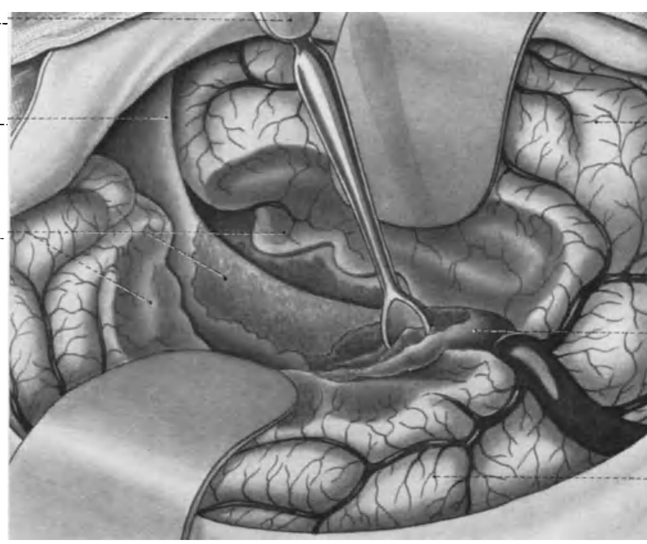


Fig. 156. *Partial* removal of *medial extent* of tumor.

Observe: 1. No loop electrode is used. Instead carefully remove tumor in small portions with sharp curette to avoid damaging the internal carotid artery and its branches and the right optic nerve. 2. Tumor tissue will have to be left in place in this case.

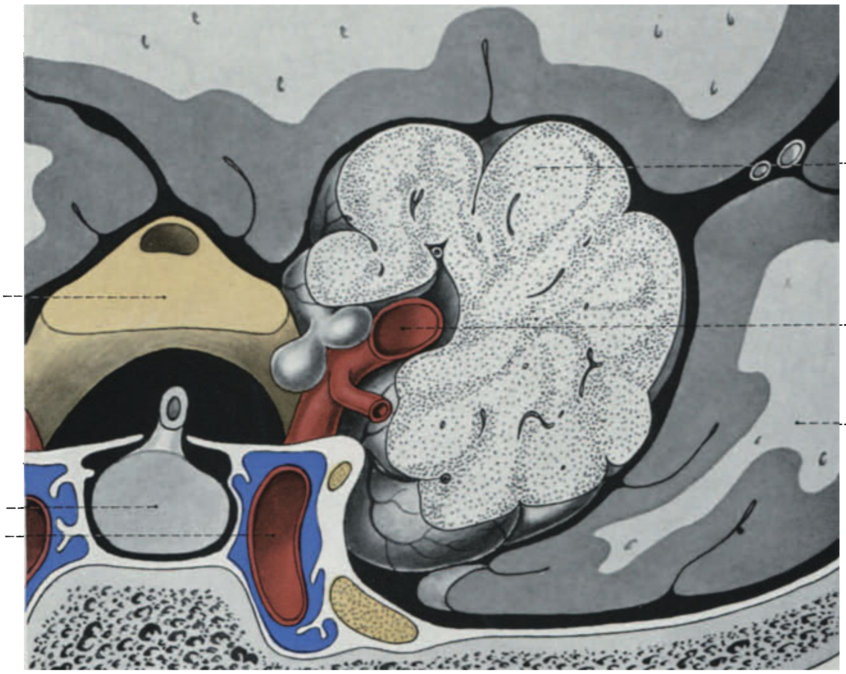


Fig. 157. Anatomical demonstration of coronal section of medially placed sphenoid wing meningioma where total removal is possible because the vascular structures (internal carotid artery and its branches) are not involved.

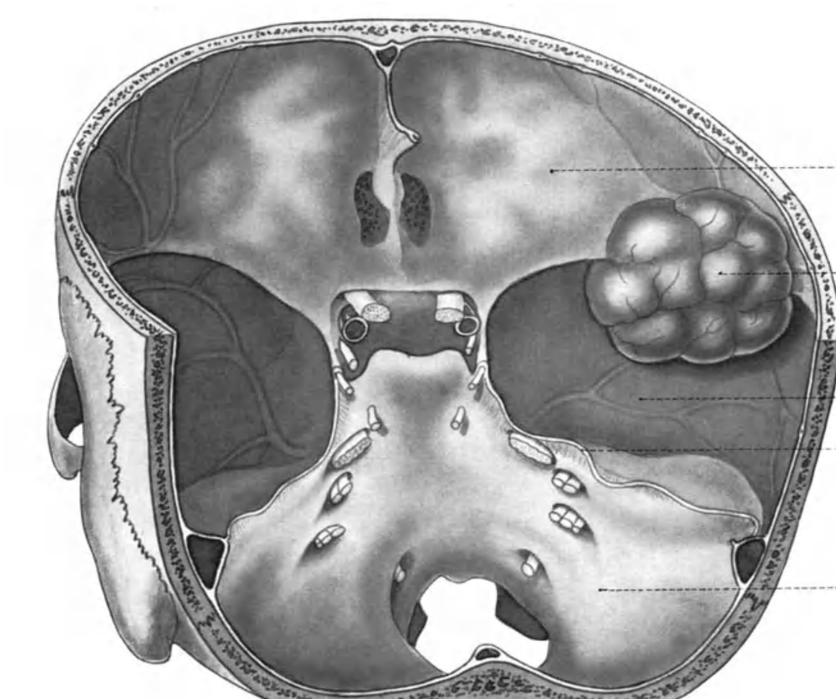


Fig. 158. Anatomical demonstration of right lateral sphenoid wing-pterion meningioma.

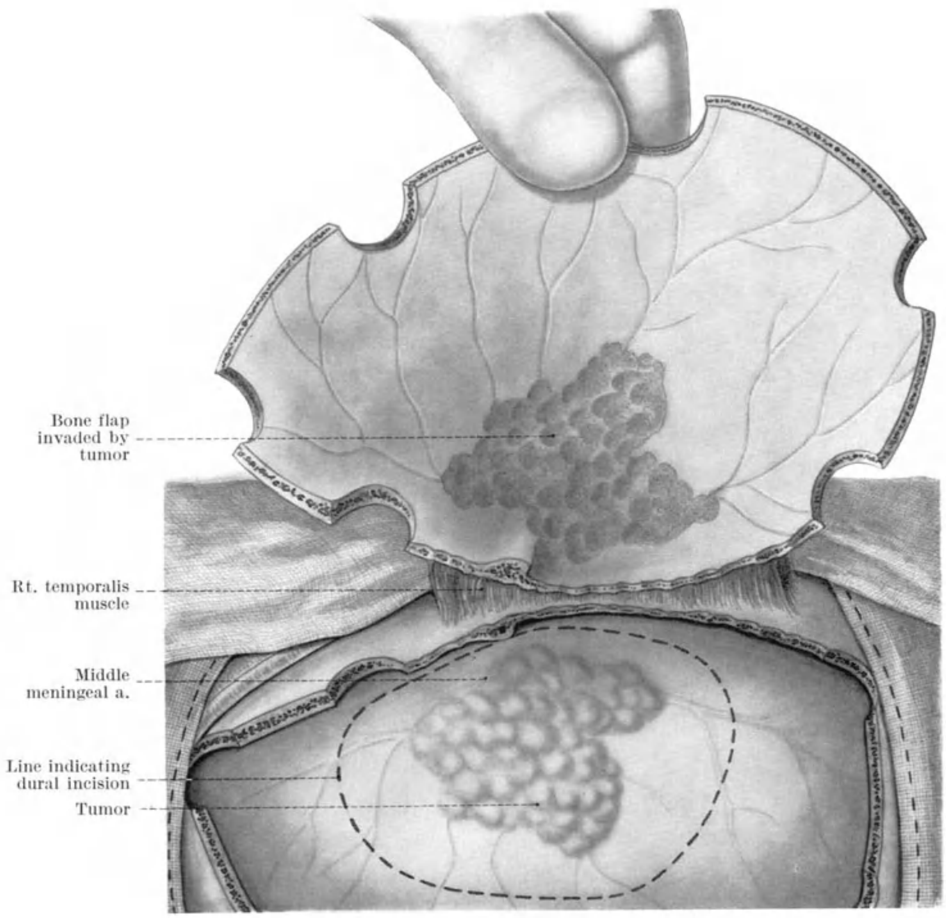


Fig. 159. Elevation of bone flap for right pterion meningioma.

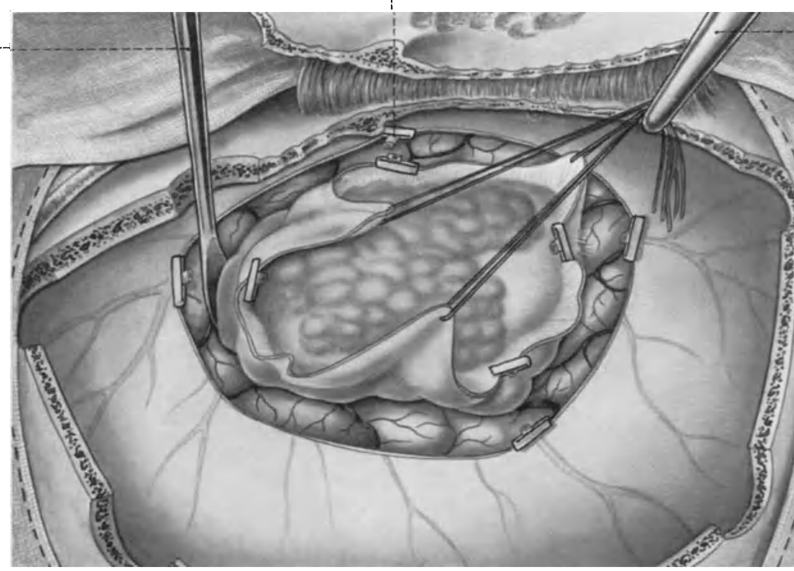


Fig. 160. Pterion meningioma.
Observe: Circular excision of dura.

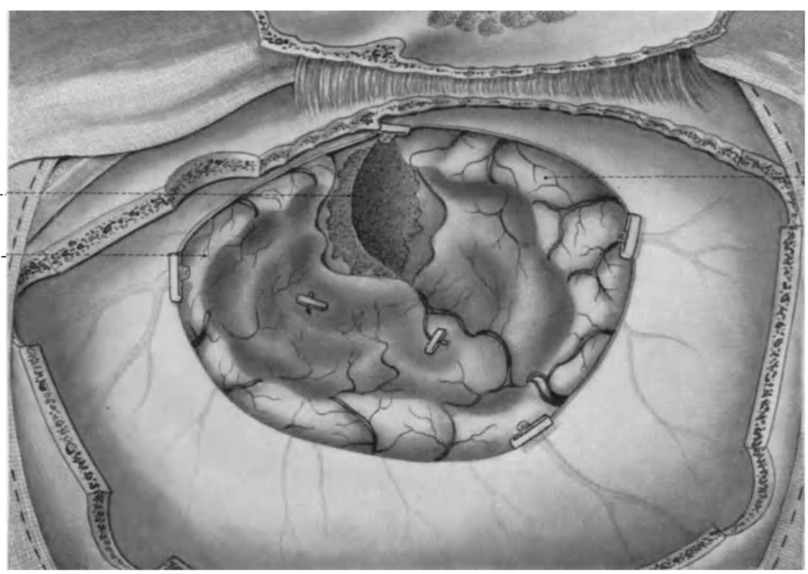


Fig. 161. Tumor bed after removal of right lateral sphenoid wing meningioma.

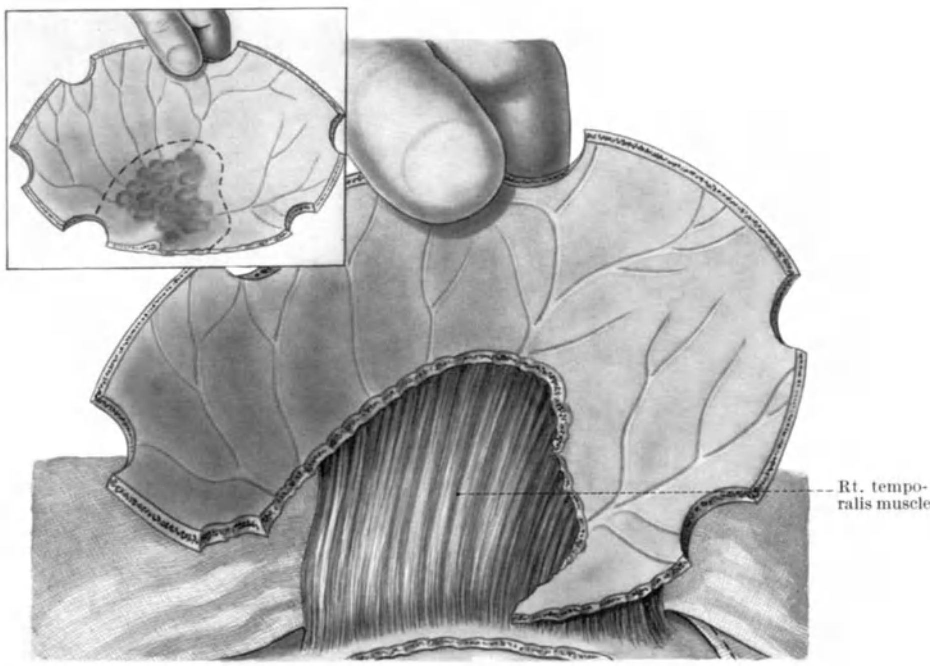


Fig. 162. Partial craniectomy of bone flap for removal of tumor invading the skull.

Chapter X

Cerebral Spinal Fluid Fistula (Rhinorrhea)

The etiologies of cerebrospinal fluid fistulas are numerous; for example, prolonged intracranial pressure with thinning of the cribiform plate, invading extracranial neoplasm with erosion of the base of the skull, chronic paranasal sinus infection, defects in the base of the skull after removal of meningo-encephalocele of the roof of the nasal cavity, stereotactic trans-sphenoidal approach to the sella turcica, etc.; but, the most common cause is trauma.

Fig. 163 outlines the possible sites of cerebrospinal fluid fistulas. The defect in the cribiform plate is most frequently encountered with drainage into the ethmoidal sinus. Next in frequency is into the frontal sinus and that is followed, in our experience, by drainage into the sphenoid sinus. The latter is usually the result of a fracture of the sphenoid bone and tear in the dura which runs along the floor of the middle fossa and cerebrospinal fluid drains into the lateral extension of the sphenoid sinus near the foramen ovale. Another fistulous tract is medial to the optic foramen over the lateral extension of the tuberculum sellae. Less frequently encountered is otorrhea caused by fracture in the petrous portion of the temporal bone with drainage into the epipharynx via the eustachian tube. Otorrhea may be seen early after trauma but spontaneous healing is usually the rule. However, four patients with persistent otorrhea required operations from the middle and posterior fossae before arrest of the drainage was obtained.

An indication for operation is persistent drainage of the cerebrospinal fluid eight to ten days after trauma. Immediate surgery is done either if the cerebrospinal fluid leak is due to a depressed fracture of the posterior wall of the frontal sinus or sphenoid ridge or if any free fragments of bone have torn the dura and lacerated the brain. The condition here is then the same as in any compound comminuted fracture and demands proper debridement. If none of these immediate operative indications are present and if the patient has, for instance, fractures and displacement of facial bones, the persistence of a cerebrospinal fluid leak is not a contraindication to repair of facial fractures. In fact, we often see an arrest of the cerebrospinal fluid drainage after the facial fractures are set. Any patient with a recurrent meningitis or with a persistent posttraumatic pneumocephalus should arouse suspicion of a cerebrospinal fluid fistula. Patient evaluation includes the chemical analysis of the nasal secretions for sugar. Of the preoperative studies stereoscopic roentgenogram of the base of the skull and cerebrospinal fluid isotopic studies are the most successful to ascertain the location of the leak.

If the defect in the dura and bone is over the left sellar and parasellar regions or in the middle fossa, the position of the patient for the operation is seen in Fig. 164 and the craniotomy in Fig. 165.

For a repair of a cerebrospinal fluid fistula over the right cribiform plate the craniotomy is shown in Fig. 166. The position of the patient is in Fig. 164b and the scalp incision is transcoronal behind the hairline. In Fig. 166 burr holes are placed in the midline, directly over the superior sagittal sinus. An alternate method is shown in Fig. 167 where two burr holes are placed immediately adjacent to the superior sagittal sinus. The placement of burr holes in either Fig. 166 or 167 is correct; however, placement of the burr holes too far lateral from the midline should be avoided to prevent entry into the sinus while advancing the Gigli saw guide. Fig. 168 explains the situation most readily. This principle applies in all craniotomies extending over the midline. The free bone fragment is removed as seen in Fig. 169 and, in this case, the frontal sinus is entered. Prior to opening the dura the mucosal lining of the frontal sinus will be separated from the wall of the sinus, enfolded and covered by gelfoam (Fig. 170). We prefer to explore the fistulous tract initially from the intrathecal space because the defect will be more readily identified by the adherence of brain tissue to fistula. An initial extradural exploration invariably causes a tear in the dura which is quite adherent to the cribiform plate and which leaves doubt as to whether or not the fistula was just made.

A transverse opening of the dura is made with ligation of the superior sagittal sinus (Fig. 169). Fig. 171 demonstrates the tip of the frontal lobe retracted and the brain adherent to the dural defect. The opposite side is always inspected. Having thus located the defect, the cribiform plate is exposed extradurally (Fig. 172). All scar and granulation tissue are removed with a curet (Fig. 172). The mucosa is pushed down and the defect filled with muscle tissue and gelfoam (Fig. 173). Thereafter, the area is covered by a thin layer of methylmethacrylate (Fig. 174). This last step has been found especially useful since it appears that recurrent drainage is due to the lack of support to the pulsating dura with the formation of new outpouchings which break to create another fistulous tract. The opening in the dura is closed by interrupted 0000 black silk sutures, and may require a free graft of pericranium (Figs. 175 and 176). Fascia lata graft is not used for there is always enough pericranium available. The pericranium is much more vascular, malleable, heals very well, and eliminates a second surgical incision to obtain fascia lata. The objective is not to cover the dural defect with a strong fascia but to seal the dura and prevent any outpouching or herniation into a bony defect.

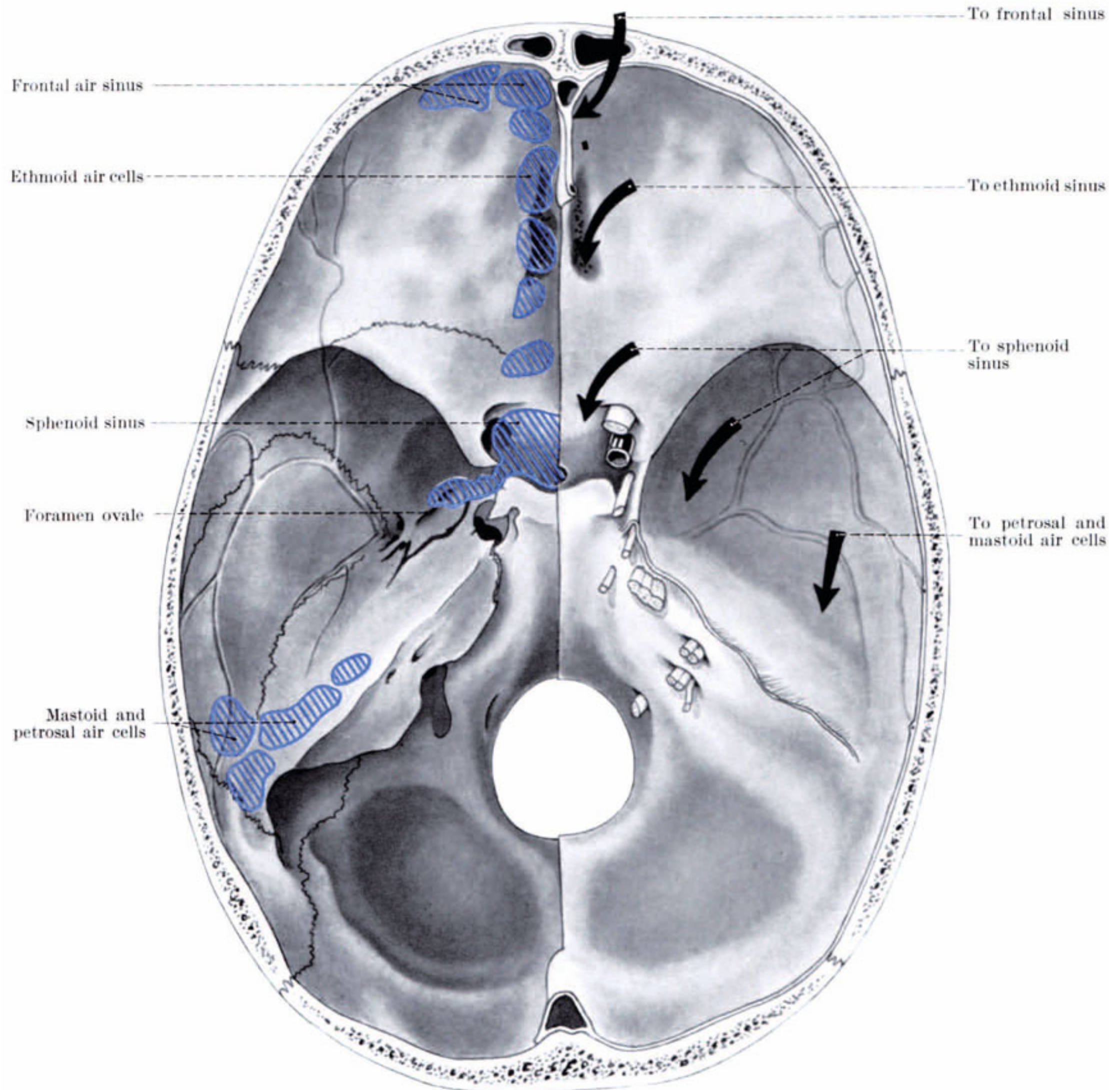


Fig. 163. Anatomical drawing showing possible sites of cerebral spinal fluid fistulas.

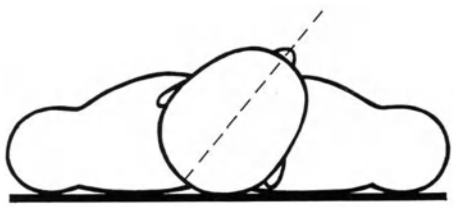


Fig. 164a.

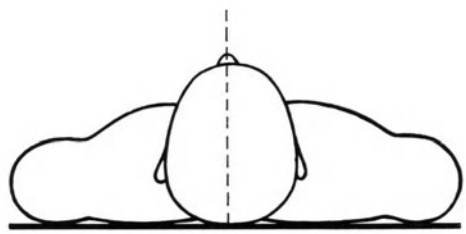


Fig. 164b.

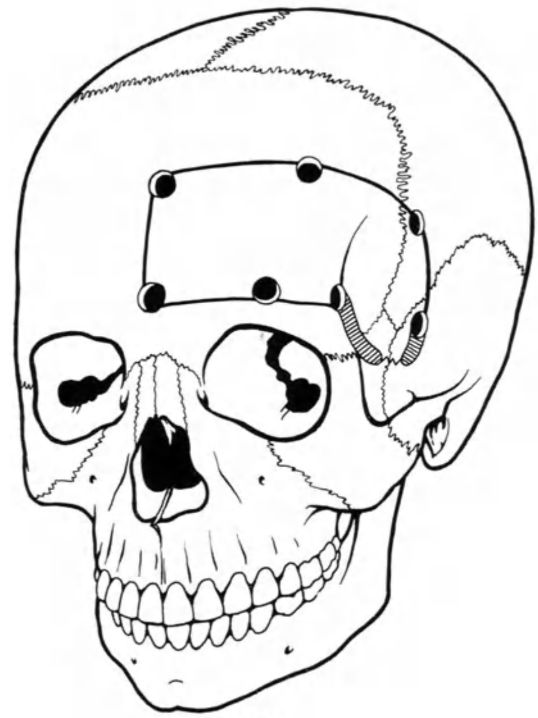


Fig. 165.

Fig. 165. Craniotomy for cerebral-spinal-fluid fistula in the sellar-parasellar region and middle fossa (skin incision: transcoronal, see Fig. 331).

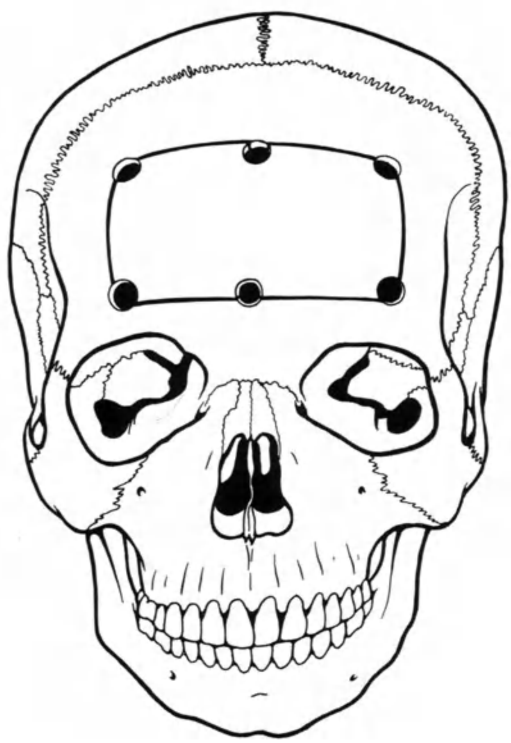


Fig. 166. Craniotomy for cerebral-spinal-fluid fistula in cribriform plate, ethmoid or frontal sinus (skin incision: transcoronal, see Fig. 331).
Observe: The burr holes directly over the midline (compare also Fig. 167).

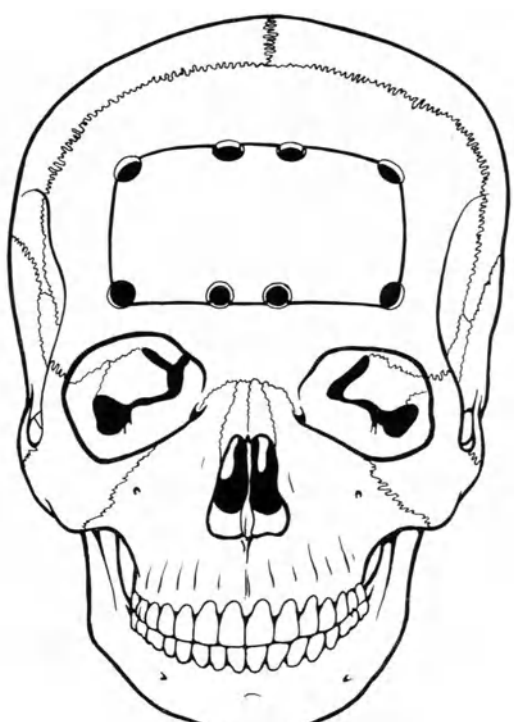


Fig. 167. Alternate craniotomy for cerebral-spinal-fluid fistula in cribriform plate, frontal sinus, or ethmoid sinus.
Observe: Placement of burr holes are not directly over the superior sagittal sinus but close to the midline (see also Fig. 166).

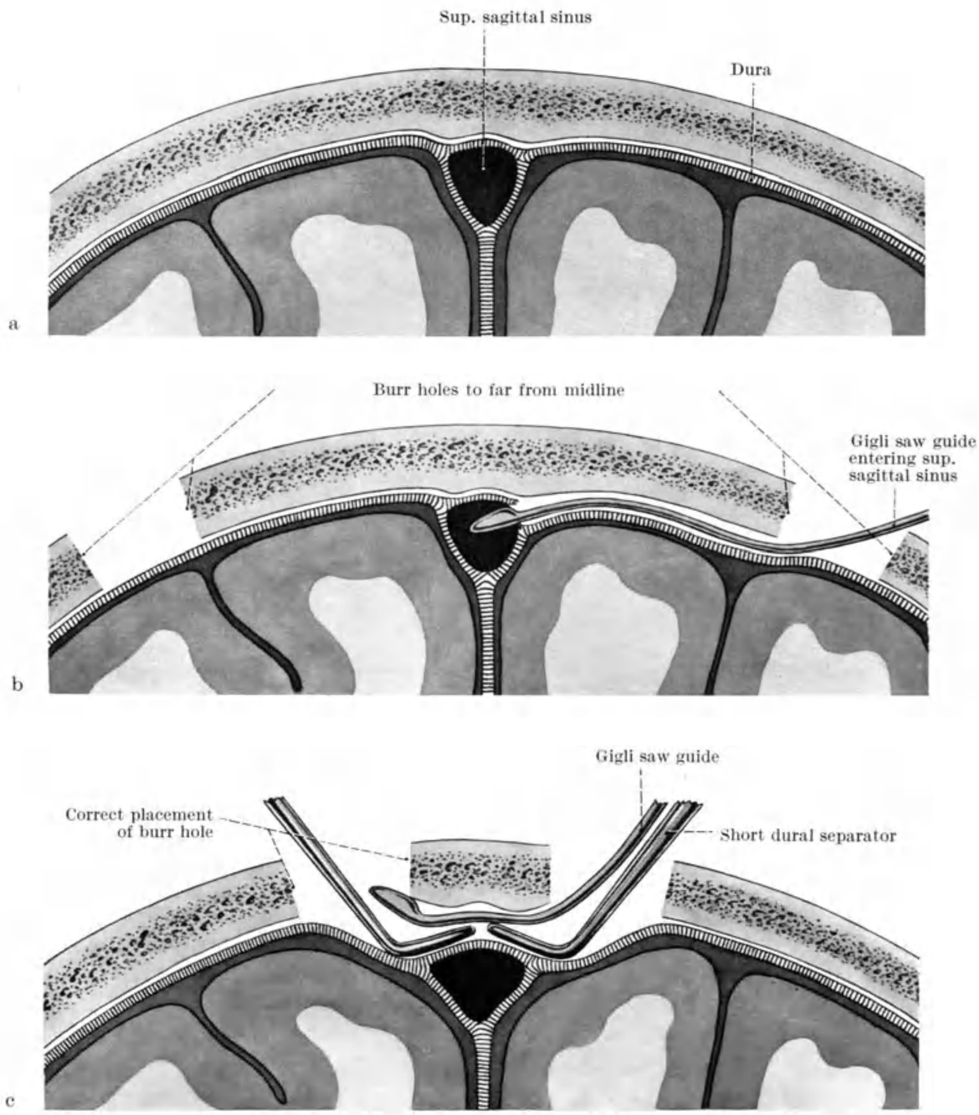


Fig. 168 a—c. Faulty (b) and correct (c) placement of burr holes in craniotomy reaching over the midline. *Observe:* 1. In Fig. 166 burr holes directly over the venous sinus is acceptable. 2. Burr holes placed too far laterally (b) from midline may result in tearing of the superior sagittal sinus by the Gigli saw guide.

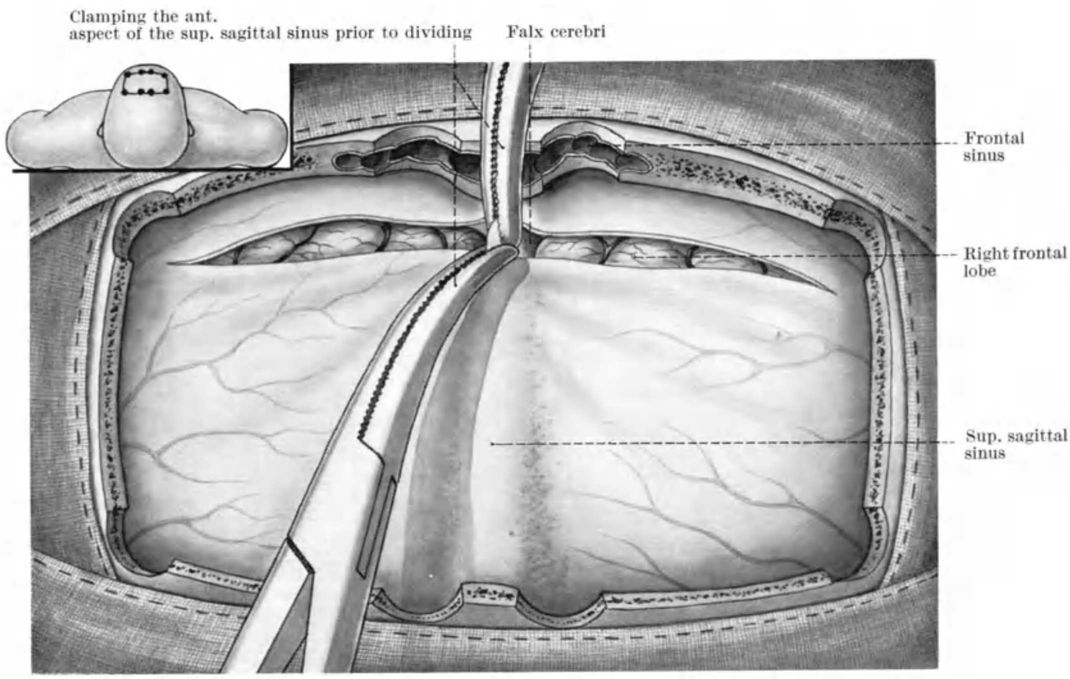


Fig. 169. Opening of dura and division of anterior part of superior sagittal sinus and falx cerebri.

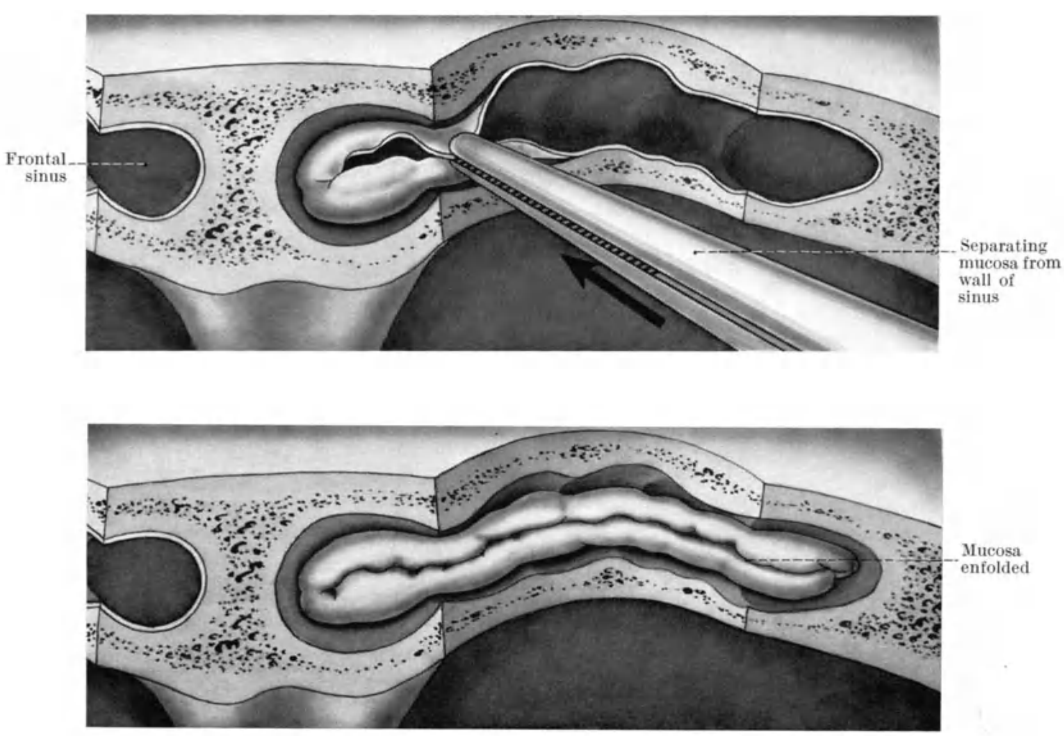


Fig. 170. Obliteration of frontal sinus.

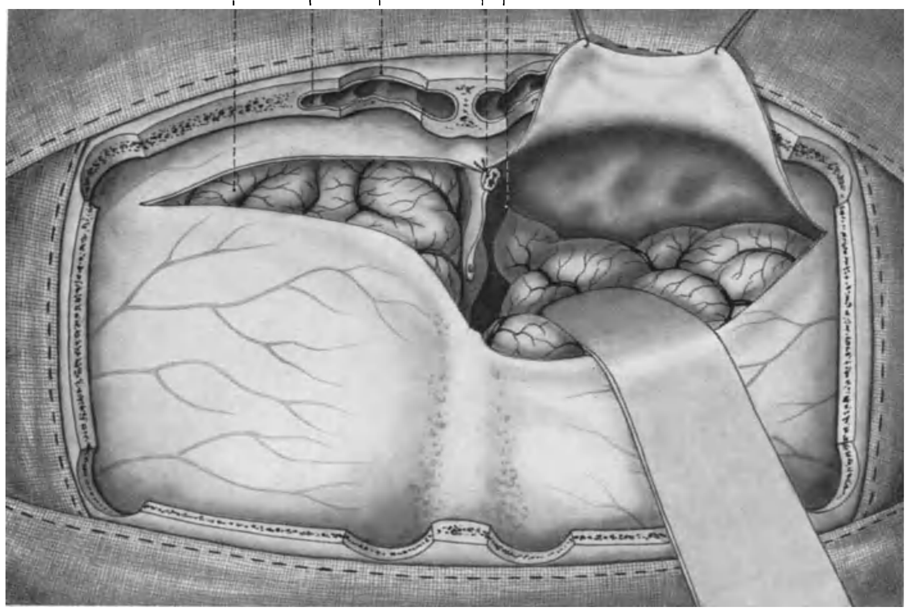


Fig. 171. Intradural exposure of cerebral-spinal-fluid fistula in right cribriform plate.

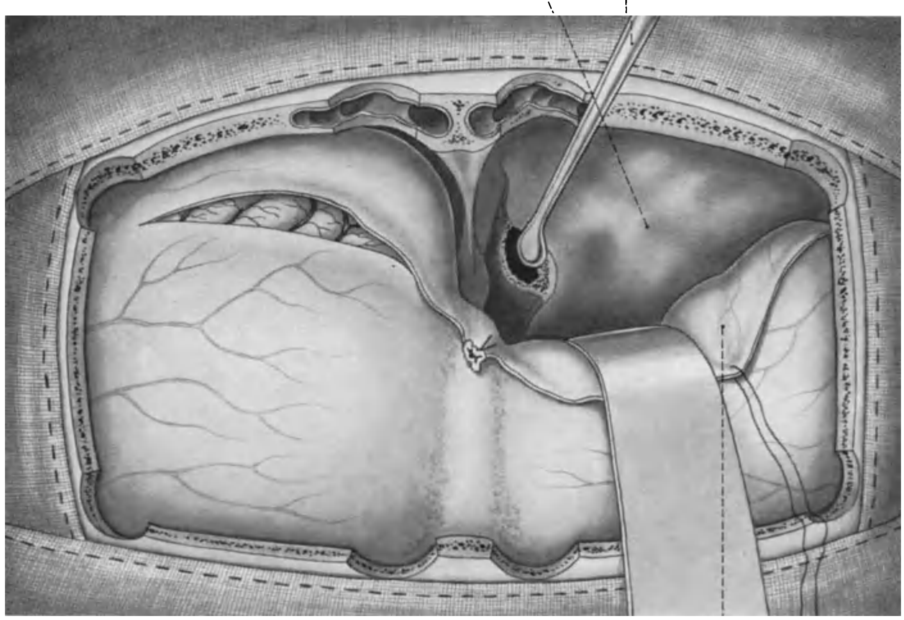


Fig. 172. Extradural exposure of defect in right cribriform plate.

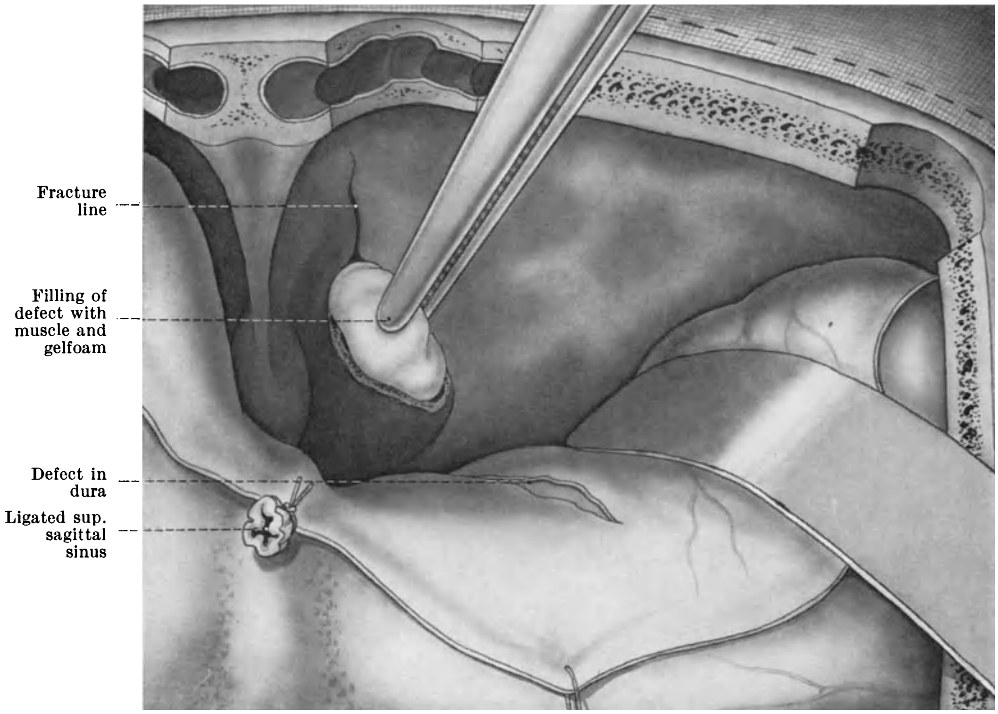


Fig. 173. Repair of defect in right cribriform plate.

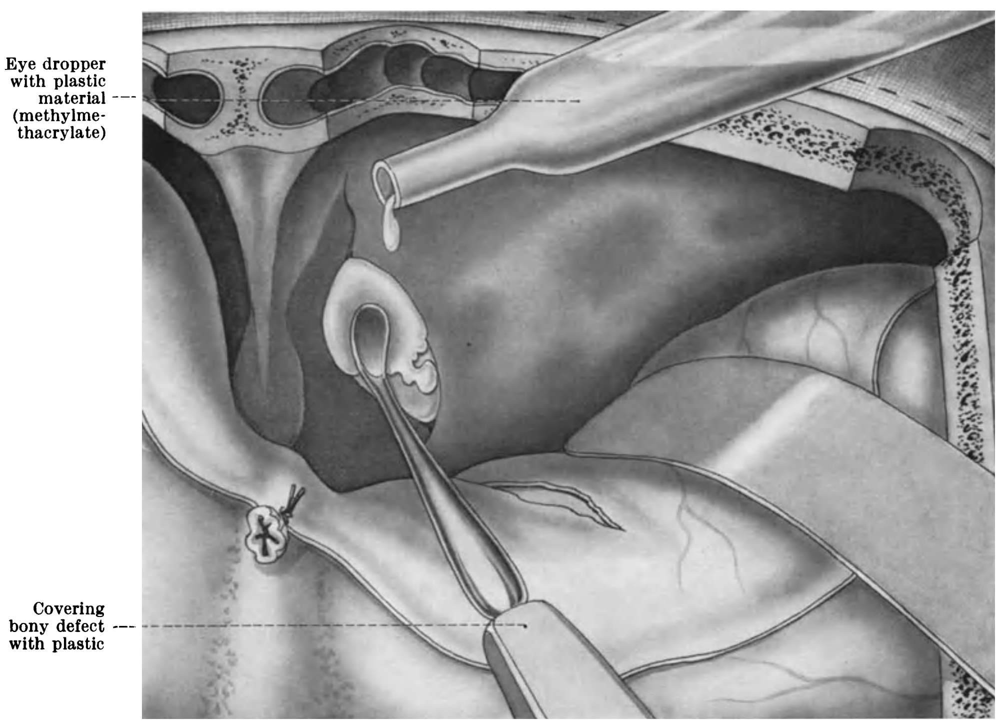


Fig. 174. Repair of defect in right cribriform plate.

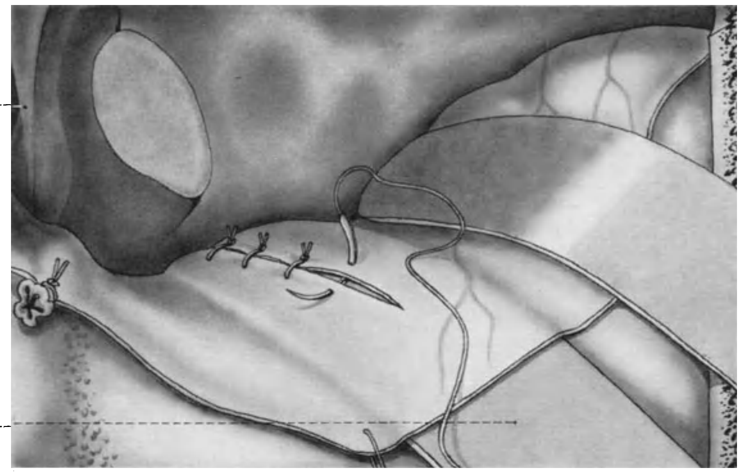


Fig. 175. Suturing of dural defect.

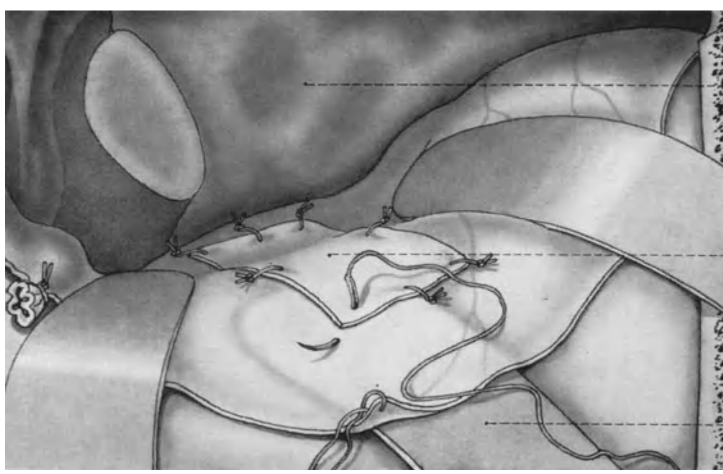


Fig. 176. Closure of dural defect using free graft of pericranium.

Chapter XI

Falx and Parasagittal Meningiomas

In this chapter the operative techniques of three meningiomas of the falx are given: (1) deep-seated unilateral falx meningioma, (2) parasagittal meningioma with invasion into the superior sagittal sinus, and (3) bilateral parasagittal meningioma. The value of the preoperative angiography in meningiomas has been discussed in Chapter VI, VIII and IX. In meningiomas of the falx not only are the same principles true but also required is a bilateral angiogram to obtain information in regard to bilateral extension of the tumor and invasion or obliteration of the venous sinus. If obstruction at the sagittal sinus is found, the main drainage of the hemispheres may go into the inferior sagittal sinus just below the tumor. Such a pathway has to be seen in the roentgenographic study and preserved during surgery. Visualization of arterial feeders to the meningiomas from branches of the external carotid artery (middle meningeal artery, superficial temporal artery, and the external occipital artery) requires the angiogram to include injection of the external carotid artery. But not all convexity meningiomas receive blood supply from the external carotid artery. In falx meningiomas especially, the main feeders may come from the pericallosal and middle cerebral arteries. Thus, the decision as to ligation of the external carotid artery to reduce bleeding is made, based on a complete angiographic study.

1. Deep-Seated Left Unilateral Falx Meningioma. The tumor chosen here is on the left side and at the level of the coronal suture line. Fig. 177 shows the lesion in a sagittal section and Fig. 178 in a coronal section. The patient is placed in the supine position (Fig. 179a or 179b) and the upper part of the body and head are elevated ten degrees. It is important to extend the craniotomy across the midline in every unilateral falx and parasagittal meningioma (Fig. 180). Any bleeding from the dural sinus, especially when the sinus has to be incised, is handled easier when it can be approached from both sides. The same holds true for the inferior sagittal sinus. Retraction of the sagittal sinus and falx is safer, room to operate is increased, and traction to the brain is decreased when the craniotomy extends over the midline.

A transcoronal skin incision or the one seen in Fig. 180 may be chosen. The dura is opened and reflected towards the superior sagittal sinus. Since the tumor is anterior at the level of the coronal suture line, any draining veins to the superior sagittal sinus can be coagulated and cut to permit retraction of the frontal lobe. If the tumor sits more posteriorly and the important communicating veins (i.e., vein of Trolard) bridge the approach and prevent the exposure of the tumor, the tumor can be removed from the opposite side. Usually it is possible to reach the tumor and to spare these important draining veins even though one may have to approach the tumor at a more disadvantageous angle. Fig. 181 shows the tumor adherent to the inferior rim of the falx, the latter which is now incised with a blunt nerve hook and to which is applied an alternating coagulation and cutting current. The falx is constantly being separated away from the hemispheres to prevent damage to the opposite cortex. A right angle scissor may be preferred rather than the cutting current. After the falx is incised completely around the tumor, a 00 black silk suture is carried through the tumor mass or its dural attachment for retraction.

We now look for the feeding vessels to the tumor coming from the anterior cerebral artery. This is done by first identifying both anterior cerebral arteries (pericallosal branches) anterior and posterior to the tumor. Thereafter, the tumor is carefully elevated and tilted

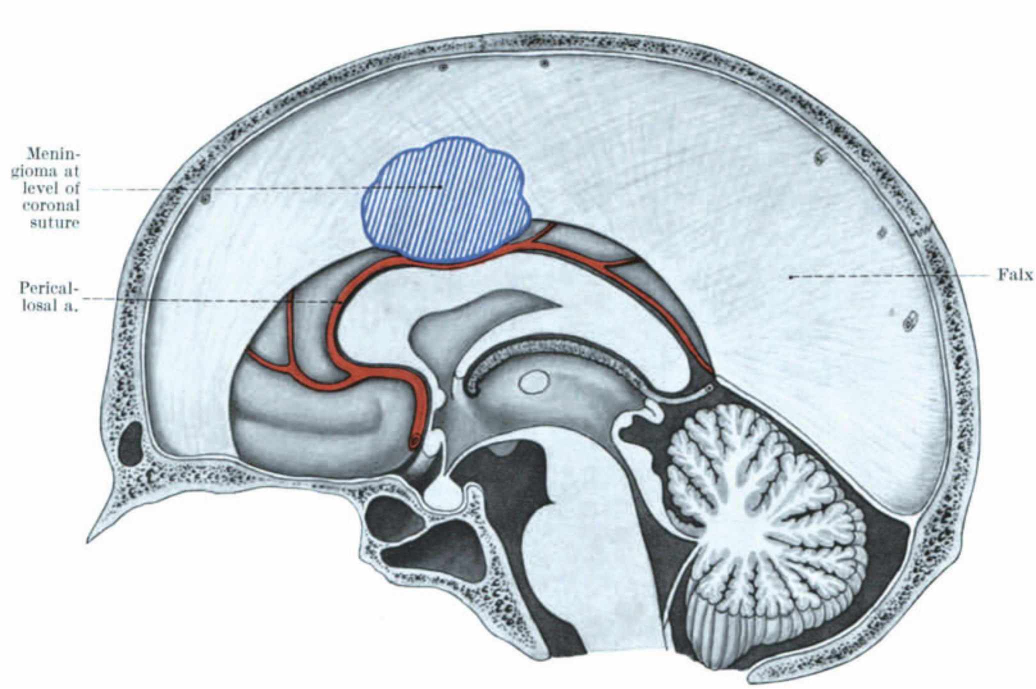


Fig. 177. Anatomical demonstration of deep parasagittal falx meningioma. (Midline sagittal section.)

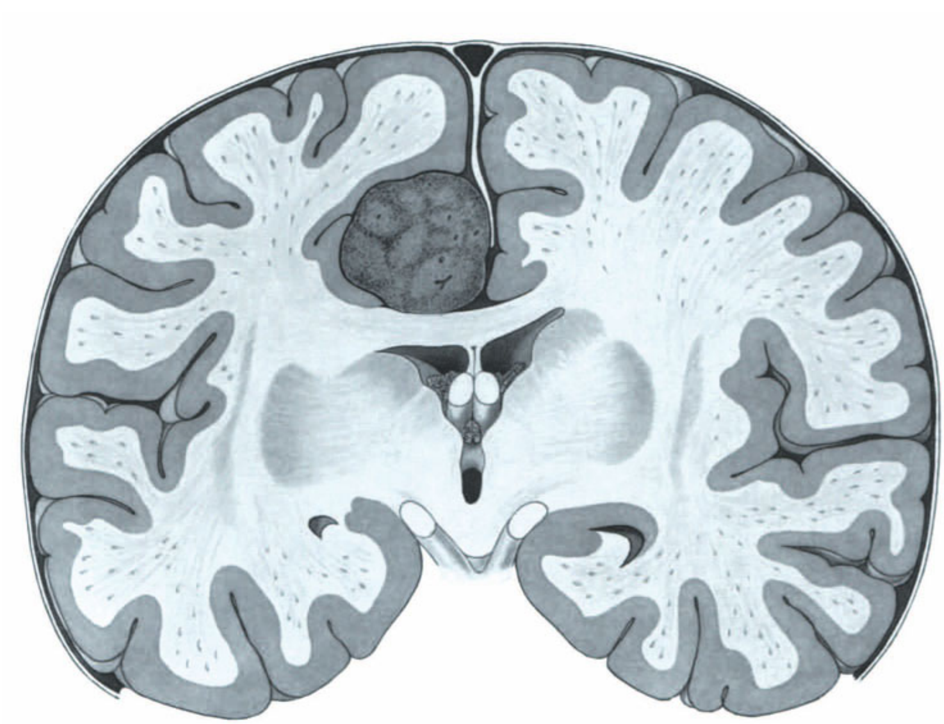


Fig. 178. Anatomical demonstration of deep left unilateral parasagittal falx meningioma in a p-a. coronal section of the brain.

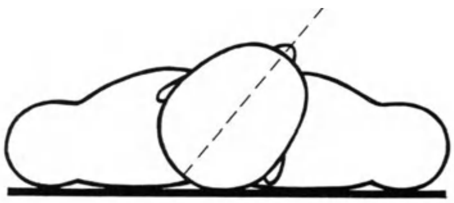


Fig. 179a.

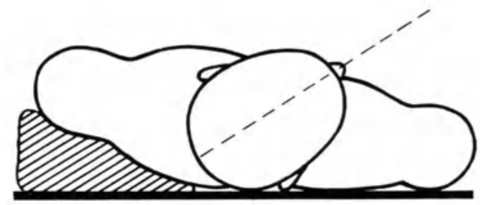


Fig. 179b.

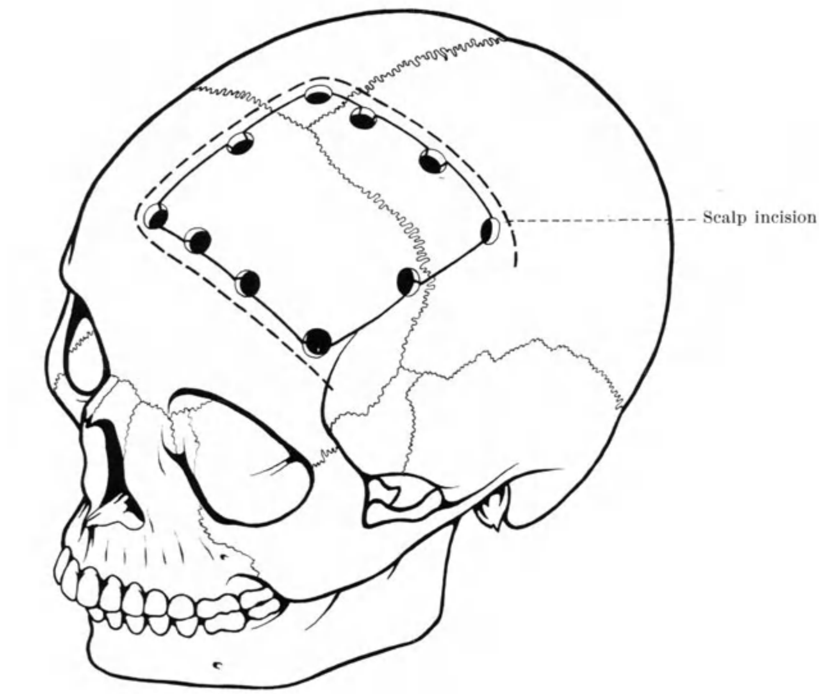


Fig. 180. Craniotomy for deep seated, unilateral, left, parasagittal falx meningioma. *Observe:* Craniotomy extends over midline.

backward and forward. Any transmission of these movements of the tumor to the vessels is observed, and then the adherent vessels are freed from the tumor. It is important not to injure the main branches of the anterior cerebral arteries; however, the main feeding artery which goes to the tumor is identified, clipped and sectioned. Fig. 182 shows the operative field after removal of the tumor.

2. Parasagittal Meningioma with Invasion into the Superior Sagittal Sinus. The illustrated case is a left-sided meningioma situated at the level of the central sulcus. In Fig. 183 a coronal section shows a tumor which has invaded, but not obliterated, the superior sagittal sinus. At this level the superior sagittal sinus cannot be ligated but instead has to be repaired.

The patient's position on the operating table is seen in Fig. 184. Fig. 185 shows the scalp incision and the craniotomy which reaches over the midline. The placement of burr

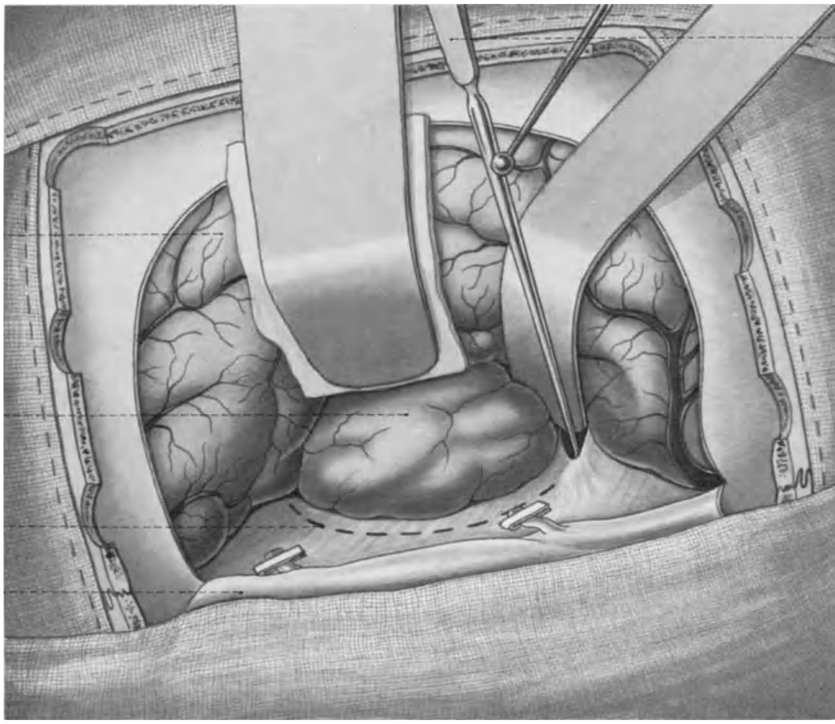


Fig. 181. Operative exposure of deep parasagittal meningioma.

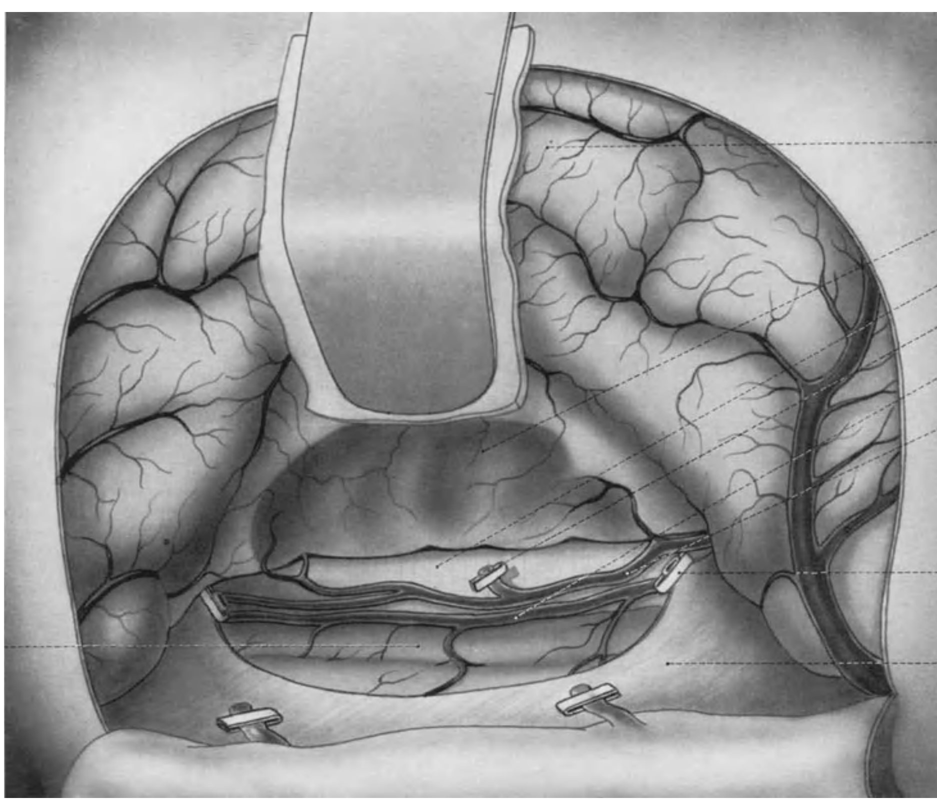


Fig. 182. Operative view after removal of left deep parasagittal meningioma.

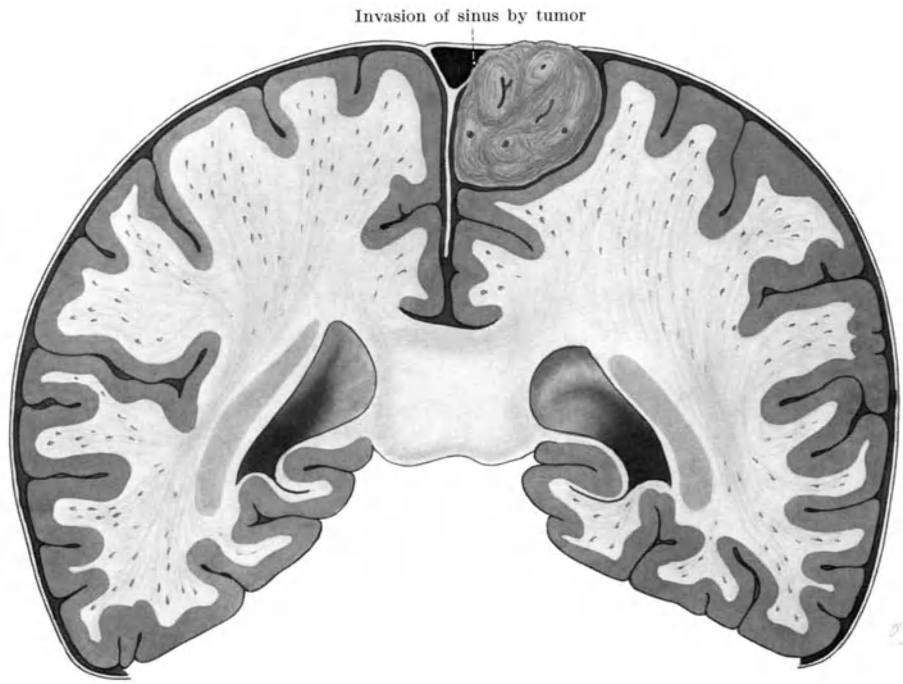


Fig. 183. Anatomical demonstration of left superior parasagittal falx meningioma invading superior sagittal sinus in an a-p. coronal section at the level of the splenium of the corpus callosum.

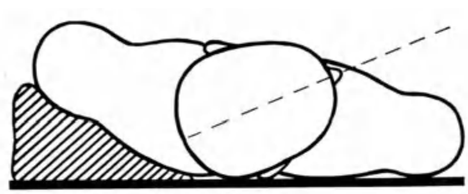


Fig. 184.

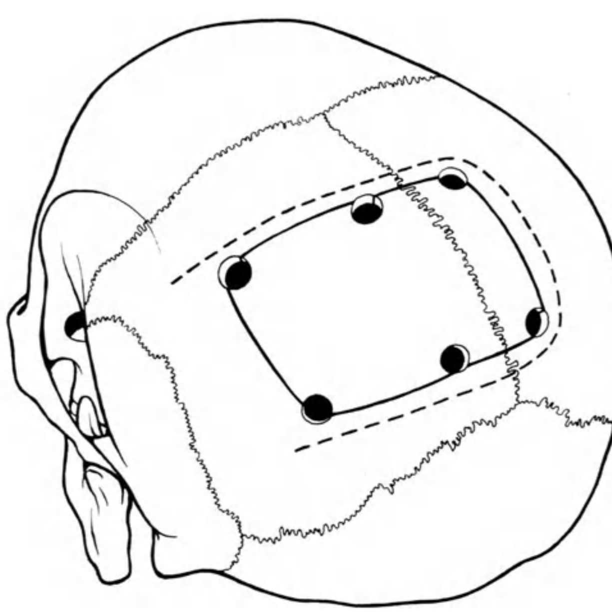


Fig. 185. Craniotomy for left superior unilateral parasagittal falx meningioma over posterior fronto-parietal lobe. *Observe:* 1. Craniotomy reaches over the midline. 2. Interrupted line indicates skin incision.

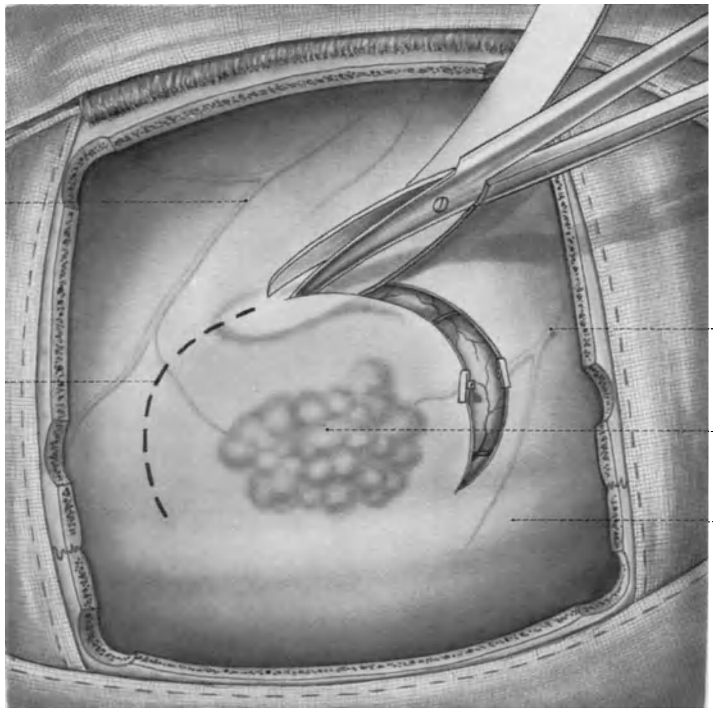


Fig. 186. Dural opening for left superior parasagittal falx meningioma. *Observe:* Relationship of sup. sagittal sinus to the dural opening.

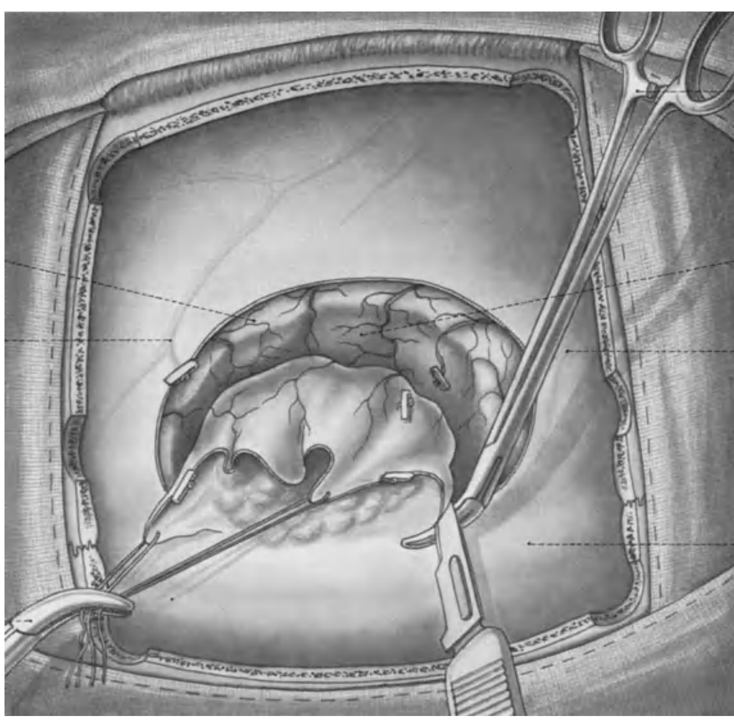


Fig. 187. Removal of meningioma invading superior sagittal sinus.

holes on both sides of the venous sinus in this craniotomy is dependent on the principles stated on page 119 and shown in Fig. 168. Any dura which has been invaded is removed along with the tumor.

We begin intracranially with a circular opening of the dura large enough to permit exposure and retraction of the surrounding brain (Fig. 186). The dura invaded by tumor is left attached and is used for retraction. The arachnoidal adhesions between brain and meningioma are separated using fine smooth coagulation forceps and the scissor. A plane of cleavage is determined and with the use of wet cotton strips and brain spatulas (not shown in the picture), this line of cleavage is broadened and deepened. Often the cleavage plane may be followed completely to the undersurface of the tumor before it is freed from the dura. In this case (Fig. 187) the tumor can be tilted towards the sinus since its relatively small size will permit complete separation from the surrounding brain. Fine hemostats grasp the wall of the sinus, and the dural wall of the sinus is incised above the hemostats (Fig. 188). The hemostat is then deflected down to evert the wall of the dural sinus (Fig. 188 and 189) so as to give hemostasis. This operative maneuver is continued until the tumor is freed from the wall of the sinus. Interrupted or continuous suture is used to close the defect in the sagittal sinus by lifting the hemostat before placing the needle (Fig. 189 and 190). The remaining dural defect is closed with a free graft of pericranium. In the event the meningioma has invaded the skull to such an extent that the bone flap cannot be lifted out without rocking the tumor and causing harm to the brain, the bone over the tumor is left in place and the outer part of the bone flap is removed. Fig. 191 shows one way of doing this. The remaining bone invaded by tumor is then reduced to a small size (Fig. 192). The fragment of bone is held firmly while it is reduced by a sharp rongeur. Then we can proceed with the operations as outlined (Fig. 186).

3. Bilateral Parasagittal Meningioma. A meningioma close to the coronal suture has been selected. The coronal section going through the foramen of Monro (Fig. 193) shows the main mass of the tumor on the right side.

The position of the patient on the operating table is seen in Fig. 194 and the outline of the scalp incision and craniotomy in Fig. 195. A transcoronal scalp incision is often preferable to the one shown here. In this example case, the preoperative angiographic studies demonstrate an occluded superior sagittal sinus. At this coronal level the patency of the sinus is less important. The dura is incised and excised bilaterally with clamping and ligation of the superior sagittal sinus (Fig. 196). Observe that the large draining vein on the right side is kept intact throughout the operation. The part of the dura not invaded by tumor is now removed (Fig. 197). If we have accurate knowledge as to the size and relationship of the tumor to the dura, we can incise and reflect a smaller portion of the dura over the right hemisphere. If we have any doubt about these relationships, we need a wider circular excision as shown here. The line of cleavage between brain and tumor is developed by separating any adhesions, by coagulating and cutting feeding vessels. Surrounding brain tissue is quite soft and fragile from prolonged compression. Wet cotton strips are introduced into the line of cleavage and the tumor mass is reduced with the wire loop electrode (Fig. 198). In this manner we remove the right half of the tumor until the falx is visualized. The latter is now incised (Fig. 199). Traction on the dura attached to the tumor aids in freeing and delivery from the surrounding brain tissue and thereby minimizes any retraction on the fragile brain. To close the dura a free graft of pericranium for that part invaded by tumor is needed (Fig. 201). The tendency to develop postoperative edema is significant enough in these meningiomas so that often the bone flap should not be replaced. This skull defect can later be corrected by cranioplasty.

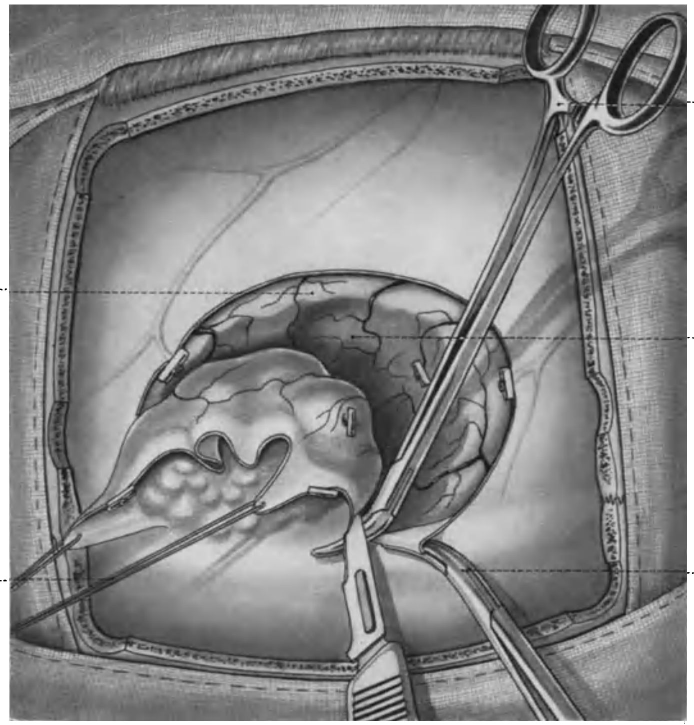


Fig. 188. Removal of left superior parasagittal falx meningioma *invading* superior sagittal sinus.

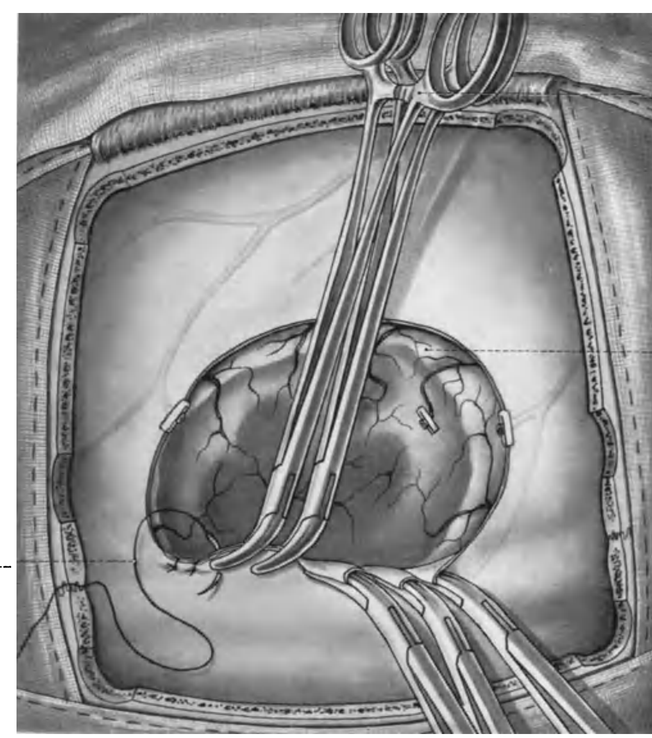


Fig. 189. Operative view after removal of superior parasagittal falx meningioma and suture repair of venous sinus.

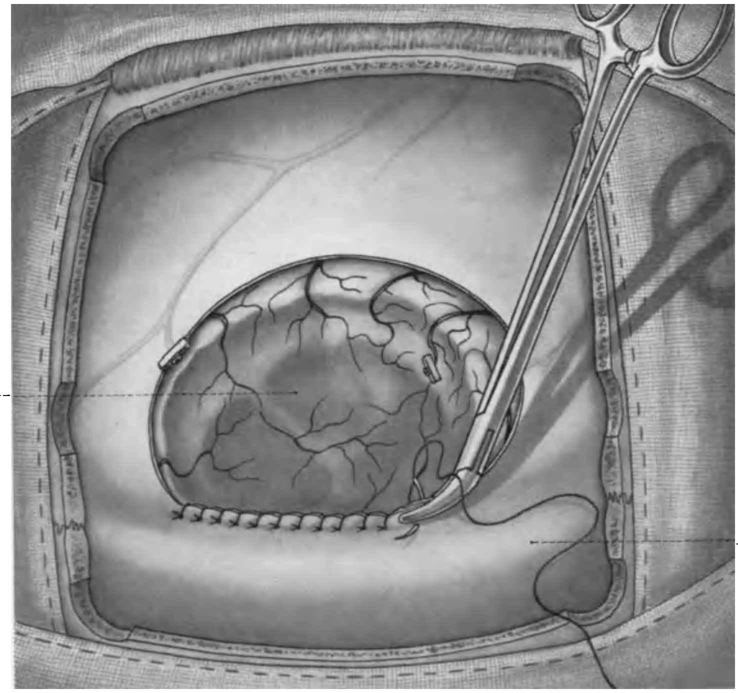


Fig. 190. Closure of left lateral wall of superior sagittal sinus.

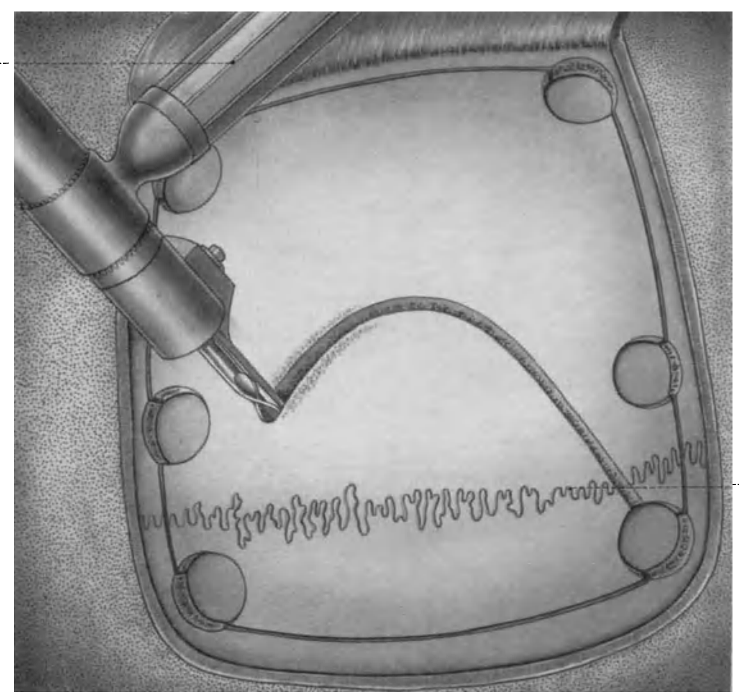


Fig. 191. Craniotomy in parasagittal meningioma with invasion of bone.
Observe: Tumor which has invaded the skull may not permit the elevation of the bone flap. In such cases part of the skull close to the tumor will be left in place.

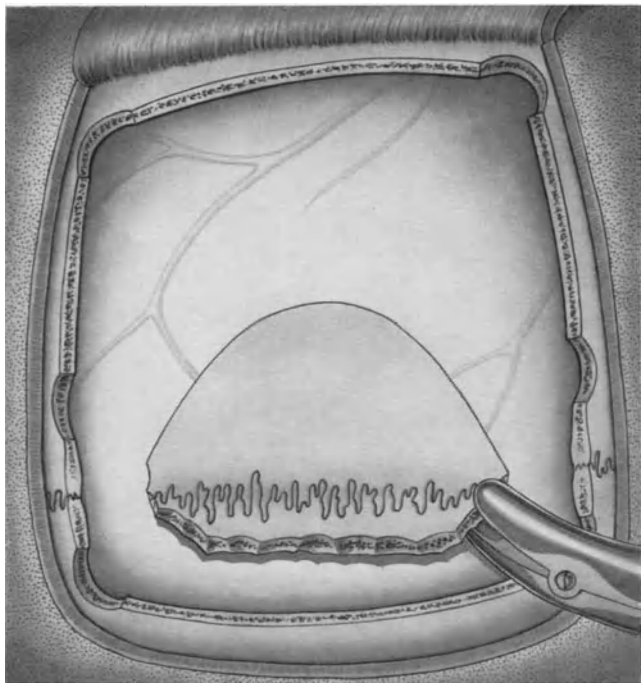


Fig. 192. Invasion of skull by meningioma.
Observe: Reduce size of bone invaded by tumor with rongeur and then proceed with the operation as previously outlined.

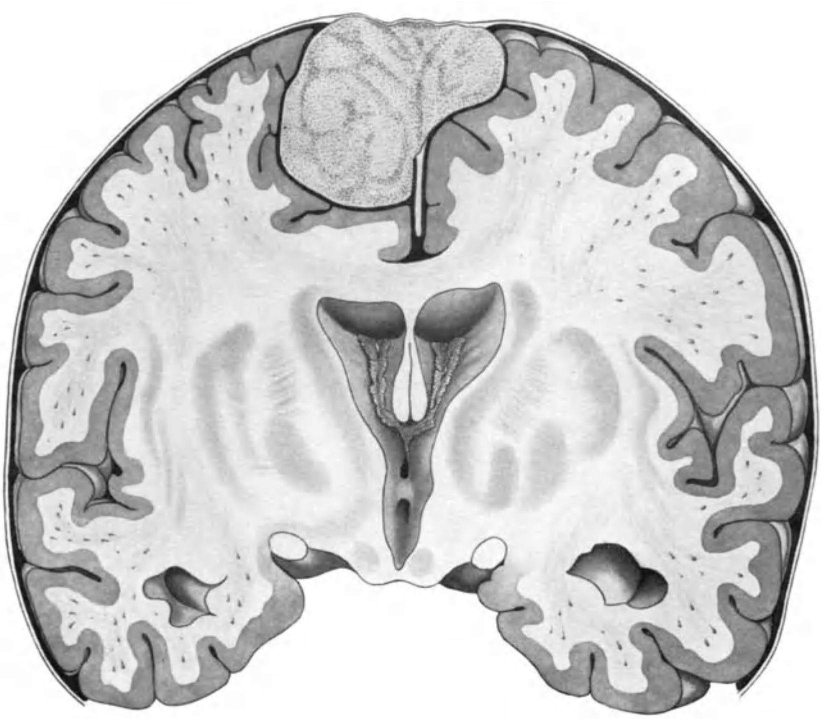


Fig. 193. Anatomical demonstration of bilateral superior parasagittal meningioma obliterating the superior sagittal sinus.
Observe: 1. Larger tumor on the right side. 2. Coronal section at level of foramen of Monro, a-p. view.

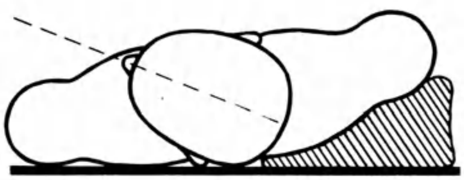


Fig. 194.

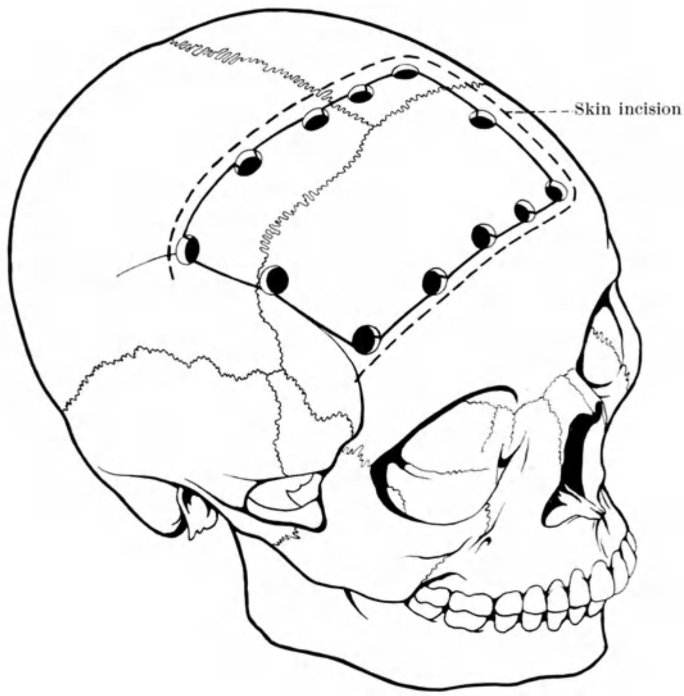


Fig. 195. Skin incision and craniotomy for predominantly right bilateral superior parasagittal frontal meningioma.

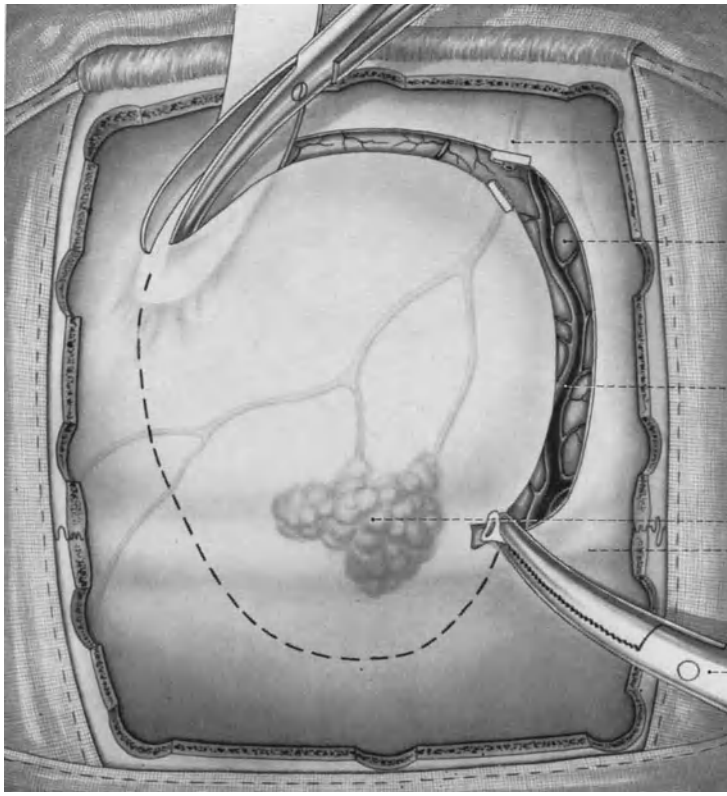


Fig. 196. Incision of dura in bilateral parasagittal falx meningioma with occlusion of venous sinus by tumor invasion.
Observe: Dura incision crosses superior sagittal sinus.

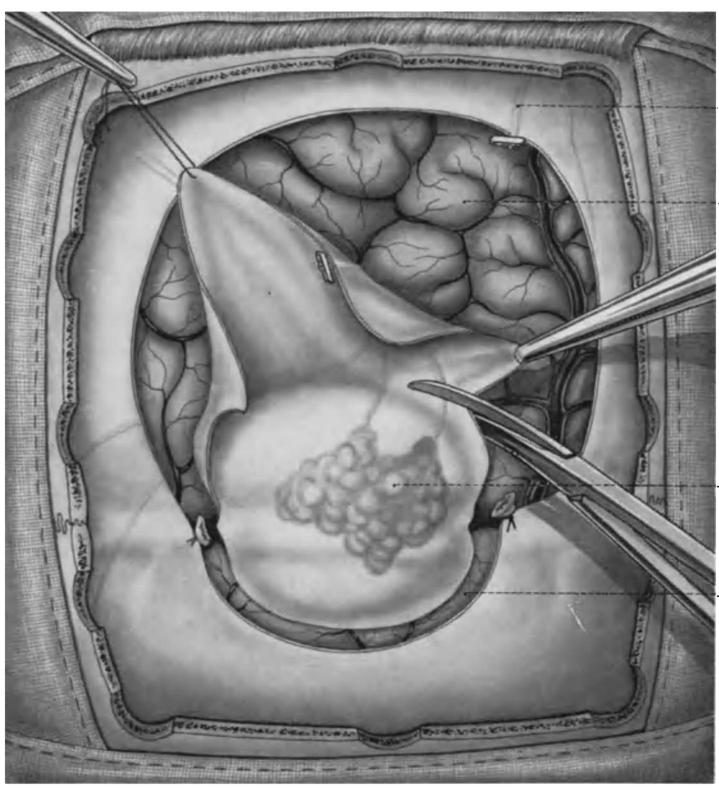


Fig. 197. Excision of dura not involved with tumor.

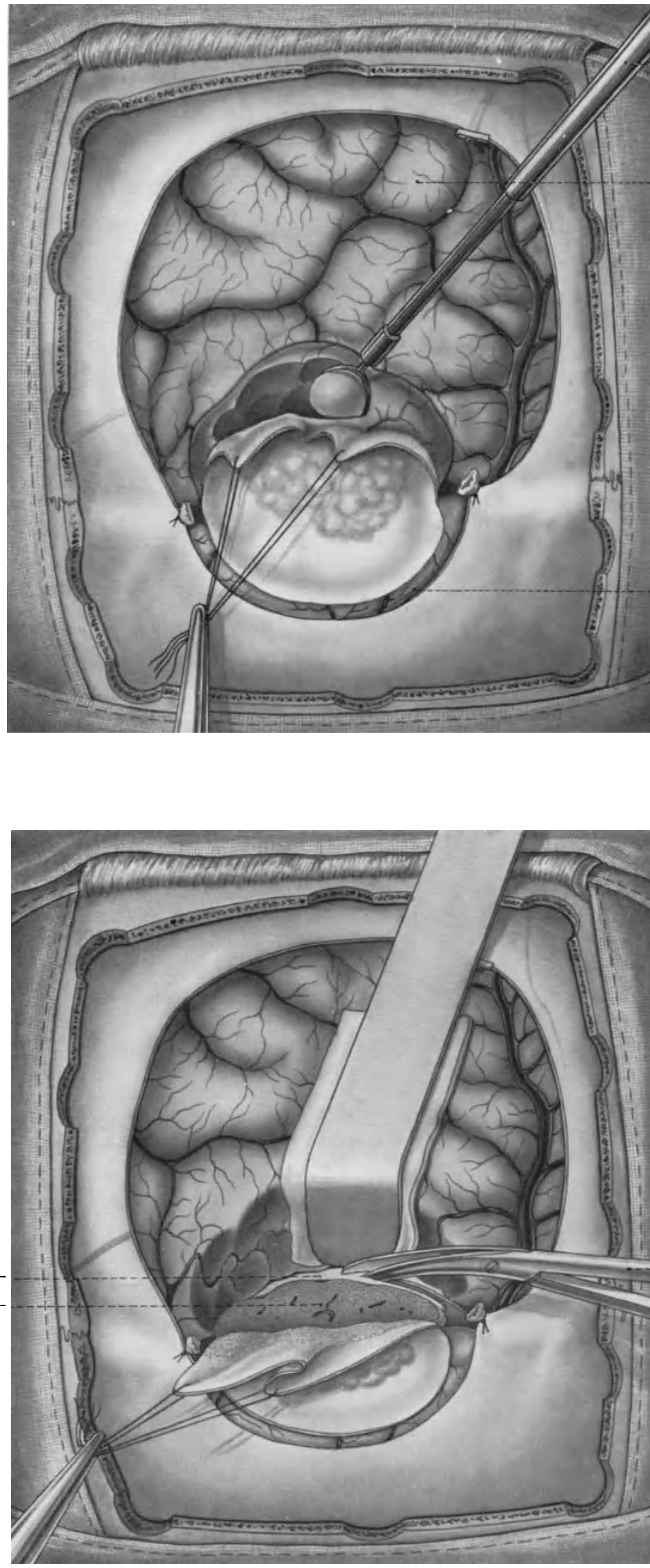


Fig. 199. Operative view of incision into the falx cerebri in bilateral falx meningioma. *Observe:* Larger portion of the tumor has been removed to facilitate incision of falx.

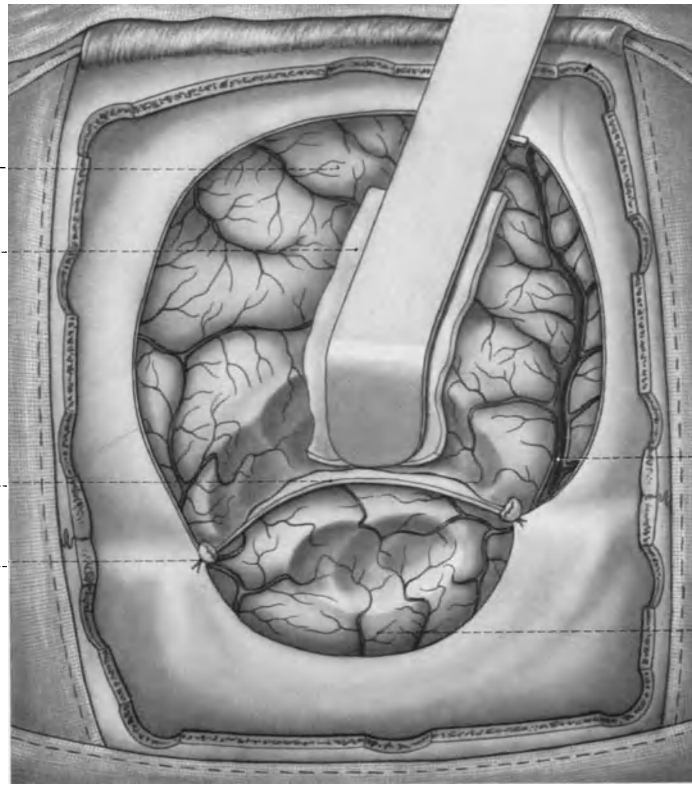


Fig. 200. Operative view after removal of bilateral parasagittal falx meningioma
Observe: Throughout the operative procedure the large draining cortical vein was saved. Anatomical studies reveal that such veins form connections with the inferior sagittal sinus.

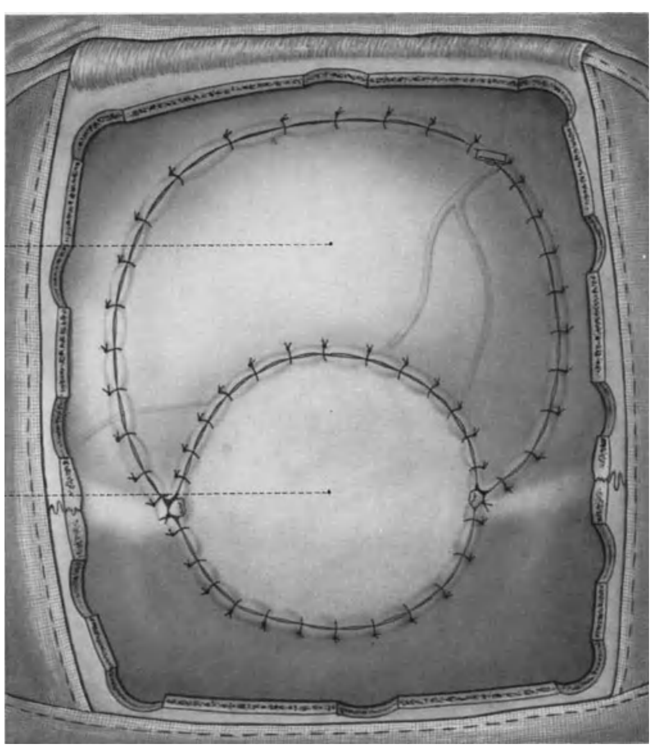


Fig. 201. Dural closure by free fascial graft and part of original dura.

Chapter XII

Operative Repair of Dural Sinus

A dural sinus may need operative repair for many reasons of which tumor and trauma are two of the more common. In fact, a dural sinus may intentionally be opened and part of its wall excised; for example, as with the meningioma presented in Chapter XI, p. 130.

Repair of the sinus is shown in Fig. 187 to 190. The repair of the wall of a dural sinus should not be undertaken without having access to the sinus from both sides. This means an exposure from the left and right sides for the superior sagittal sinus and from above and below for the transverse sinus. In the latter case the middle and posterior fossae will have to be opened (Fig. 237, p. 170). Elevation of the chest and head will assist in reducing venous pressure and bleeding. Whenever the patient's position is changed, it is necessary to be certain there is no obstruction to the venous system in the neck and chest. The possibility of air embolism with an open sinus, especially in the sitting position, has to be kept in mind and to be prevented. Coagulation over a dural sinus is not recommended since the risk of burning a hole in the sinus wall is great. A free muscle graft or gelfoam is placed over the dural defect and is secured with a figure-of-eight fine silk suture as in Fig. 202. A round and not cutting edge needle should be used.

In trauma a fragment of bone may have penetrated the sinus; therefore, prior to removal of the bone fragment it should be ascertained whether or not the fragment has lacerated the sinus wall in more than one place. Again, the necessity for complete exposure of both sides of the sinus is obvious. In repairing the laceration the assistant's finger covers the laceration or lacerations and a free fascial graft of pericranium is slid below the finger to cover the defect (Fig. 203). If the wall of the laceration shows a smooth cut without any loss of the dural wall we use an interrupted or continuous suture to close the sinus (Fig. 204). The sutured laceration is then covered by gelfoam or muscle (Fig. 202).

In massive lacerations as seen in trauma and missile wounds the use of a polyethylene catheter as a bypass, while one repairs the sinus with a venous graft taken from an autogenous vein, has been used. It may be necessary to attend to the intracranial situation before taking care of the dural sinus bleeding. A temporary tamponade of gelfoam and cotton strips together with the pulling of reflected dura over the cotton strips will do very well (Fig. 205). We have occasionally used the reflected dura for repair of a large defect in the sinus wall and the pericranial graft to close the remaining dural defect over the brain.

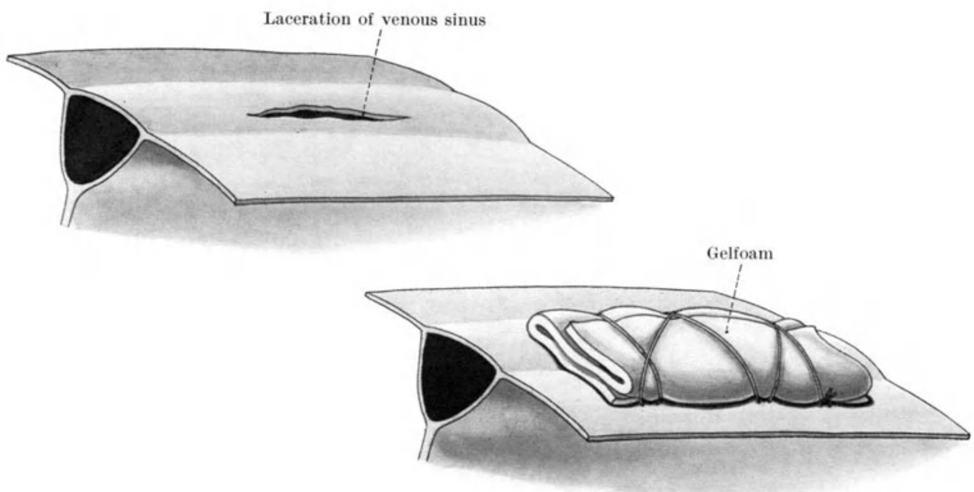


Fig. 202. Closure of venous sinus laceration by fastening gelfoam over defect with figure of eight suturing. *Observe:* Suture placement is lateral to the sagittal sinus.

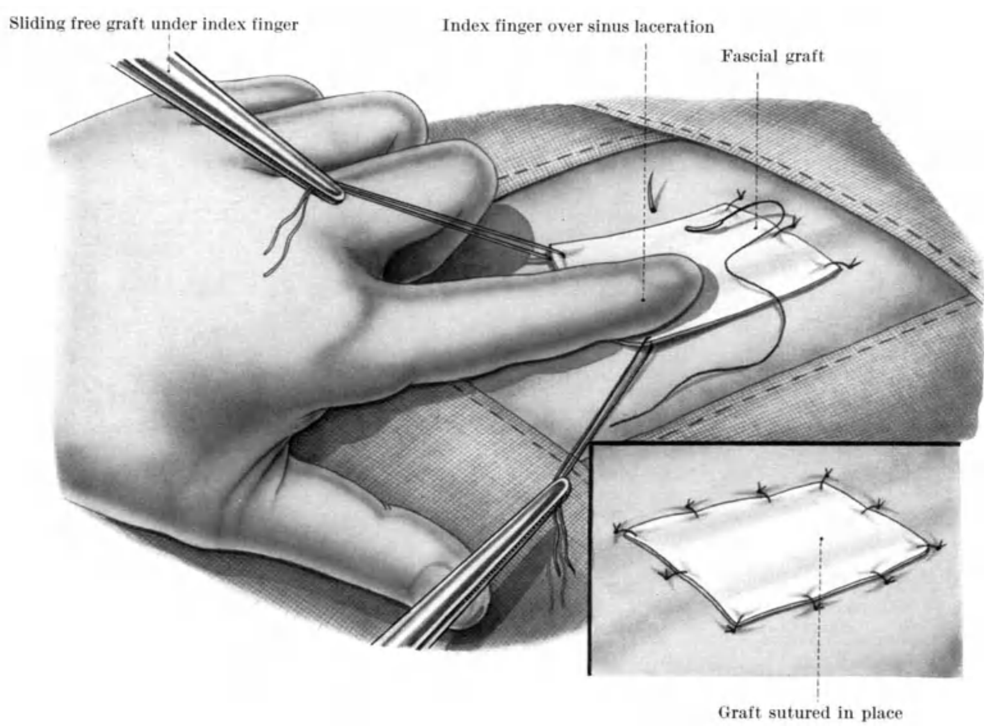


Fig. 203. Repair of venous sinus laceration using free graft of pericranium or temporalis muscle fascia.

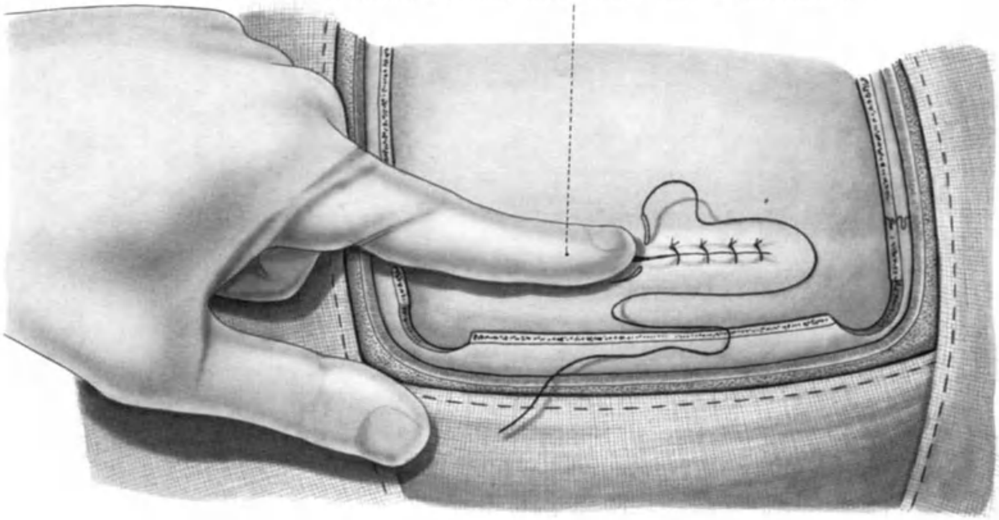


Fig. 204. Repairing venous sinus laceration by interrupted silk suture.

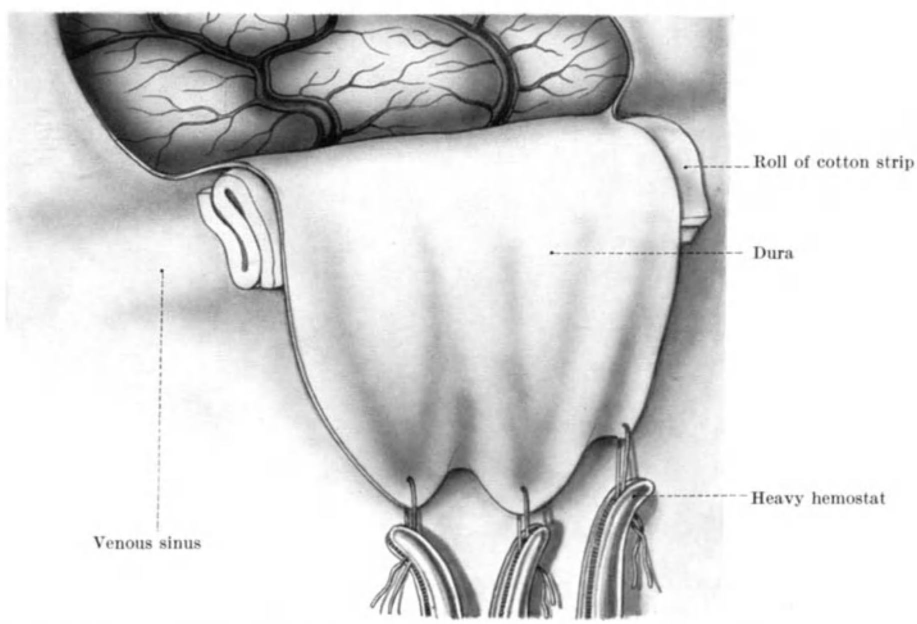


Fig. 205. Temporary closure of venous sinus defect by pressure tamponade.

Chapter XIII

Tumors of the Third Ventricle

The third ventricle may be invaded from below by a pituitary tumor or a craniopharyngioma; if such is the case the operative technique is as described in Chapters IV and V. A large aneurysm situated at the bifurcation of the basilar artery may bulge into the third ventricle, cause obstructive hydrocephalus and be mistaken for a third ventricular tumor. If properly diagnosed the aneurysm will be handled subtemporally and is discussed in a later chapter. For true third ventricular tumors (colloid cyst, pinealoma, etc.) and for the occasionally superiorly placed craniopharyngioma, the operative approach is from above. There are two such approaches to the third ventricle. One is from above anteriorly through the lateral ventricle and the foramen of Monro (Fig. 206) and the other approach is from above and posteriorly through the splenium of the corpus callosum (Fig. 216).

For tumors of the third ventricle the removal of a colloid cyst will be presented, as an example, for the anterior approach and the exposure of a pinealoma, as an example, for the posterior approach.

1. Anterior Third Ventricular Tumor — Colloid Cyst. A pneumoencephalogram is the diagnostic study of choice to outline the tumor. Because there is usually increased intracranial pressure, a ventricular catheter is placed first and air is thereafter introduced from below. This gives a better view of the cyst, especially when it has completely blocked the foramen of Monro (Fig. 207 and 208).

The position of the patient on the operating table is seen in Fig. 209. The craniotomy (Fig. 210) is done over the right, nondominant, hemisphere and consists of a small 7×7 cm. segment of bone situated about 1 cm. anterior to the coronal suture and 1 cm. lateral from the midsagittal line. A core of brain tissue, about 35 mm. in diameter, is removed and the anterior horn of the right lateral ventricle is entered. There is less trauma to the brain by excising a core of tissue than retracting a linear incision. The ventricular fluid is not completely removed, especially when the ventricle is quite dilated. Keeping the ventricle distended the anatomy is easily identified. The cyst is recognized by its greenish coloration as it bulges through the foramen of Monro with the choroid plexus being attached (Fig. 211). Aspirating the cyst reduces its size, permits delivery into the lateral ventricle, and reveals the extent of attachment of the choroid plexus to the cyst. The choroid plexus is best coagulated using bipolar coagulation. The base of the cyst is clipped and a minute remnant of the wall of the cyst is left behind after excision (Fig. 212). The ventricles are filled with saline and the dura closed.

2. Posterior Third Ventricular Tumor — Pinealoma. Over the past twelve years we have explored every mass lesion in the posterior part of the third ventricle prior to doing a shunting procedure and giving x-ray therapy. In a few patients a cystic lesion of benign nature was found which could be removed and for which radiation therapy would have been useless. Several teratomas were successfully removed. In the remaining patients exposure and biopsy did not present a great risk and pathologic information obtained could accurately dictate the amount of radiation therapy.

If one of the following observations exists, complete removal of the lesion may be considered: (a) A smooth round mass which separates well from vascular and known anatomical structures, (b) air which is seen below the tumor and which fills the suprapineal

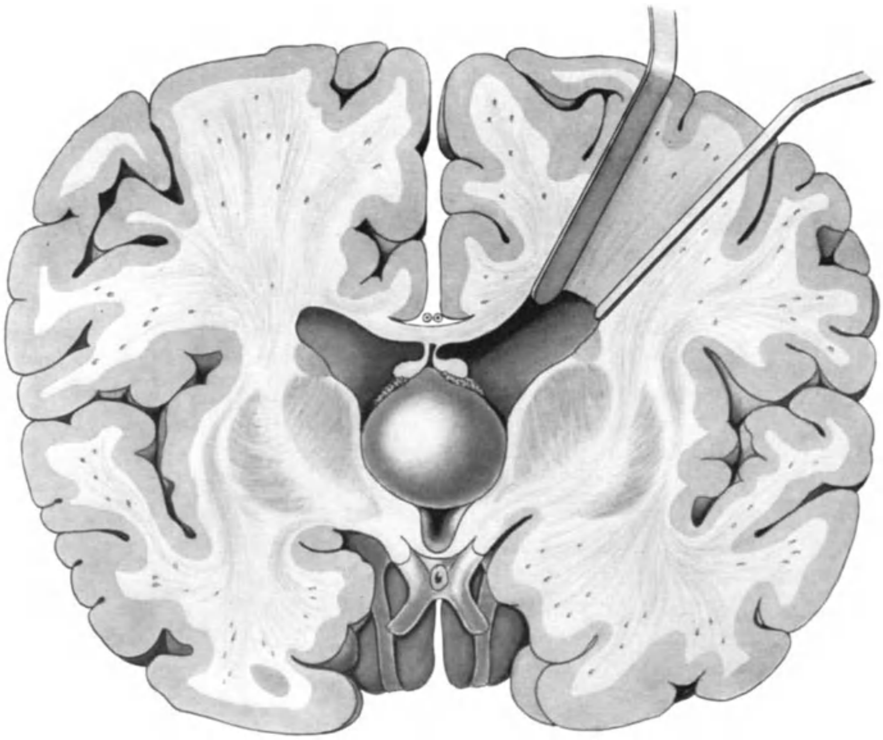


Fig. 206. Anatomical representation of the operative approach for colloid cyst in a coronal section, p-a. view. *Observe:* Operative approach through right prefrontal cortex.

recess or (c) the absence of tela choroidae and central vein over the dorsum of the tumor after the splenium of the corpus callosum has been divided.

In Fig. 213 an anatomic pathological specimen of a pinealoma is topographically presented. This type of lesion presents a difficult problem. The tela choroidae is above the dorsum of the tumor and carrys the central veins. However, the tumor appears to be clearly separated from normal, but compressed, anatomical structures. Total removal is possible but carries a high mortality because of postoperative infarction of the mesencephalic tectum and tegmentum.

The position of the patient on the operating table is seen in Fig. 214. The craniotomy is predominantly over the parietal and occipital bones on the right side (Fig. 215). It is important to extend the opening over the midline in order to be able to retract both sides. The dura is opened and reflected toward the superior sagittal sinus. In Fig. 217 we see the tentorium exposed while we retract the posterior parietal lobe on the one side and the falx on the other. The tentorium may cover the splenium of the corpus callosum for several millimeters. The tentorium is coagulated and then incised by lifting it on the right side with a blunt nerve hook (Fig. 217). We make sure not to injure the vein of Galen and its branches which may be compressed and displaced. The thinned out corpus callosum is divided bluntly and the tumor will come into view. Retraction on the edges of the incised tentorium will verify the posterior extent of the lesion (Fig. 218). In the lesion here the central vein is seen going over the tumor. Also, the basal vein of Rosenthal is identified. This same tumor is seen in Fig. 213. These veins may be thinned out. While we incise the tumor and remove parts of it with a sharp spoon curette (Fig. 219), the veins become decompressed and distend considerably. Great care is taken not to injure these vessels. Total removal depends entirely on the criteria earlier outlined. If the interventricular pathways cannot be opened by complete or incomplete removal of the tumor, a ventricular subarachnoidal shunt (Torkildsen procedure) is performed.

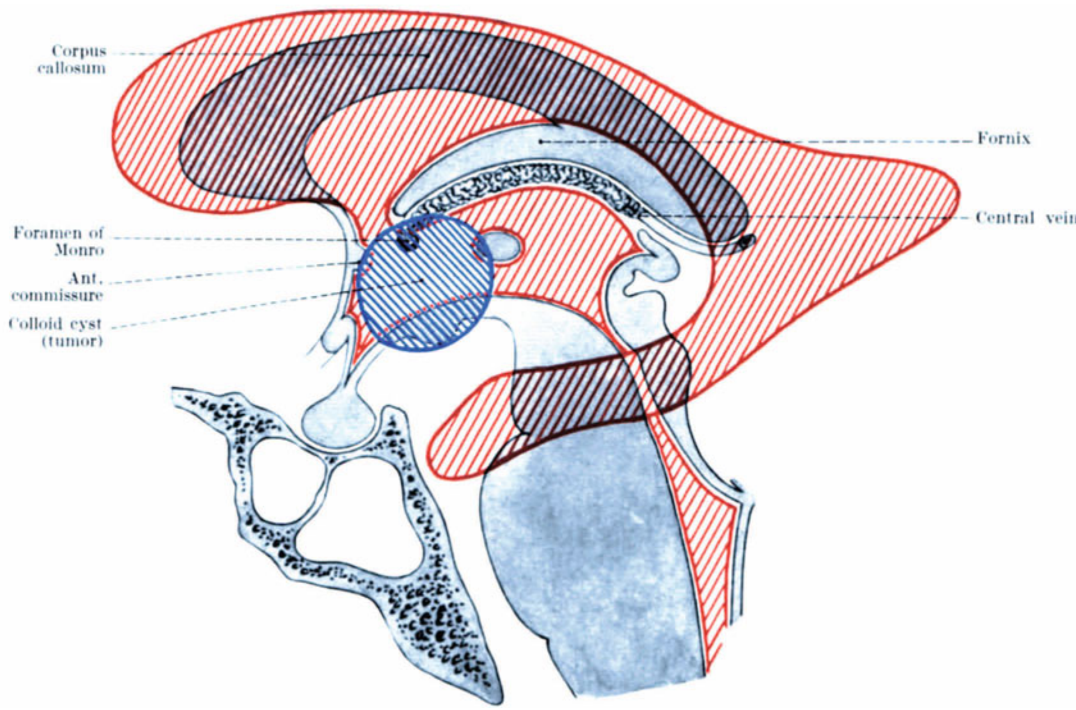


Fig. 207. Schematic drawing of colloid cyst projected onto normal anatomical ventricular structures.

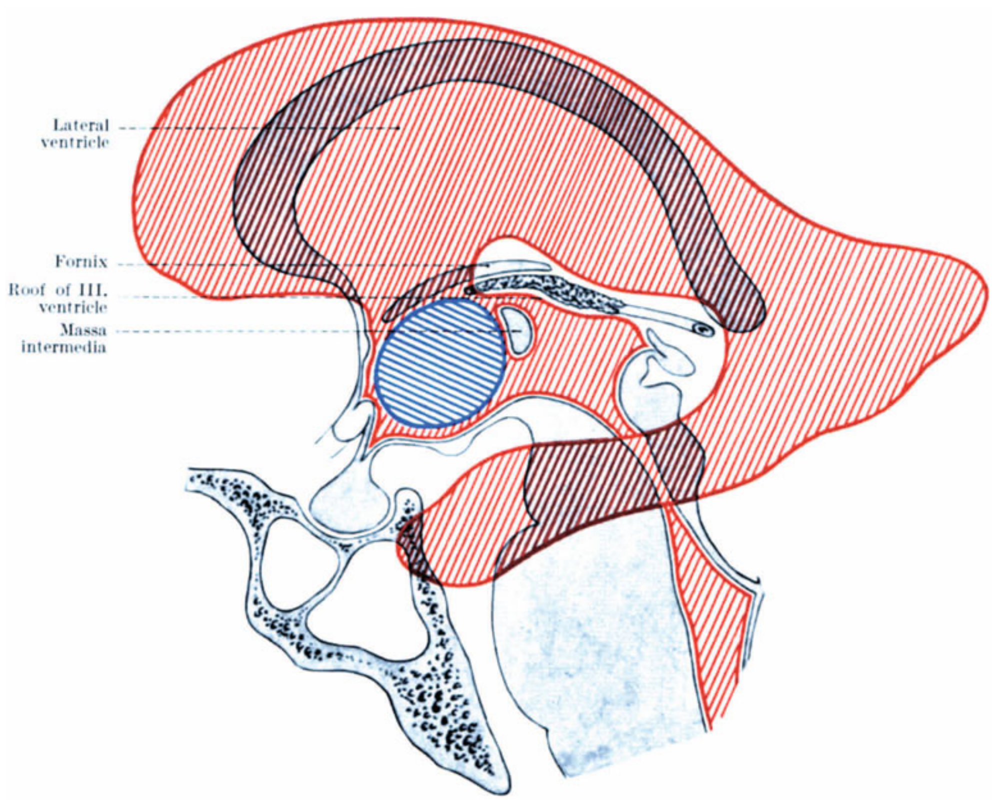


Fig. 208. Schematic drawing of colloid cyst causing obliteration of foramen of Monro. *Observe:* 1. Enlargement of lat. ventricles. 2. Depression of roof of third ventricle.

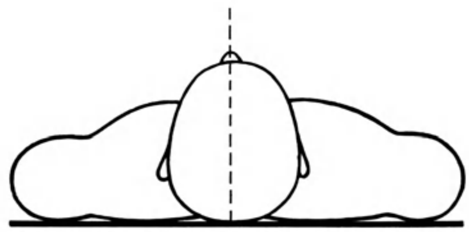


Fig 209.

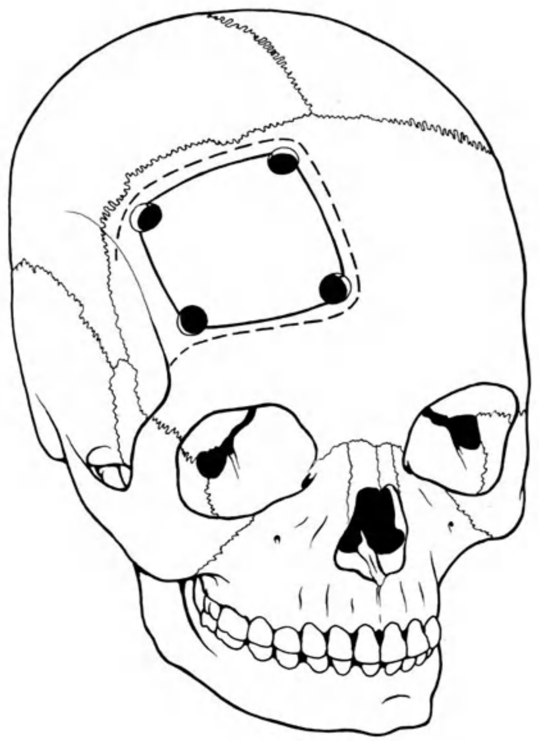


Fig. 210. Skin incision and craniotomy for colloid cyst.
Observe: Operative approach is from the right nondominant side.

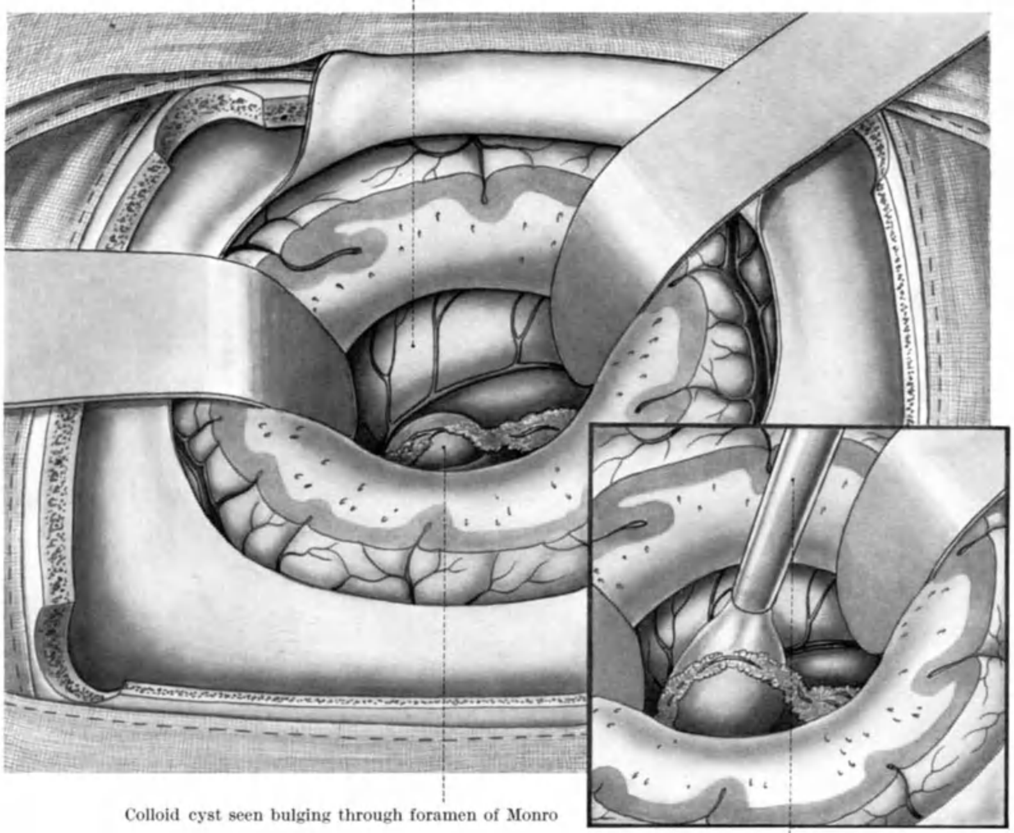


Fig. 211. Operative view of colloid cyst through ant. horn of rt. lat. ventricle.
Observe: 1. A round cone of brain tissue has been excised to enter the lateral ventricle. 2. Insert illustrates use of suction to reduce and deliver the cyst.

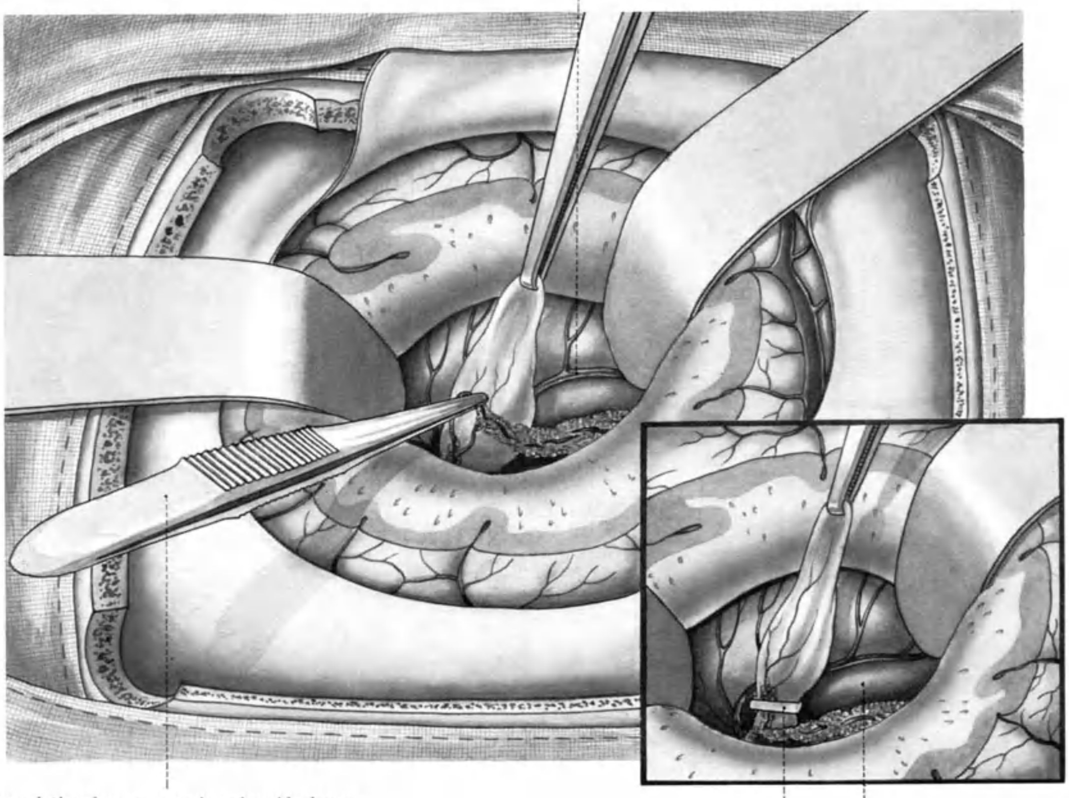


Fig. 212. Delivery of colloid cyst.

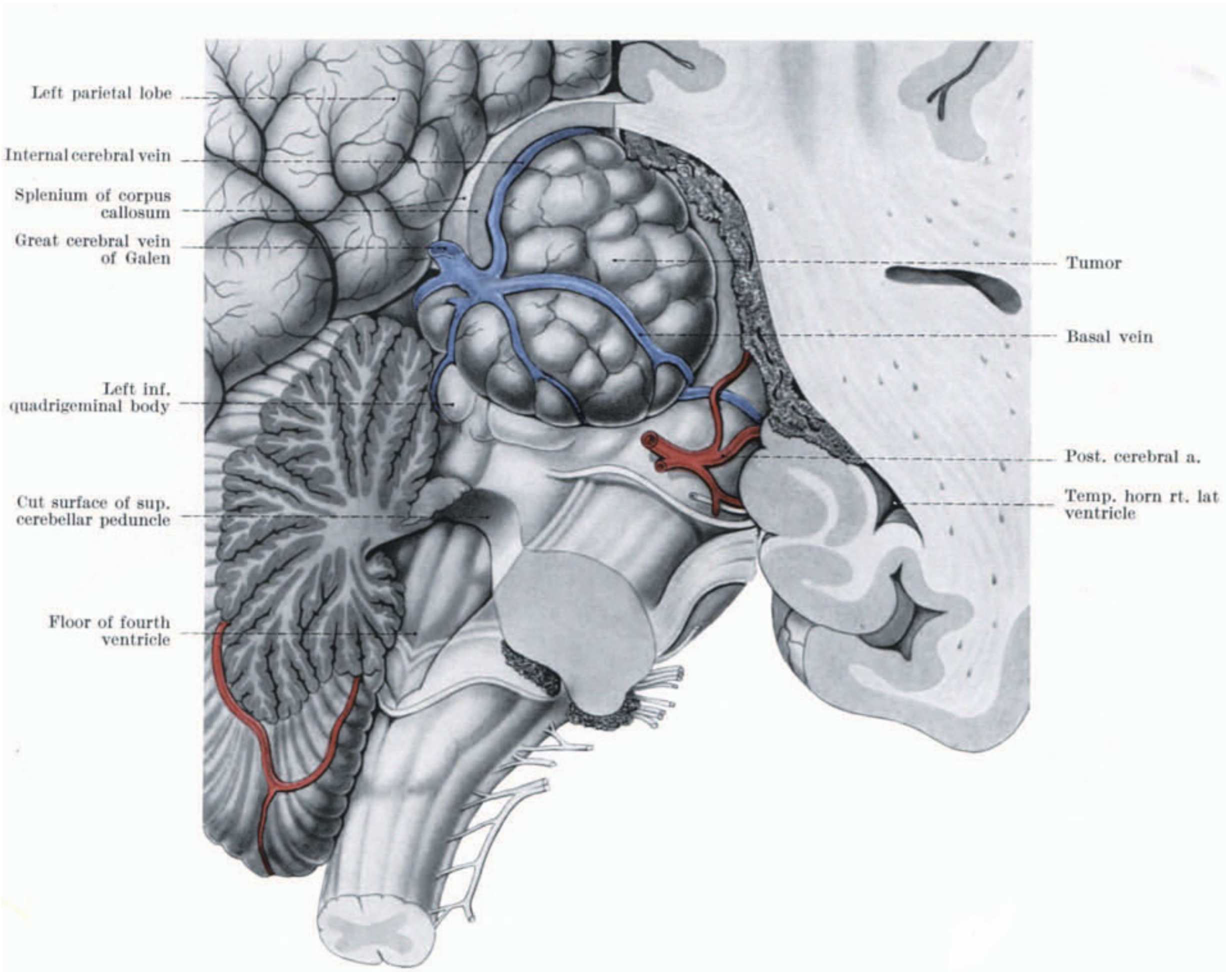


Fig. 213. Topographic presentation of pinealoma.

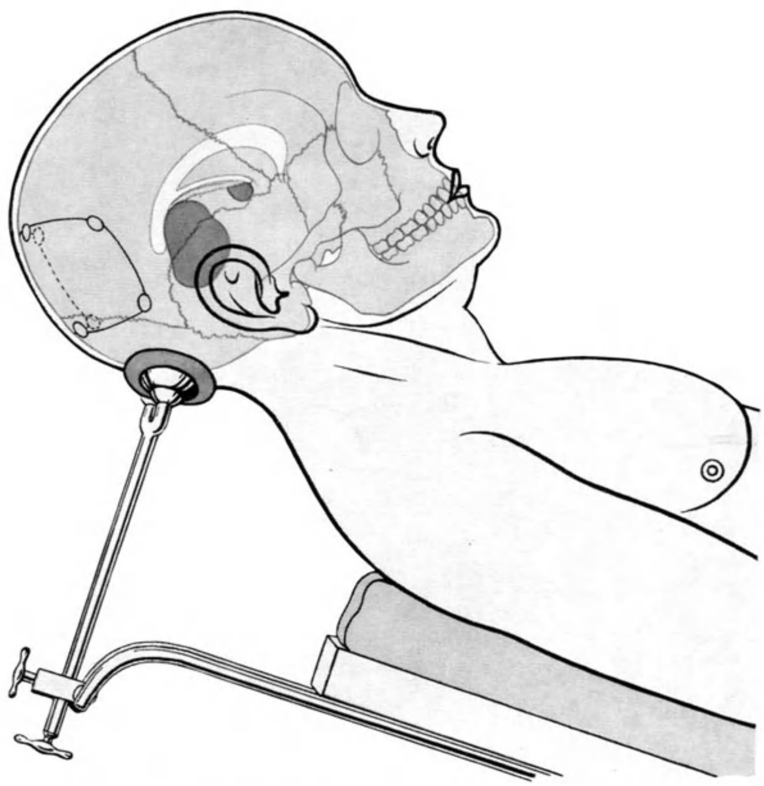


Fig. 214. Position of patient for surgery for pinealoma or posterior third ventricular tumor.

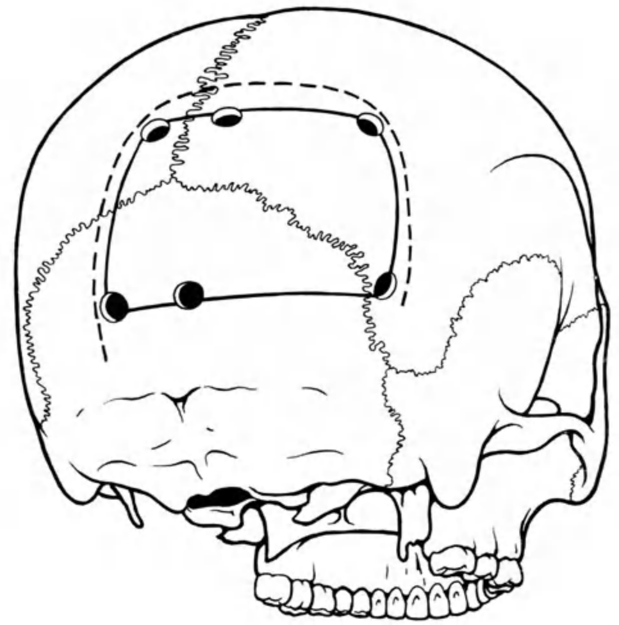


Fig. 215. Skin incision and craniotomy for pinealoma or posterior third ventricular tumor.
Observe: 1. Craniotomy extends over midline. 2. Operative approach is from the right, nondominant side.

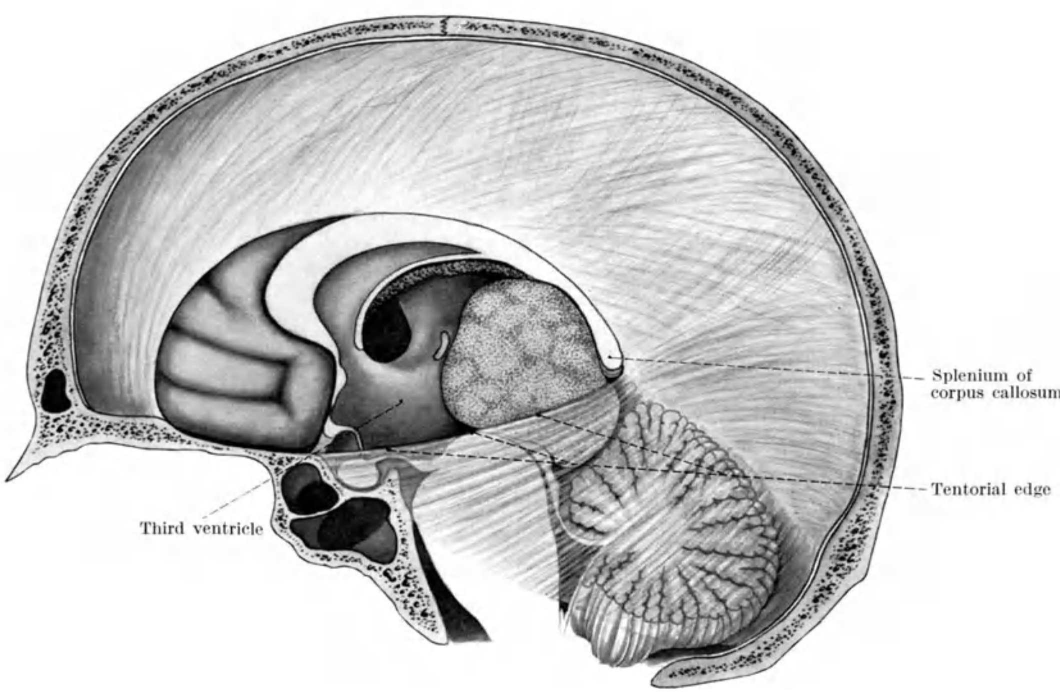


Fig. 216. Schematic presentation of anatomical relationship in tumor of pineal region.
Observe: 1. Enlarged third ventricle. 2. Position of splenium of the corpus callosum and tentorium to the tumor mass.

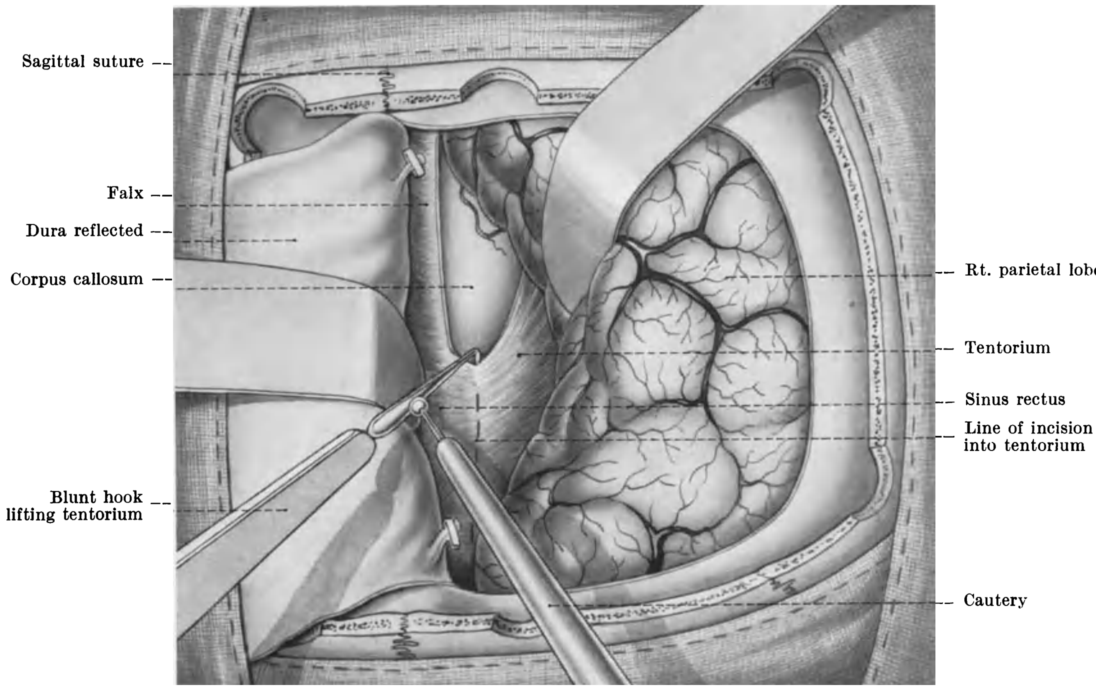


Fig. 217. Operative exposure for pinealoma.

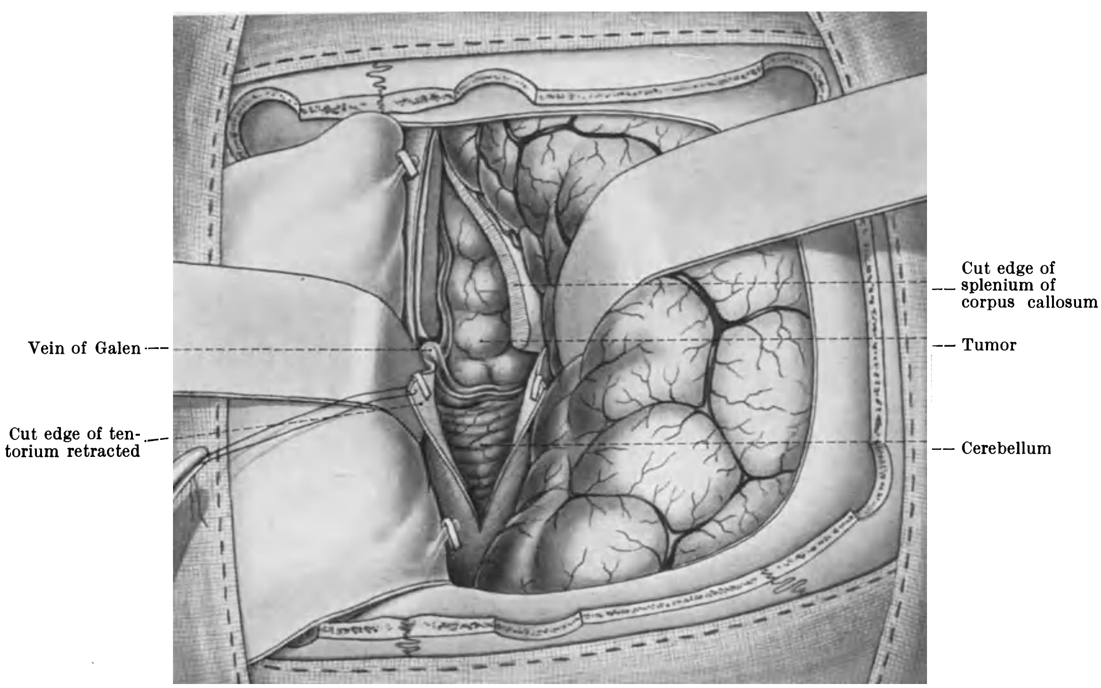


Fig. 218. Operative exposure of pinealoma.
Observe: Additional exposure is gained by incising tentorium.

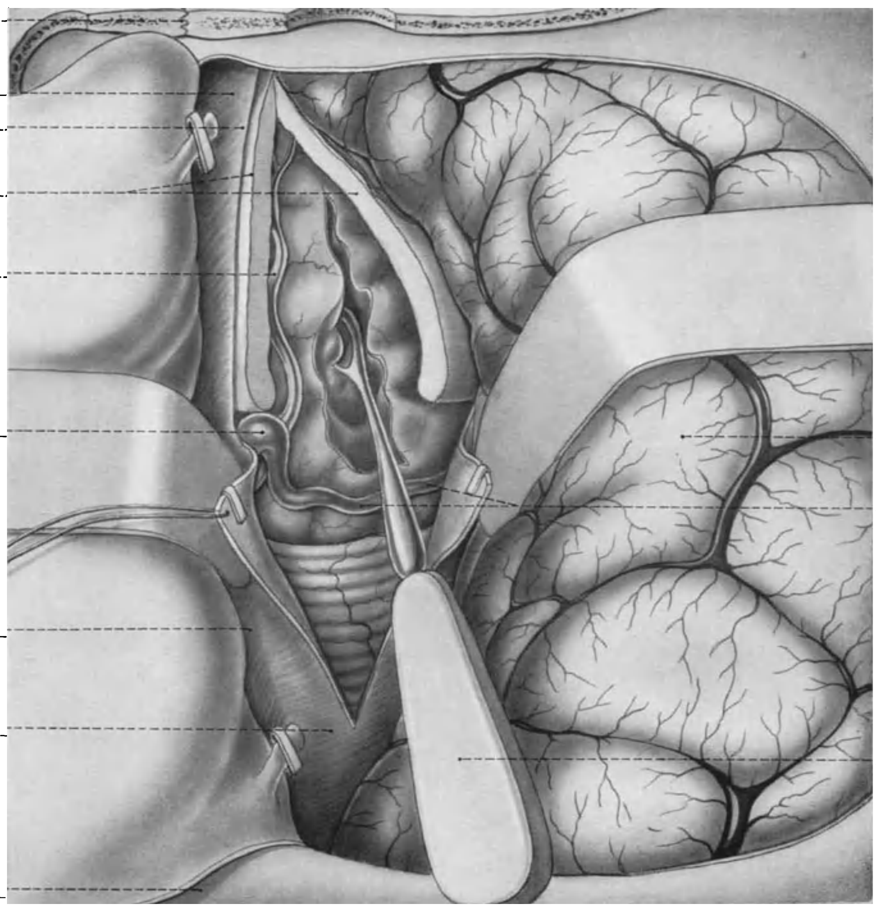


Fig. 219. Removal of tumor with the help of sharp spoon curette.

Chapter XIV

Subdural Hematoma

The subdural hematomas of the adult are illustrated in this chapter. Subdural hematomas in infants present a different problem. The source of the original bleeding in most cases is the surface cortical veins where they enter the superior sagittal sinus. If the number and size of torn vessels and/or contusion of the brain is small and compatible with survival, the patient after an initial acute episode may enter the subacute and chronic phase of the disease. The acute phase may be indistinguishable from a epidural hematoma. During this phase surgical removal of the blood often does little for the patient; however, an epidural hematoma may be encountered and the operative handling is as outlined in Chapter XV. In time a membrane will form around the blood clot in the subdural space and the high protein content of the liquifying hematoma causes an influx of more and more fluid which results in expansion of the lesion. Angiography will show the location of the hematoma. If no angiography is done bilateral exploration is needed with burr holes also over the lower temporal lobes.

Most subdural hematomas are located over the frontal and temporal surfaces. The operation may be done under local anesthesia if the patient is lethargic or comatose. The position of the patient on the operating table for bilateral burr holes is seen in Figs. 220a, b and c. In Fig. 221 we see the position of the patient's head for a left frontal subdural hematoma. The burr holes are placed in such a way so that they can be included, if it should be necessary, in the turning of a bone flap (Fig. 221). The direction of the skin incision should also be in line with the possible scalp flap. In subacute subdural hematomas it is usually suffice to open the dura in the stellate fashion at which time the dark liquid blood will extrude. At least two burr holes are made and the subdural space is irrigated using a rubber catheter inserted over the surface of the cerebral hemisphere to irrigate and dislodge the remaining blood clot (Fig. 222). If there is not a thick outer membrane over the hematoma and if the underlying brain expands readily, this thorough irrigation may be all that is necessary. Placement of a silver clip on the dura and another one in the leptomeninges directly below the clip on the dura will aid in evaluation of postoperative tangential skull x-rays, for if a renewed accumulation of fluid has occurred the surface of the brain will be depressed and the clips will become separated.

In the event a thick outer membrane is seen and the brain does not expand, as in many chronic subdural hematomas, a craniotomy is performed which includes the previously made scalp incision and burr holes. Fig. 223 shows a coronal section through a chronic subdural hematoma. The hematoma membrane which is close to the sagittal sinus with the draining veins and pacchionian granulations are left alone, while the other part of the membranous sac is removed (Fig. 223 and 224). The inner, more delicate, membrane may be quite adherent to the surface of the brain and therefore impossible to remove without causing bleeding from small cortical vessels. In this event it is better to leave the inner membrane in place.

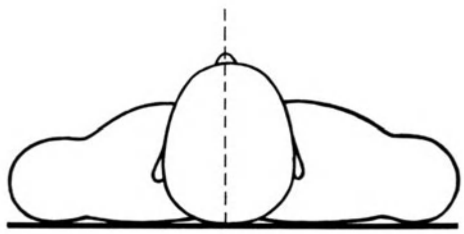


Fig. 220 a.

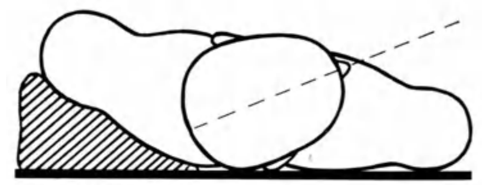


Fig. 220 b.

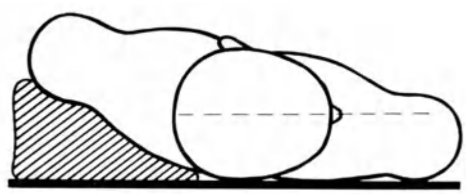


Fig. 220 c.

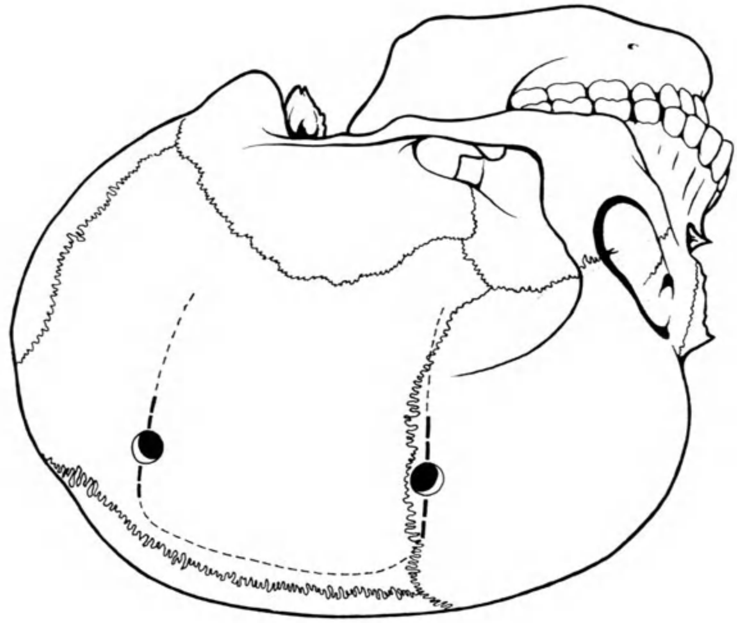


Fig. 221. Position of burr holes in fronto-parietal convexity subdural hematoma.
Observe: 1. Burr holes are placed in such a way permitting their use in a bone flap. 2. Skin incision for possible craniotomy is outlined.

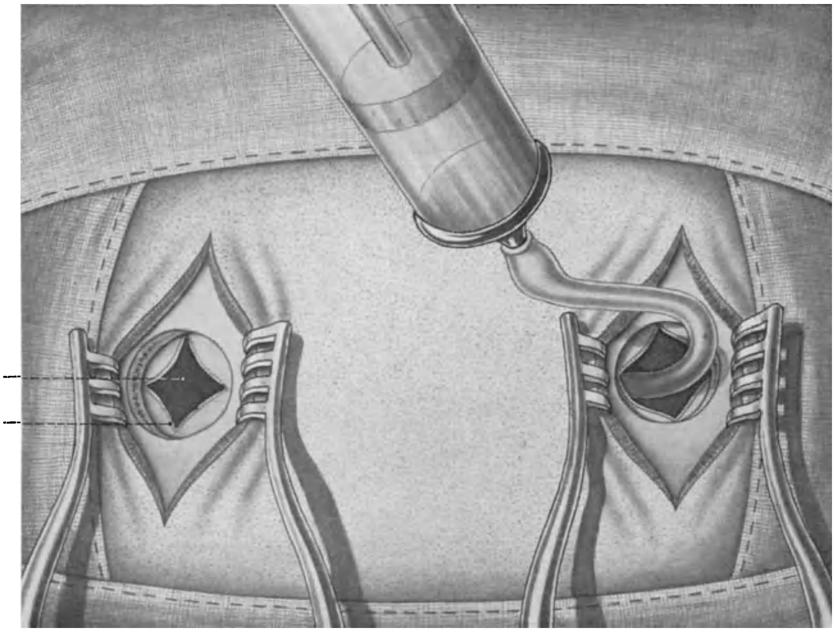


Fig. 222. Irrigation of subdural hematoma.

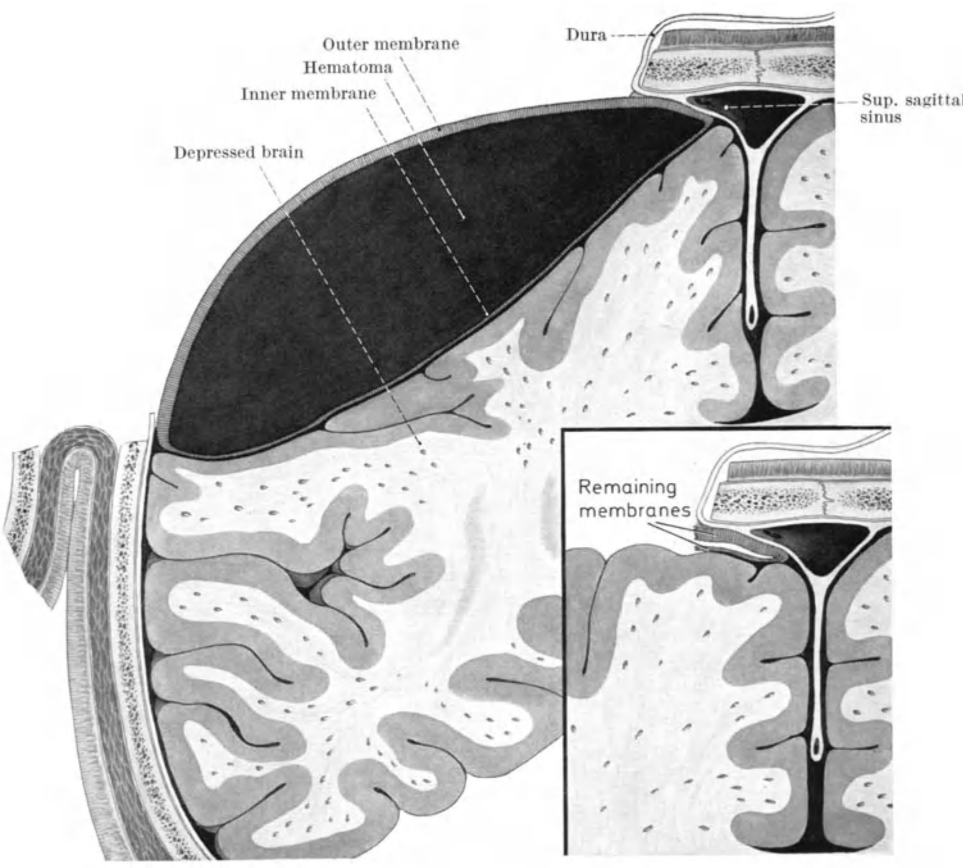


Fig. 223. Chronic subdural hematoma coronal section.
Observe: Insert shows part of the membranes to be left in place.

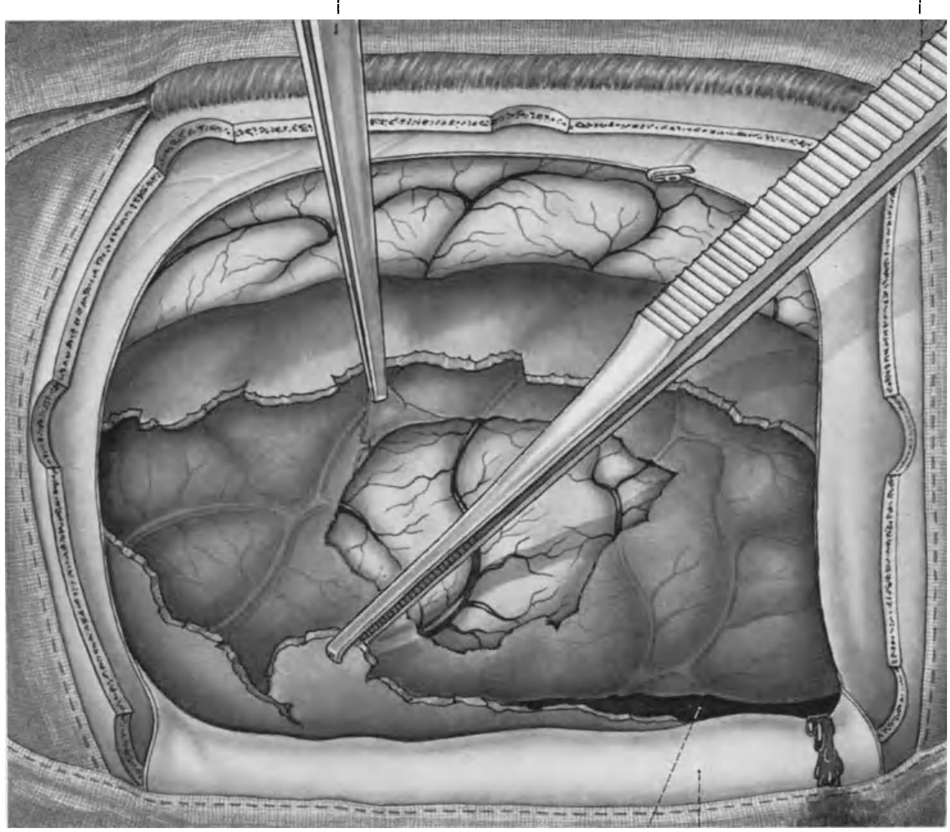


Fig. 224. Operative view of partially removed chronic subdural hematoma.
Observe: 1. Thick outer membrane. 2. Delicate inner membrane.

Chapter XV

Extradural Hemorrhage

1. Epidural Hematoma Due to Arterial Bleeding. (The classical epidural hematoma due to arterial bleeding from the middle meningeal artery and its branches.) This disorder does not present any technical difficulties as long as the operation is done early, before the expanding hematoma has ripped the dura from the inner table over a wide enough area which, in turn, adds to the arterial, emmissary venous, and dural sinus bleeding. If definitive care is delayed and if the patient is still living, the operation becomes formidable and will require a wide craniotomy done with speed and the dura must be tented in many places to the pericranium, to the bone, or even to the galea. Therefore, if there is any early suspicion about the presence of expanding epidural hematoma, it is better *not* to hesitate in doing bilateral low temporal burr holes. These two burr holes will do no harm to the patient and the time spent in doing an angiographic study may be wasteful. The statements made here are directed to the general surgeon who, in our experience, is the one who primarily sees these patients. It is true that there are epidural hemorrhages which have developed over days, but these are the exception.

In Fig. 225 an oblique coronal section of the brain illustrates the compression of the cerebral peduncle opposite the hematoma. This compression at the tentorium leads to upper motor neuron signs on the side of the hematoma.

The approach to the entrance of the middle meningeal artery into the intracranial cavity, the foramen spinosum, is an easy and a short one if the opening of the temporal squama reaches down to the floor of the temporal fossa (Fig. 226). The position of the patient's head for bilateral temporal burr holes is seen in Fig. 227a and for a left-sided lesion, as is here discussed, in Fig. 227b. The vertical skin incision is placed one inch anterior to the external acoustic meatus, is about 7 cm. long, and reaches down to the zygomatic process. The incision should not go below the zygomatic process in order to prevent cutting the branches of the facial nerve which innervates the frontalis and orbicularis oculi muscles. The temporalis muscle and fascia are incised along their fibers and retracted by a self-retaining retractor. A burr hole is made and enlarged with a rongeur (Fig. 228). In this case a fracture line is seen. The craniectomy is carried down to the floor of the temporal fossa and the hematoma is removed by suction (Fig. 229). If the middle meningeal artery lies just over the fracture site, it may be coagulated at this point or it may be necessary to coagulate the middle meningeal artery at the foramen spinosum. After coagulation the artery is divided and a cotton pledget is pressed into the foramen spinosum. It should be remembered that the middle meningeal artery is fused into the outer layer of the dura and may have to be separated from this layer at the foramen spinosum to coagulate and cut the artery properly without incising the dura (Fig. 230). Diffuse bleeding from the floor of the middle fossa may be controlled by bone wax but the dura should always be tented to the pericranium or to fine drill holes in the skull to prevent postoperative accumulation of blood in the epidural space.

2. Epidural Hematoma Due to Dural Sinus Laceration. An extradural hematoma may develop from a fracture of the skull opening large diploic channels. The situation illustrated is commonly seen in fracture of the occipital bone which extends down to the foramen magnum (Fig. 231). In these cases a transverse sinus laceration has to be considered, and since the hematoma may extend into the posterior fossa, the early clinical signs and symptoms may include respiratory failure.

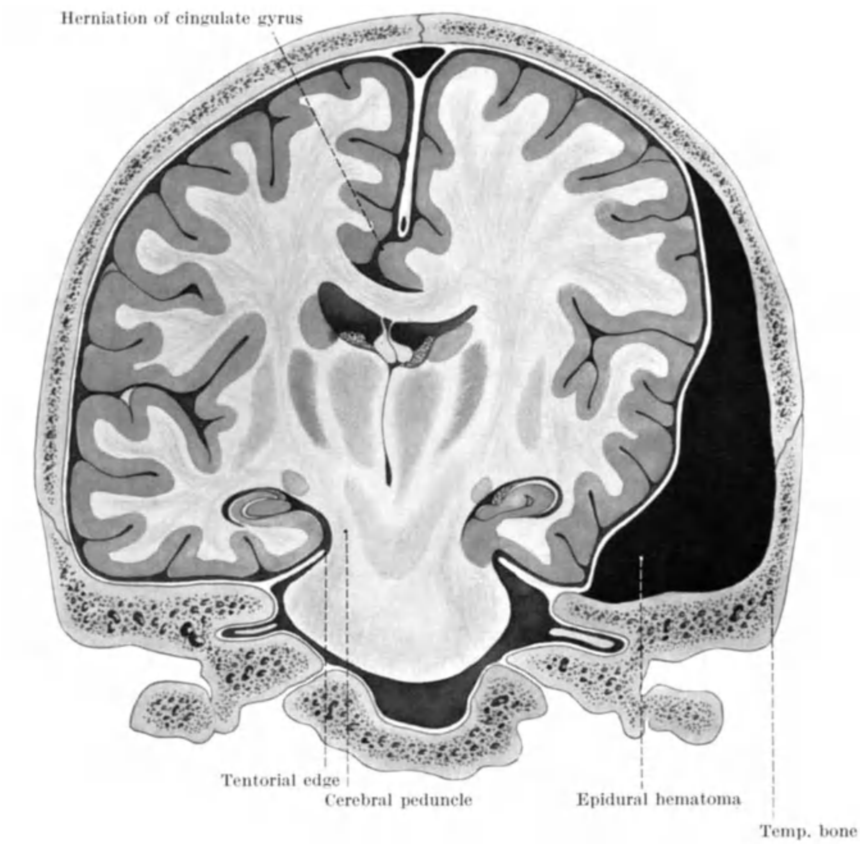


Fig. 225. Anatomical demonstration of epidural hematoma in a coronal section.
Observe: 1. This section runs in an oblique fashion from ant. sup. to post. inf. to demonstrate the compression on the cerebral peduncle on the side opposite the hematoma.

For operative relief of the compression caused by the hematoma the patient is placed in the prone position with an endotracheal tube in place (Fig. 232). The length of the skin incision is shown in Fig. 233. The trapezius muscle and its insertion at the superior nuchal line is identified and exposed widely by undermining and retracting the skin. The muscle is cut 1 cm. below its insertion and parallel to the superior nuchal line, separated medially along its fibers (Fig. 234), and scraped off the occipital bone with a periosteal elevator. Two burr holes are made above and below the superior nuchal line, which means above and below the transverse sinus or into the occipital and posterior fossae. The burr holes are enlarged by a rongeur (Fig. 231 and 235). After the extradural hematoma is removed by suction and irrigation, stay sutures are placed and the dura along with sinus is tented against the bony rim left between the two craniectomies (Fig. 237). Gelfoam or muscle tissue may have to be inserted between the bone and the sinus laceration. The rim of trapezius muscle insertion left over the bony bridge permits the anchoring of many dural stay sutures. After the dura is securely held against the inner table, it may be advisable to open the dura over the posterior fossa and occipital lobe to assure that there is no subdural hematoma.

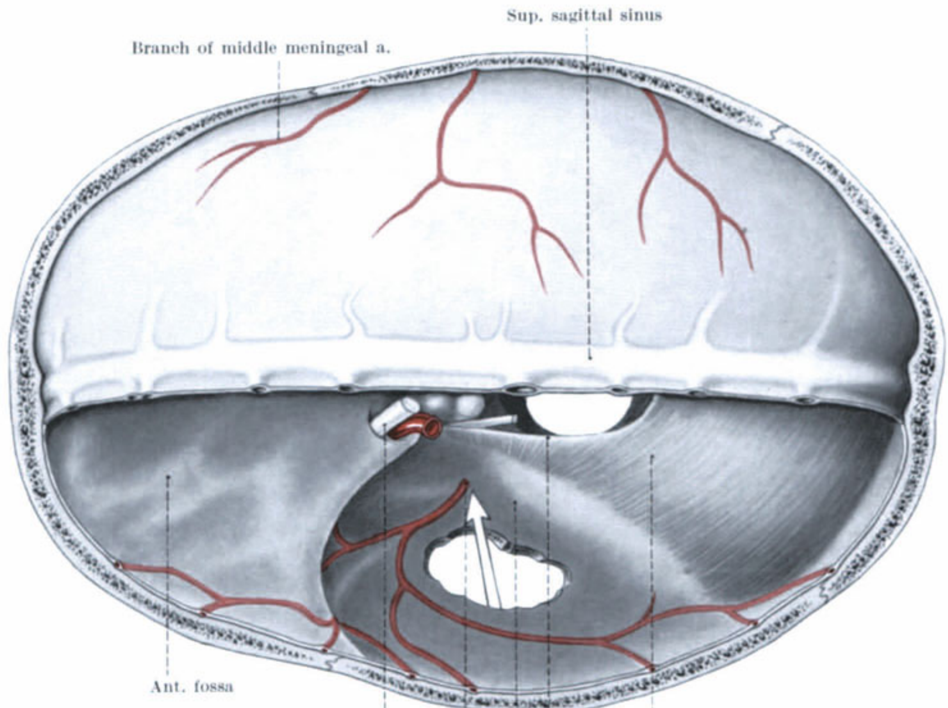


Fig. 226. Topographic demonstration of craniectomy for epidural hematoma.
Observe: The direct route to the foramen spinosum.

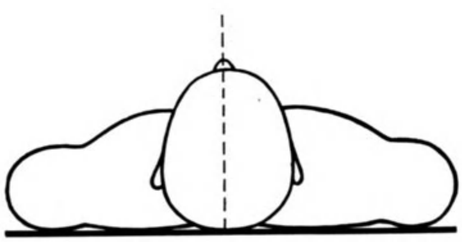


Fig. 227 a.

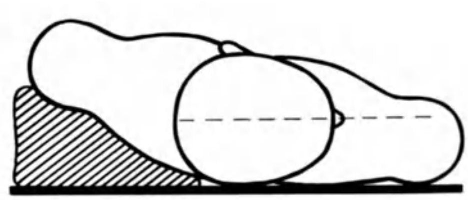


Fig. 227 b.

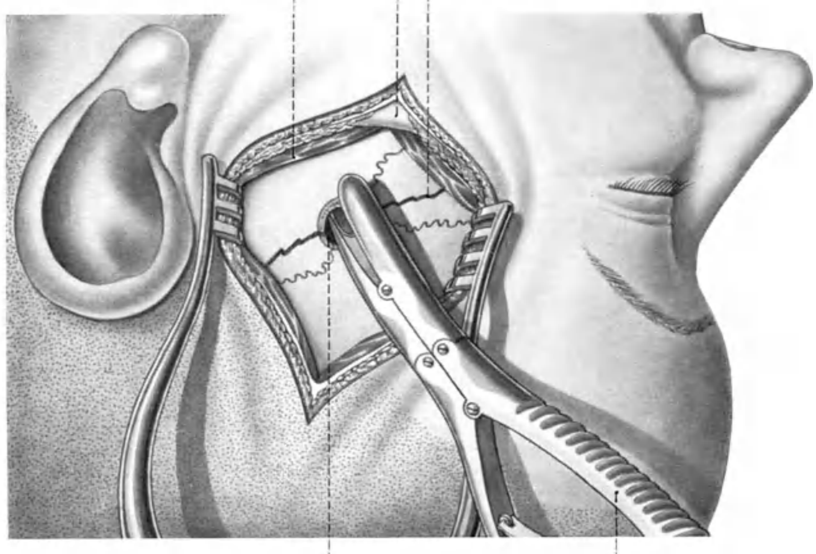


Fig. 228. Enlarging burr hole for left temporal craniectomy.

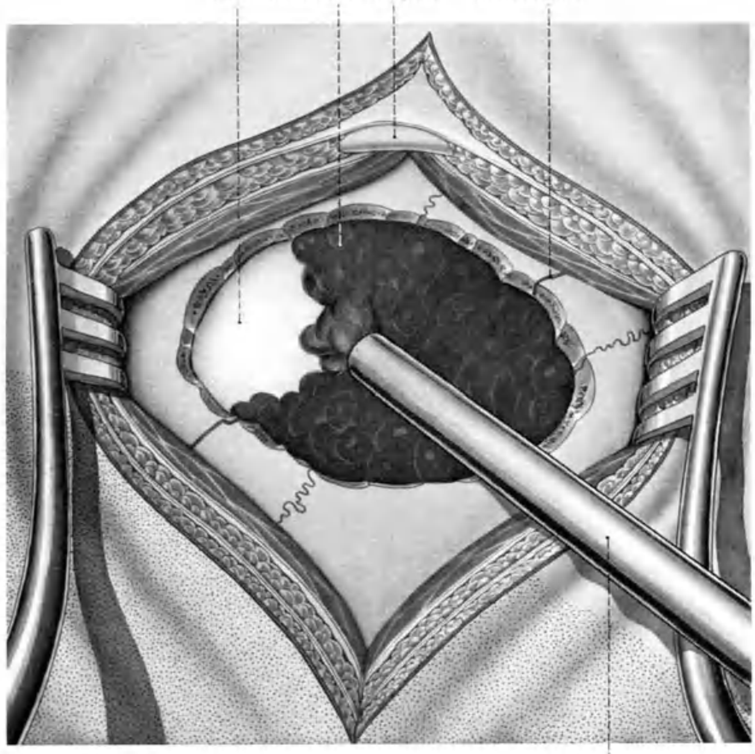


Fig. 229. Temporal craniectomy for epidural hematoma.
Observe: Craniectomy reaches down to be *level with* the zygoma.

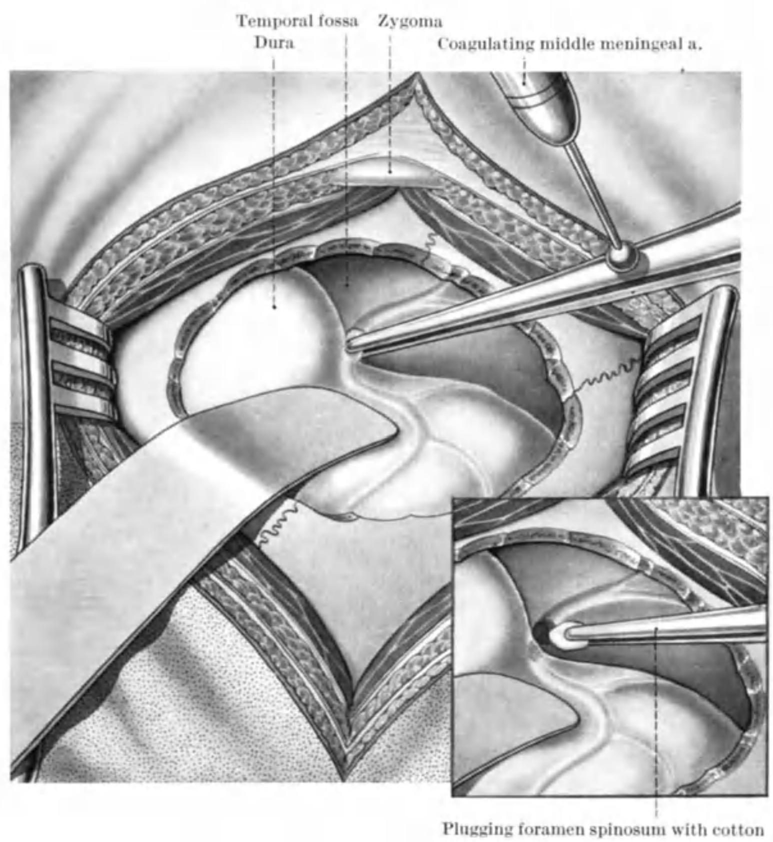


Fig. 230. Operative view exposing foramen spinosum.
Observe: Fusion of middle meningeal artery with dura.

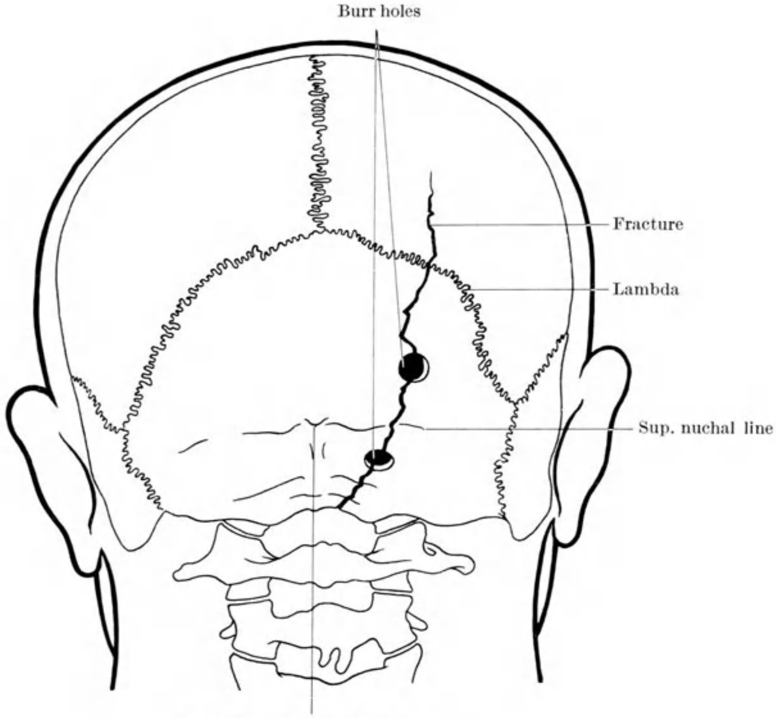


Fig. 231. Placement of burr-holes in extradural hematoma over occipital and suboccipital area.

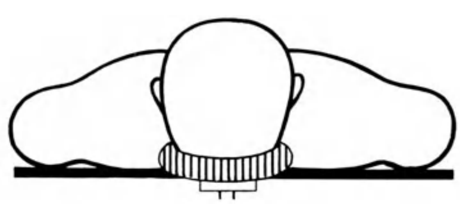


Fig. 232.

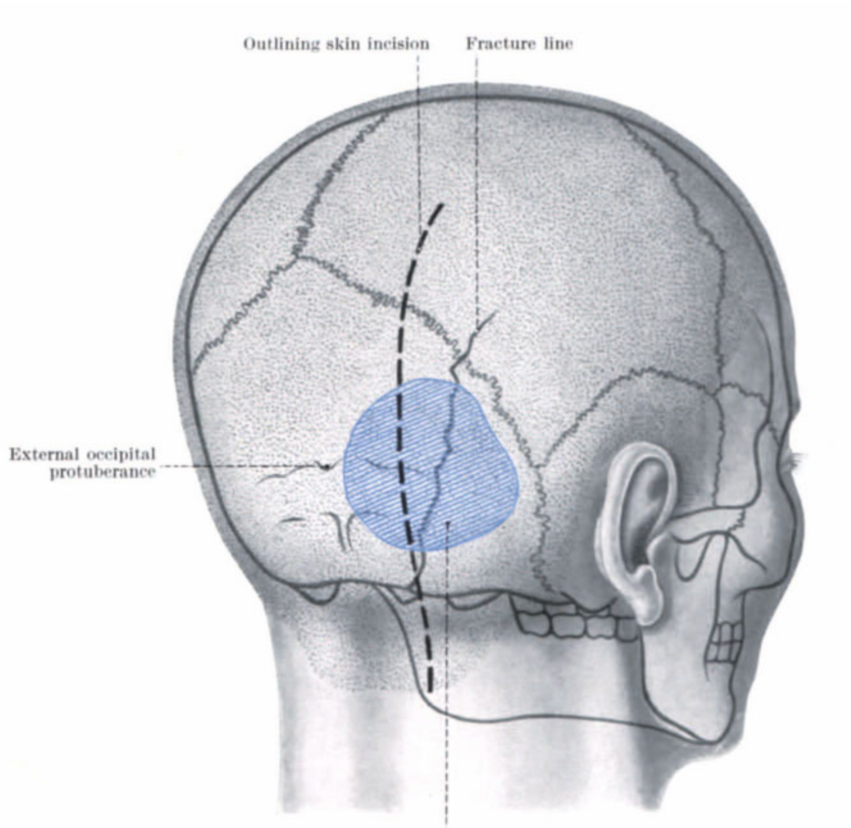


Fig. 233. Extradural hematoma over occipital and suboccipital area.

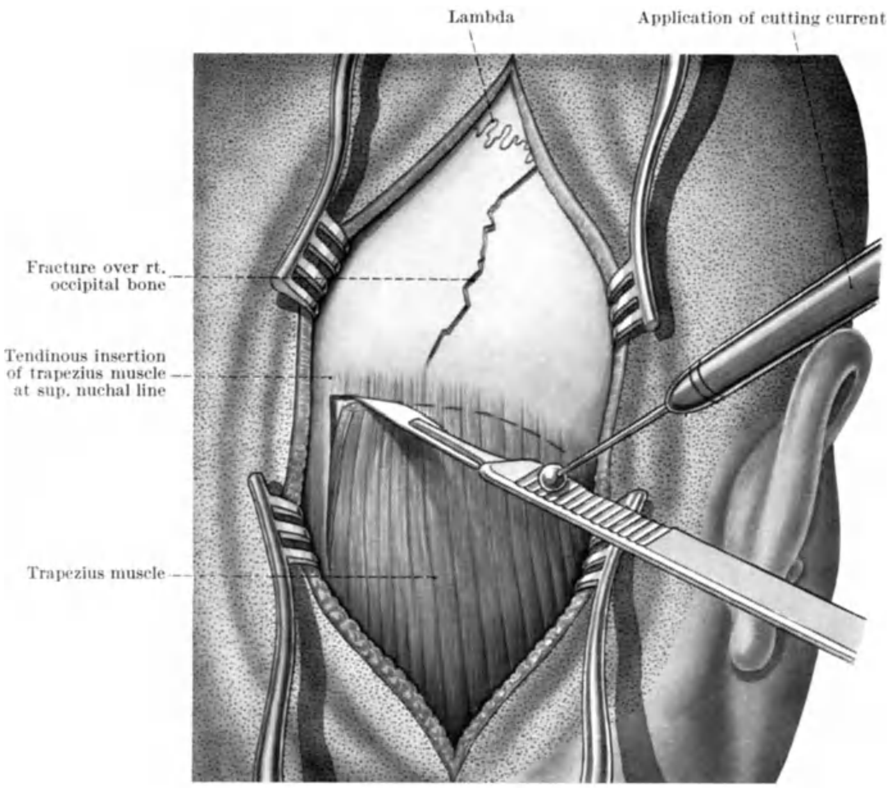


Fig. 234. Operative approach for occipital-suboccipital extradural hematoma.
Observe: Leave rim of muscular insertion to be used for epidural stay sutures and for better muscle layer closure.

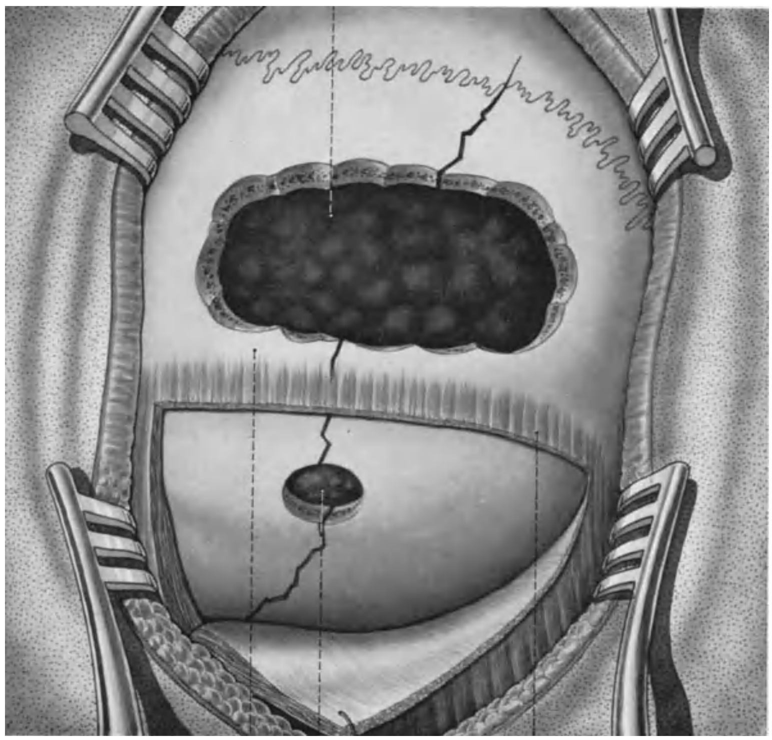


Fig. 235. Occipital craniectomy and placement of burr hole over posterior fossa for extradural hematoma.

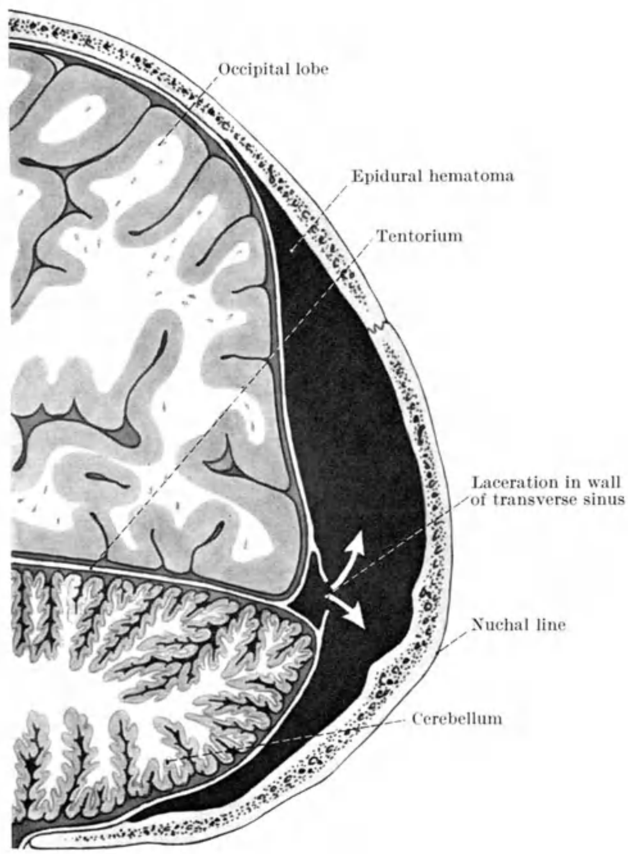


Fig. 236. Anatomical demonstration of extradural hematoma over occipital and suboccipital area due to laceration of transverse sinus (parasagittal section 2 cm from the midline).

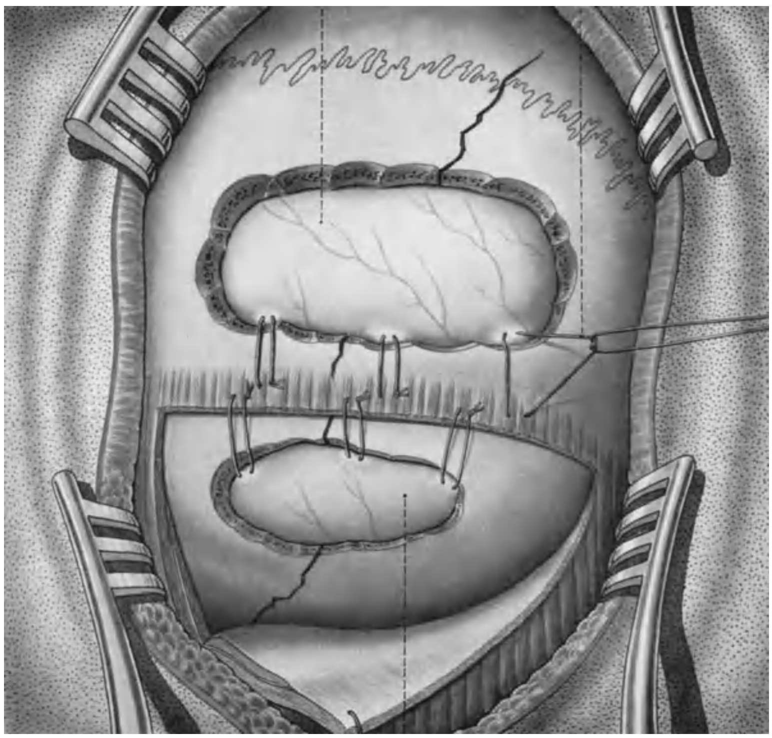


Fig. 237. Operative exposure of tenting of dura after removal of occipital-suboccipital hematoma.
Observe: The purpose of leaving bony bridge with rim of muscular insertion is for firm tenting of dura to achieve hemostasis.

Chapter XVI

Trigeminal Rhizotomy (Temporal Approach)

For the operative approach to the fifth nerve root via the temporal fossa, the patient is placed in the sitting position. The lower extremities are wrapped in elastic stockings or the patient is placed in a pressurized suit to protect against a sudden drop in blood pressure. The patient's head should not be tilted or turned; for if the head is absolutely straight, the surgeon will not go in an unwanted direction. The danger in surgery for tic douloureux via the temporal approach is in being misguided posteriorly towards the posterior fossa, entering the latter, and causing injury to the superficial petrosal nerve with a resultant facial nerve paralysis.

The following anatomical relationships in the operation for rhizotomy of the fifth nerve are important and may be seen in Figs. 238, 239: (a) The dura propria to the dura over the floor of the temporal fossa; (b) the middle meningeal artery and foramen spinosum to the third division of the fifth nerve; (c) the superficial petrosal nerve to the dura propria and the third division of the fifth nerve; and, (d) the dura propria to the entrance into Meckel's cave and the posterior fossa. Keeping these pictures (Figs. 238, 239) in mind will clarify why it is best to expose initially the second division of the trigeminal nerve to protect the superficial petrosal nerve before one trys to find the foramen spinosum with the middle meningeal artery. Then with the second division exposed, one can slide laterally and posteriorly to expose the foramen ovale and the foramen spinosum, the latter which is about 2 mm. more laterally. By coming from anteriorly to the posterio-lateral area of the middle fossa, any undue traction on the superficial petrosal nerve will be prevented.

The skin incision and craniectomy are outlined in Fig. 240. The skin incision does not go below the zygomatic process to prevent injury to the branches of the facial nerve going to the frontal and orbicularis oculi muscles. A burr hole is made in the squama of the temporal bone (Fig. 241), and is enlarged with the rongeur to be level with the floor of the temporal fossa. The craniectomy is about 4 cm. wide. The dura is freed around the entire craniectomy to assist in better separation and elevation of the dura from the temporal fossa. As stated earlier the dura is elevated anteriorly in the direction of the maxillary division of the fifth nerve without trying to find the foramen spinosum first. As soon as the dura propria over the maxillary nerve is seen, the spatula elevating the temporal dura is retracted a few millimeters and advanced posteriorly. This should expose the dura propria at the entrance to the foramen ovale. Sliding the retractor about 2 to 3 mm. slightly posteriorly will lead to the foramen spinosum. The middle meningeal artery is then coagulated and sectioned, and a cotton pledget is forced into the foramen spinosum. The brain spatula is thereafter inserted 2 to 3 mm. medially at the same level and the dura propria is freed from the temporal dura with a fine separator millimeter by millimeter. The dura propria will be recognized by its bluish color due to its thinness and by the extension of the subarachnoid space which ends at the Ganglion. After we have exposed the lateral rim of the dura propria, an incision is made lengthwise (Fig. 242). Re-insertion of the separator will give additional exposure (Fig. 243). The sensory roots of all three divisions of the trigeminal nerve lie together and are not anatomically separated. The fibers separate distally after the semilunar ganglion. A fine blunt nerve hook or the mastoid seeker is used to pick up and lift a few rootlets. These rootlets are divided by coagulation, by touching the coagulating electrode to the nerve hook. In this way more and more rootlets are separated until we see the motor root which runs medially and

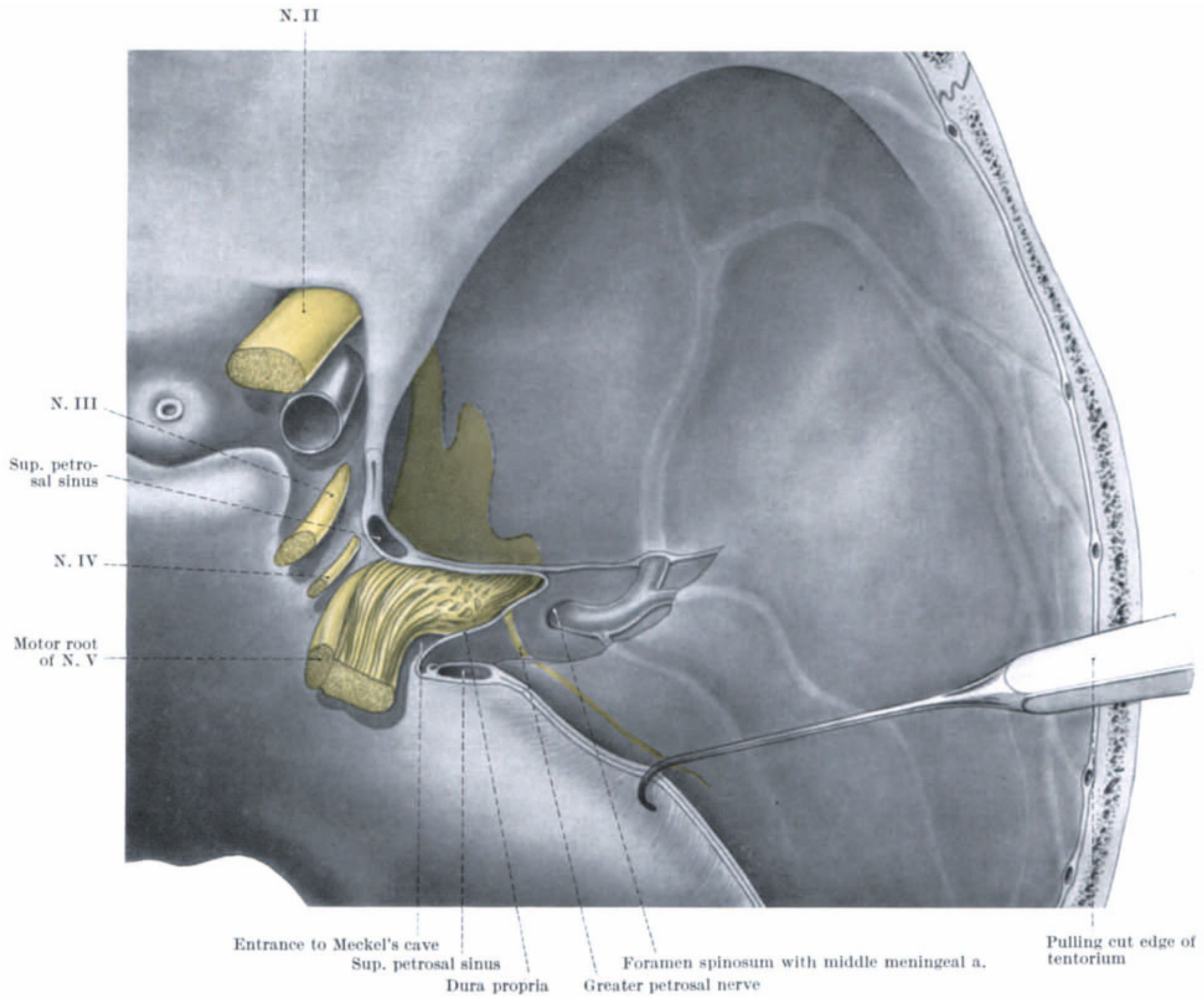


Fig. 238. Anatomical demonstration at Meckel's cave.
Observe: 1. Dura propria covering Gasserian ganglion. 2. Position of greater petrosal nerve and foramen spinosum to third division of N.V. 2. Superior petrosal sinus bridging roof of entrance to Meckel's cave.

superiorly at a slightly different angle behind the sensory root. The motor root may be adherent to few sensory fascicles, but it can be identified usually by its whitish appearance when compared to the sensory root (Fig. 244). Dividing the rootlets in the described manner will also prevent any injury to the carotid artery which, in elderly patients, may be quite tortuous and bulging from below. In Fig. 246 the roots to the mandibular and maxillary divisions of the fifth nerve are sectioned with sparing of the ophthalmic division.

If the temporal dura is paper thin and adherent to the floor of the middle fossa, the intrathecal space may be entered while trying to separate the dura from the bone. If this should occur the operation is continued intradurally and Meckel's cave is opened from above. It is important not to open Meckel's cave too far medially and posteriorly because this may open the cavernous sinus and/or the superior petrosal sinus. Palpation with the separator over the middle fossa may help in outlining the lateral extent of Meckel's cave. The foramen spinosum can be found by following the middle meningeal artery which is fused with the dura.

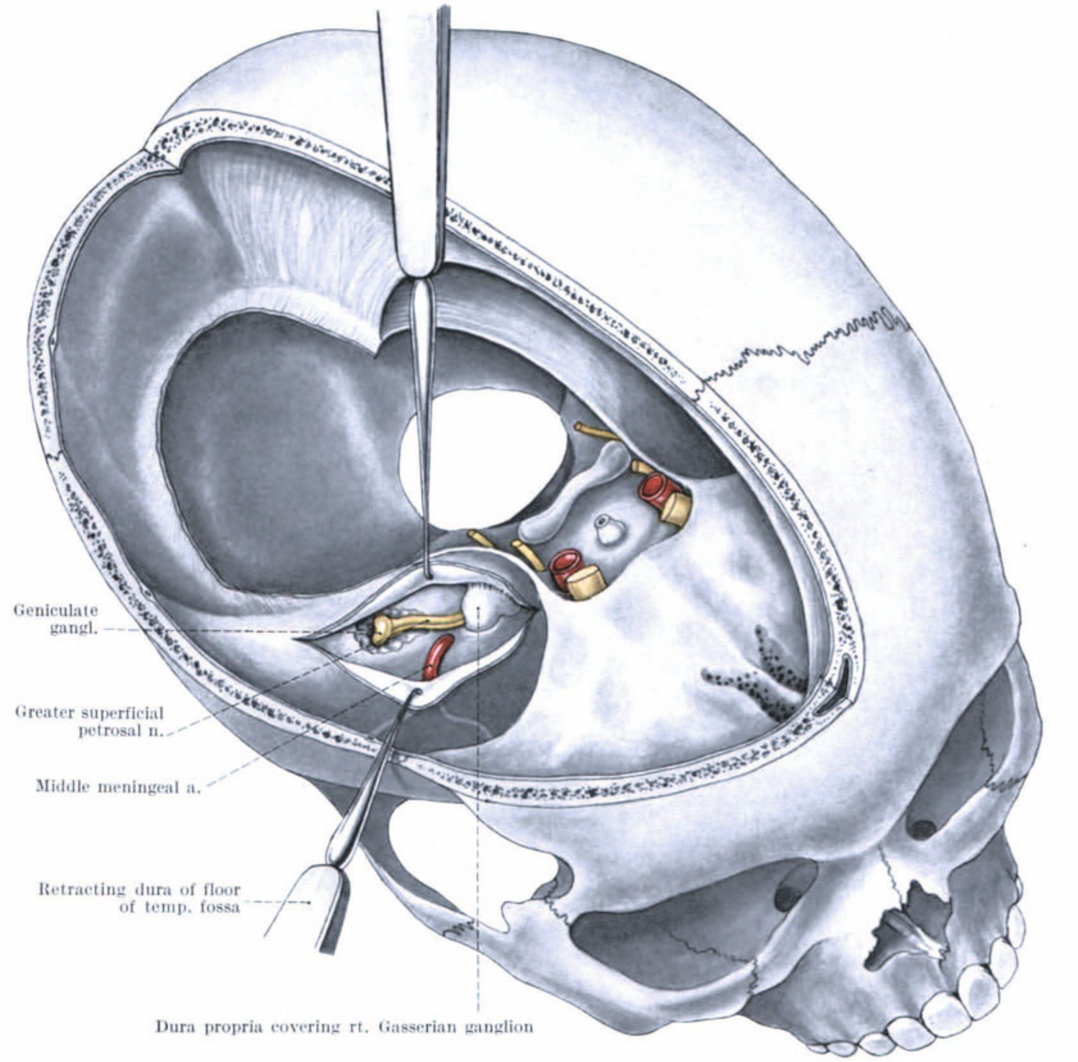


Fig. 239. Anatomical relationship of greater superficial petrosal nerve to middle meningeal artery, foramen spinosum and Gasserian ganglion.
Observe: Petrous bone removed to expose geniculate ganglion.

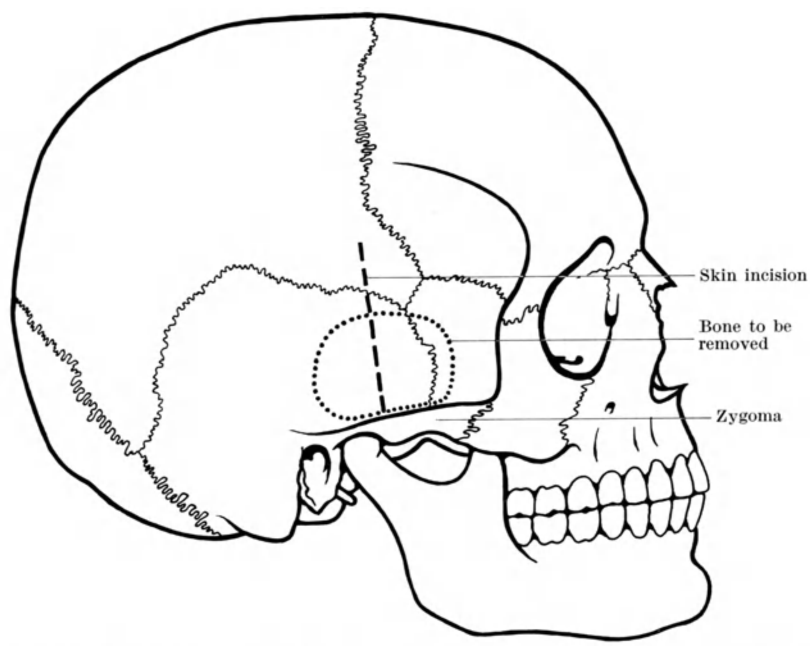


Fig. 240. Outline of skin incision and craniectomy in right N.V root section via temporal fossa.

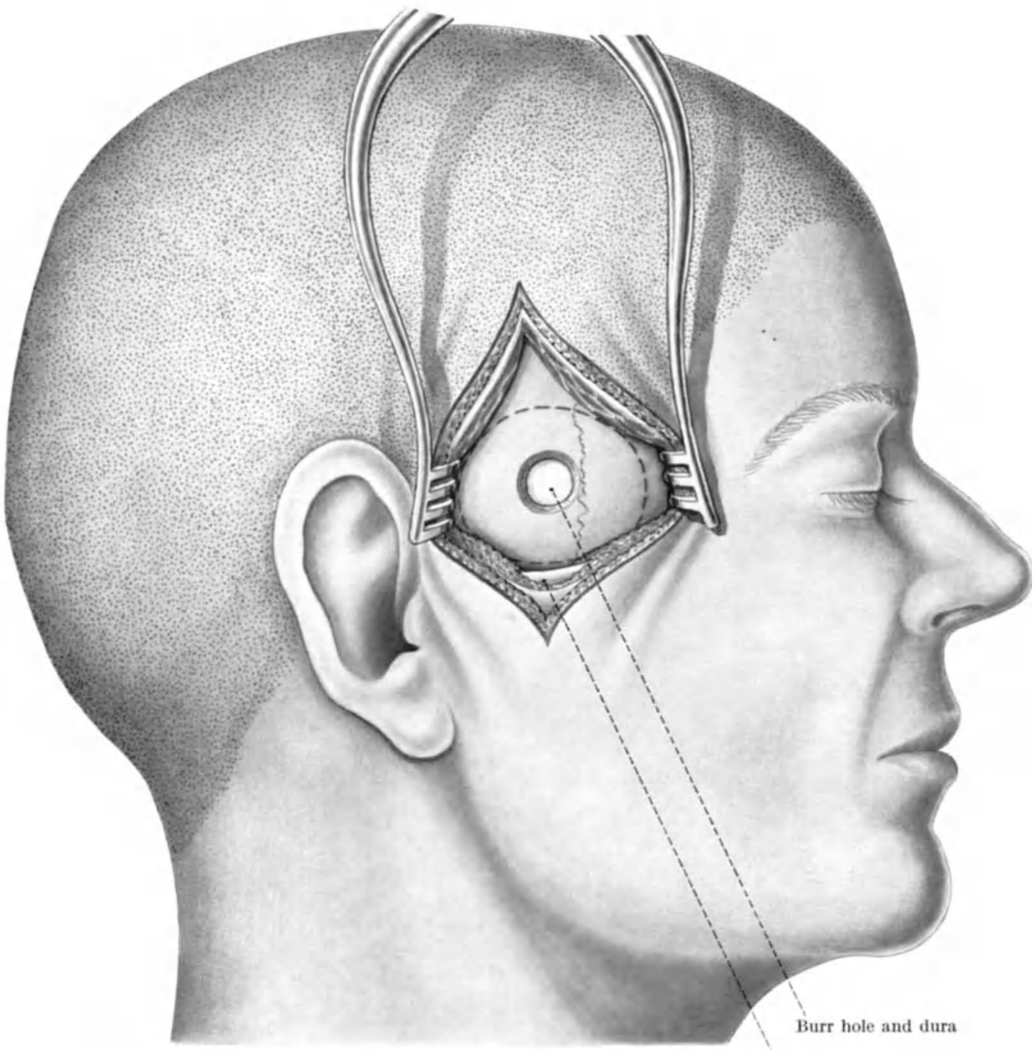


Fig. 241. Operative position of patient with exposure of temporal bone and burr hole. *Observe:* Exposure of upper rim of Zygoma only to prevent damage to facial nerve fibers.

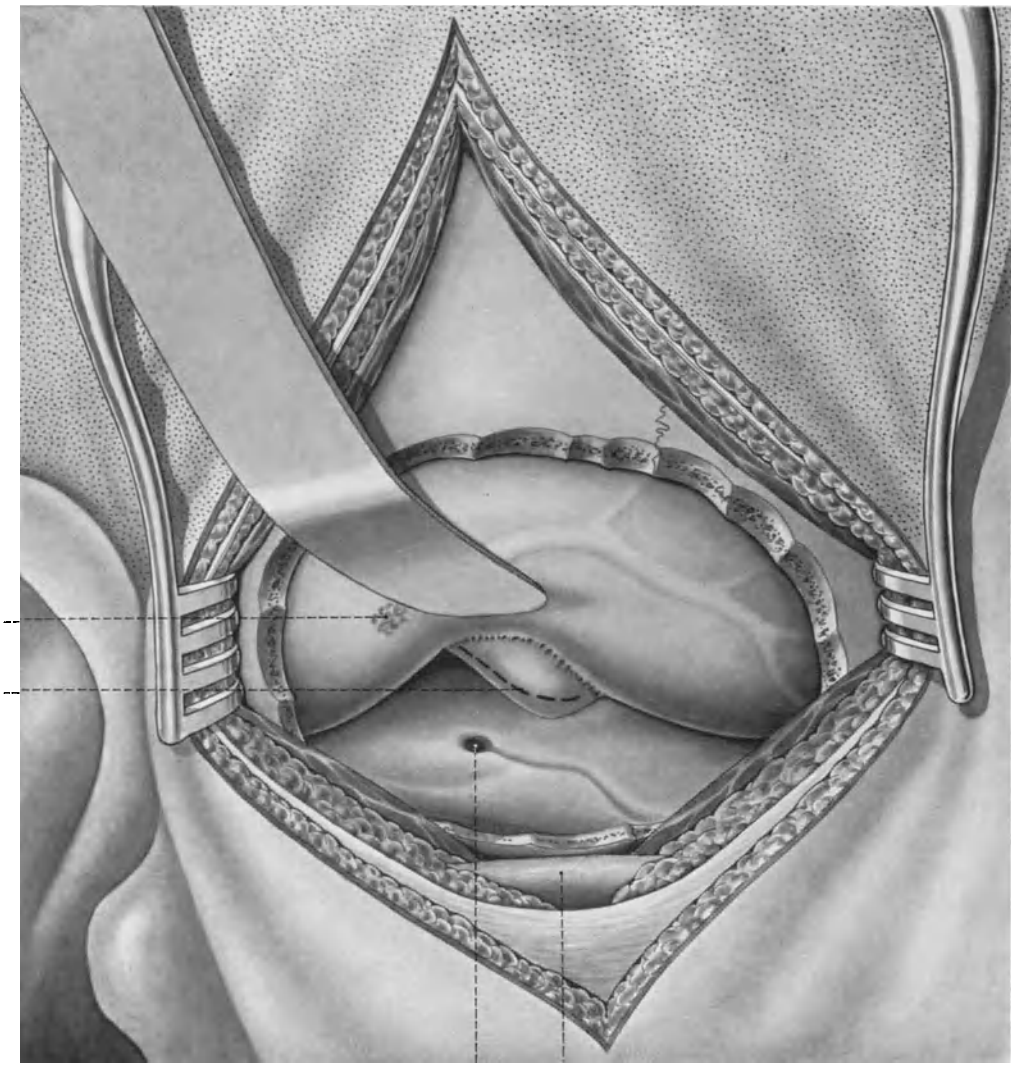


Fig. 242. Craniectomy for right V^th. Nerve root section.
Observe: Craniectomy extends to floor of temporal fossa.

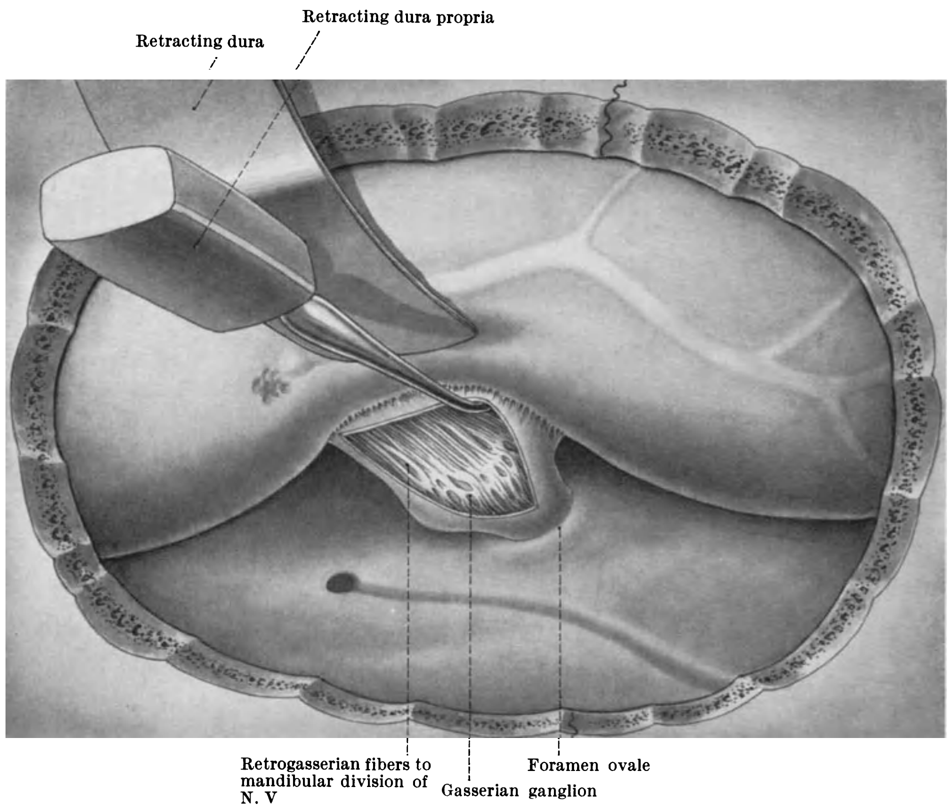


Fig. 243. Operative exposure of V. nerve root mandibular division.
Observe: Retrogasserian fibers of first and second division not seen in this picture.

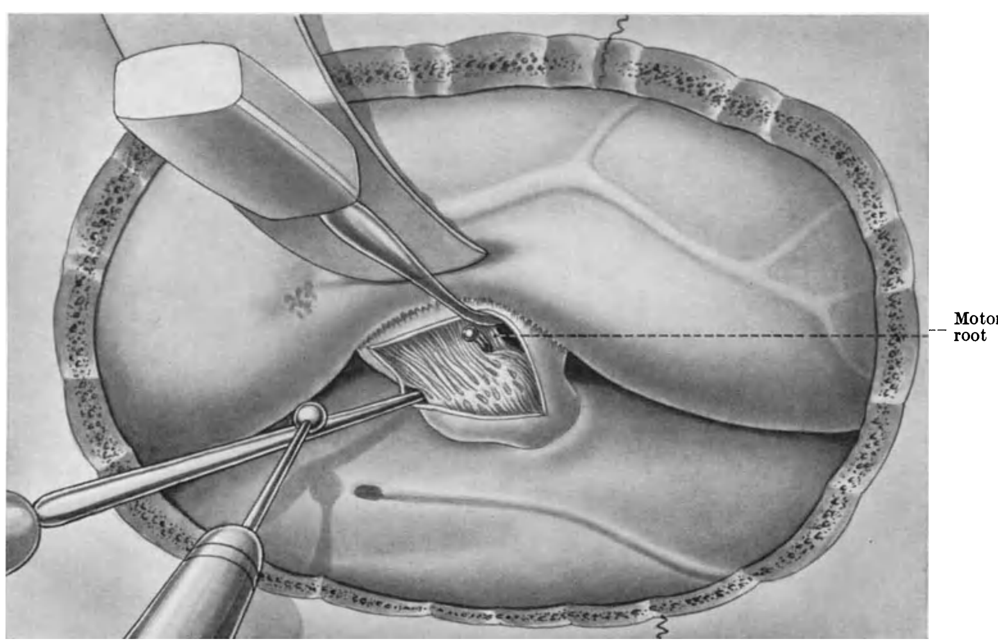


Fig. 244. Retrogasserian rhizotomy.
Observe: 1. The motor root lying posteriorly and superiorly to the mandibular division. 2. The nerve hook is retracting laterally to visualize and protect the motor root while dividing the nerve fibers.

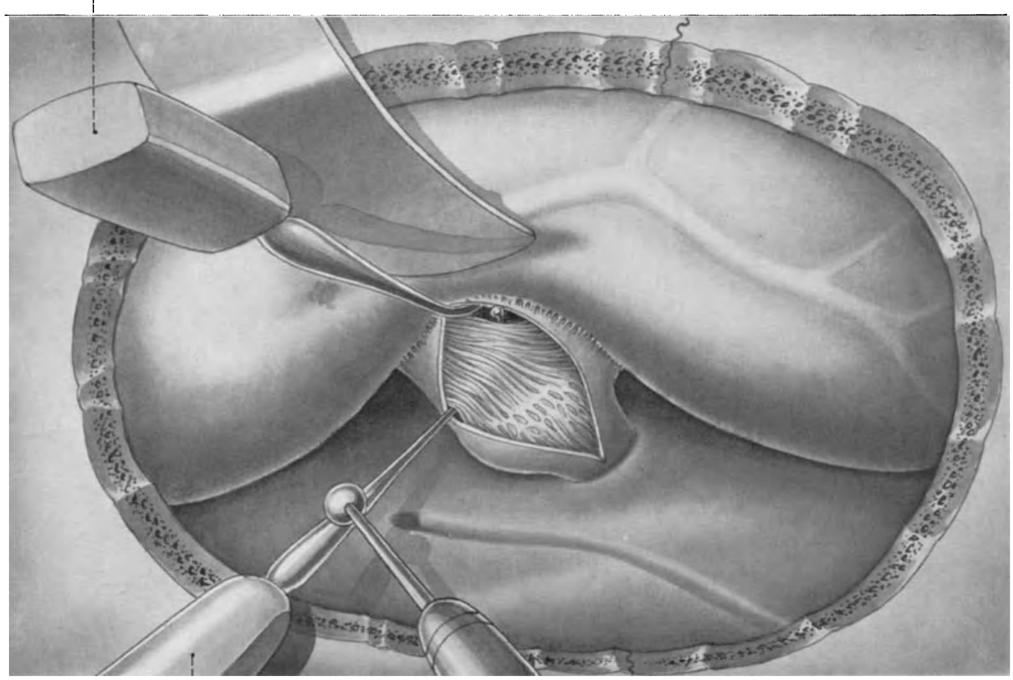


Fig. 245. Retrogasserian rhizotomy.

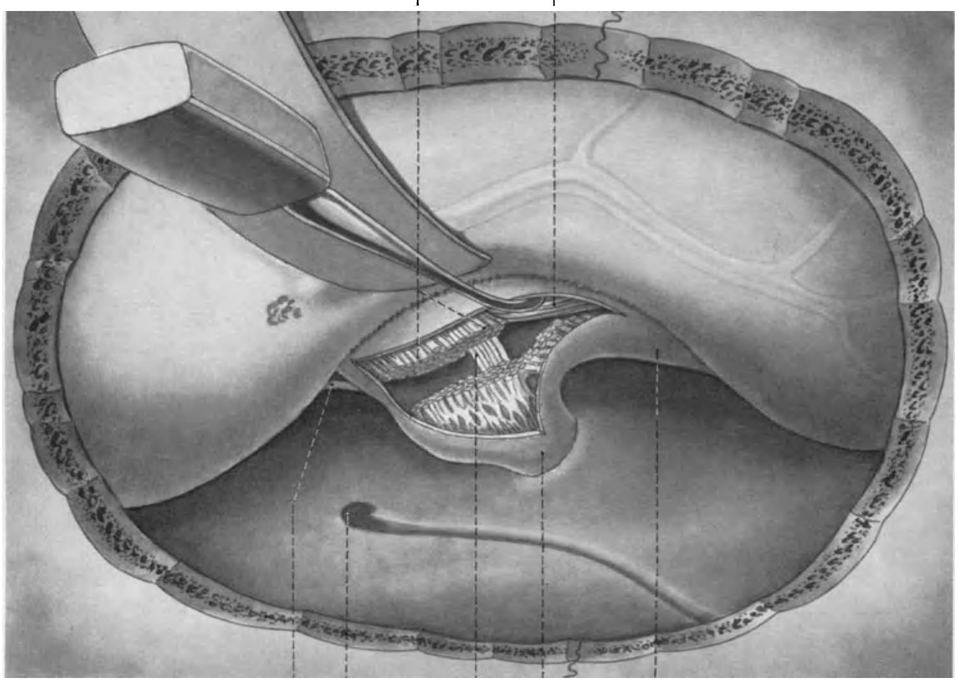


Fig. 246. Retrogasserian rhizotomy of mandibular and maxillary division.
Observe: 1. Wider exposure of dura propria covering the maxillary division. 2. Position of motor root running medial to the sensory portion of N. V. 3. Position of the greater superficial petrosal nerve.

Chapter XVII

Hemispherectomy

The indication for complete hemispherectomy is persistent focal seizures, hemiplegia and mental deterioration in an infant or a child with unilateral cerebral atrophy.

In a coronal section of the brain Fig. 247 demonstrates the line of excision of the hemisphere. This line leads through the corpus callosum and lateral to the striatum (caudate nucleus and putamen). In the same picture (Fig. 247) a clip on the middle cerebral artery distal to the small perforating artery indicates the location where the middle cerebral artery is to be divided.

The position of the patient on the operating table is seen in Fig. 248a or 248b. The scalp incision for this large craniotomy (Fig. 249) forms two skin flaps as illustrated in Fig. 250. To prevent any necrosis of the skin edges cotton strips are placed over the cut edges and held securely by closely approximated Michel clips. The bone flap hinges on the temporal muscle and the dural incision is outlined (Fig. 251). It is important to reflect the dura towards the superior sagittal sinus and towards the transverse sinus (Fig. 251 and 252). The Sylvian fissure is then opened to expose the middle cerebral artery, for here we proceed in the same technique as described in Chapter II, p. 44, and Fig. 58 where we were exposing an aneurysm of the middle cerebral artery. The bridging veins over the tip of the temporal lobe are coagulated and sectioned to permit retraction of the temporal lobe, easier access to the medial part of the Sylvian fissure and exposure of the pars sphenoidalis of the middle cerebral artery (Fig. 253). Usually these patients have widely atrophic hemispheres and dilated ventricles which give additional operative space. Care is taken to avoid injury to the small perforating vessels which come off the posterior superior part of the pars sphenoidalis of the middle cerebral artery. The middle cerebral artery is clipped and divided distal to these small perforating arteries at the anatomical area of the limen insulae. If there is any question about the vascular anatomy, the internal carotid artery may be visualized by elevating the frontal lobe, next freed from arachnoid coverings, and followed to its bifurcation. Then the middle cerebral artery is clipped at the limen insulae.

The medial aspect of the frontal lobe is now lifted away from the falx after we coagulate and section the draining veins to the anterior part of superior sagittal sinus. The anterior cerebral arteries, as they come over the genu of the corpus callosum are identified, and the left anterior cerebral artery is clipped and divided (Fig. 254). The remaining large communicating draining veins are now coagulated and sectioned after ligation of the middle and anterior cerebral arteries. After the vein of Labbé has been divided, the temporal lobe is lifted from the floor or the middle fossa, and the tentorial edge is exposed. The arachnoid which covers the third nerve, the cerebral peduncle, and the posterior cerebral artery is torn parallel to the tentorial edge; thereafter, we follow the posterior cerebral artery laterally and posteriorly. The vessel is dorsal to the tentorial edge. Once we have isolated the posterior cerebral artery it is clipped and divided. For exposure of this region compare Fig. 277, p. 210. After the main arteries have been divided, an incision is made into the corpus callosum and the lateral ventricle is entered. Another incision is then made over the lateral extent of the caudate nucleus (Fig. 255) and carried through the capsula externa just lateral to the putamen. The brain substance is divided with the spatula and suction. Anteriorly the incision will lead to the limen insulae, where the stump of the middle cerebral artery comes into view (Fig. 256). Posteriorly the incision will transect the internal

Fig. 247. Anatomical demonstration of line of resection of left hemispherectomy in a coronal p. a. view. *Observe:* Preservation of small perforating vessels to maintain the basal ganglia.

capsule (including its posterior limb which consists of the lenticulothalamic, retrolenticular and sublenticular portions) and brings the stump of the posterior cerebral artery into view (Fig. 256). The choroid plexus has to be divided at the level of the lateral genticulate body; or better, it is completely removed on this side (Fig. 256). After we make certain that bridging veins over the tip of the frontal and occipital lobes are coagulated and sectioned the entire hemisphere is ready to be lifted out. The dura is tented to the pericranium or the bone edge around the antire craniotomy opening. The dura is closed in such a way that tension is placed on the tented dural edges by excising any redundant dura. In this way the smaller intrathecal space diminishes any shifting of the remaining brain. The bone flap is secured after all spaces, subdural and epidural, are filled with saline.

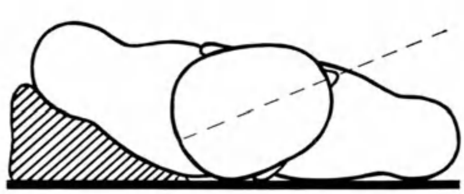


Fig. 248 a.

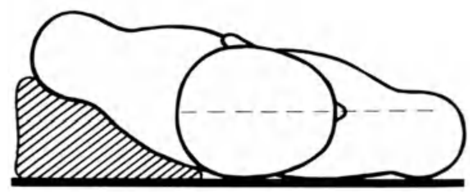


Fig. 248 b.

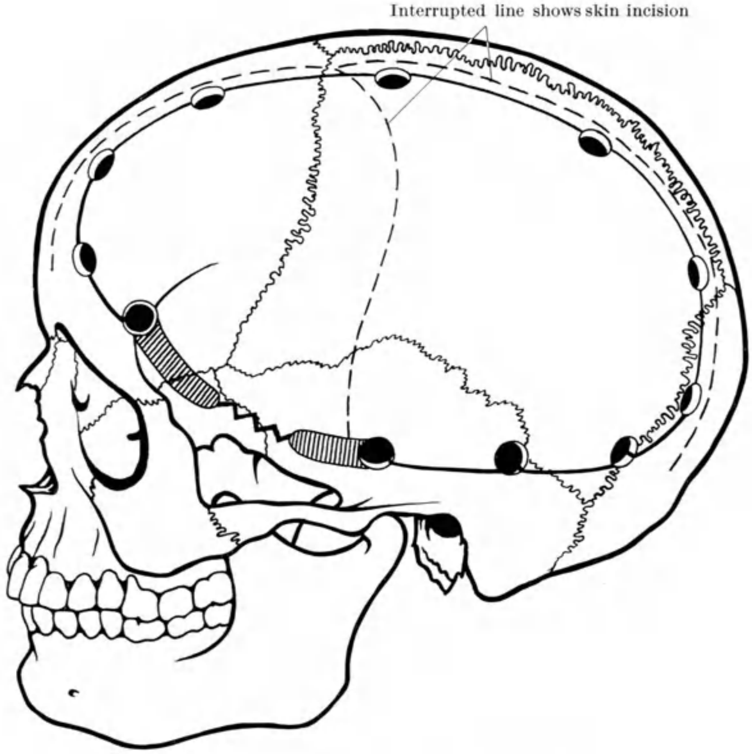


Fig. 249. Craniotomy for left sided hemispherectomy.
Observe: Skin incision outlined to give two flaps.

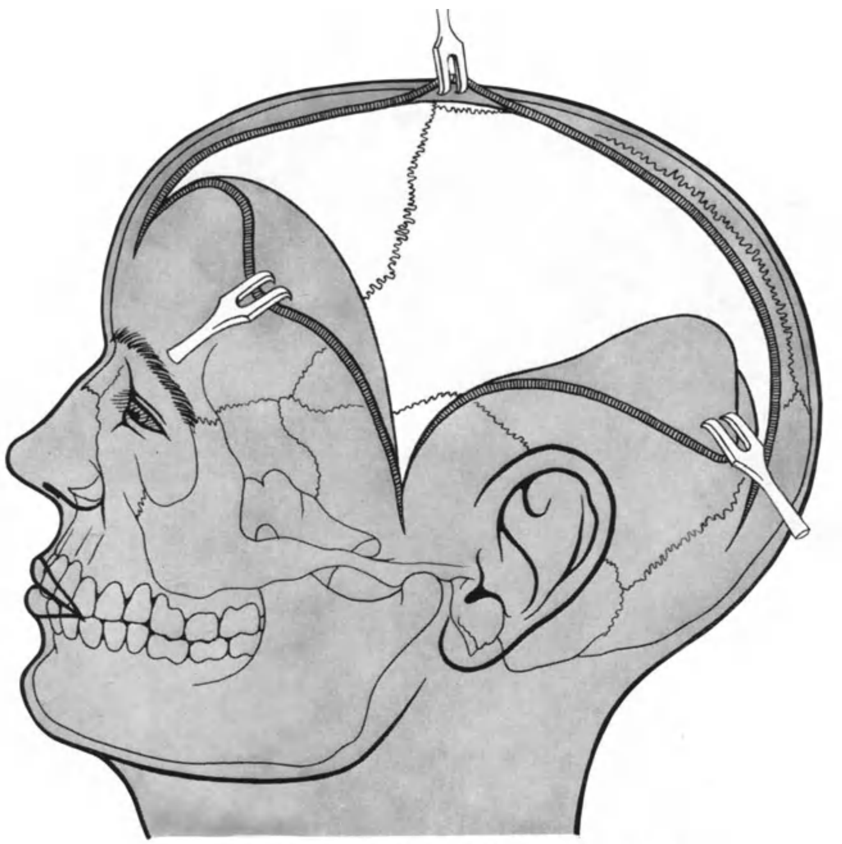


Fig. 250. Scalp flaps for left sided hemispherectomy.

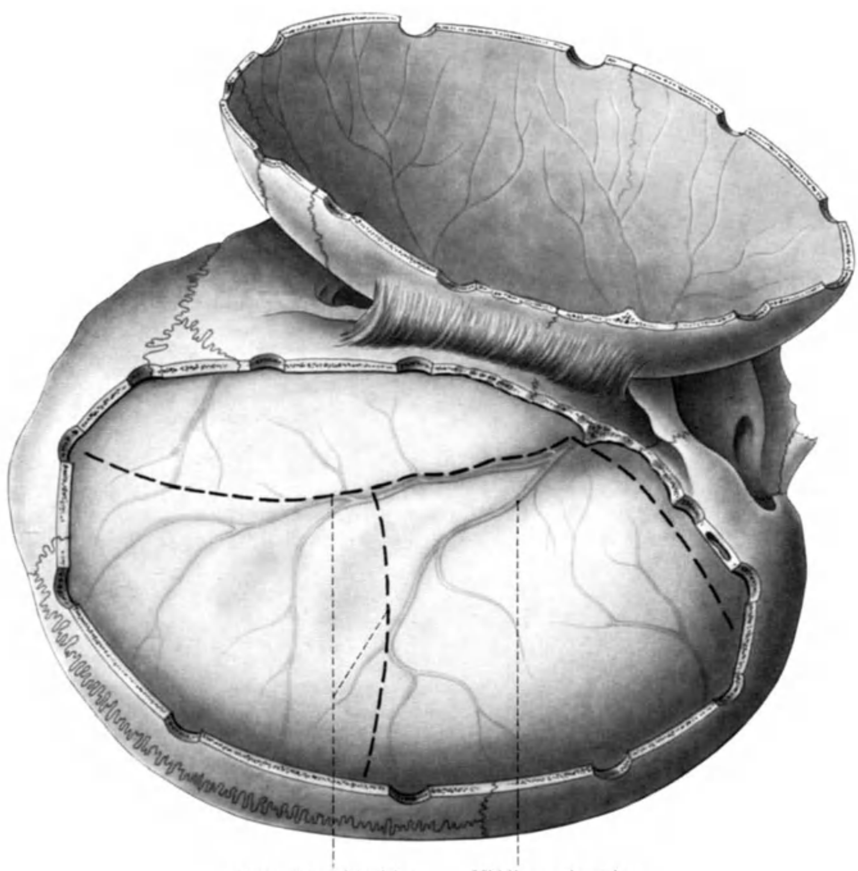


Fig. 251. Dural opening for hemispherectomy.

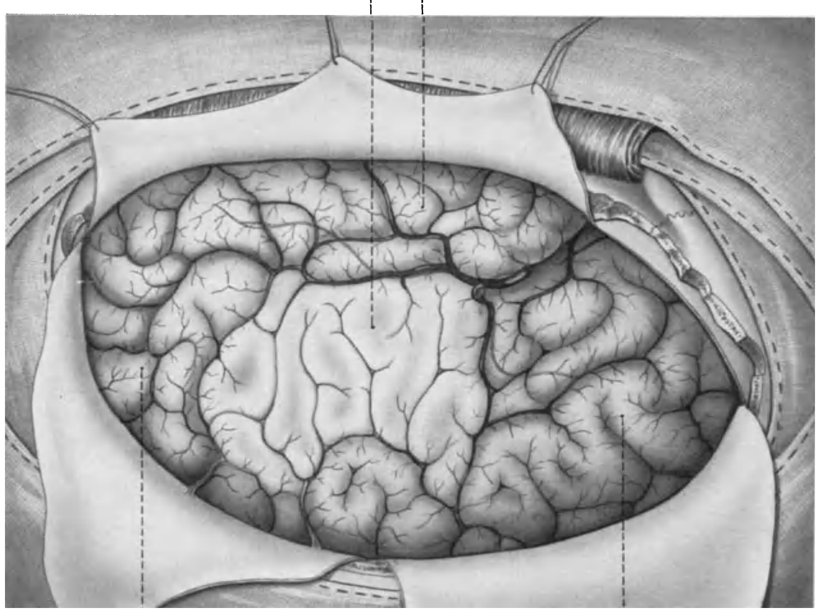


Fig. 252. Left hemisphere exposed for hemispherectomy.

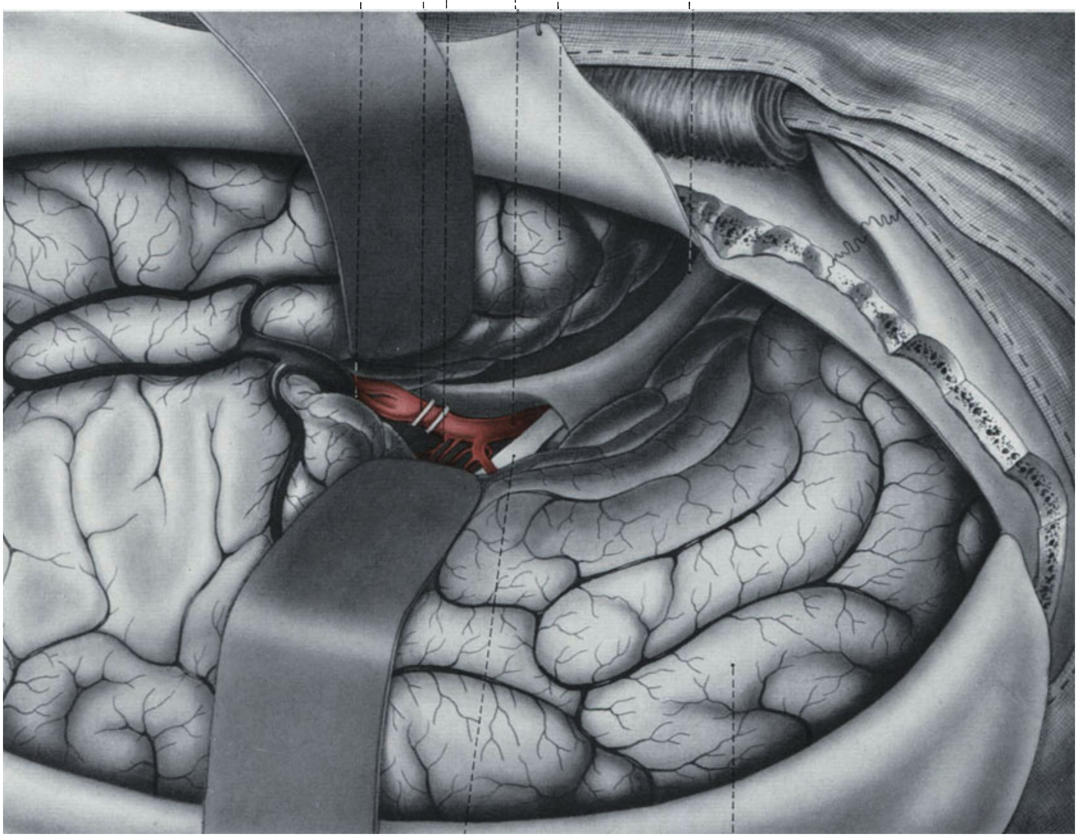


Fig. 253. Operative view exposing left middle cerebral artery.
Observe: Middle cerebral artery is clipped distal to the small perforating vessels (lenticulostriate aa).

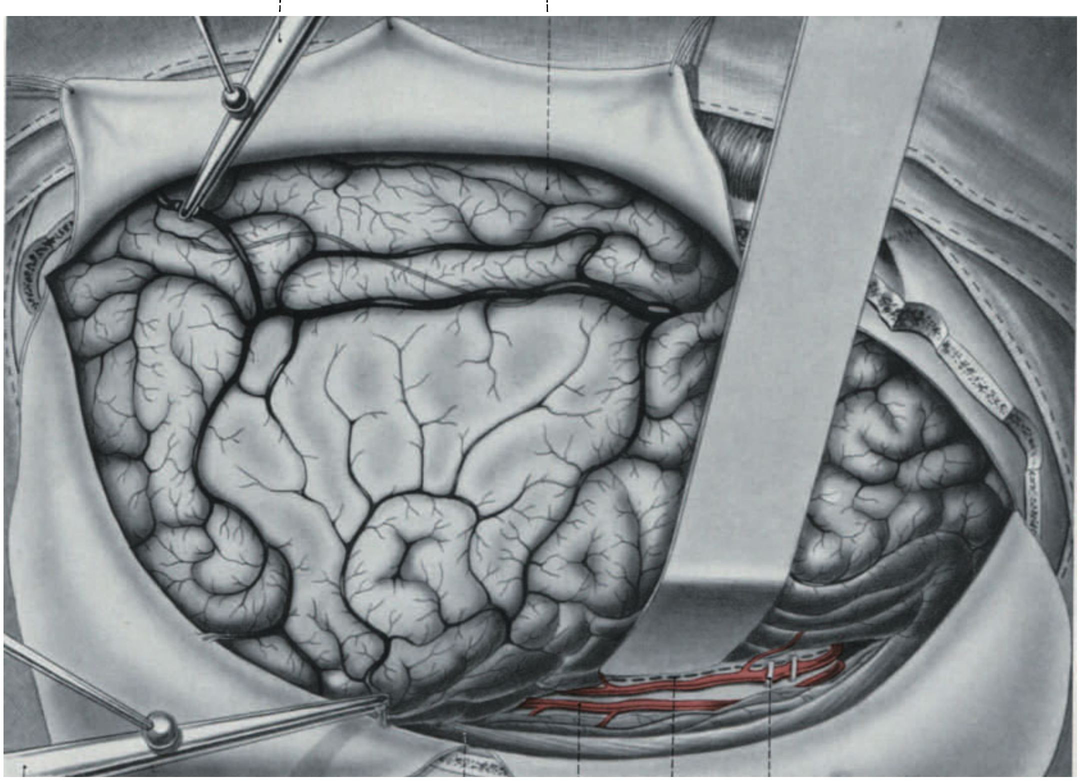


Fig. 254. Retraction of left frontal lobe for exposure, clipping and division of left anterior cerebral artery.

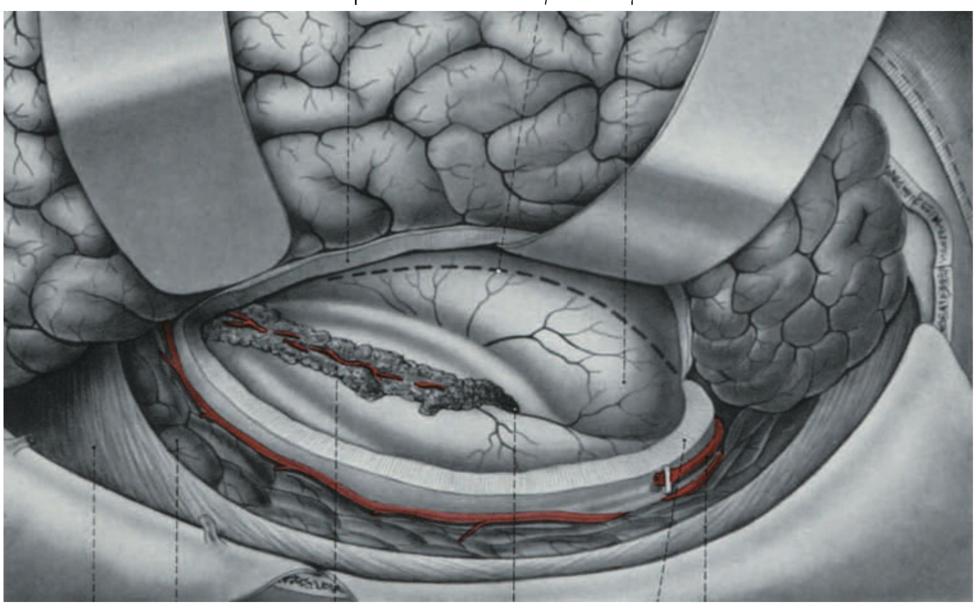


Fig. 255. Operative exposure of left lateral ventricle after incision through corpus callosum. *Observe:* Line of incision over caudate nucleus.

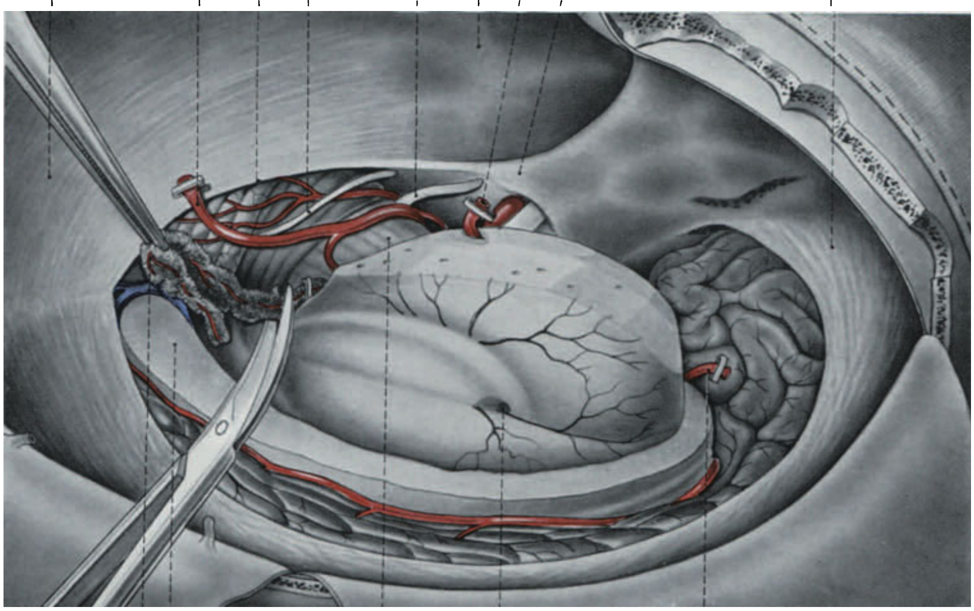


Fig. 256. Operative view after removal of left hemisphere.
Observe: 1. Level of ligation of the three main cerebral arteries (middle cerebral a., anterior cerebral a., posterior cerebral a.). 2. Removal of choroid plexus. 3. Plane of excision lateral to the basal ganglia.

Chapter XVIII

Temporal Lobectomy

The indications for removal of a lobe from the cerebral hemisphere are discussed in Chapter VII (frontal lobectomy). The position of the patient on the operating table is seen in Fig. 257a or 257b. The scalp incision and craniotomy are outlined in Fig. 258. The craniotomy reaches about $3^1/_2$ cm. posterior to the external acoustic meatus. After the bone flap which hinges on the temporalis muscle has been turned, the remaining squama of the temporal bone (shaded area in Fig. 258) is removed down to the floor of the middle fossa by a rongeur. In Fig. 259 the dura is opened and the broken line indicates the incision to be made into the cortex. Over the nondominant hemisphere the excision may be extended to include the posterior third of the superior temporal gyrus and the bordering superior marginal gyrus. On the dominant side the posterior third of the superior temporal gyrus should be avoided to prevent sensory aphasia (WERNICKE). In a unilateral temporal lobe lobectomy, including the transverse temporal gyri, no hearing difficulties are observed. The communicating vein of Labbé cannot be used as an anatomical landmark because of its irregular and unpredictable anatomical position. The bridging veins over the anterior part of the temporal lobe are coagulated and cut near the brain and not near the sinuses. These veins are exposed by riding along the sphenoid ridge with a brain spatula (Fig. 260). It is important not to miss the most medial and inferior veins which drain into the cavernous sinus on the undersurface of the temporal lobe (Fig. 32, p. 28). The cortex of the superior temporal gyrus is incised after we coagulate the pia arachnoid and superficial layers of the cortex. Care is taken to spare the Sylvian vein. The white matter is divided bluntly with a brain spatula, the temporal horn is entered and is covered with a cotton strip to prevent any blood from entering the ventricular system. The choroid plexus is clipped, coagulated and cut. Bipolar coagulation is preferred. Several branches of the middle cerebral artery which go over the temporal tip are clipped and sectioned. It is important to avoid clipping any major branch of the middle cerebral artery which takes a forward loop before it enters the island of Reil. The superior surface of the temporal lobe is left behind (Fig. 261) to preserve the hidden transverse temporal gyrus of Heschl. If the objective in removal of the temporal lobe is primarily to give internal decompression, the excision is stopped at the collateral sulcus and rhinal fissure (Fig. 262). When we expose the undersurface of the temporal lobe and if a lateral (fusiform) branch of the posterior cerebral artery has to be divided, the main trunk of the posterior cerebral artery must be left intact to prevent a cerebral infarction to the occipital lobe.

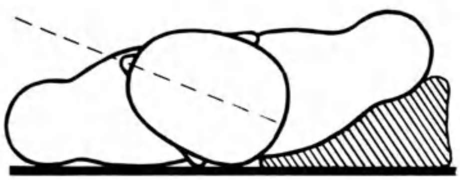


Fig. 257 a.

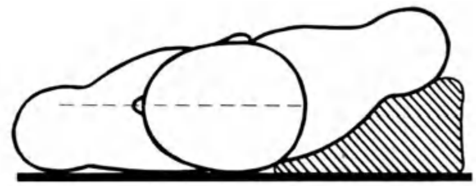


Fig. 257 b.

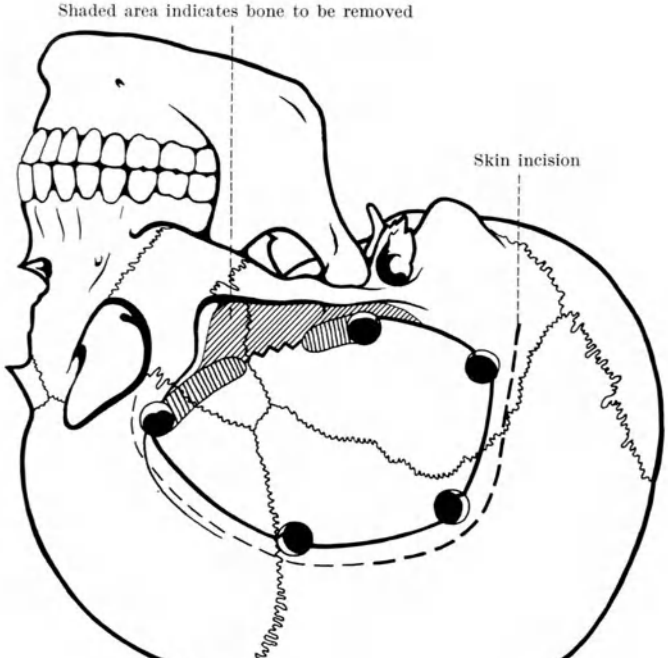


Fig. 258. Skin incision and craniotomy for right temporal lobectomy.
Observe: Cranial opening reaches down to the floor of the temporal fossa.

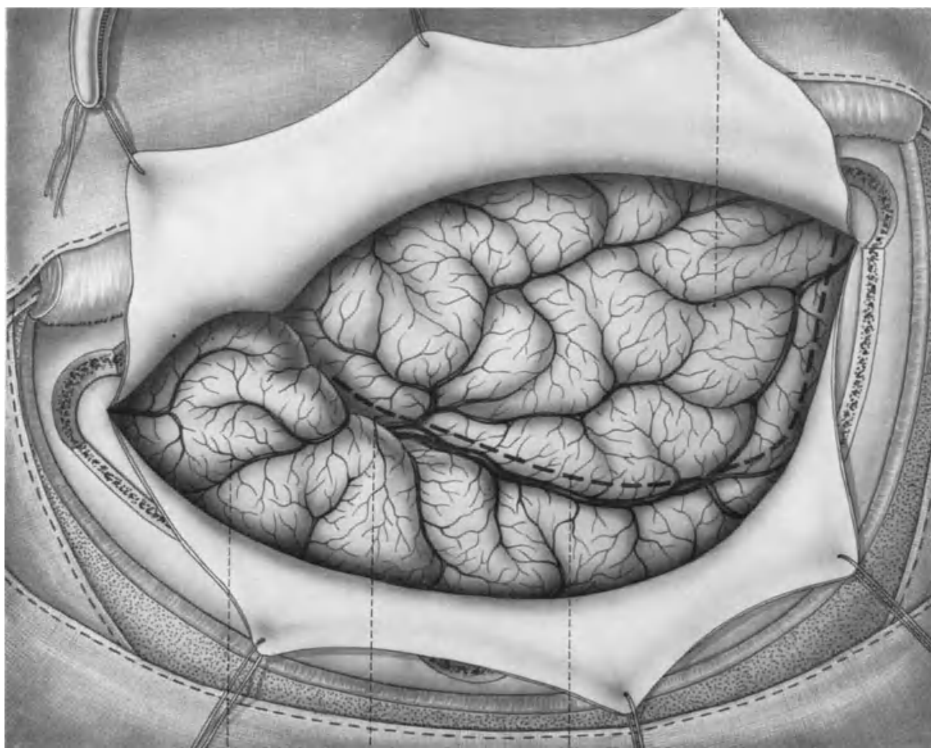


Fig. 259. Operative exposure of rt. temporal lobe.

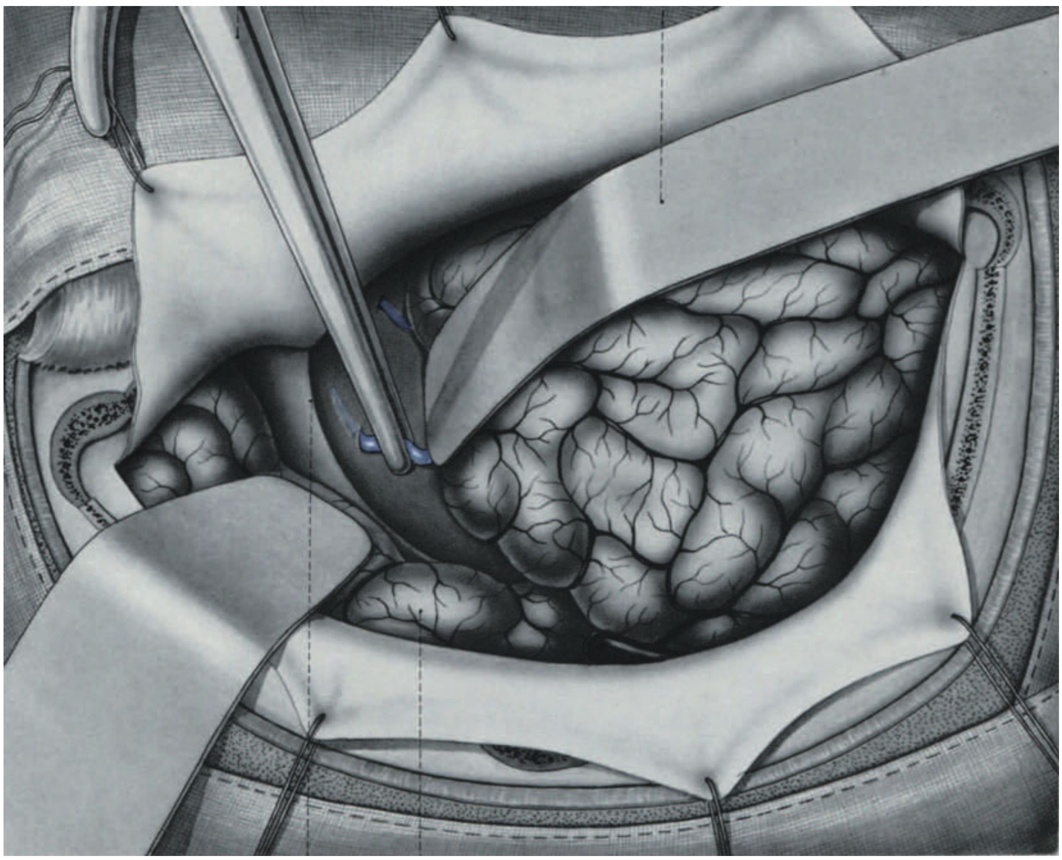


Fig. 260. Mobilization of temporal lobe by coagulation and cutting of bridging veins.

Fig. 261. Dissection of white matter in right temporal lobectomy.

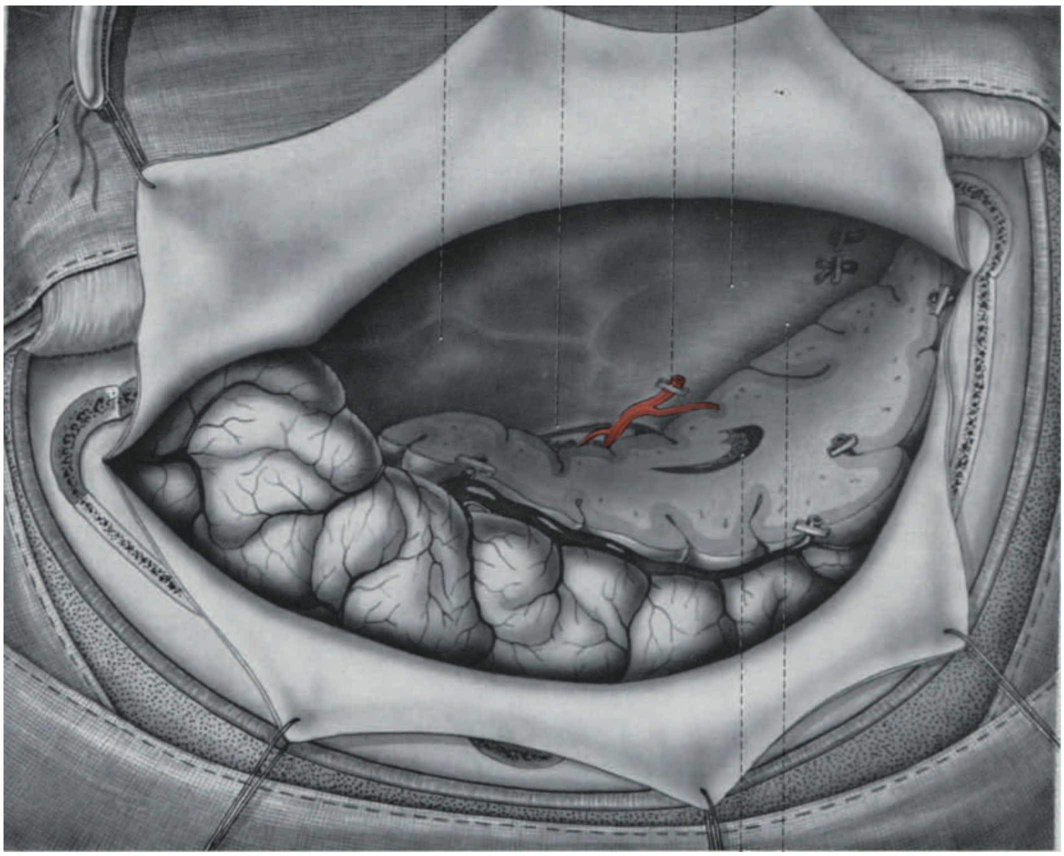


Fig. 262. Operative view after removal of right temporal lobe

Chapter XIX

Lateral Intraventricular Tumor

(Choroid Plexus Papilloma of the Left Lateral Ventricle)

A left-sided lateral intraventricular tumor is presented intentionally to demonstrate the proper placement of the cortical incision in the middle temporal gyrus on the dominant hemisphere and to show how to avoid the posterior third of the superior temporal gyrus, the supramarginal gyrus, and an associated severe neurological deficit. Anatomical drawings in Figs. 263, 264 and 265 are of a choroid plexus papilloma in its typical location, the trigonum of the left lateral ventricle, and will assist in giving a three dimensional conception of the lesion. In Figs. 264 and 265 the incision over the middle temporal gyrus is outlined. Usually the temporal horn is distended by the tumor and/or from ventricular fluid obstruction and the resultant dilatation adds operative room for tumor removal. The tumor receives its blood supply from the anterior and posterior choroidal arteries.

The position of the patient on the operating table is shown in Fig. 266a or 266b. The scalp incision and craniotomy reach posteriorly, close to the lambdoid suture line and extend higher than the craniotomy for temporal lobectomy (Fig. 267). The dura is reflected towards the transverse sinus. The cortex is coagulated and incised over the posterior and middle thirds of the middle temporal gyrus (Fig. 268). The white matter is divided bluntly until the ependyma of the lateral ventricle comes into view. The ependyma, which is usually covered by distended veins, is coagulated. In Fig. 269 the tumor can be seen with the choroid plexus leading to and beneath the tumor. The choroid plexus is divided wherever this can most easily be done. However, prior to dividing the choroid plexus it is clipped and thereafter coagulated with the bipolar coagulation forceps. The use of bipolar coagulation is most helpful to avoid the spread of heat to the important neighboring structures such as hippocampus, calcar avis and collateral eminence. After the choroid plexus is divided only one important feeding vessel, the anterior choroid artery, is interrupted. The branches of the posterior choroidal artery which reach the tumor more diffusely at the level of the lateral geniculate body are usually the main blood supply. The tumor itself cannot be pulled out without tearing the plexus with it and causing profuse bleeding. Therefore, the tumor is only slightly elevated to expose, step by step, the choroid plexus and the feeding vessels over the tumor's medial inferior surface. Moving the tumor towards the occipital horn will bring further exposure of the choroid plexus and feeding vessels which are grasped and coagulated (Fig. 270). In this way the tumor will be separated from its blood supply and delivered. The highly vascular tumor should be covered by wet cotton strips while it is retracted; however, the cotton strips are not shown in the drawings in order to clarify anatomic structures. If the tumor is of such size as to prevent any movement without tearing brain tissue, the highly vascular lesion can be uncapped, reduced in size using the bipolar coagulation, and removed in small bites, until the tumor can be elevated to reach its base over the glomus. After removal the tumor bed is irrigated profusely and inspected for bleeding.

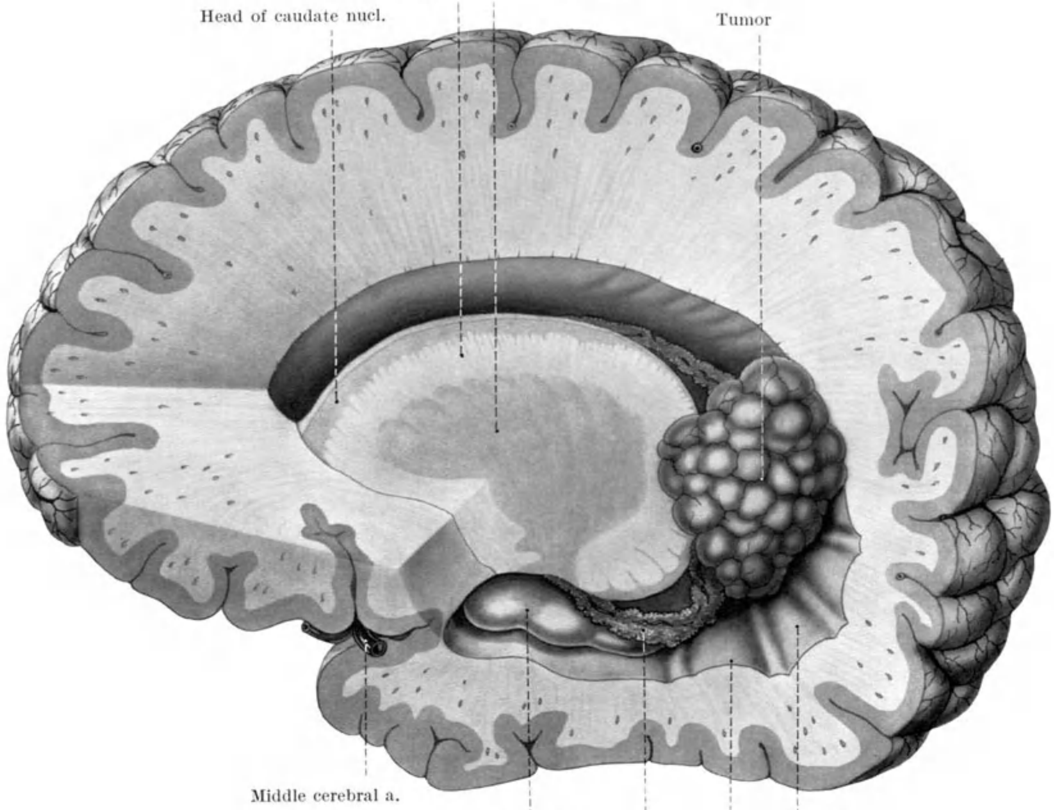


Fig. 263. Anatomical presentation of choroid plexus papilloma in left lateral ventricle. *Observe:* Dilatation of lateral ventricle distal to tumor.

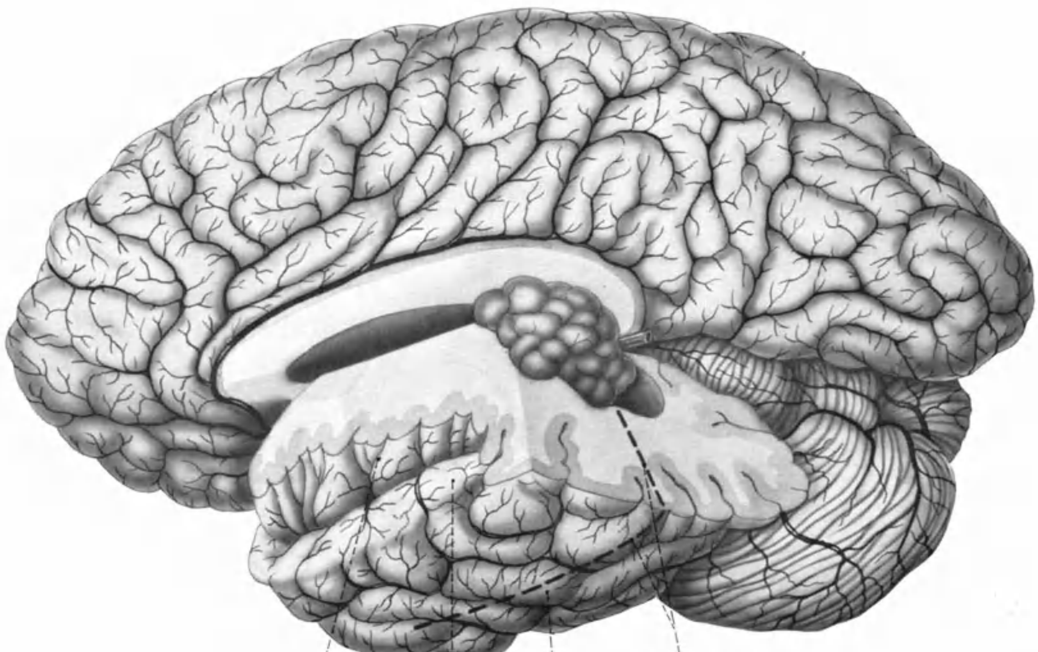


Fig. 264. Anatomical demonstration of choroid plexus papilloma in left lateral ventricle.
Observe: 1. To demonstrate the tumor and the ventricle, the depth of the Sylvian fissure has been opened and the temporal lobe reflected inferiorly. 2. Line of incision on the dominant hemisphere through middle temporal gyrus.

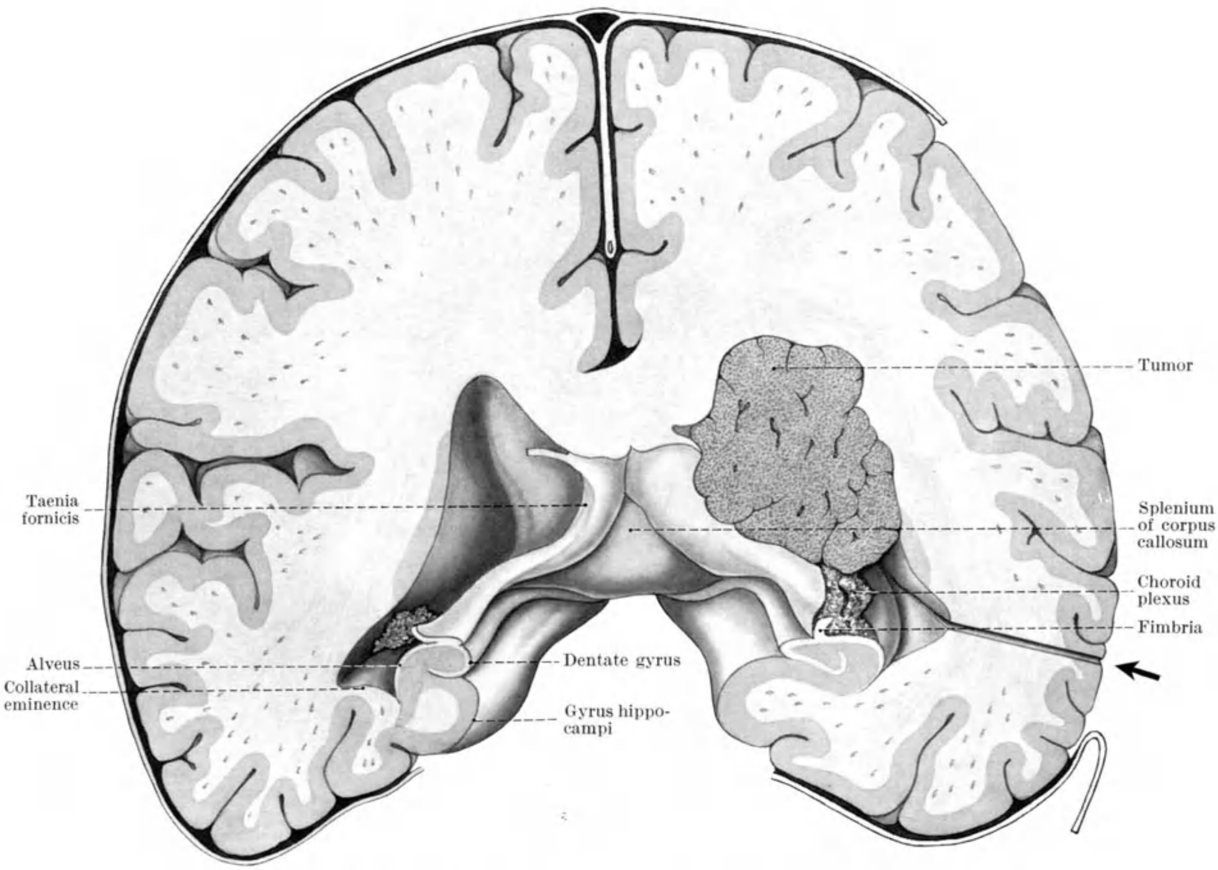


Fig. 265. Coronal section of left intraventricular tumor (papilloma of choroid plexus). *Observe:* 1. Arrow points to incision over middle temporal gyrus. 2. Dilated left temporal horn.

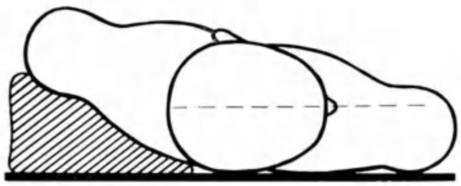


Fig. 266 a.

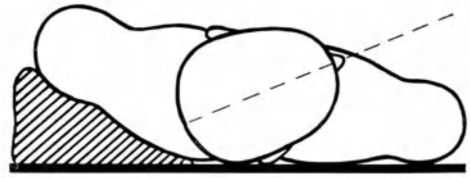


Fig. 266 b.

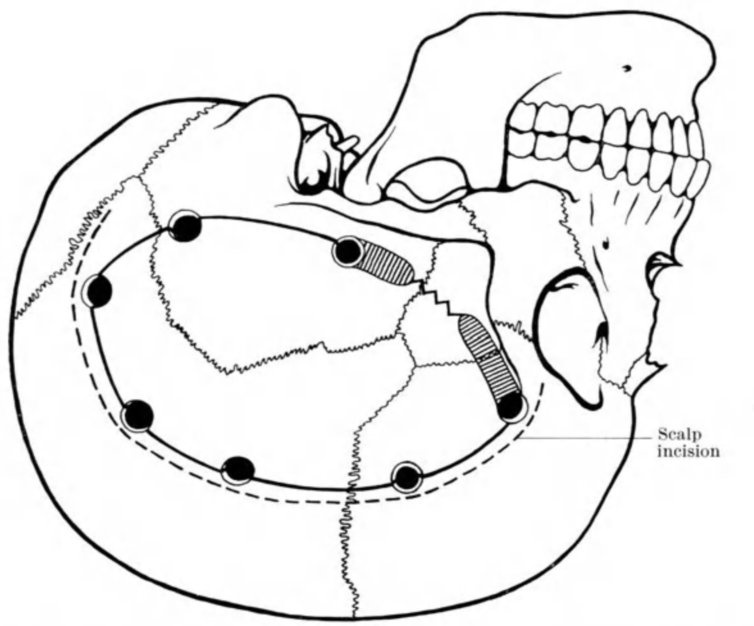


Fig. 267. Skin incision and craniotomy for intraventricular tumor in left trigonum.

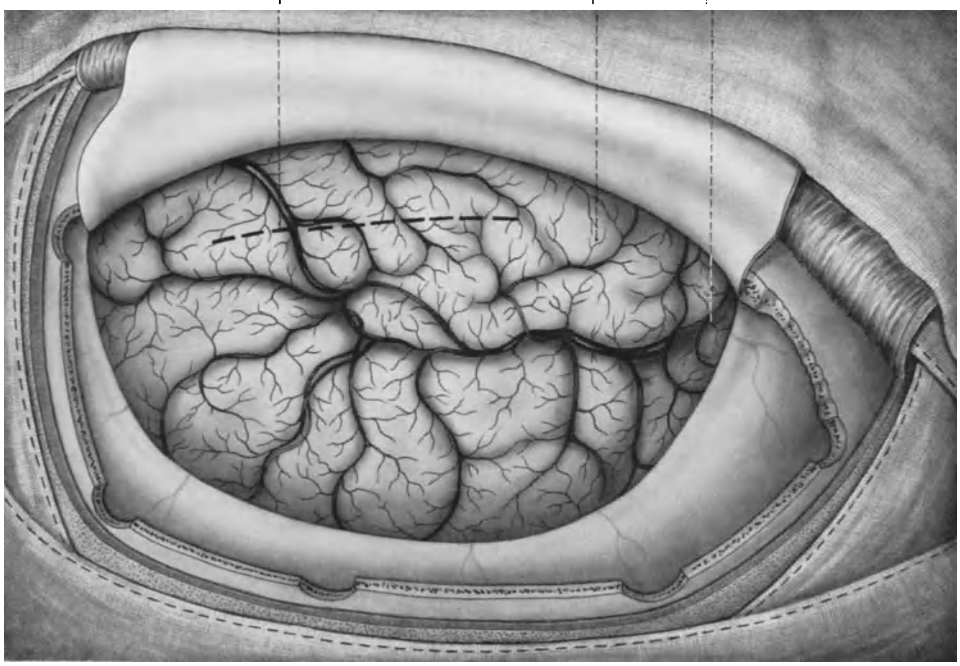


Fig. 268. Operative exposure for intraventricular tumor in left trigonum.

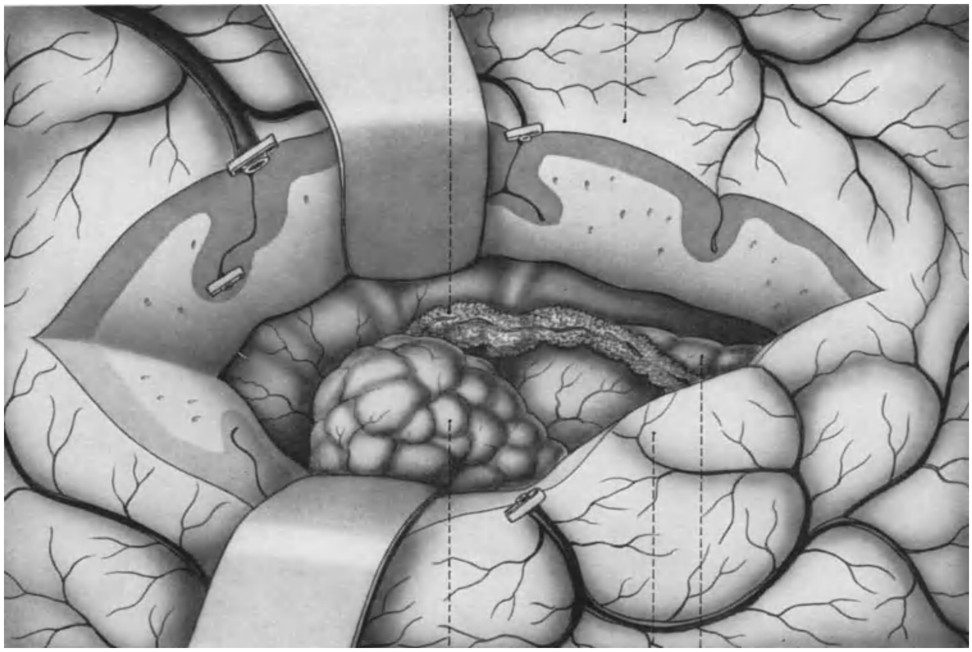


Fig. 269. Operative view of choroid plexus papilloma in left trigonum.

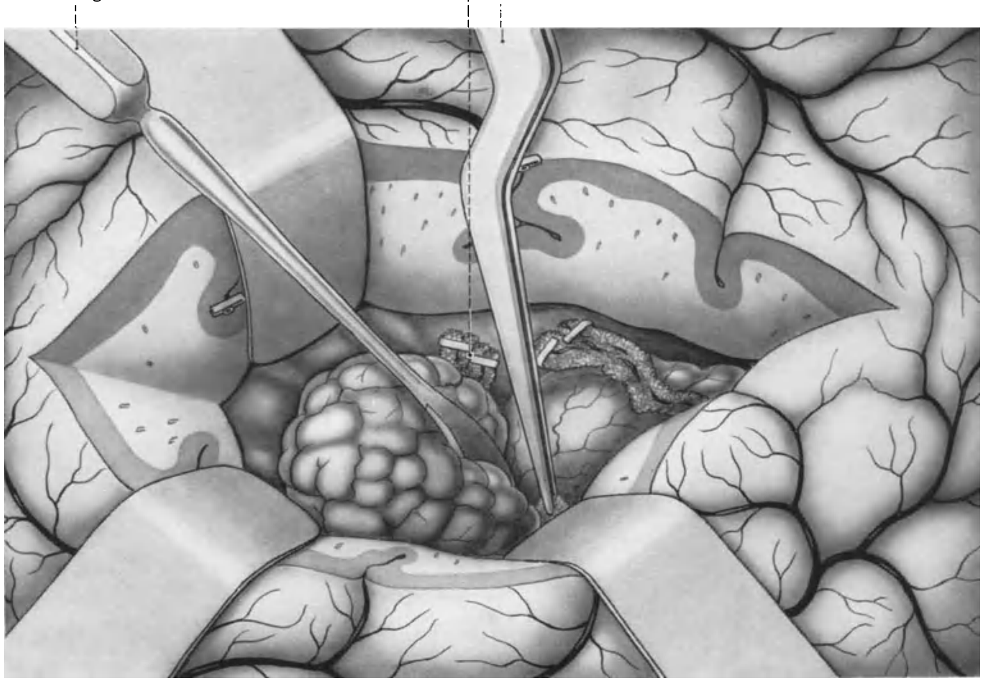


Fig. 270. Removal of choroid plexus papilloma.
Observe: 1. Divide the choroid plexus from the tumor. 2. Retract the tumor at its base and use *bipolar* coagulation.

Chapter XX

Aneurysm of the Basilar Artery

Many of the same principles which apply to the operative treatment of aneurysms of the anterior part of the circle of Willis are observed in the surgical therapy of aneurysms of the basilar artery. We have found no advantage in hypothermia or hypotensive techniques prior to ligating the aneurysm, for the possible advantages appear to be outweighed by the disadvantages. If the aneurysm should bleed at the time of exposure, hypothermia affords little extra protection and prolongs significantly anesthesia with an associated increase in postoperative problems. Also, pre-existing hypotension accentuates hypoxia and ischemic damage to the brain stem with fresh bleeding. However, controlled hyperventilation anesthesia is used as in all neurosurgical procedures as long as the patient is not in the sitting position. In the majority of our cases aneurysms of the basilar artery are reached via the subtemporal approach and this method is described.

In a composite drawing (Fig. 271) the anatomic relationship of the aneurysms of the basilar artery is shown. The drawing also illustrates the operative approach to these aneurysms, from above, via the temporal fossa. The aneurysm situated at the bifurcation of the basilar artery or at the junction of the superior cerebellar artery with the basilar artery is exposed without having to incise the tentorial edge. Any aneurysm below the superior cerebellar artery requires incision of the tentorium. On the left side of the brain in Fig. 271 the lower oblique section goes through the petrous bone at the level of the internal and external acoustic meati. The tentorium is incised and reflected and the aneurysm at the junction of the basilar artery and anterior inferior cerebellar artery is obliterated at the neck of the aneurysm. This picture may be compared with Fig. 281 where the operative exposure is demonstrated as seen at the time of surgery.

From the operative point of view the aneurysm at the bifurcation of the basilar artery can be classified into two groups. The first includes those aneurysms which point anteriorly without any perforating vessels coming from the base or wall of the aneurysm itself (Fig. 272). This is the type of aneurysm which can be surgically obliterated. The second are those aneurysms which point in a posterior direction into the interpeduncular fossa and towards the posterior perforated substance. Many important small vessels come from the base and wall of the aneurysm itself (Fig. 273). This latter type of aneurysm, which cannot be obliterated by simple clipping, necessitates the use of fast-setting methyl methacrylate (see Chapter II, p. 48). It is poured into the interpeduncular fossa after having filled the prepontine space with layers of gelfoam to prevent the liquid plastic from running down the clivus. Obviously this is not the solution to the treatment of this type of aneurysm, if the aneurysm remains adherent to brain tissue. The headlight and magnifying loupe (Fig. 68, p. 56) are essential for the operation of aneurysms of the basilar artery. Generally we prefer the magnifying loupes rather than the dissecting microscope, for the latter can be in the way when and if sudden bleeding should occur. However, we respect each surgeon's personal preference.

The operative approach to the aneurysm at the bifurcation of the basilar artery is from the right, nondominant, side. The position of the patient on the operating table is seen in Fig. 274a—c. During the operation it will be necessary to move the patient's head to one of the positions seen in Fig. 274a, b and c. The position as seen in Fig. 274a is the one to be used if the aneurysm is located over the proximal part of the basilar artery. The scalp incision and craniotomy are seen in Fig. 275. After turning the bone flap, which comes to hinge on the temporal muscle, the remaining bone of the temporal squama is removed down to the floor of the middle fossa. The shaded area in Fig. 275 points out the part of the bone to be removed which also includes part of the larger wing of the sphenoid. It is important to have all this bone removed in order to approach the area of the interpeduncular fossa. The temporal lobe is mobilized by coagulating and sectioning the bridging veins over the anterior extent of the temporal lobe (Fig. 276; compare also Fig. 30, 31, 32, p. 25, Chapter II). The temporal lobe is now ready to be elevated which will bring the tentorial edge into view. The arachnoid that covers the right lateral extent of the tentorial hiatus is grasped and torn parallel to the tentorial edge as wide, anteriorly and posteriorly, as is possible. The cerebrospinal fluid will escape and is aspirated. The third nerve, identified by its whitish color, will present itself readily and will be followed posteriorly to its emergence between the posterior cerebral artery above and the superior cerebellar artery below (Fig. 277). The brain spatula is now re-applied over the anterior third of the temporal lobe pointing towards the interpeduncular fossa. The approach from this angle will provide a clear view of the interpeduncular fossa, the posterior cerebral artery, and the bifurcation of the basilar artery with the aneurysm (Fig. 278).

In Fig. 278 an aneurysm that points anteriorly is shown and Fig. 279 shows a close-up view of the same. The aneurysm is outlined with the fine blunt nerve hook or mastoid seeker to establish its relationship to the bifurcation of the basilar artery and to some of the small perforating vessels which may loop around and have to be freed before selecting the best method for obliteration of the aneurysm. The size of the clip and the angle of clip application will be determined only at the time of surgery with the anatomy completely explored and exposed.

If the aneurysm has its origin below the origin of the superior cerebellar artery the tentorium has to be incised. An aneurysm which originates at the junction of the anterior-inferior cerebellar artery with the basilar artery is presented. For the anatomy, Fig. 271 may be reviewed.

The craniotomy is the same as described in Fig. 275. The temporal lobe is mobilized and elevated and the arachnoid opened parallel to the tentorial edge (Fig. 277). The tentorium is palpated to outline the petrous ridge. After having established the position of the petrous ridge the tentorium is incised 1 cm posteriorly and parallel to the petrous ridge. This is done by lifting the tentorial edge with a blunt nerve hook and coagulating the tentorium prior to incising it with a right-angle scissor (Fig. 280). It is important to identify the fourth nerve so that this nerve is not lifted with the tentorium. A small cotton pledget covering the nerve will prevent the nerve from falling against the nerve hook and being coagulated. The medial edge of the tentorium is also clipped to prevent bleednig from the tentorial artery which lies between the two layers of the dura at the edge of the tentorium. Stay sutures are placed at the edge of the incised tentorium and carefully pulled apart to prevent any tearing of the cerebellar bridging veins going to the superior petrosal sinus (Fig. 281). Some of these veins are grasped by a small coagulating forceps, coagulated and cut, to permit further reflection of the tentorium. The fifth nerve is identified where it enters Meckel's cave and the aneurysm is seen in the depths below (Fig. 281) at the junction of the right anterior-inferior cerebellar artery with the basilar artery. With the neck of the aneurysm identified, the appropriate clip applier with clip is carefully introduced and without interrupting or impinging blood flow in the basilar or anterior-inferior cerebellar artery the aneurysm is obliterated from the circulation. We have done four such cases.

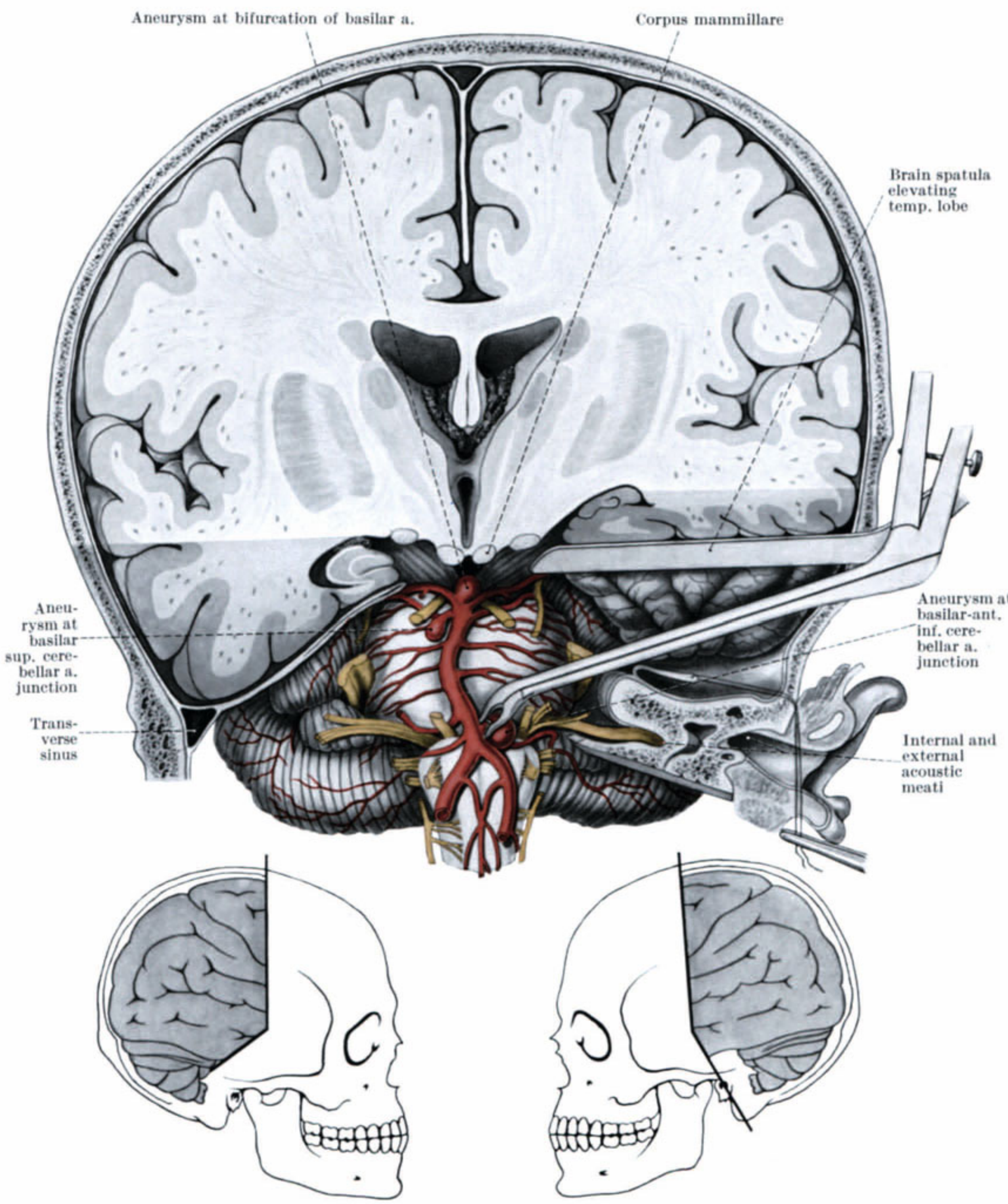


Fig. 271. Combined coronal and oblique section showing anatomical structures related to basilar artery aneurysms. Lateral projections below the main picture represent the ipsilateral oblique section.
Observe: For exposure of aneurysm at the bifurcation it is not necessary to incise the tentorium (see Fig. 278 for the operative exposure). However, an aneurysm proximal to the bifurcation requires incision into the tentorium to gain adequate exposure (see Fig. 281).

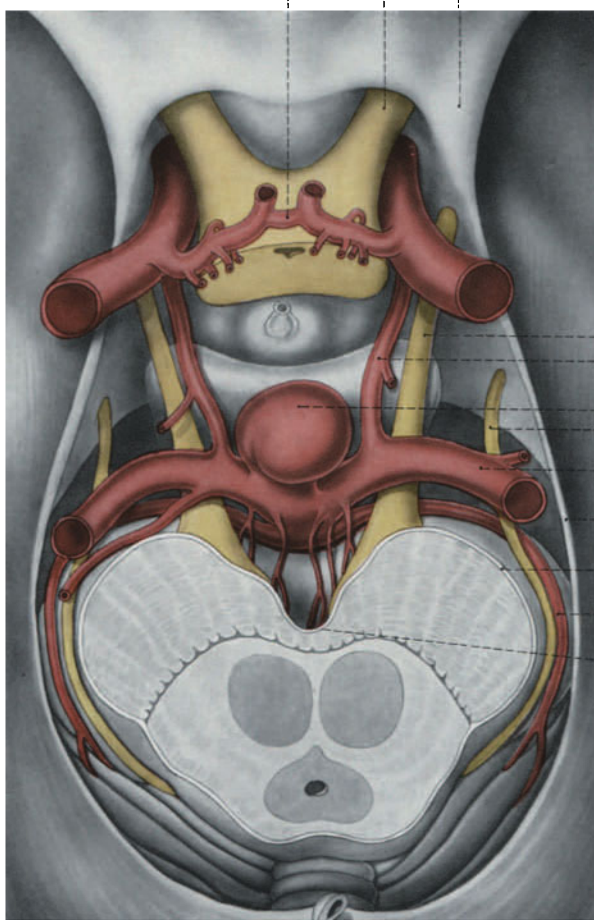


Fig. 272. Anatomical demonstration of aneurysm at bifurcation of basilar artery pointing anteriorly. *Observe:* Small vessels entering the interpeduncular fossa (posterior perforate substance) away from the base and dome of the aneurysm.

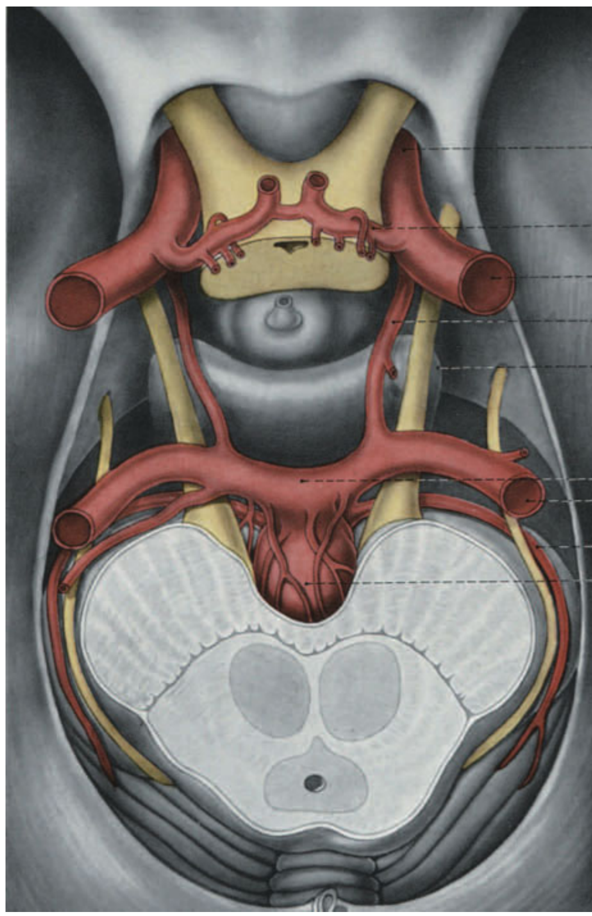


Fig. 273. Anatomical demonstration of aneurysm at bifurcation of basilar artery pointing posteriorly. *Observe:* Relationship of small perforating vessels to aneurysm.

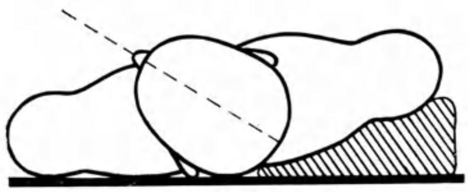


Fig. 274 a.

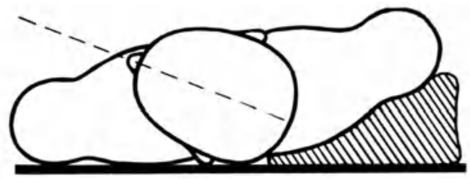


Fig. 274 b

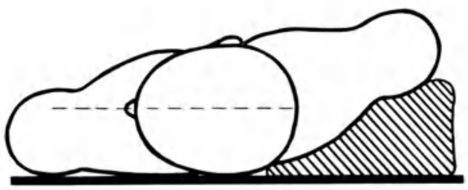


Fig. 274 c.

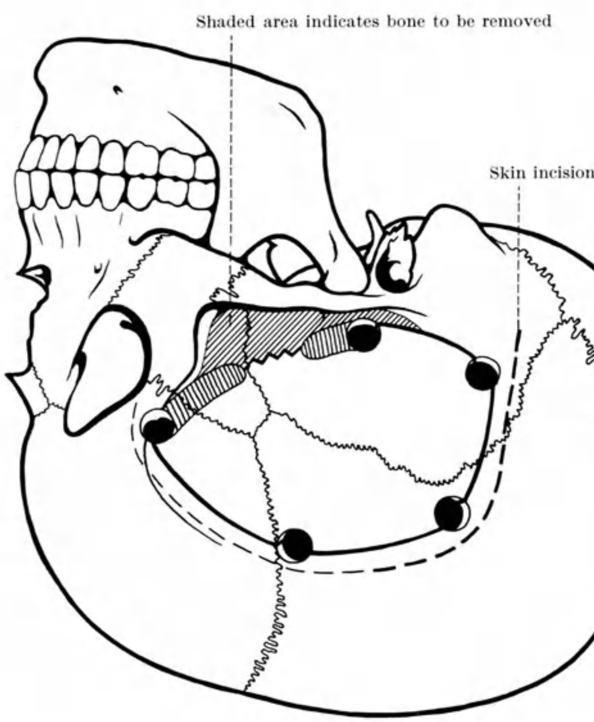


Fig. 275. Skin incision and craniotomy for aneurysm of the basilar artery.
Observe: 1. Shaded area of squama of temporal bone and greater wing of sphenoid, indicates part of bone to be removed by rongeur. 2. Operative approach is from non-dominant side.

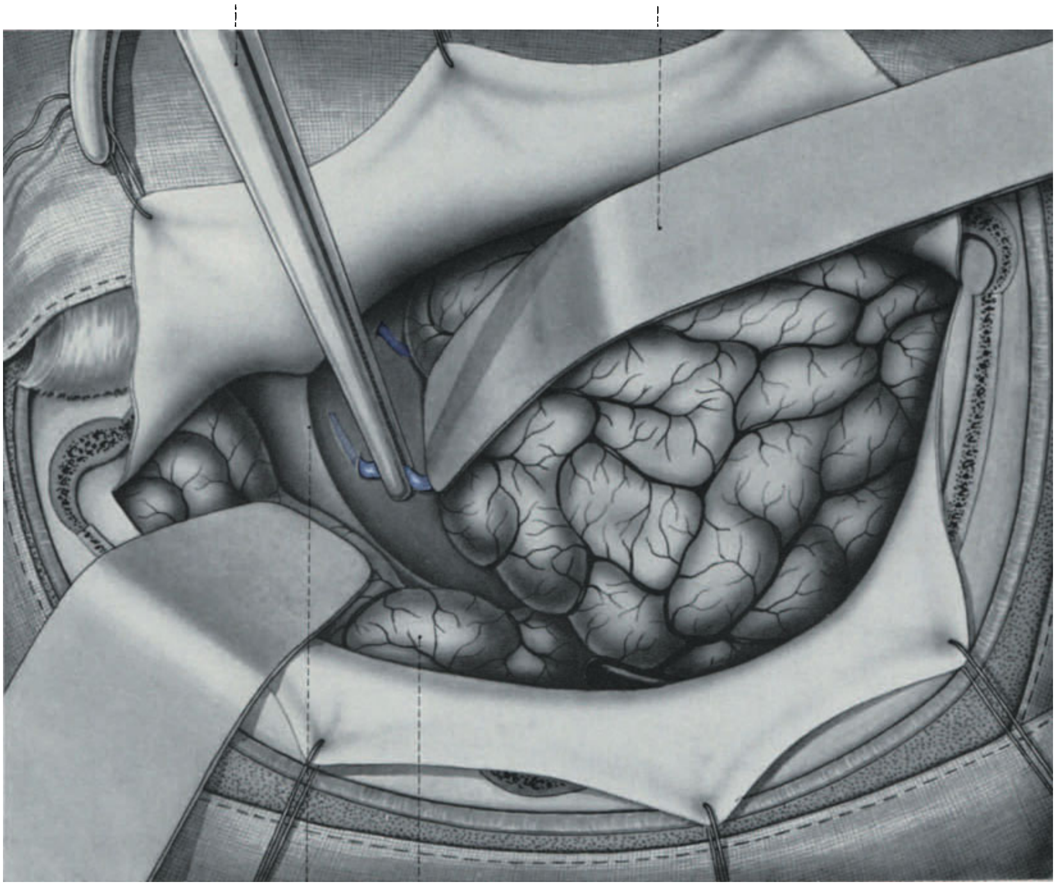


Fig. 276. Mobilization of temporal lobe by coagulation and transection of bridging veins.

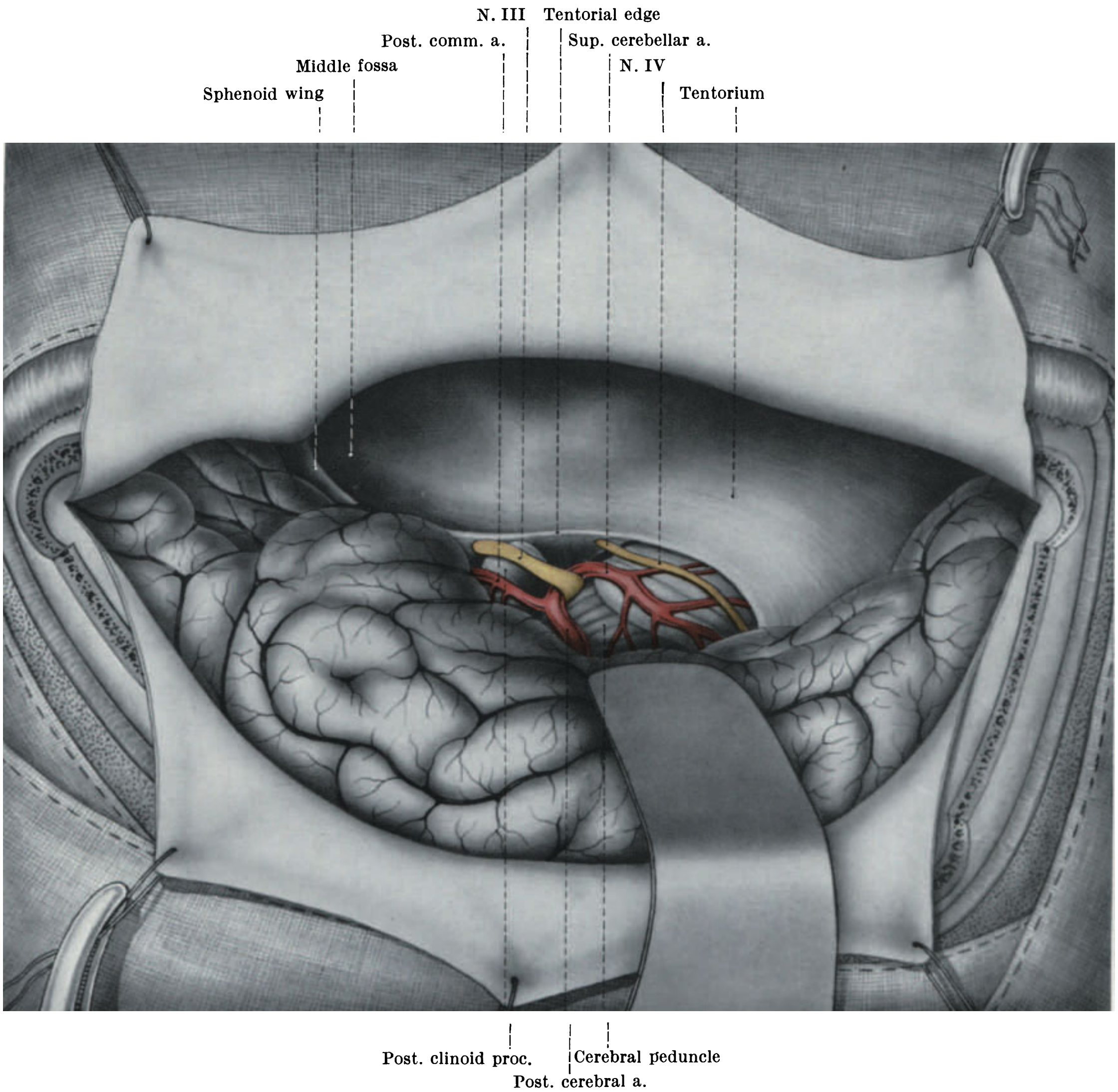


Fig. 277. Operative exposure for aneurysm at bifurcation of basilar artery.
Observe: 1. Elevation of right temporal lobe reveales lateral aspect of tentorial hiatus. 2. Arachnoid is not shown for better clarification.

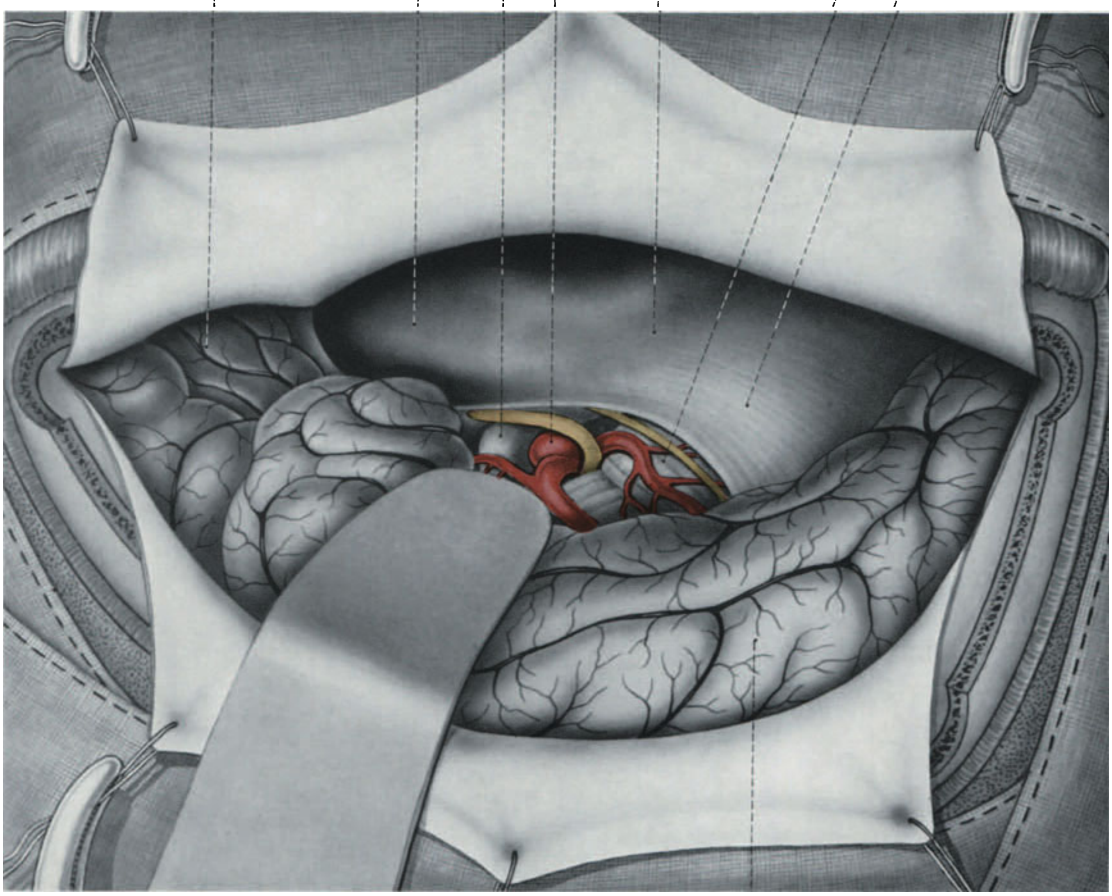


Fig. 278. Exposure of aneurysm at bifurcation of basilar artery.
Observe: Retractor is pointing towards posterior clinoid process.

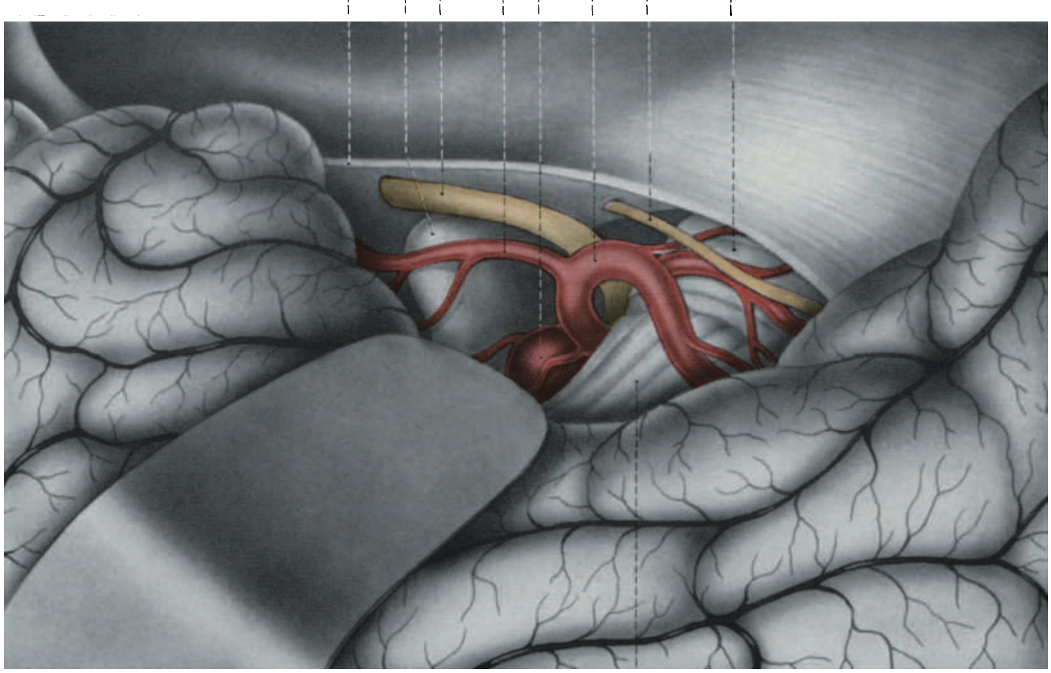


Fig. 279. Close up view of operative exposure of aneurysm at bifurcation of basilar artery.
Observe: Dome of aneurysm pointing anteriorly.

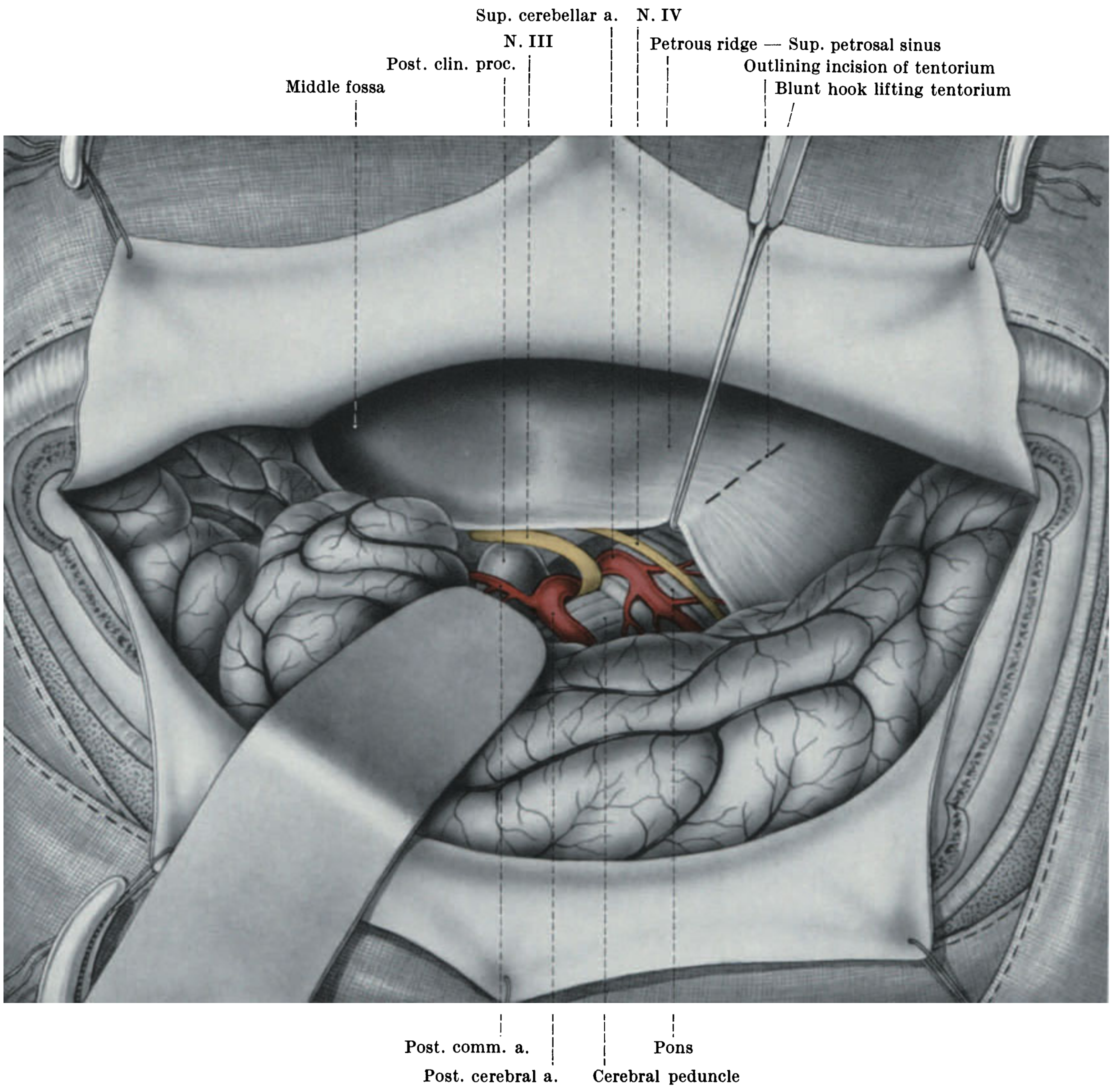


Fig. 280. Operative approach for aneurysm of the basilar artery below the bifurcation. *Observe:* Incision into the tentorium is 10 mm posterior and parallel to the superior petrosal sinus (petrous ridge).

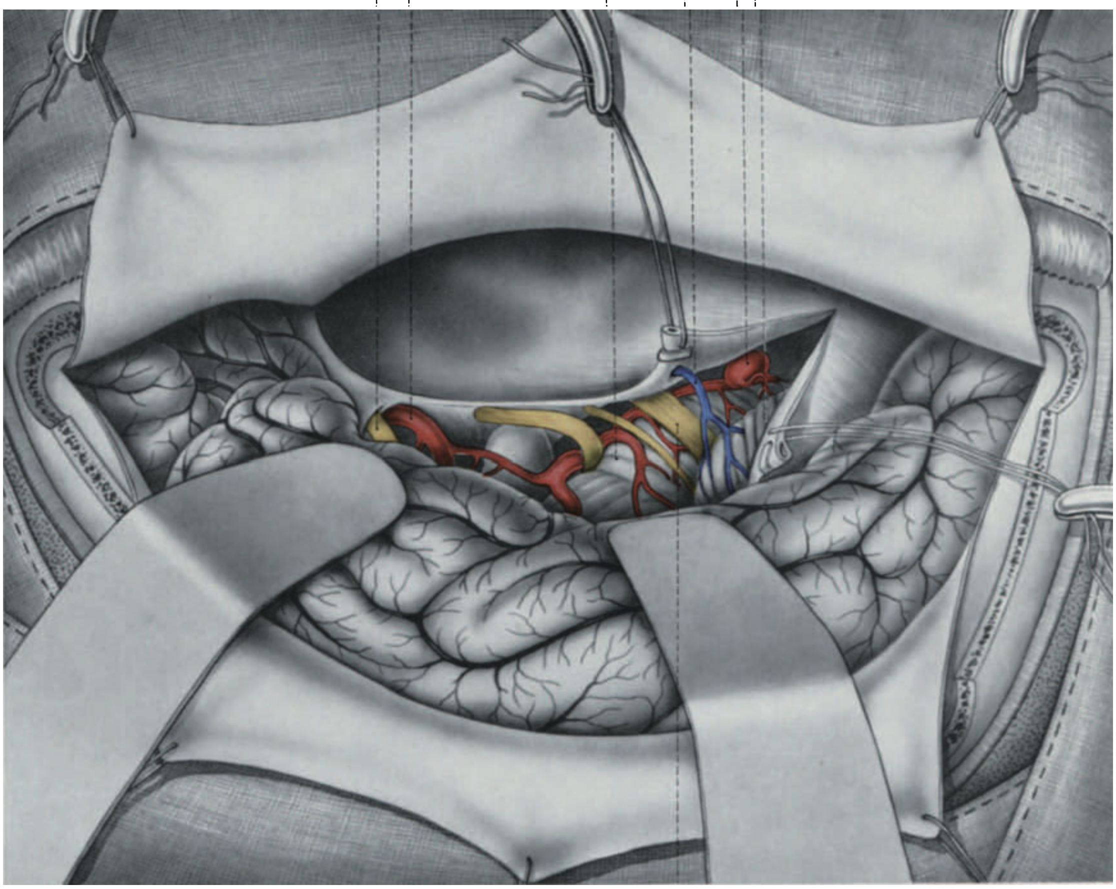


Fig. 281. Operative view of aneurysm of basilar artery at junction of right anterior inferior cerebellar artery. *Observe:* This exposure also shows the superior petrosal vein and the root of the trigeminal nerve.

Chapter XXI

Subtemporal Meningioma

(Medial Tentorial Meningioma with Extension into the Posterior Fossa)

Meningiomas situated near the petrous ridge and the tentorial edge receive their blood supply from branches of the intracavernous sinus portion of the internal carotid artery (tentorial artery of BERNASCONI and CASSINARI). Fig. 282 outlines the topographic aspects of the tentorial meningioma where the main blood supply from the internal carotid artery runs close to the tentorial edge. The tumor reaches down subtentorially and compresses the cerebral peduncle on the left side. This example will be used to demonstrate the surgical removal, and Fig. 283 shows a complete view of the relationships of the tumor as seen by looking from the right side through the open skull. It will be recognized that about 35 per cent of the tumor mass extends below the tentorium and rests on the superior surface of the cerebellum or, more cogently stated, indents the superior surface of the cerebellum.

The position of the patient on the operating table is seen in Fig. 284a or b. The skin incision and craniotomy are outlined in Fig. 285. The opening extends about 6 cm posterior to the external acoustic meatus. Reflecting the dura down towards the transverse sinus exposes the temporal lobe. If at all possible the vein of Labbé is spared. The tumor may be approached more anteriorly than seen in this picture if only one large communicating vein in the form of the vein of Labbé is present and has to be preserved. In this latter situation, the anterior aspect of the temporal lobe is then freed by sectioning the draining veins over the tip of the temporal lobe as seen in Fig. 276, p. 209. However, in the case presented here the veins leading to the transverse and sigmoid sinuses can be coagulated and cut and the draining veins over the anterior part of the temporal lobe are therefore left intact. The posterior part of the temporal lobe is then elevated. As soon as a part of the tumor comes into view a wet cottonoid is placed against the tumor wall and a brain spatula is guided into the line of cleavage between the tumor and the under and medial surfaces of the temporal lobe. Should the tumor be very large in size, an intracapsular removal is done using the wire loop electrode. In the case presented the tumor size permits complete isolation of the temporal lobe from the tumor (Fig. 286). The small branches which come from the posterior cerebral artery and go to the tumor are coagulated and sectioned. The wire loop electrode is not used over the medial extent of the tumor to prevent injury to the cerebral peduncle. Also, the tentorium is avoided by the wire loop electrode because the main blood supply to the tumor may be interrupted without any proximal control. After the tumor has been partially reduced in size by the wire loop or sharp spoon curette, the extent of its attachment to the tentorium is determined by palpating and partly freeing the tumor from its base with a fine brain spatula (Fig. 286). If the tumor has a subtentorial extension, either the tentorium is incised around the tumor avoiding the petrous ridge with the superior petrosal sinus or, preferably, the tentorium is opened just lateral to the tumor (Fig. 287) to obtain information as to the extent of the tumor projecting into the posterior fossa. The tumor is then pulled medially and the incision is advanced towards the medial side, or in other words, towards the tentorial edge. The remaining shell of the tumor is dislodged from its base with hemostasis obtained by bipolar coagulation. A large clip has to be applied towards the tentorial edge to obliterate the meningeal branch from the internal carotid artery (tentorial artery) (Fig. 288). The tumor is carefully freed from the superior surface of the cerebellum by using a wet cottonoid

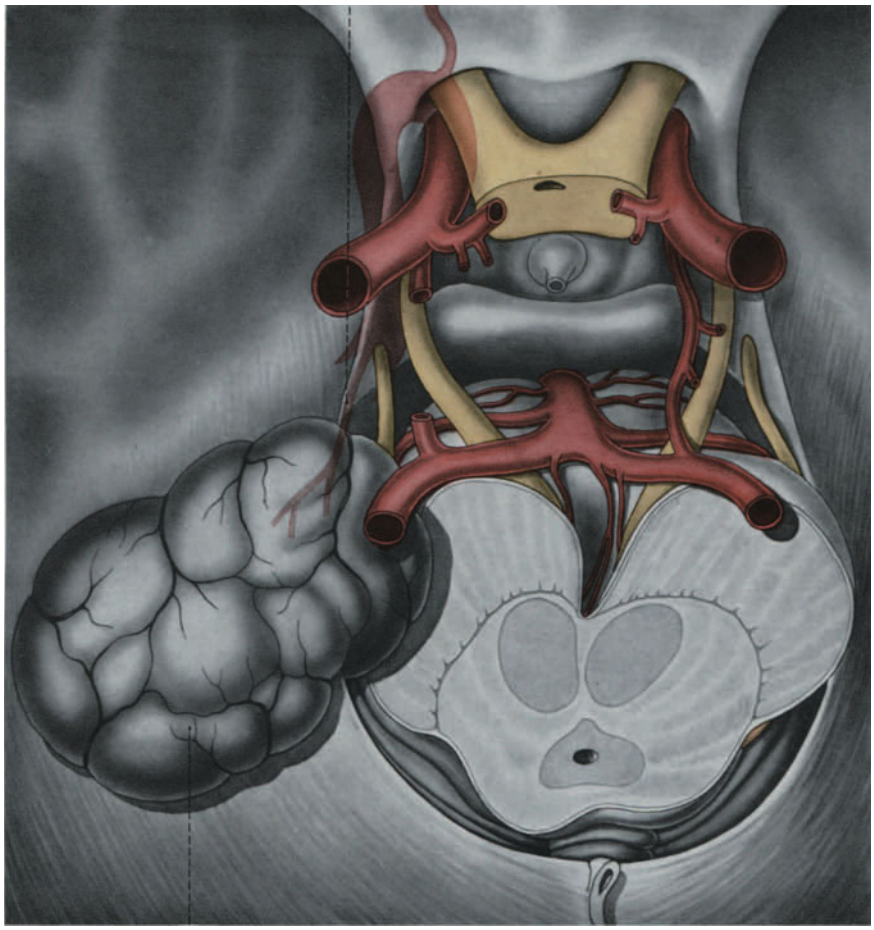


Fig. 282. Topographical demonstration of left tentorial meningioma situated medially. *Observe:* Main blood supply of tumor from tentorial artery.

to protect the cerebellum and by steadily lifting the tumor. Possible adherence of the tumor to the fourth nerve and superior cerebellar artery is kept in mind (Fig. 282 and 289). Fig. 289 reveals the situation after removal of the tumor. Part of the tentorium has to be excised but care is taken *not* to enter the posterior extent of the cavernous sinus or the lateral extent of the petrosal sinus. Should the tumor have invaded the petrosal and cavernous sinuses, that part of the tumor may have to be left in place. Careful bipolar coagulation may destroy such retained tumor, but the proximity of the tumor base to these sinuses, the internal carotid artery, and the third, fourth and fifth cranial nerves has to be kept in mind (compare Fig. 281, p. 214) and may limit further operative extirpation.

Fig. 283. Tentorial meningioma situated medially.
Observe: Extension of tumor into the posterior fossa.

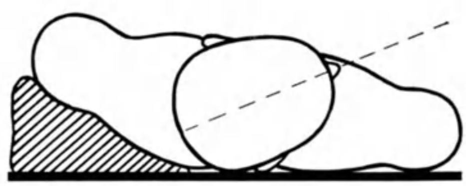


Fig. 284 a.

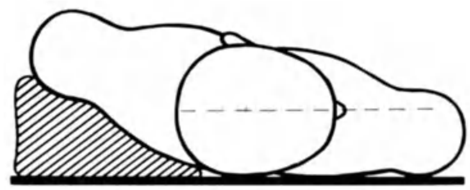


Fig. 284 b.

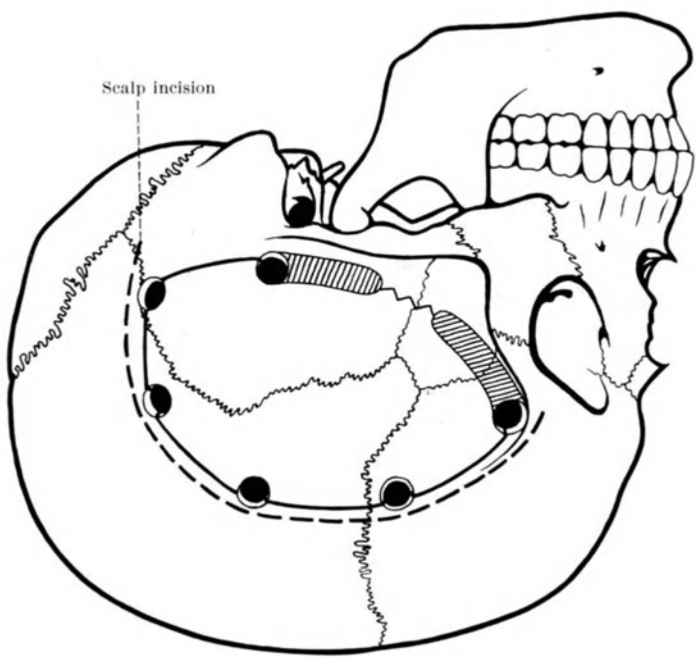


Fig. 285. Skin incision and craniotomy for tentorial meningioma situated medially at left tentorial edge.

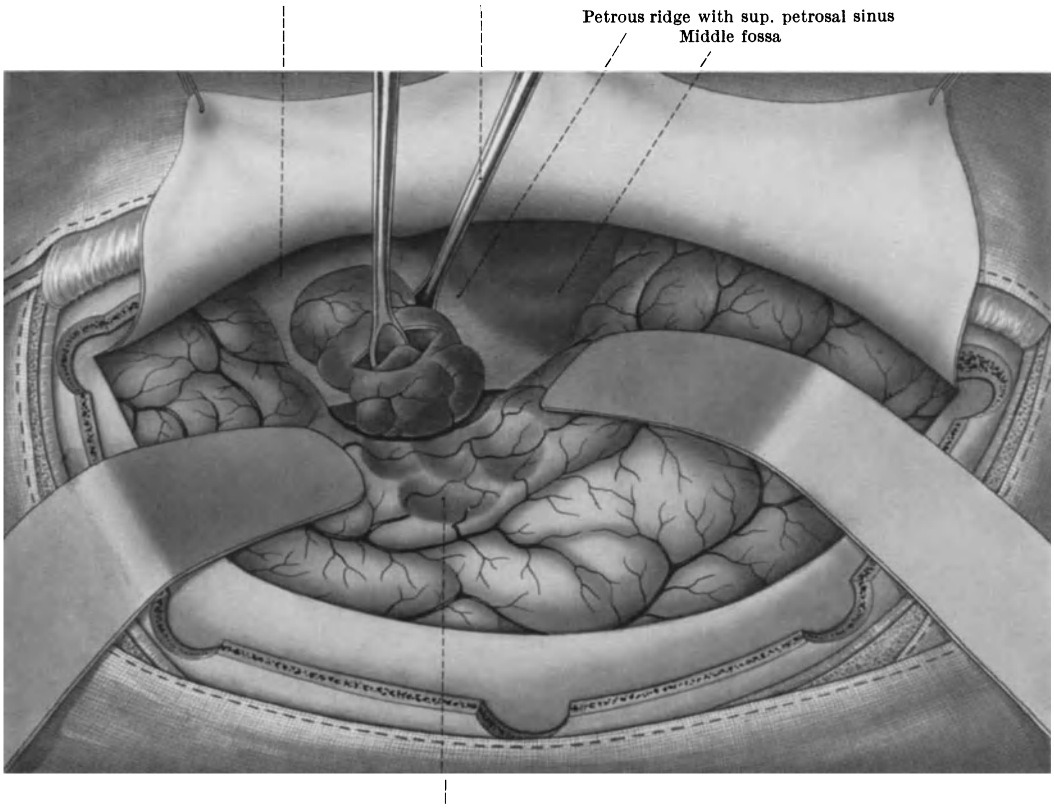


Fig. 286. Operative view of medial tentorial meningioma.
Observe: Reduction of tumor bulk by sharp spoon curettement within tumor.

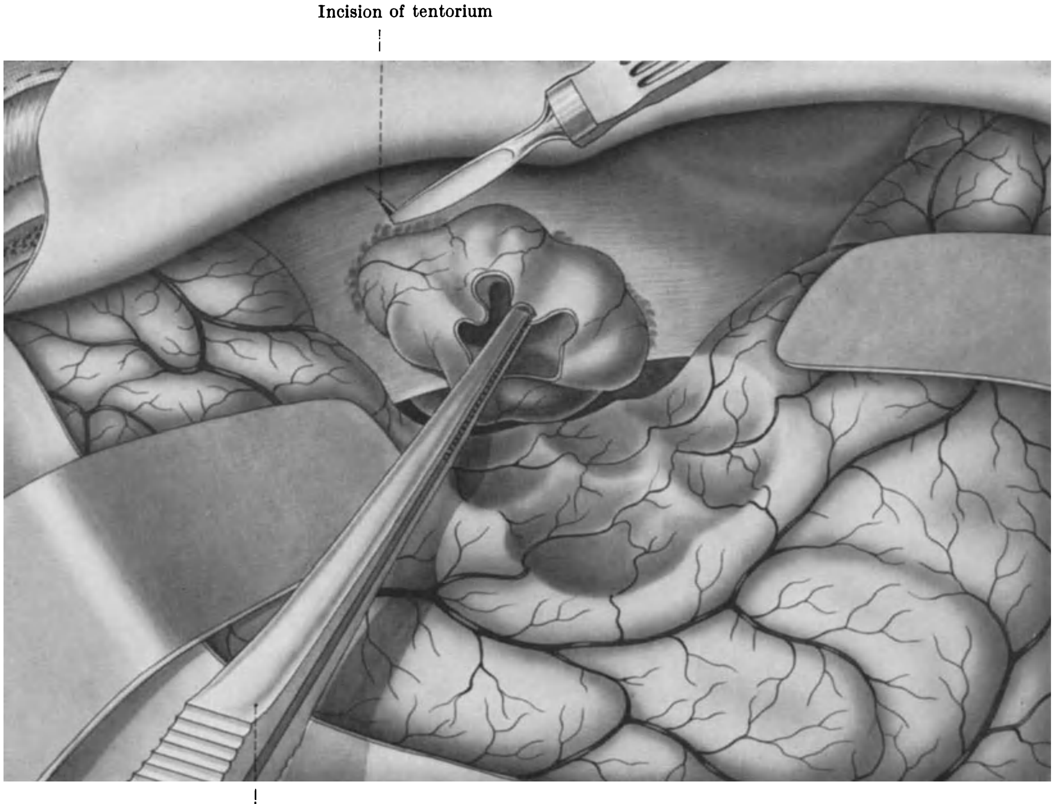


Fig. 287. Initial step for removing infratentorial portion of tumor.

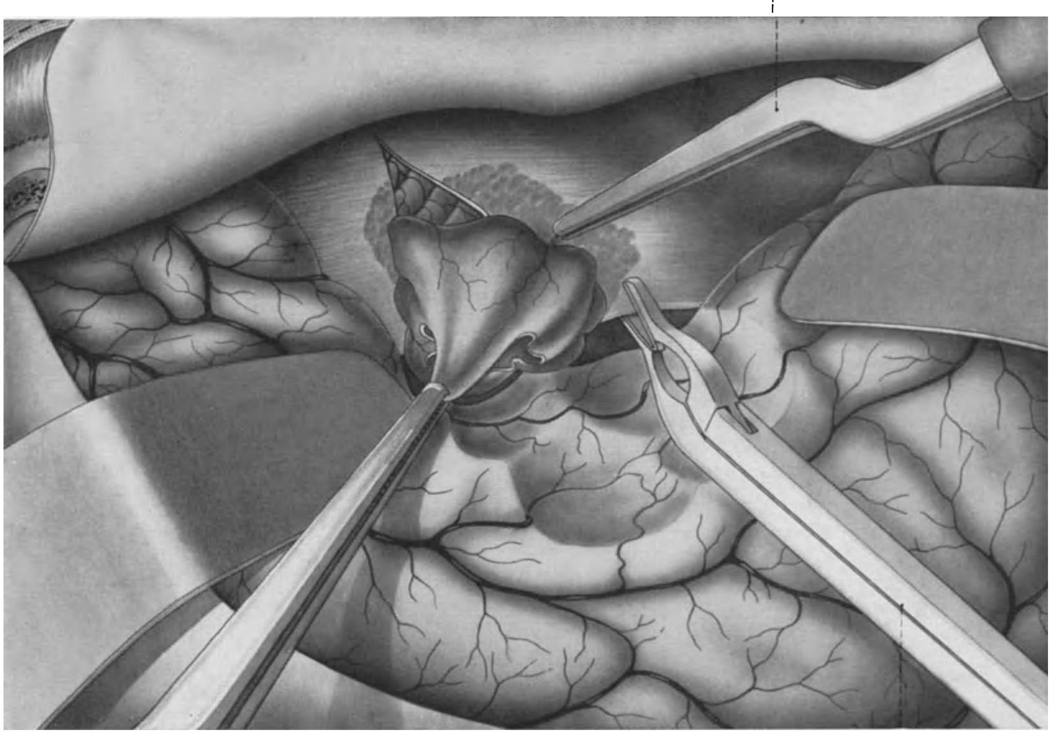


Fig. 288. Obliteration of the main blood supply to tumor by clipping of tentorial edge containing feeding artery (see also Fig. 282).

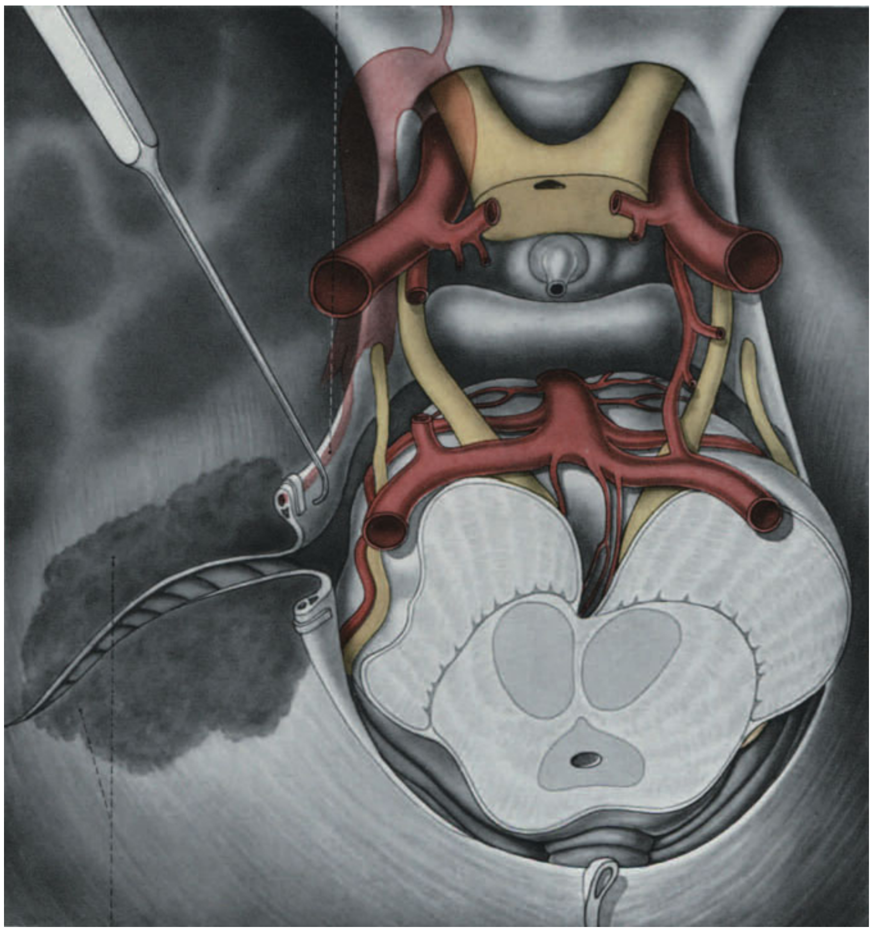


Fig. 289. Schematic demonstration of tumor bed (insertion on tentorium) and divided tentorial artery. *Observe:* Origin of tentorial artery from intracavernous portion of internal carotid artery.

Chapter XXII

Clivus Meningioma

In this chapter we could recapitulate what was stated about the sellar and parasellar tumors (pituitary adenoma, craniopharyngioma, tuberculum sella meningioma, and medial sphenoid ridge meningioma); however, it is not the removal of the tumor alone which has to be considered but it is the surrounding structures, vessels and brain which, in certain locations (diencephalon and mesencephalon), should not be damaged because of the disastrous sequelae. In the case of a clivus tumor, as seen in Fig. 291 and 293, removal is technically feasible but carries a great risk of infarction to (1) the part of the diencephalon which receives its blood supply from the small vessels from the posterior communicating artery and (2) the part of the mesencephalon which receives its blood supply via the posterior perforated substance. In the tremendous stretching, distortion or compression the cerebral vasculature and substance will suffer little from a very slow growing tumor and can be astonishingly compatible with life and function (Fig. 290 to 293). These figures are composite drawings from 14 tumors and 18 operative procedures. Fig. 292 and 293 give the view of the lesion from above after removal of the brain. Only one of the small perforating vessels is shown coming off the posterior communicating artery (Fig. 293). From the illustrations and statements it should be obvious that great care has to be taken to keep the vascular structures intact and prevent thrombosis from any prolonged handling. Just decompression of the prolonged compressed central nervous system structures may lead to infarction. Gluco-corticoid medication has reduced this hazard slightly.

The operative approach to a midline, upper clivus lesion is from the right, nondominant, hemisphere. The position of the patient is seen in Fig. 294a or b. The scalp incision and craniotomy are outlined in Fig. 295. The squama of the temporal bone and part of the large sphenoid wing need to be removed to bring the opening down to the floor of the temporal fossa. The shaded area in Fig. 295 indicates the part of the bone to be rongeured. The bridging veins over the anterior extent of the temporal lobe are coagulated and cut to allow elevation of the temporal lobe (Fig. 296). By the use of wet cotton strips and the brain spatula, a line of cleavage between the medial aspect of the temporal lobe and the tumor is found, widened and maintained. Keeping the important vascular and nervous structures in mind, the tumor is nibbled away by entering it in an area free of nerves and vessels (Fig. 297). Tumor tissue is removed only in the direction where we know, even allowing for the great distortion of normal anatomy that no important structures will be encountered. Preoperative angiography and pneumoencephalography will give some insight into this problem; however, we will have little information about the adherence or complete envelopment of a vessel by the tumor.

Diminishing the tumor in size by freeing the important brain and vascular structures under complete vision can be accomplished without undue trauma (Fig. 298). In the removal of these usually highly vascular lesions we should not proceed to a point where bleeding becomes so profuse that only the use of a bulky tamponade will stop it. To avoid such a bulky tamponade, which may even be bigger than the neoplasm we are trying to remove, the following safeguards in the operative steps are to be taken. The feeding vessels to the clivus meningioma are short meningeal branches (Fig. 291) which come from lateral to medial from both internal carotid arteries and are only visible on subtraction angiography of the submental vertex view. Accordingly the removal of such tumors first begins laterally where the main feeding vessels can be plugged with small pieces of muscle, surgicel or gelfoam to control the bleeding and thereby assist in the further removal of the tumor. The possible invasion of tumor into the posterior extent of the cavernous sinus has to be kept in mind and if this invasion occurs some tumor may have to be left in place.

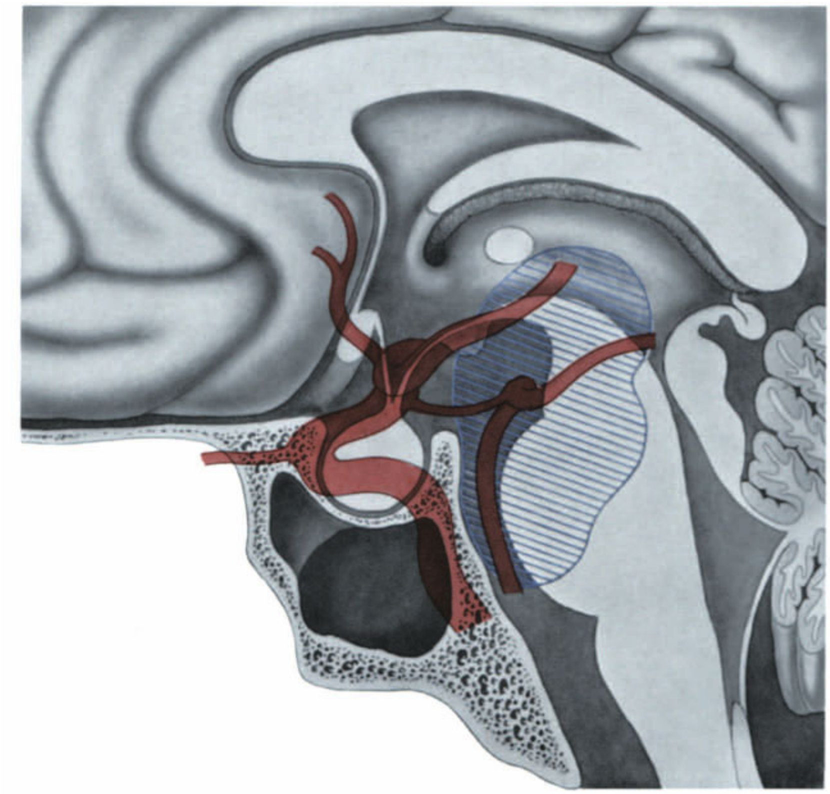


Fig. 290. Sagittal section of clivus meningioma superimposed on normal intracranial anatomical structures

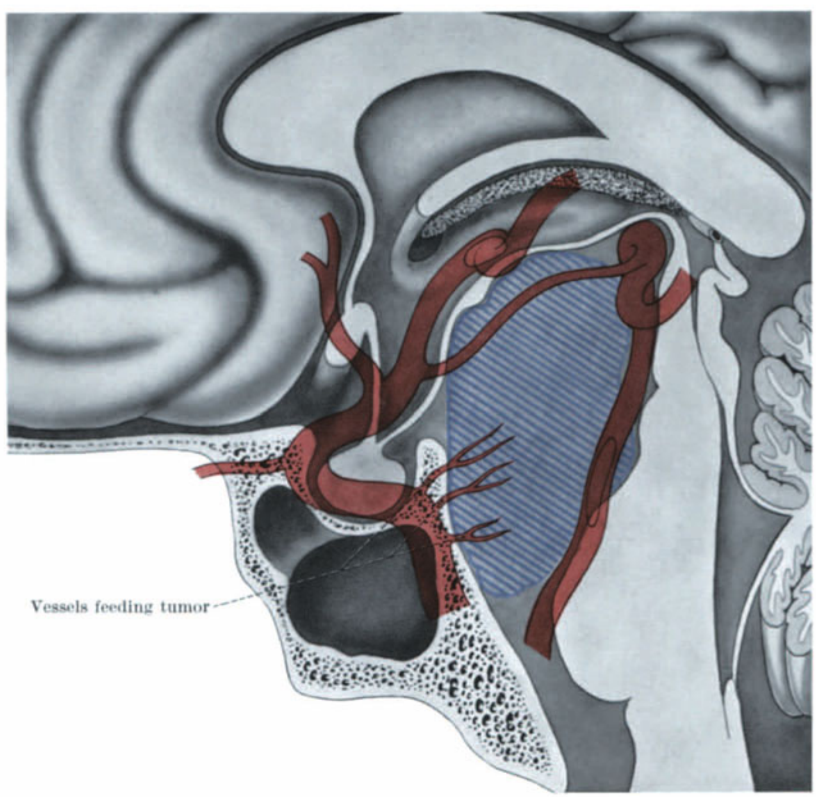


Fig. 291. Sagittal section of clivus meningioma distorting intracranial structures.

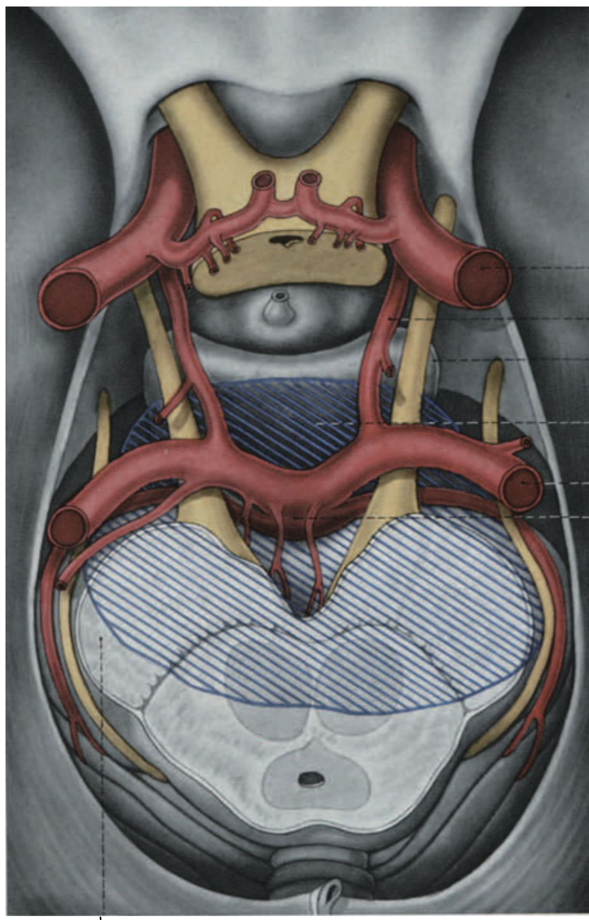


Fig. 292. Drawing of clivus tumor superimposed on normal anatomical structures.

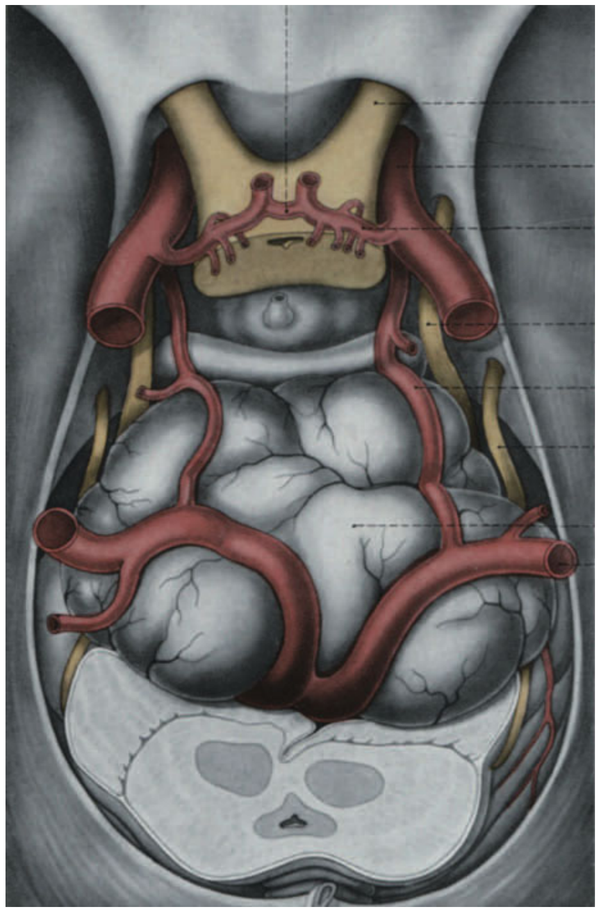


Fig. 293. Topographic presentation showing distortion of intracranial structures by clivus meningioma.

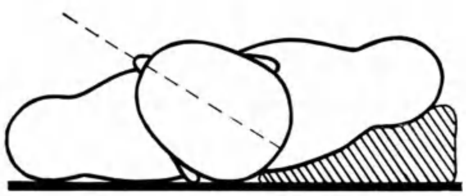


Fig. 294 a.

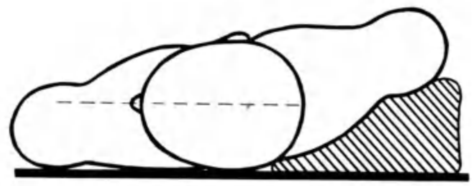


Fig. 294 b.

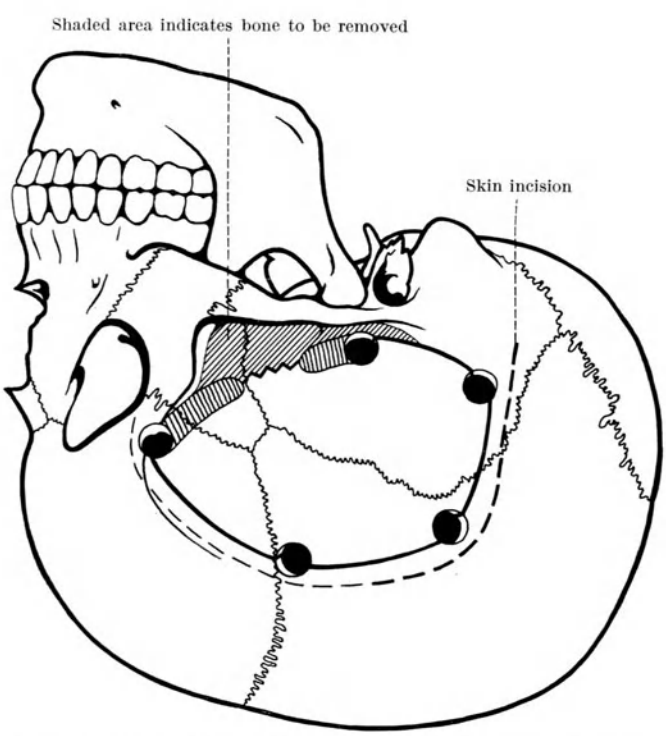


Fig. 295. Skin incision and craniotomy for clivus meningioma.
Observe: 1. Shaded portion shows bone to be removed. 2. Operative approach from non-dominant right side.

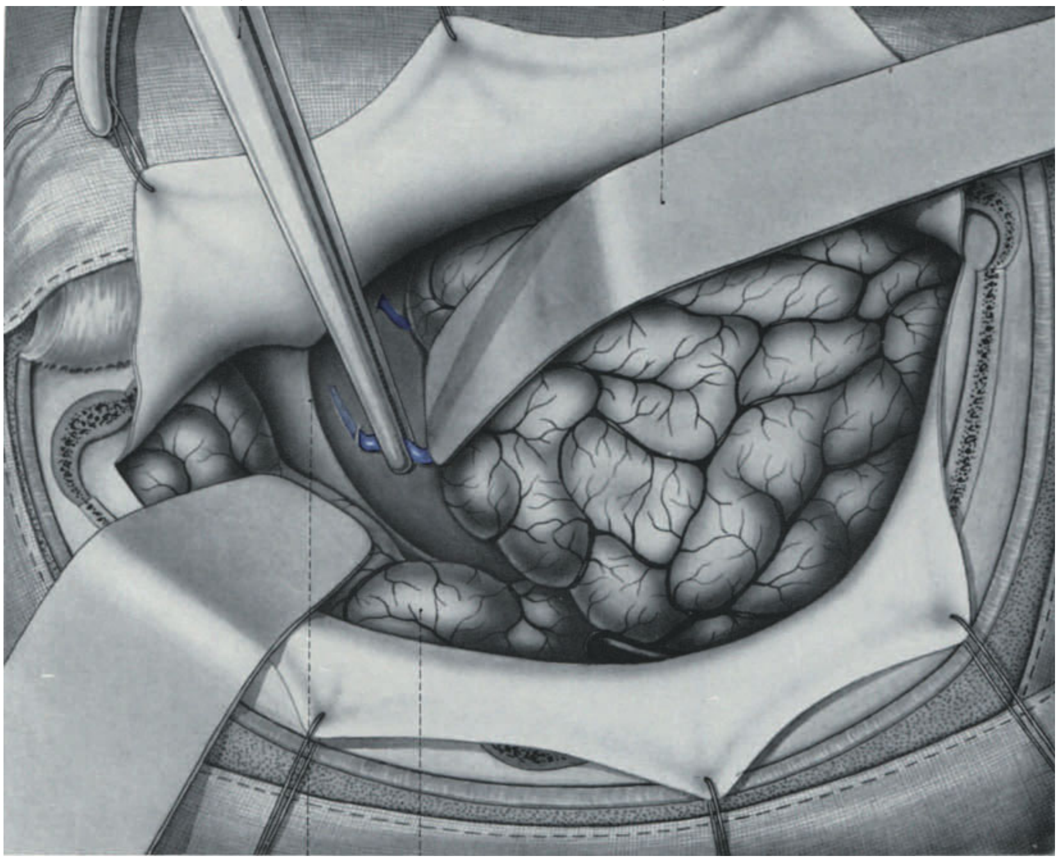


Fig. 296. Coagulation of bridging veins over tip of right temporal lobe.

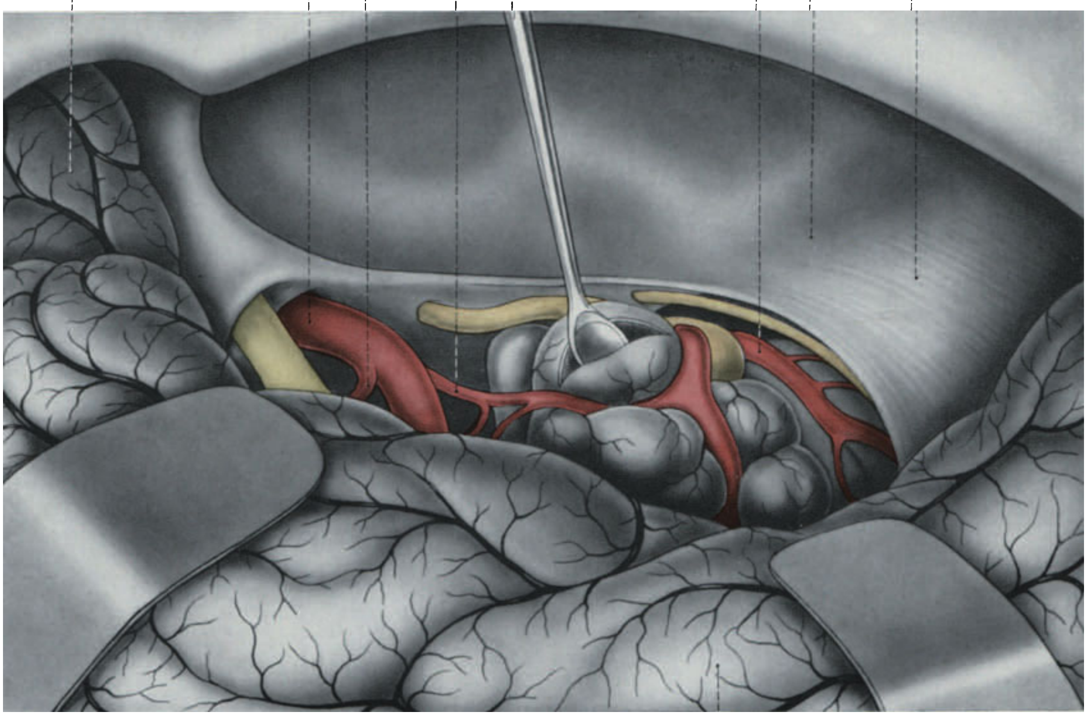


Fig. 297. Reduction of tumor size by sharp spoon curettement within tumor.
Observe: For clarity the arachnoid is not shown.

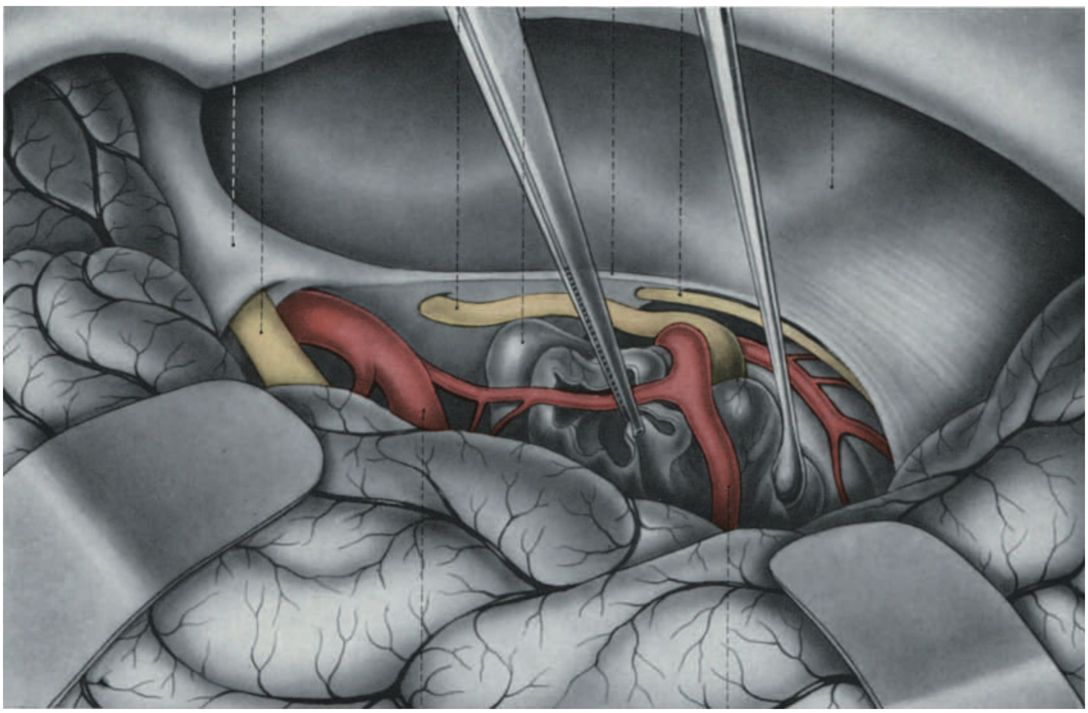


Fig. 298. Freeing shell of tumor from surrounding structures.

Chapter XXIII

Lateral Tentorial Meningiomas

Twelve meningiomas situated in the region of the asterion have been operated upon over the past 18 years at Walter Reed General Hospital. These tumors invaded the transverse sinus at its junction into the sigmoid sinus. The superior petrosal sinus which enters the transverse sinus in this area had to be ligated separately only in two instances. However, most of these tumors did extend from the middle into the posterior fossa and required a combined temporal-suboccipital craniectomy. In Fig. 299 an anatomical drawing outlines the relationships of the tumor to the skull, dura, dural sinus, and tentorium. The temporal lobe, the cerebellum, the tumor and its invasion into the transverse sigmoid sinus are seen in a coronal section (Fig. 300). The main blood supply to the asterion meningioma comes from the middle meningeal artery and the occipital artery. The richness of this blood supply demonstrated angiographically will help decide if ligation of the external carotid artery should be done prior to removal of the tumor.

There are two ways to position the patient for surgery, either prone or sitting. However, both have their advantages and disadvantages. The prone position (Fig. 301) is often fraught with more bleeding and may not be as comfortable to the surgeon. In the sitting position (Fig. 302, controlled hyperventilation should not be used because of the risk of air embolism. The patient should be in a pressure suit as a precaution against sudden drop in blood pressure.

The skin incision starts in front of the ear, sweeps around and comes down between the mastoid process and the external occipital protuberance (Figs. 303 and 304). A craniectomy, not a craniotomy, is done as outlined in Fig. 303. Two separate burr holes are made over the temporal and over the posterior fossa (Fig. 303). These burr holes are enlarged by the rongeur. The incision in the dura is outlined in Fig. 304 and should be carried parallel above and below the dural sinus. This further exposure will facilitate access to and ligation of the transverse sigmoid sinus. As we stated previously in the earlier chapter on meningiomas, bilateral angiography is required. These studies are important not only to reveal the blood supply to the tumor and to see the extent of the tumor by the blush in the venous phase, but also to study the patency and/or presence of the dural sinuses. If the opposite transverse sigmoid sinus is patent, and the superior sagittal and straight sinuses each draining bilaterally the involved sinus can be clamped and then ligated (Figs. 305 to 307). The cerebrum and cerebellum are freed from the tumor using wet cotton strips (which are not shown for the sake, of clarity. The dura attached to the tumor is used for traction (Fig. 306) in delivery and exposure of the tentorium around the tumor (Fig. 306). The dura is closed using a free graft of pericranium or synthetic dura substitute (Fig. 308). Methylmethacrylate cranioplasty may be used to cover the skull defect.

There are certain surgical principles common to the operative management of meningiomas and they are not repeated in each chapter dealing with meningiomas. It may therefore be recommended here to review Chapters VI, VIII, IX, XI, XXII, XXIII together.

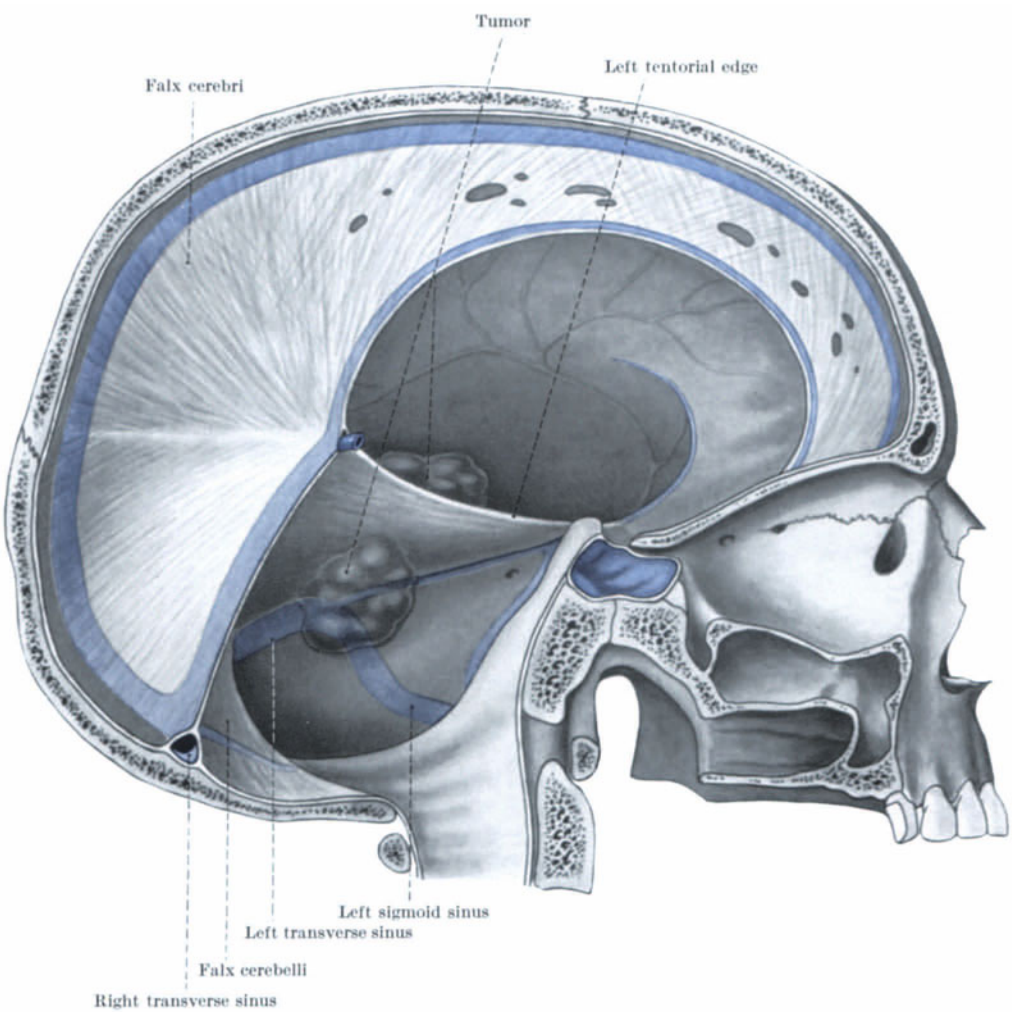


Fig. 299. Anatomical demonstration of left lateral tentorial meningioma.
Observe: 1. Extent of tumor into middle and posterior fossa. 2. Relationship of tumor to transverse and sigmoid sinus.

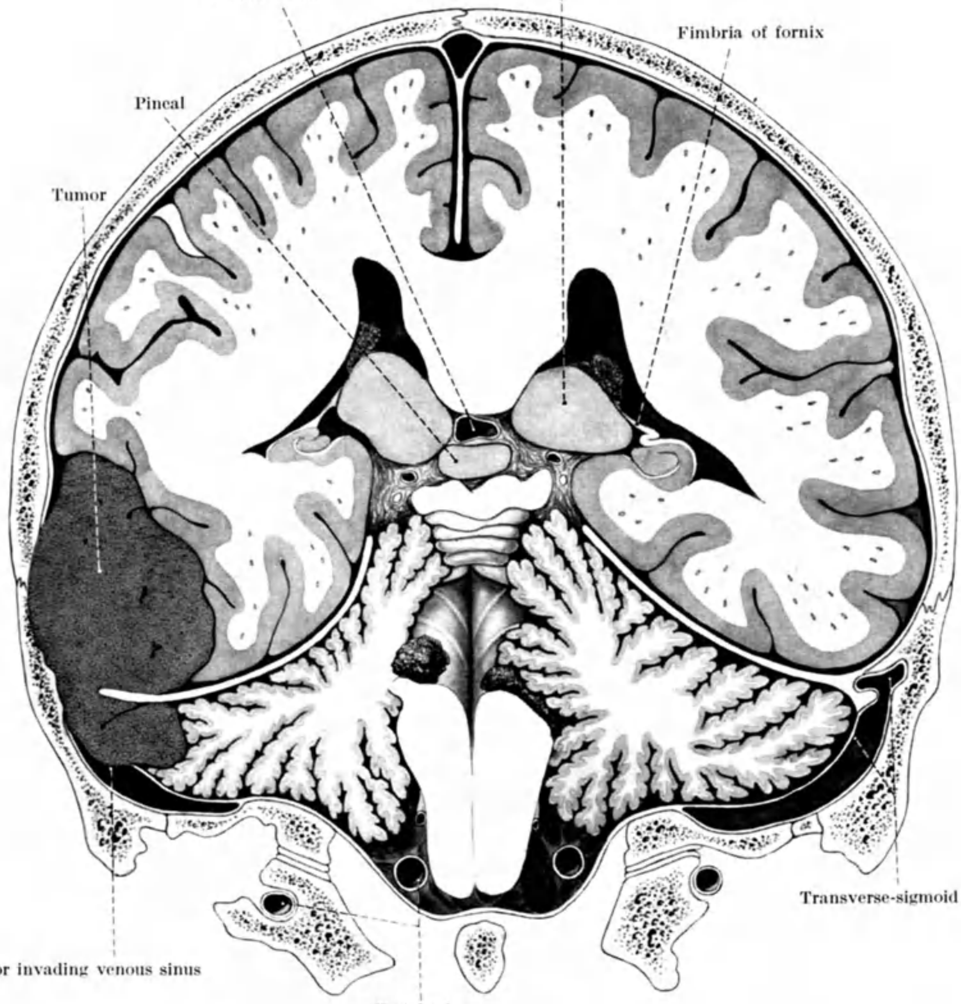


Fig. 300. Anatomical demonstration of left lateral tentorial meningioma in a coronal section at the level of the pineal body (p.a. view).

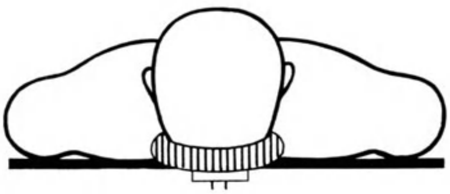


Fig. 301.

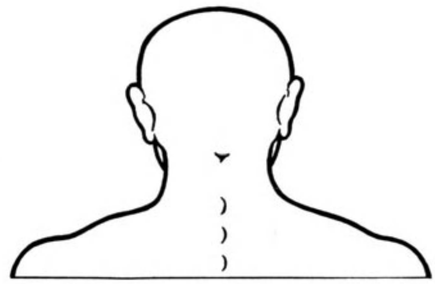


Fig. 302.

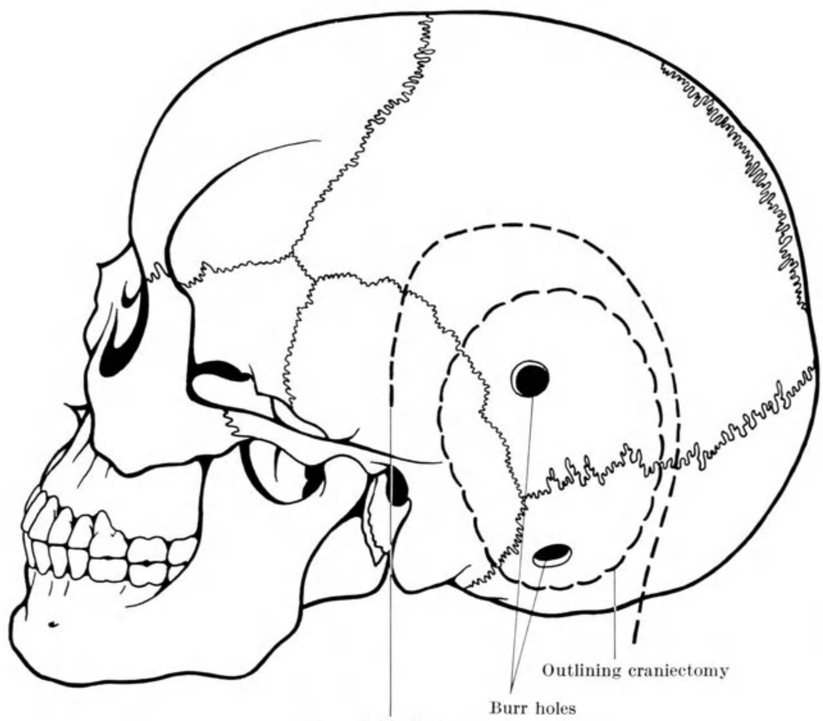


Fig. 303. Skin incision and craniectomy for left lateral tentorial meningioma.
Observe: Placement of burr holes above and below transverse sinus (overlying middle and posterior fossa respectively).

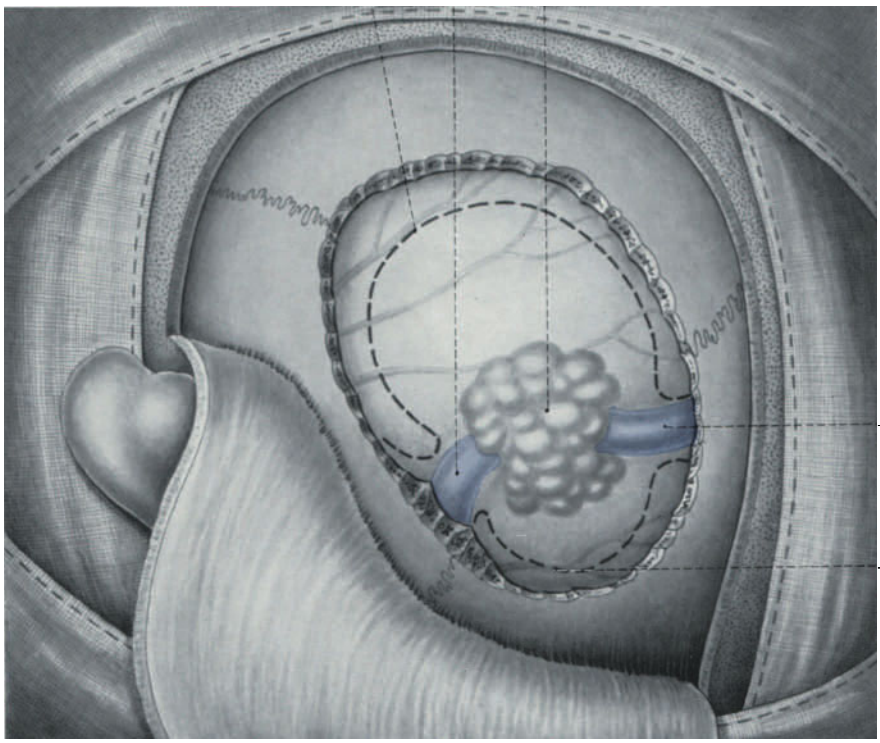


Fig. 304. Craniectomy for left lateral tentorial meningioma extending over middle and posterior fossa. *Observe:* Dural incision extends along transverse-sigmoid sinus to facilitate ligation of sinus.

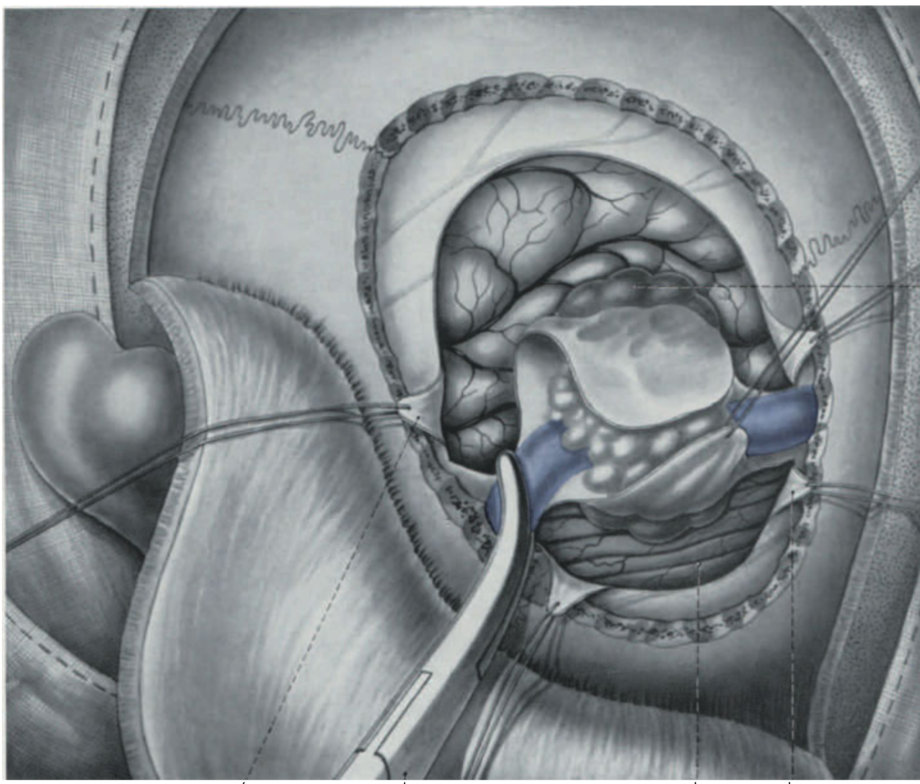


Fig. 305. Operative view of lateral tentorial meningioma after opening of dura. *Observe:* Reflection of dura to expose venous sinus.

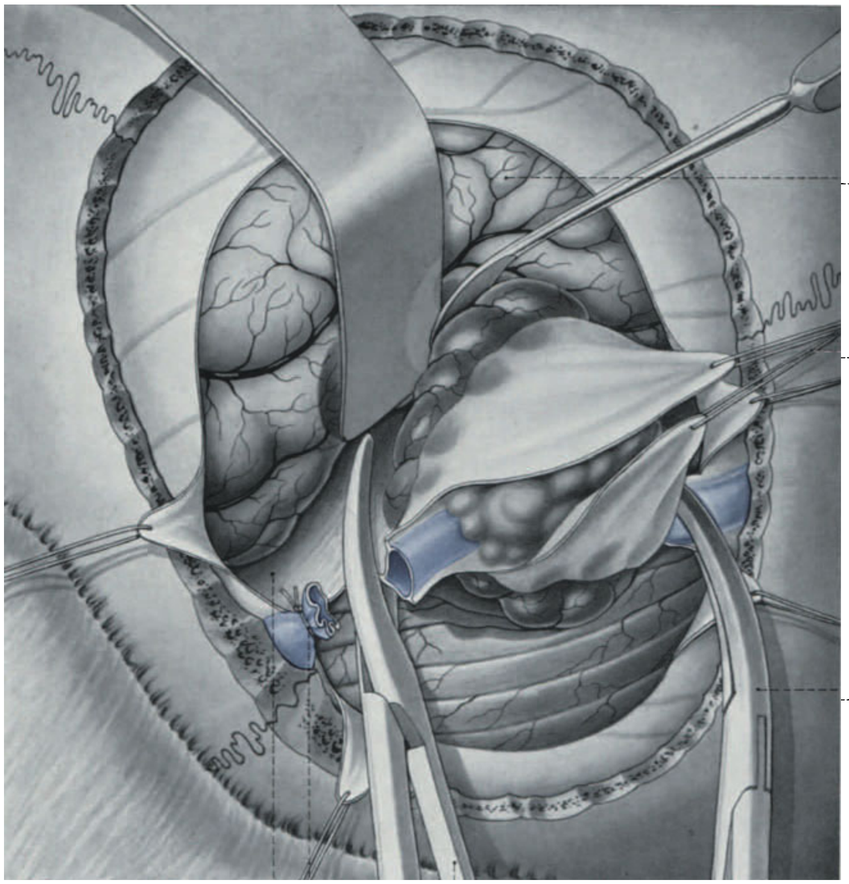


Fig. 306. Incision of tentorium.

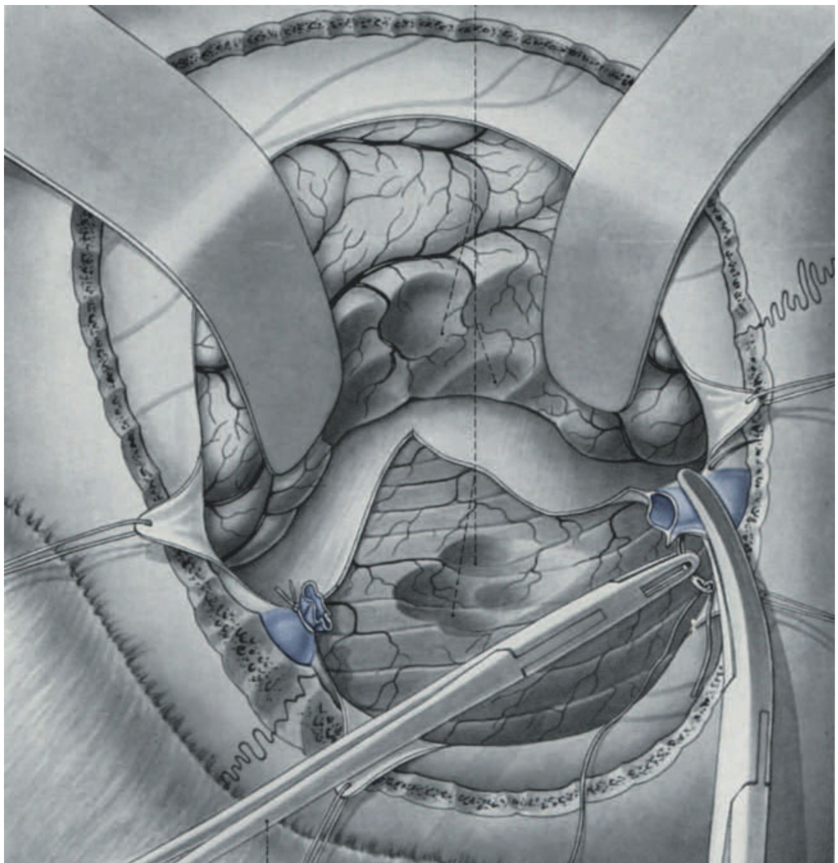


Fig. 307. Operative view after removal of left lateral tentorial meningioma.

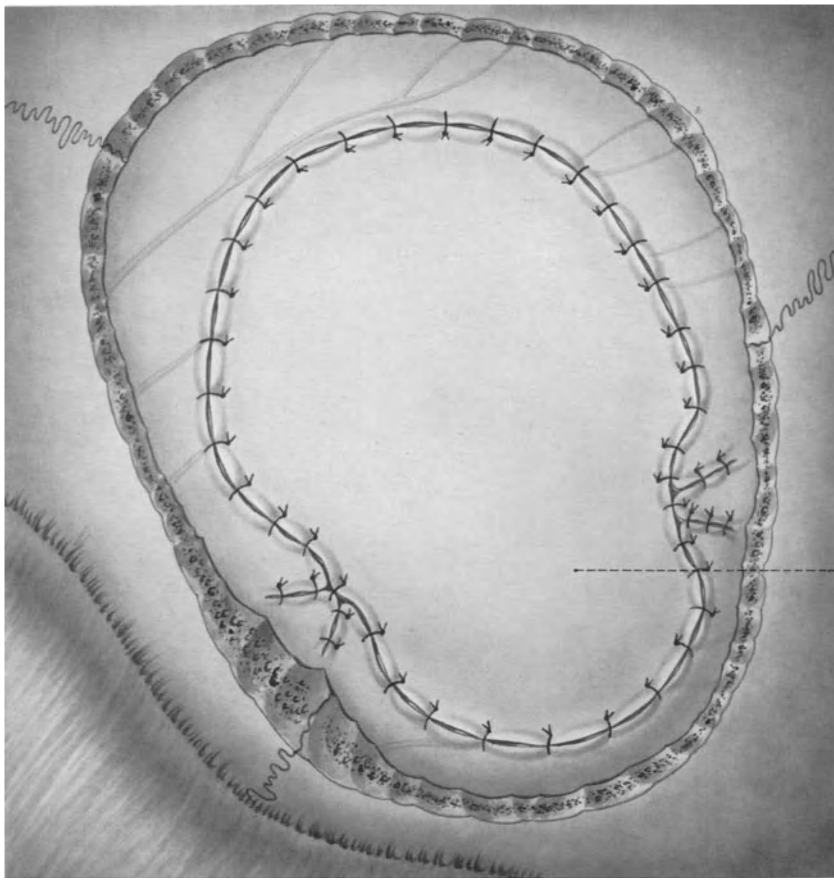


Fig. 308. Dural closure by fascial or pericranial tissue graft after removal of left lateral tentorial meningioma involving middle and posterior fossa.

Chapter XXIV

Occipital Lobectomy

Many of the reasons for removal of a cerebral lobe are stated in Chapter VII (Frontal Lobectomy). The most common occasion necessitating removal of the occipital lobe and posterior parietal lobe, as shown here, is for internal decompression of malignant gliomas, certain arteriovenous malformations and large meningiomas over the torcular region.

The scalp incision and craniotomy are seen in Figs. 309, 310. It will be recognized that the scalp flap is opened toward the occipital area to preserve the main blood supply from the occipital artery. This incision will also leave the greater and lesser occipital nerves intact. The craniotomy (Figs. 309, 310) is about 1 cm lateral to the superior sagittal sinus and an equal distance above the transverse sinus. If the surgical procedure is being done for a torcular meningioma, the craniotomy must be extended across the midline and below the transverse sinuses so that all sinuses draining into the confluens of sinuses can be controlled, in keeping with the principles discussed for surgery of meningiomas which involve a dural sinus (see Chapters XI, XII and XXIII).

The position of the patient on the operating table is depicted in Fig. 311. After removal of the free bone flap the dura is incised in such a way as to permit reflection toward the superior sagittal sinus and the transverse sinus (Fig. 312 and 313). The veins bridging towards these sinuses are coagulated and cut close to the brain side. Fig. 313 shows the line of incision into the cortex which is carried circumferentially as far as possible. For the step by step details in incising the cerebral cortex, Chapter VII, p. 98, may be consulted. The white matter is divided with a blunt instrument (compare Fig. 261). If the occipital horn of the lateral ventricle is entered this opening is covered by a wet cotton strip to prevent blood from entering the ventricular system. In the depths of the calcarine fissure the posterior cerebral artery is clipped, sectioned, and divided. The last step in the removal of the occipital lobe is the separation of the occipital pole from the very rich draining veins that enter the confluens of sinuses (torcular Herophili). Holding the resected occipital posterior parietal lobe in one hand and feeling the bridging veins with the tips of the fingers of the same hand will assist in the clipping and coagulating of these bridging veins (Fig. 314). The very large draining veins may be successfully coagulated with bipolar coagulation forceps but it is important to coagulate near the brain and not near the sinuses. Finally, the remaining cavity (Fig. 315) is filled with dripping wet cotton fluffs to control all bleeding from the smaller vessels (compare Chapter VII, p. 103, Fig. 139).

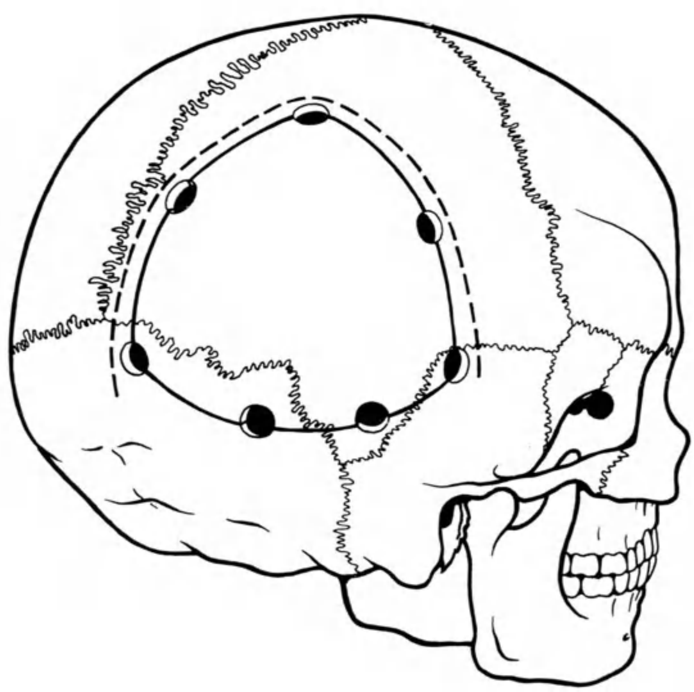


Fig. 309. Skin incision and craniotomy for right occipital lobectomy (interrupted line indicates incision of scalp).

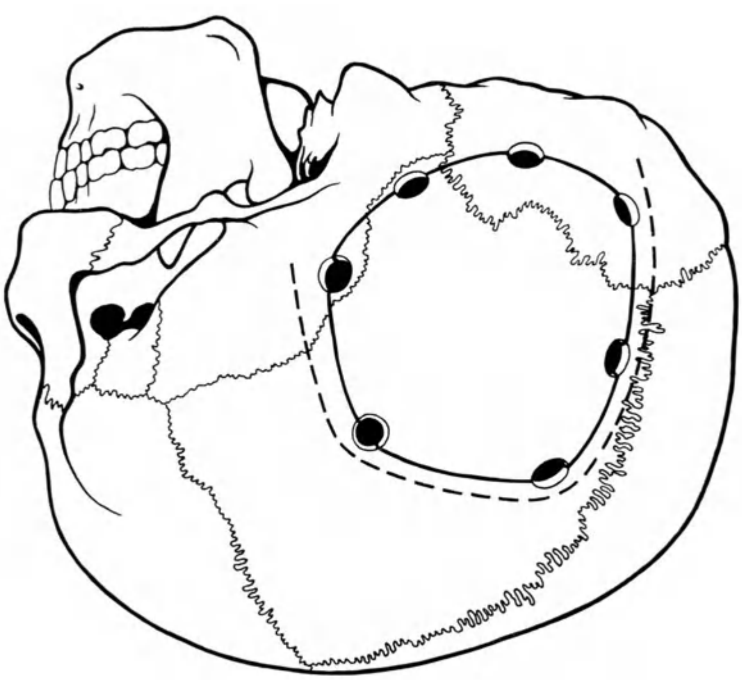


Fig. 310. Skin incision and craniotomy for occipital lobectomy in the position as seen by the surgeon.

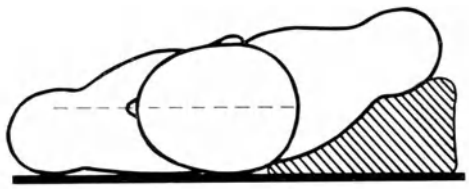


Fig. 311.

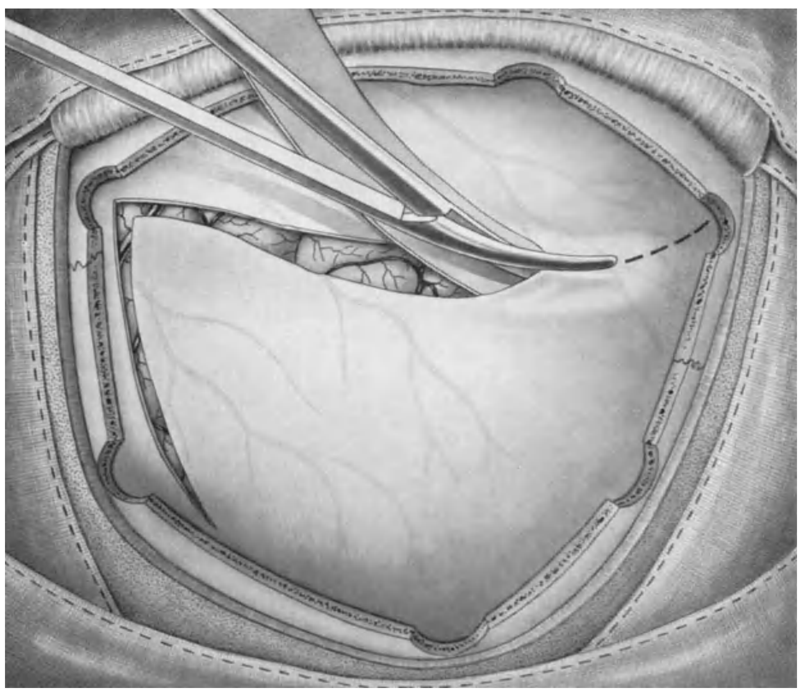


Fig. 312. Dural opening for occipital lobectomy.
Observe: Compare this drawing with Fig. 309 and Fig. 310 to visualize the position of the sagittal and transverse sinuses toward which the dura is reflected.

Fig. 313. Operative view of right occipital lobe.

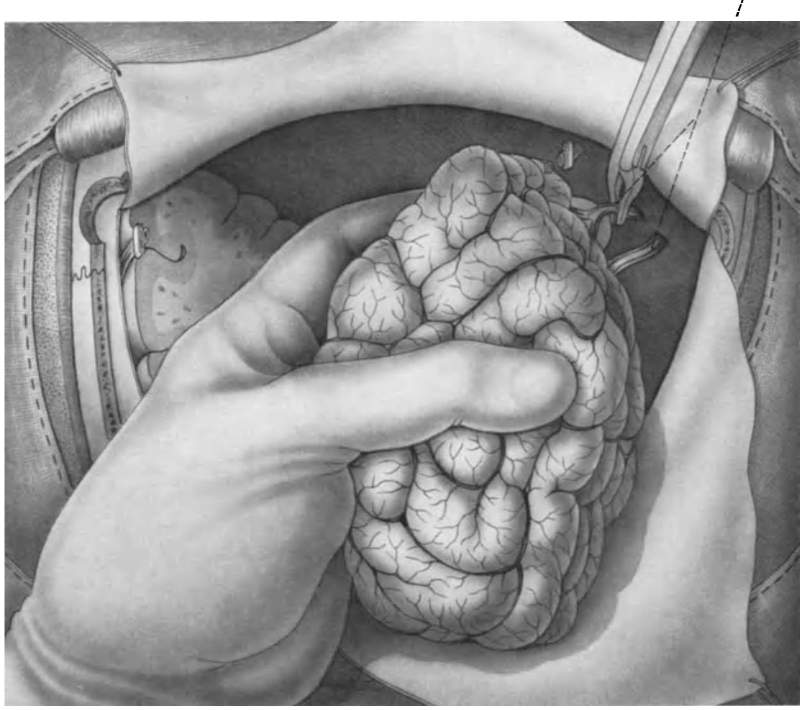


Fig. 314. Removal of right occipital lobe.
Observe: Clipping and transection of draining veins as the last step in the removal.

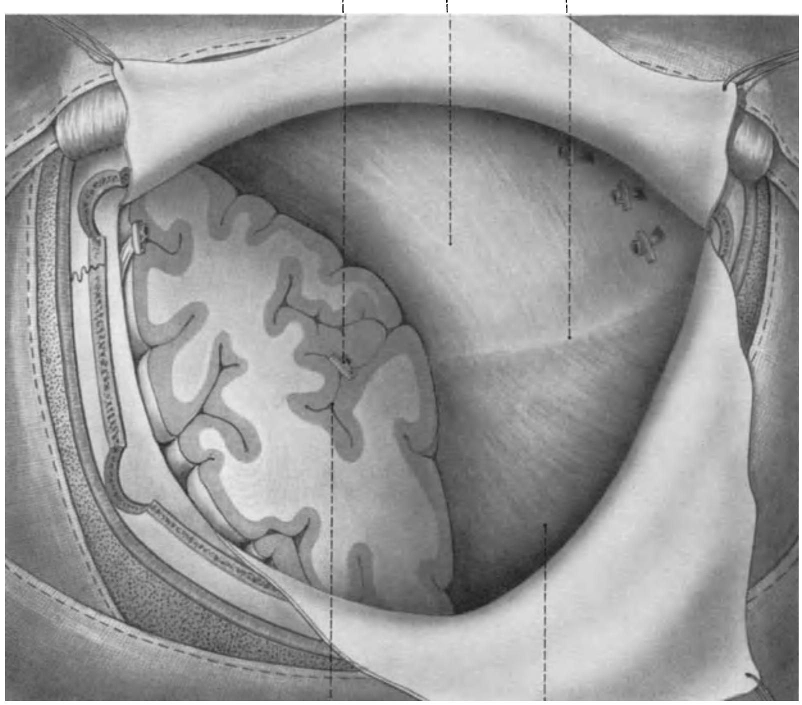


Fig. 315. Operative view after removal of right occipital lobe.
Observe: Position of posterior cerebral artery deep within the calcarine fissure.

Chapter XXV

Arteriovenous Malformation

The typical clinical symptoms of arteriovenous malformation are increasingly frequent and severe focal seizures, intermittent headaches and episodic attacks of headaches with stiffness of the neck. Pathologically these symptoms most often represent repeated subarachnoidal hemorrhage. Plain x-rays of the skull may show unusually large vascular channels and/or intracranial calcification. Auscultation over the cranium may reveal a bruit, especially if the extracranial circulation contributes. Serial angiography is not only the diagnostic method of choice but also essential to assess the operability and method of operative attack.

In regard to the operability and inoperability of an arteriovenous malformation the following criteria are pertinent. First, only if total removal of the lesion can be done is surgery indicated. Partial removal or division of the main arterial feeders only is worthless because vascular channels not seen initially will soon supply the anomaly. Secondly, ligation of a major blood vessel away from the lesion itself, for instance, the internal carotid artery in the neck, is not only of no value but is usually disastrous since the arteriovenous anomaly will demand its blood supply by its diminished pressure and resistances and will thereby upset the already possible precarious balance of blood supply to the brain. Thirdly, an arteriovenous malformation occupying, for instance, the main voluntary motor area is no contraindication to surgery if the removal is kept to the anomalous structures. No functioning neurons are in this area and therefore none are lost in removal. Next, it has been repeatedly observed that a most formidable lesion which receives its blood supply from branches of both the middle cerebral and anterior cerebral arteries and which can be approached only via the corona radiata close to the internal capsule, may in time become more accessible for operative removal. After repeated bleeding angiography has on occasion shown that such an arteriovenous malformation can surround itself by a mantel of thrombosed blood in the depths of the brain. The lesion, so to speak, can isolate itself thereby permitting total removal contrary to any initial impression. Finally, because of disastrous neurological deficits induced, a supratentorial arteriovenous malformation is inoperable if the basal ganglia are involved (Fig. 316).

The operative procedures of two arteriovenous malformations are presented: (1) A lesion over the left parietal lobe and (2) one predominantly intraventricular.

1. Arteriovenous Malformation over Left Parietal Lobe. The anatomical situation in a three dimensional drawing shows the arteriovenous malformation over the left parietal lobe (Fig. 317). The lesion is fed by the anterior and middle cerebral arteries. The depth of the lesion can be seen in a coronal section (Fig. 318). That picture demonstrates also that there could be few, if any, functioning neurons where the somatic sensory area should be. The steps in operating on arteriovenous malformation are: (1) To ligate the feeding vessels without disturbing the outflow, (2) to ligate these feeding arteries before they are distended and before they become most fragile, and (3) to stay close to the lesion after the main feeders have been ligated by using a very fine suction coagulation cannula.

The position of the patient on the operating table is depicted in Fig. 319a or b. As seen in Fig. 320 we extend the scalp incision and craniotomy over the midline. This step is essential to be able to handle any possible major bleeding from the dural sinus (Chapter XII, p. 142). The dura is opened and reflected toward the superior sagittal sinus. The feeding vessels from the anterior cerebral artery are identified by retracting the left hemisphere from the midline and falx (Fig. 321). Care is taken not to rupture the main

Fig. 316. Coronal section of inoperable arteriovenous malformation involving left basal ganglia and lateral ventricle.

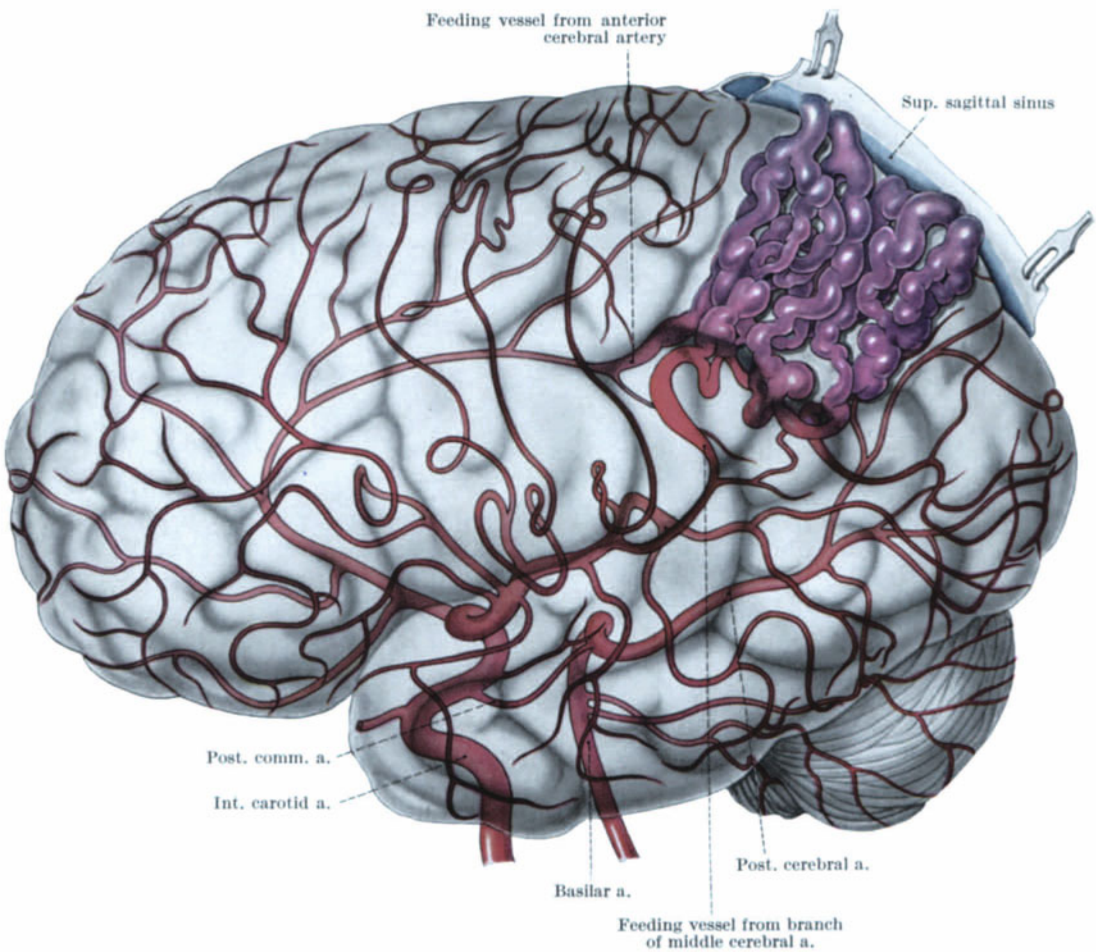


Fig. 317. Anatomical demonstration of arterio-venous malformation of left parietal lobe. *Observe:* Feeding vessels from middle and anterior cerebral arteries.

Fig. 318. Anatomical presentation of arterio-venous malformation over left parietal lobe in a coronal section.

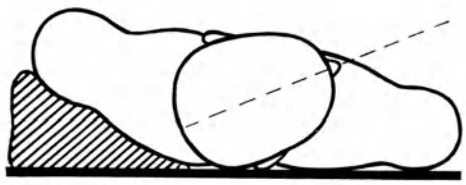


Fig. 319 a

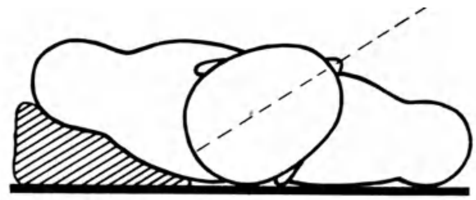


Fig. 319 b

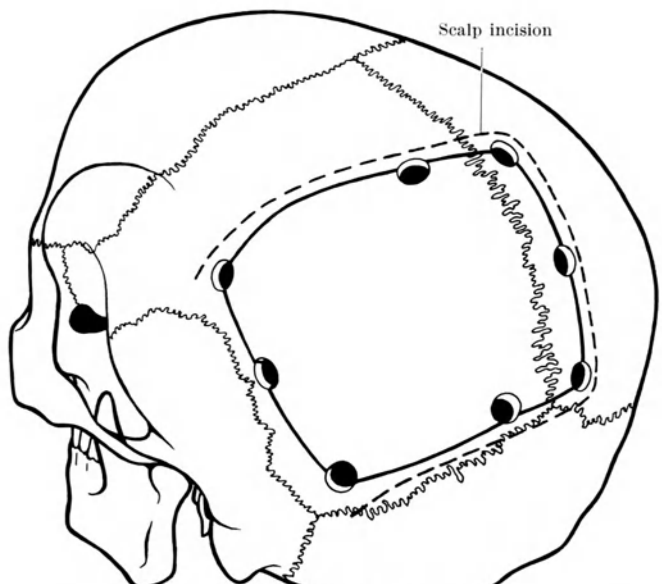


Fig. 320. Skin incision and craniotomy for arteriovenous malformation over left parietal lobe. *Observe:* Craniotomy extends over midline.

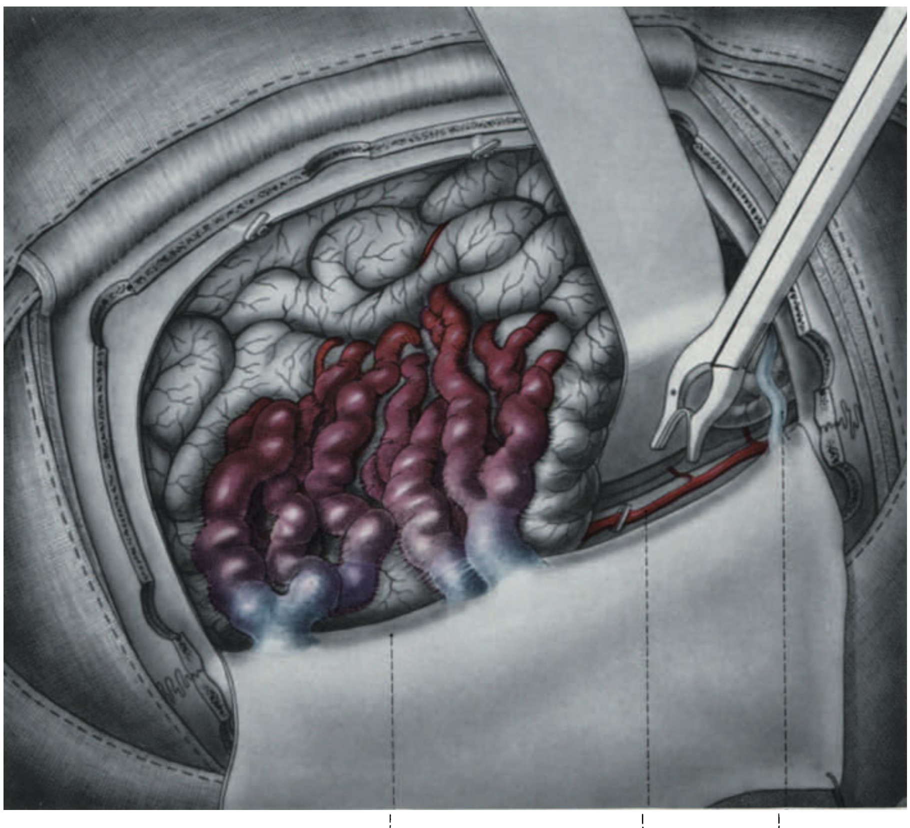


Fig. 321. Operative view of arterio-venous malformation with exposure and clipping of feeding vessel (left pericallosal artery).

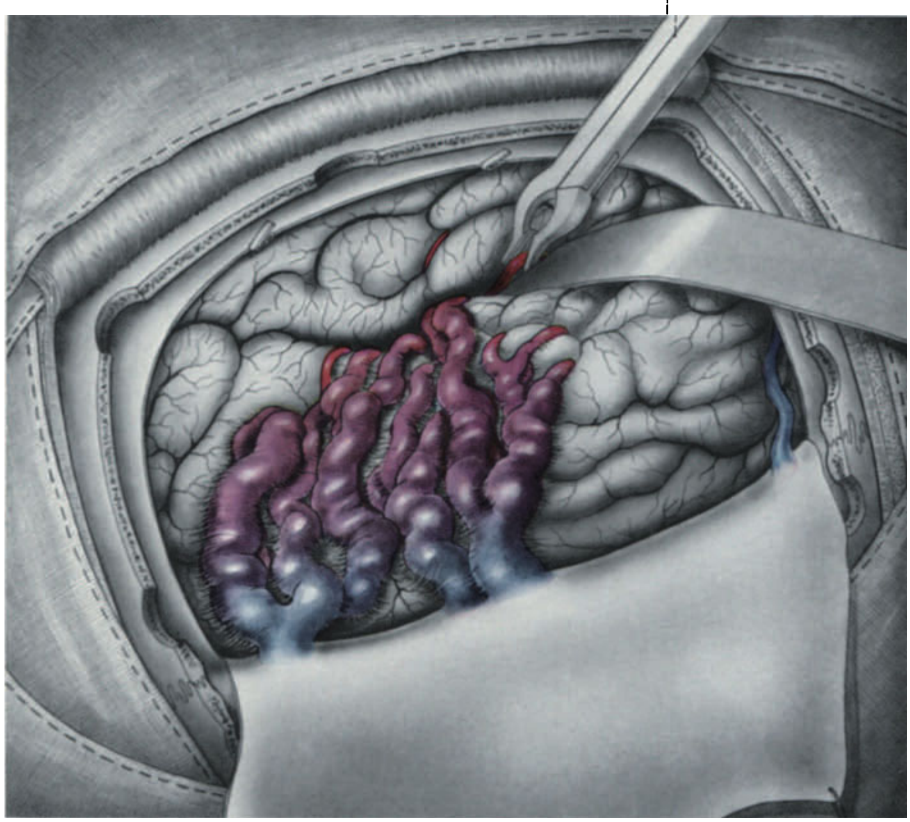


Fig. 322. Operative view of left parietal arteriovenous malformation with exposure of feeding vessel from middle cerebral artery.
Observe: Feeding arteries are first located, clipped and divided in the depth of the sulci and fissures prior to making any incision into the brain proper.

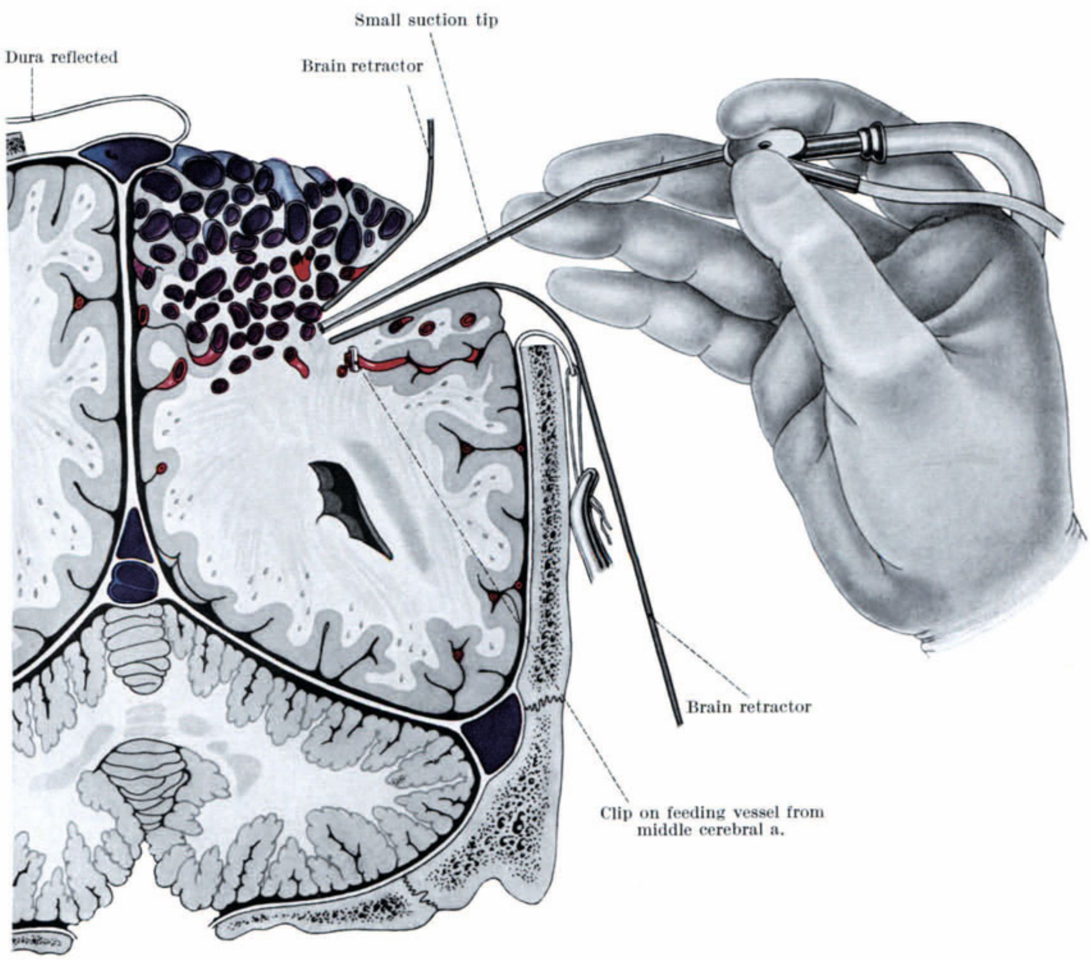


Fig. 323. Coronal section of cerebral arterio-venous malformation at operation.
Observe: 1. Use of very fine suction tip for dissection around malformation. 2. Keep close to lesion. 3. At this stage of the operation main feeding arteries are ligated and major draining veins are left intact.

Fig. 324. Angiogram, arterial phase (A—P view).

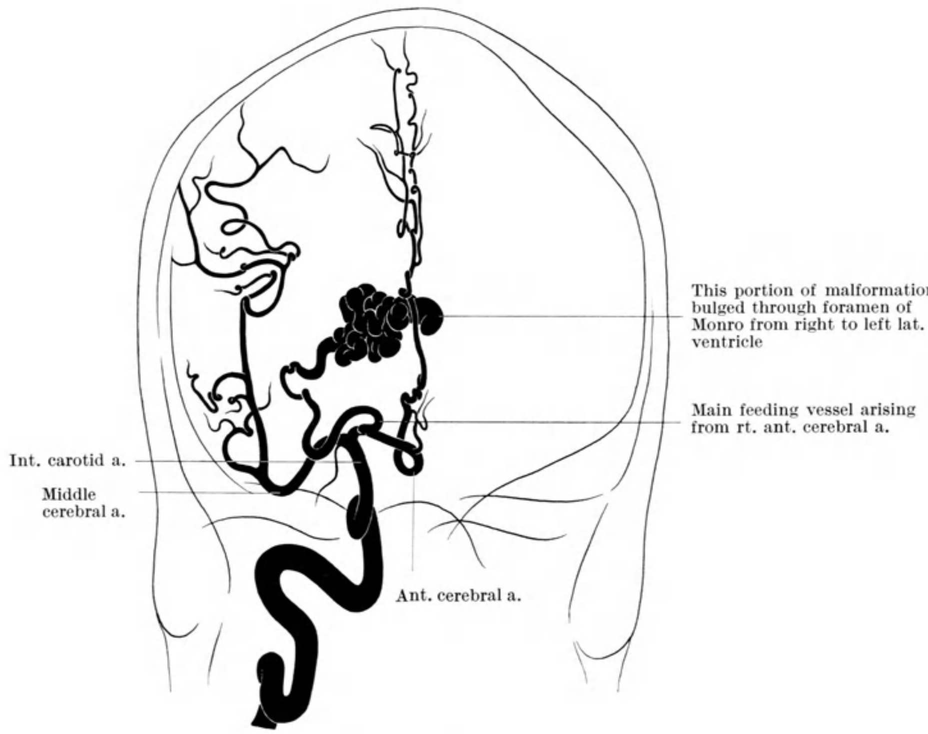


Fig. 325. Diagram of angiogram Fig. 324.

draining veins between the arteriovenous malformation and the superior sagittal sinus. Some of the smaller draining veins may have to be coagulated and clipped in order to retract the hemisphere to obtain exposure of the anterior cerebral artery. The feeding artery coming off the anterior cerebral artery is clipped and divided. The next step is to find, isolate and clip or ligate the feeding branches from the middle cerebral artery. It is important to isolate the main feeding vessels proximal to their thin-walled distension. The sulci leading to and around the malformation are opened and in their depth every feeding artery is clipped and ligated (Fig. 322). It may be mentioned that the surgeon should be thoroughly familiar with the serial angiographic findings and may consult these films during surgery. The pictures should be available in the operating room on the viewing box. After we are satisfied that the majority of the main feeders have been found and ligated without having entered the brain substance itself, we use the very fine suction coagulation cannula to separate the lesion (Fig. 323). Bit by bit the anomaly is freed from the surrounding brain tissue by coagulating the small feeding vessels and by clipping and dividing the larger ones. The use of the small suction cannula will prevent rupture of the extremely thinwalled anomalous vessels. Careful pressure can be applied to the malformation to milk its blood towards the draining veins and to assist in collapsing and coagulating some of the vascular structures. If space permits this compression can best be done by the fingers. The arteriovenous anomaly may extend in a cone-shaped fashion to the lateral ventricle and receive feeding vessels from a choroidal artery. These feeding vessels are not always detected in the angiogram since the bulk of the lesion may cover and obscure that area. The possible existence of these feeders has to be thought of for nothing is more troublesome than to have blood welling from the depth of the remaining brain after the lesion has been removed. It is therefore important to methodically coagulate and divide even the smallest vessels situated in the depths. These vessels are easily torn; however, the fine suction cannula will assist in isolating and coagulating these vessels. The large draining veins may have to be ligated or clipped by self-made gold clips of readily available dental gold plate (see insertion of Fig. 76, p. 62).

2. Arteriovenous Malformation of Right Lateral Ventricle. The angiogram in the AP position (Figs. 334 and 325) indicates that the main feeding artery comes from the right anterior cerebral artery. This vessel enters the lateral extent of the anterior perforating substance, penetrates the substance of the brain lateral to the basal ganglia at the external capsule and enters the right lateral ventricle over the head of the caudate nucleus (Fig. 326). The lateral angiographic picture shows the arteriovenous malformation draining into the internal cerebral vein and finally into the straight sinus via the vein of Galen (Figs. 327 and 328). The large bulbous formation seen in the angiogram presents a vascular loop which reaches through the foramen of Monro from the right into the left lateral ventricles and which causes some obstruction and moderate dilatation of the lateral ventricles. The ventricular enlargement often aids in exposure and removal of the lesion. In Fig. 329 the anatomic situation can be seen from the unroofed lateral ventricles.

This is an operable lesion and its removal is presented here. The patient on the operative table is positioned as in Fig. 330a or b. The coronal scalp incision and the craniotomy are depicted in Fig. 331. The opening should permit exposure of the main feeding vessels from the right anterior cerebral artery and permit an entry into the lateral ventricle through an excised cone of prefrontal brain tissue. The bone flap hinges on the temporalis muscle. The opening of the dura is seen in Fig. 332. The frontal lobe is elevated to expose the prechiasmatic cistern which is entered and from which cerebrospinal fluid is aspirated to obtain additional space. The temporal lobe is mobilized by coagulating and cutting the bridging veins to the sphenoparietal sinus. The internal carotid artery has its arachnoidal coverings removed up to the bifurcation, and the anterior cerebral artery is identified and followed medially until the abnormally enlarged feeding vessel which crosses Heubner's artery can be identified. The artery is clipped and divided (Fig. 333). Then, a core of cerebral tissue over the superior and middle frontal gyri is removed to enter the

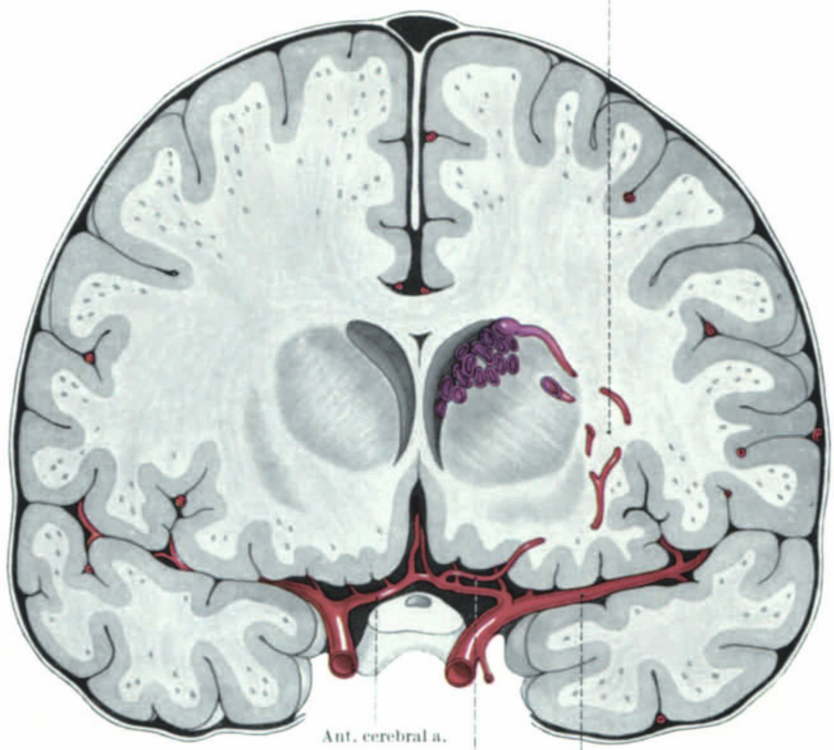


Fig. 326. Coronal section of operable intraventricular arterio-venous malformation. *Observe:* Main feeding artery corresponds at its origin to Heubner's artery.

right lateral ventricle (Fig. 324). (Compare Chapter XIII, p. 149, Fig. 211.) Less damage is done to the cerebrum in removing a core of tissue than in approaching the lateral ventricle through a linear incision and the exposure is better. Partial collapse and a more (dark) congested appearance of the arteriovenous malformation when the ventricle is opened will indicate whether the main feeding vessels had been interrupted. In Fig. 335 the vessel which hangs through the foramen of Monro is pulled free and the draining vessels to the right internal cerebral vein are interrupted (compare Fig. 329). The bipolar coagulation is preferred for coagulating any remaining small feeding vessels from the posterior choroidal artery. The use of the bipolar coagulation should prevent damage to the underlying thalamus. With the lesion totally removed, the dura and craniotomy (as in all these cases) is closed as described in the first chapter.

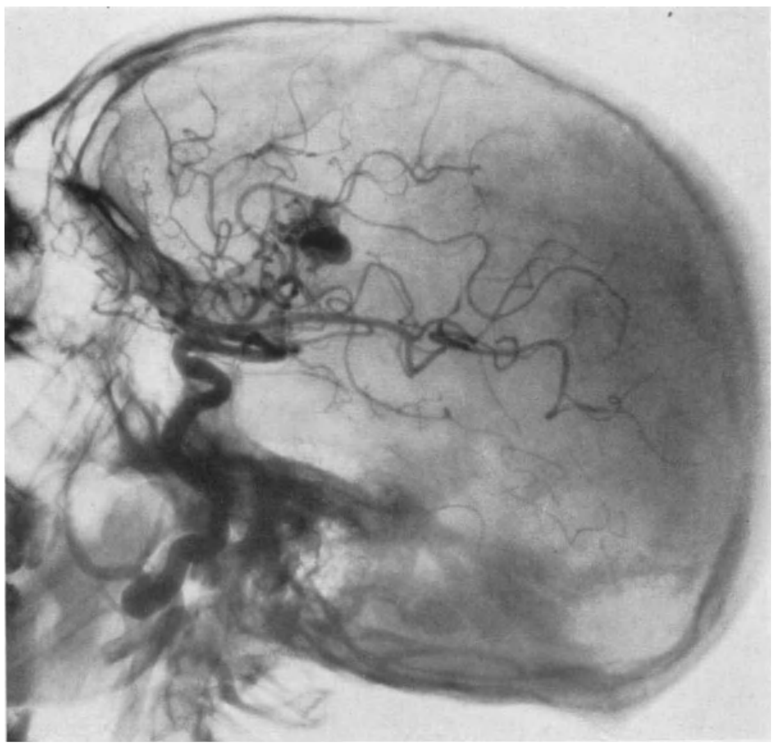


Fig. 327. Angiogram, lat. view, arterial phase.

Fig. 328. Angiogram, venous phase.

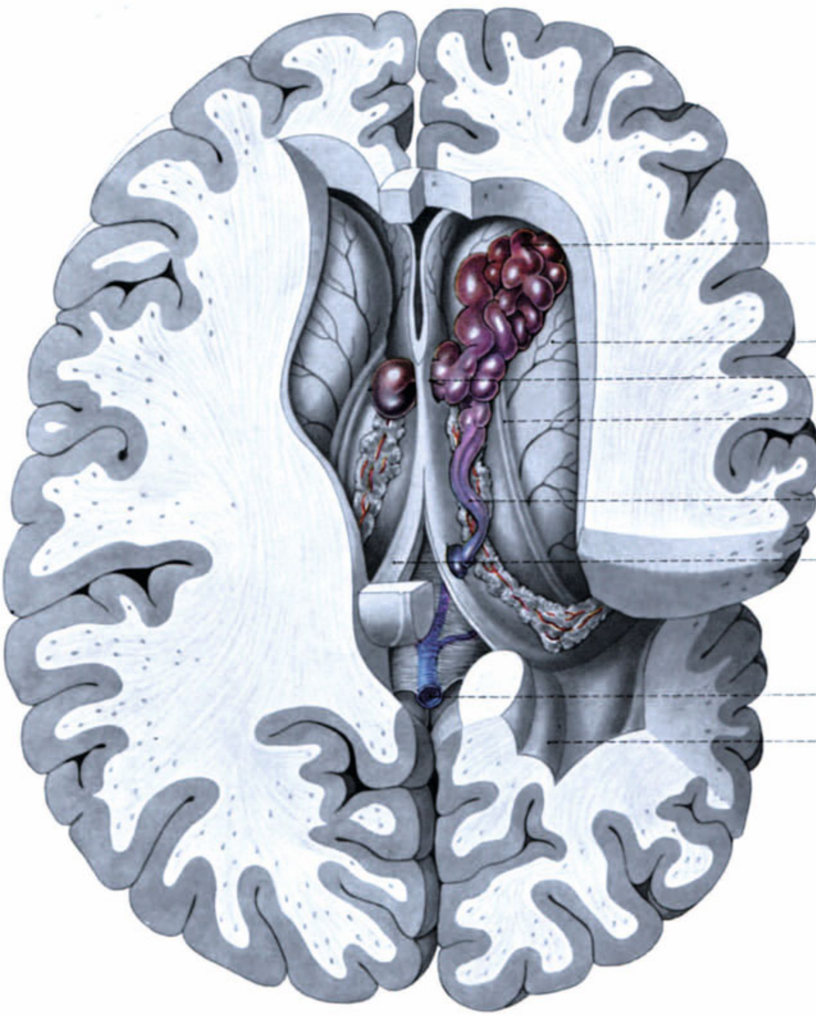


Fig. 329. Anatomical presentation of intraventricular arterio-venous malformation.
Observe: Projection of large vascular loop through both foramina of Monro causing obstructive dilatation of lateral ventricles.

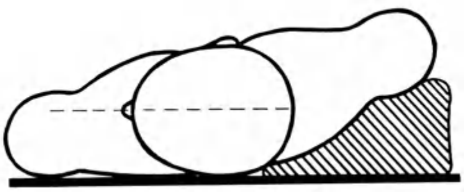


Fig. 330a

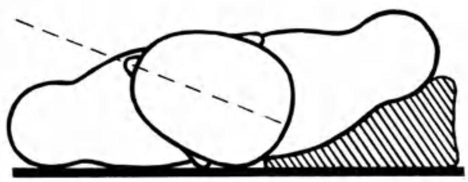


Fig. 330b

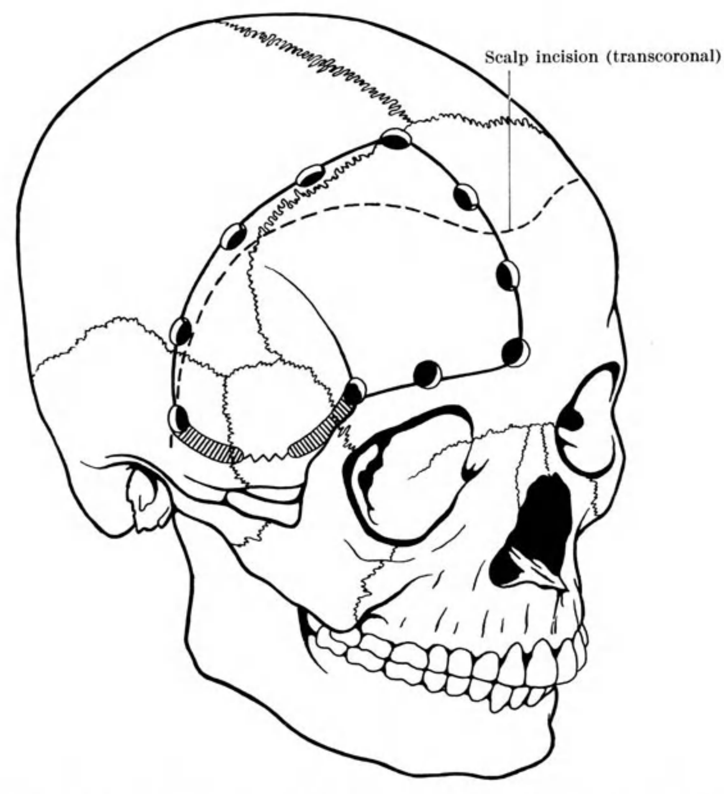


Fig. 331. Skin incision and craniotomy for right intraventricular arterio-venous malformation. *Observe:* Scalp incision inside the hairline.

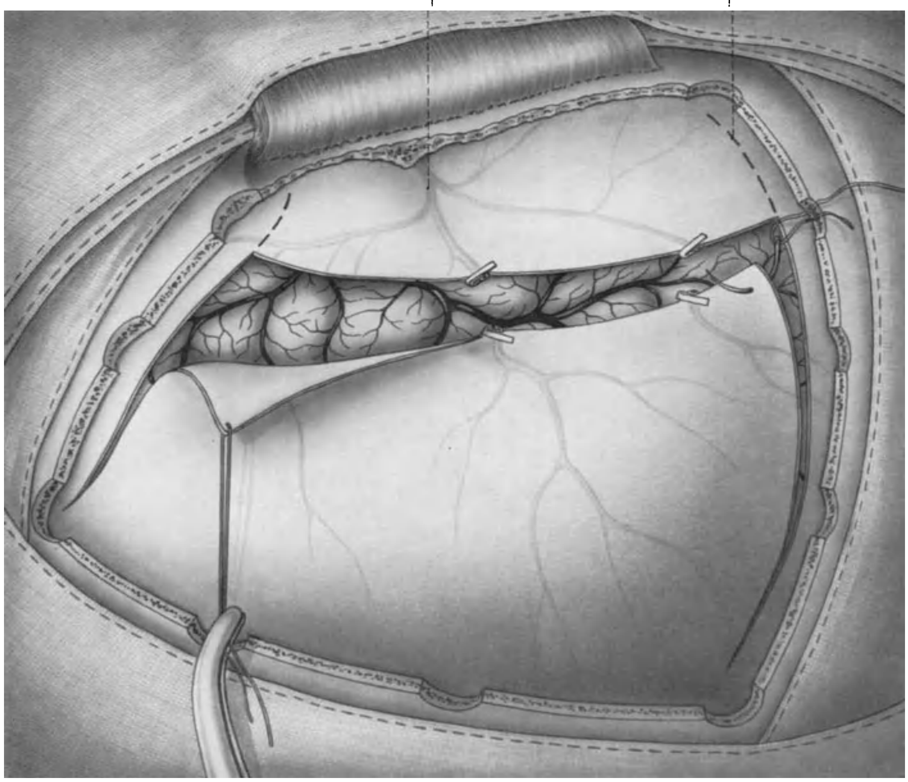


Fig. 332. Dural opening over right fronto-temporal lobe.

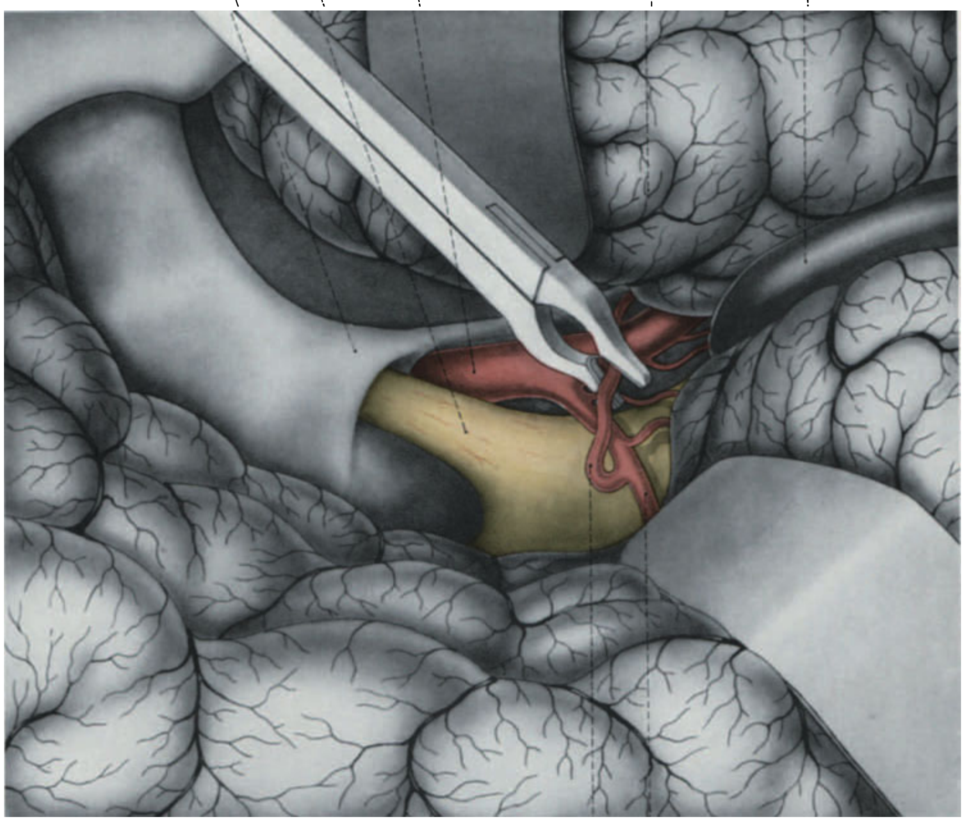


Fig. 333. Operative exposure of main feeding vessel to intraventricular arterio-venous malformation. *Observe:* In this case the abnormal enlarged feeding vessel has its origin similar to that of Heubner's artery.

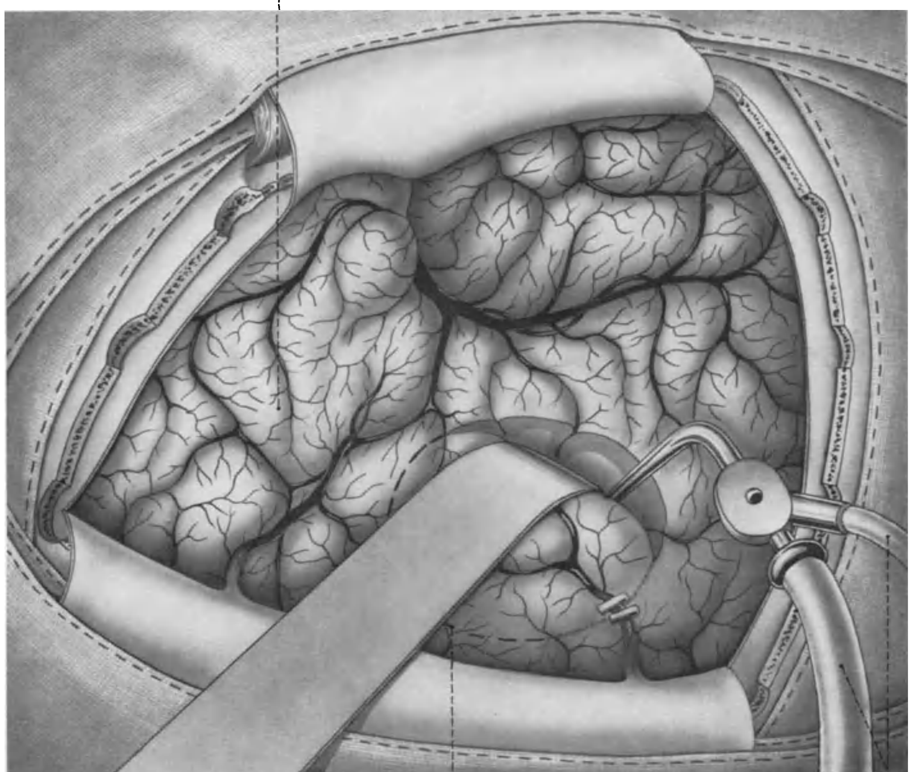


Fig. 334. Removal of core of cerebral tissue to enter right lateral ventricle.

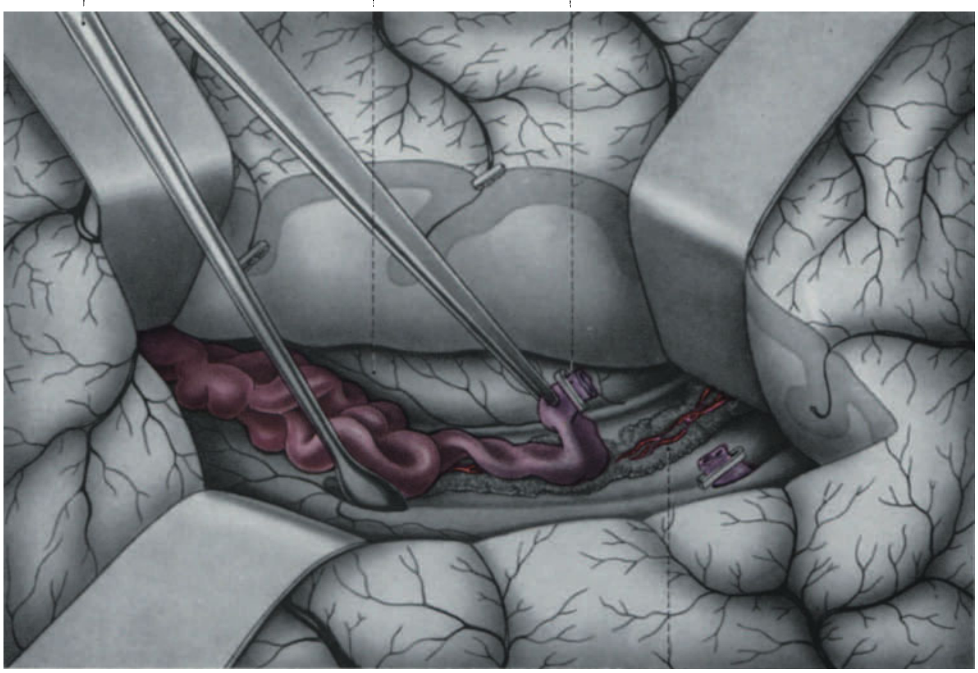


Fig. 335. Operative view of arterio-venous malformation in right lateral ventricle.

Epilogue

The preceding chapters have been written and the figures presented in an attempt to clarify to the reader the regional surgical anatomy, the surgical approaches to some of the disease processes of the central nervous system amenable to surgery, and to emphasize the step-wise relative simplicity but thoroughness which is necessary to assure surgical success.

It is not the intent of the author to imply that the operative procedures described herein are necessarily the only ones that will lead to successful completion of a given operation. It is felt, however, that they have proven themselves to be the best for the author and can therefore be recommended.

It is again stressed that a thorough knowledge of the normal anatomy in a three-dimensional concept is vital to the accurate recognition and better understanding of the abnormal. With a relatively uniform, wellplanned, understood and executed surgical exposure, the surgeon is best able to accomplish his goal. It is therefore hoped that the preceding pages will have made clear the successful types of operative exposures and techniques that have aided this surgeon.

L. G. Kempe

Subject Index

Italics refer to figure numbers. Normal type refers to page numbers