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Selective Hippampectomy Sparing Amygdala and Neocortex for Temporal Lobe Epilepsy

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Excision of the anterior temporal lobe is the most frequently performed procedure for temporo-limbic epilepsy and has been classically associated with good seizure control. Surgical outcome can be significantly improved if there is lateralized initial focal sphenoidal onset with ictal scalp electroencephalogram (EEG) recordings, preoperative evidence of localized metabolic dysfunction on fluorodeoxyglucose positron emission tomography (FDG-PET), and if hippocampal sclerosis is identified as the underlying pathological substrate in the absence of extra-hippocampal lesion (dual pathology). Anterior temporal lobectomy, however, creates new pervasive cognitive deficits in learning and memory functions and moderate to severe affective disorders in some patients. The need to develop a more selective procedure was pioneered by Niemeyer, and led to the technique of selective amygdalohippampectomy by Yasargil. We have modified these surgical techniques based on the hypothesis that the entorhinal-hippocampal complex is the generator and amplifier of abnormal epileptiform discharges and that hippocampal sclerosis is a necessary and sufficient pathological substrate of nontumoral temporo-limbic epilepsy.

Patient Selection

Patients are selected after electrographic and behavioral seizure onsets are documented with noninvasive video-telemetry recordings. Magnetic resonance imaging (MRI) with and without contrast agent will rule out any structural lesion. Hippocampal volumetric studies on coronal MRI can also quantify degrees of hippocampal atrophy. A battery of neuropsychometric tests is administered to all patients and scored according to standard procedures. Before surgery, a Wada test (intracarotid amygdala injection) will document language lateralization and contralateral memory functions to minimize risks of global amnesia. The ideal candidate for the selective anterior hippocampectomy-sparing procedure will have a focal sphenoidal seizure onset on scalp EEG localizing to one temporal lobe, convergent neuropsychological deficits, nonlesional imaging studies, and a supportive Wada test. In some cases, quantitative cerebral [¹⁸F]-FDG-PET can be performed to complete the evaluation.

Stereotactic intracranial recording of chronically implanted depth electrodes can also be used to select patients for this procedure when noninvasive localization fails to indicate a focal onset.

Preoperative Preparation

The introduction of frameless stereotactic image guidance has greatly facilitated the planning and execution of the selective hippocampectomy-sparing amygdala and neocortex procedure. A preoperative MRI of the brain is obtained with fiducial markers attached to the patient's scalp and images are transferred to the workstation. The entry point and extent of the craniotomy can be planned before surgery and the trajectory from the sylvian fissure to the lateral horn outlined and injected later in the viewfinder of the operating microscope. Under general anesthesia, the patient will receive a loading dose of phenytoin to reach therapeutic levels, prophylactic antibiotherapy, and dexamethasone. Other medications or anticonvulsants delaying bleeding time (such as valproic acid) will be stopped at least two weeks before the procedure.

Operative Procedure

In the supine position, the head is turned to the contralateral side of the exposure and a small roll placed under the ipsilateral shoulder. The head is then secured in the Mayfield three-point headrest (Integra Lifesciences, Plainsboro, NJ) with the temporal branch of the zygoma placed along the horizontal plane. The sagittal midline is then elevated to 30 degrees, similar to the position for anterior temporal lobectomy. This allows a better exposure of the plane to the hippocampal sulcus and entorhinal cortex. The fiducial markers placed preoperatively are then read with a wand, activating the receivers from the image guidance system. After standard sterile draping, a frontotemporal skin flap is elevated and wrapped in a moist laparotomy sponge (**Fig. 2.1**). A longitudinal incision of the temporalis muscle along its fiber is made toward the origin of the zygomatic arch and divided along its superior attachment. The two flaps of

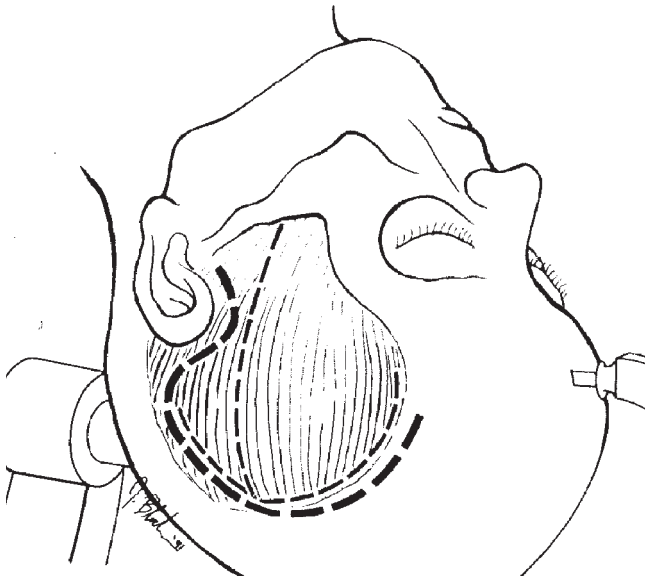


Fig. 2.1 Diagram showing the positioning of the head in the Mayfield headrest. The scalp incision is outlined with a bold dashed line, and the temporalis muscle incision with the finer dashed line.

muscle are elevated with a periosteal elevator and retracted anteriorly and inferiorly. A frontotemporal craniotomy is then performed to expose the sylvian fissure, without drilling the pterion down. The surgical approach and eventual resection margins are illustrated in **Fig. 2.2**.

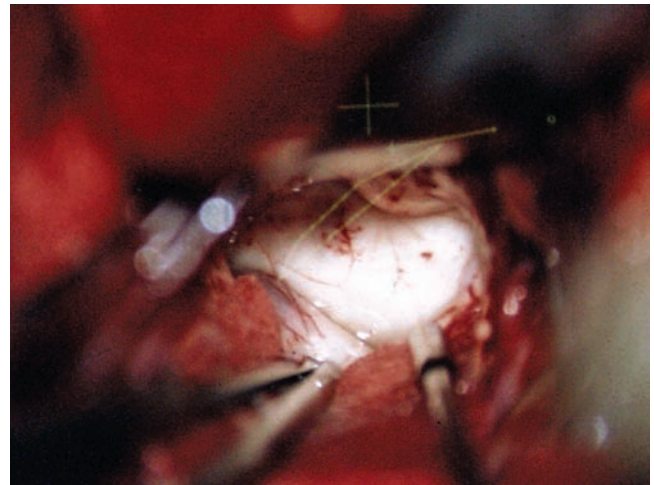


Fig. 2.3 Intraoperative photograph of the initial opening into the sylvian fissure following the arachnoid dissection.

At a distance of 5 cm from the tip of the temporal pole, the microscope is brought over the surgical field and the entry point selected preoperatively is identified. Two microsurgical jewelers' forceps are used to mobilize and separate the arachnoid layer covering the sylvian draining veins to access the sylvian fissure. The sylvian draining veins are mobilized and gently elevated laterally or superiorly according to the variable anatomy of this region. This exposes the sylvian cistern between the temporal and frontoparietal operculum (**Fig. 2.3**). The subarachnoid space is entered mesially and

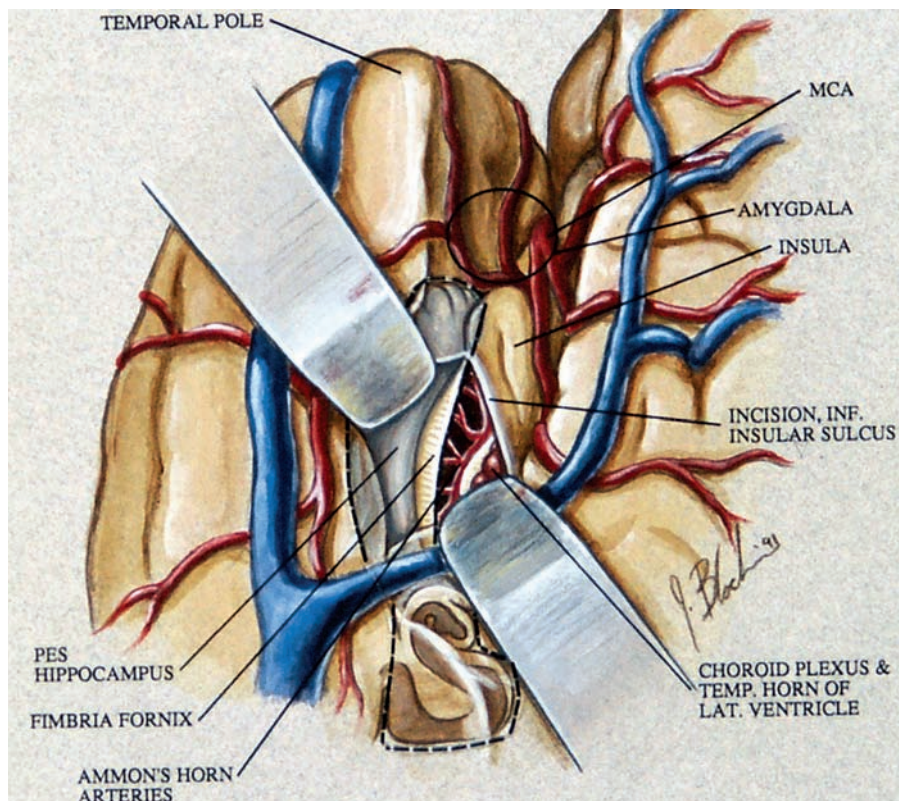


Fig. 2.2 Illustration of the selective hippocampectomy by posterior trans-insular approach.

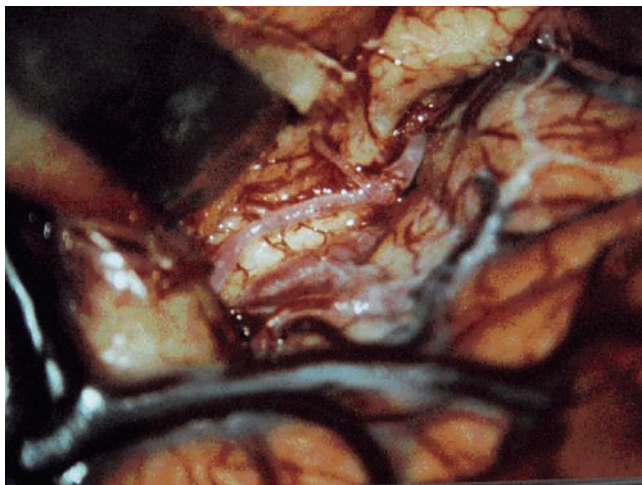


Fig. 2.4 Exposure of the inferolateral sulcus of the insula at the site of entry toward the lateral horn of the ventricle. Note the relative avascular plane parallel to a distal branch of the middle cerebral artery.

inferiorly along branches of the sylvian trifurcation, distal to the temporo-polar artery, anterior to the Heschl gyrus and angular artery. The inferoposterior insular sulcus is then exposed along an avascular region (**Fig. 2.4**). A 1 cm longitudinal keyhole incision is made along the sulcus leptomeninges with microbipolars and a microsuction tip. The direction of the dissection into the lateral temporal horn is here critical and should be at 45 degrees lateral and within 1 cm of the entry point from the inferior insular sulcus. Longitudinal ependymal arterioles usually indicate the vicinity of the roof of the ventricle, identified by a gush of clear cerebrospinal fluid. A tapered 5 mm wide microretractor can be used to elevate the lateral roof of the ventricle. This exposes the dorsal hippocampus, which is identified from the anterior tip of the ventricle to the trigone region.

The inferolateral boundary of the resection parallels the collateral eminence, lateral to the curved pes hippocampus to reach the collateral sulcus above the tentorial edge. This initial lateral dissection is performed with microbipolars and a microsuction tip. Microcottonoid pledgets are left anteriorly and posteriorly and will be retrieved after the mesial dissection is completed. Our attention and microscope are then directed toward the mesial structures above the pes hippocampus. With a microcottonoid, the choroid plexus is gently elevated mesially to expose the white fimbria-fornix. This structure is dissected and elevated longitudinally from anterior to posterior with a blunt micro-nerve hook or microbipolar and traversed to reach the subarachnoid space (**Fig. 2.5**). The choroidal fissure remains unexposed and no attempt is made to identify the optic tract located superiorly and mesially to the choroidal fissure. This dissection is carried inferiorly, leading to the ambiens cistern. Ammon's horn arteries arising distally from the lateral trunk of the anterior choroidal artery or posterior cerebral artery are identified and divided at their closest entry points into the hippocampal sulcus. The uncus artery is also divided and the uncus is dissected anteriorly then laterally at the pes-amygdala junction to reach the collat-

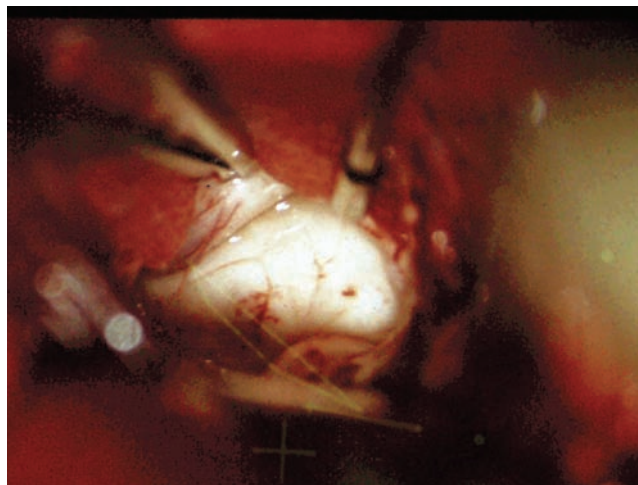


Fig. 2.5 Elevation of the fimbria-fornix mesial to the dorsal hippocampus. This leads to the perforating Ammon's horn arteries along the hippocampal sulcus.

eral sulcus where the anterior microcottonoid is retrieved. The posterior hippocampus is transected along a coronal plane at 3 cm from the pes to reach the initial posterior lateral dissection and posterior microcottonoid. The pia of the entorhinal-parahippocampal gyrus is incised and the entorhinal hippocampus is elevated to produce an en bloc specimen (**Fig. 2.6**) suitable for quantitative histology or in vitro neurophysiological studies.

This sharp dissection is avascular and the blood loss is minimal. The dural closure is performed in a watertight fashion and the skull, temporalis muscle, and skin closures are standard.

Postoperative Management Including Possible Complications

The patient is extubated and sent to the recovery room and the intensive care unit for overnight observation. A postoperative computerized tomography of the brain is performed the next day before the patient's transfer to the floor, where he is kept for an additional 24 to 48 hours before discharge. One or two anticonvulsants are adjusted to maintain therapeutic serum levels. The dexamethasone, accompanied by an antacid, is tapered over the following 10 days. Headaches and jaw pain from the temporalis muscle are usual postoperative complaints. Complications of upper quadrantanopia, transient dysnomia, or transient hemiparesis are much less frequent than those found after temporal lobectomies.

The major advantage of this selective hippocampectomy procedure is that the amygdala and neocortex are spared, producing a seizure-free outcome with minimal cognitive and affective changes. The preservation of the temporal neocortex is beneficial to the patient's cognitive outcome because it is involved in perception and immediate memory functions by its coordinated and distributed activity, and in long-term declarative memory following



Fig. 2.6 Pathological specimen obtained after selective hippocampectomy. The sclerotic hippocampus and entorhinal tissue measure ~3cm.

slow synaptic changes. These functions are independent from mesiotemporal lobe structures and justify a more selective resection that preserves a functional neocortex remote from the “zone of seizure origin.” The amygdala, a major projection center for several neurochemical systems, has a more controversial role in the generation of temporo-limbic epilepsy. We believe this structure is not part of the generator-amplifier complex of hippocampal epilepsy and is not subject to selective vulnerability that leads to dynamic pathological changes in the hippocampus. Leaving the amygdala intact should prevent severe affective disorders seen after amygdalohippampectomy and temporal lobectomy.

Our technique of selective transinsular hippocampectomy is safer than selective amygdalohippampectomy and offers the shortest route to the inferior horn of the lateral ventricle. It does not require drilling of the pterion, does not expose the carotid artery, optic nerve, or the origin of the anterior choroidal artery into the lateral ventricle. Selective amygdalohippampectomy reaches only the anterior portion of the hippocampus after a large removal of the amygdala and retraction back into the ventricle, allowing a limited resection of the anterior pes. Postoperative MRIs following our technique are presented in **Figure 2.7**. We have demonstrated a seizure-free status in about 95% of our patients and shown significant improvement in verbal and memory scores compared with patients who receive anterior temporal lobectomies. None of our patients have suffered severe depressive symptoms during a mean follow-up period of 36 months.

Selective transinsular hippocampectomy does not replace an anterior temporal lobectomy in cases of regional temporal seizure onset, associated with more widespread pathology, or posterior lateral onset requiring epicortical language and seizure mapping. Because the incidence of hippocampal epilepsy represents about 65% of patients with temporal lobe epilepsy, this may reflect the incidence of patients who may benefit from this technique.

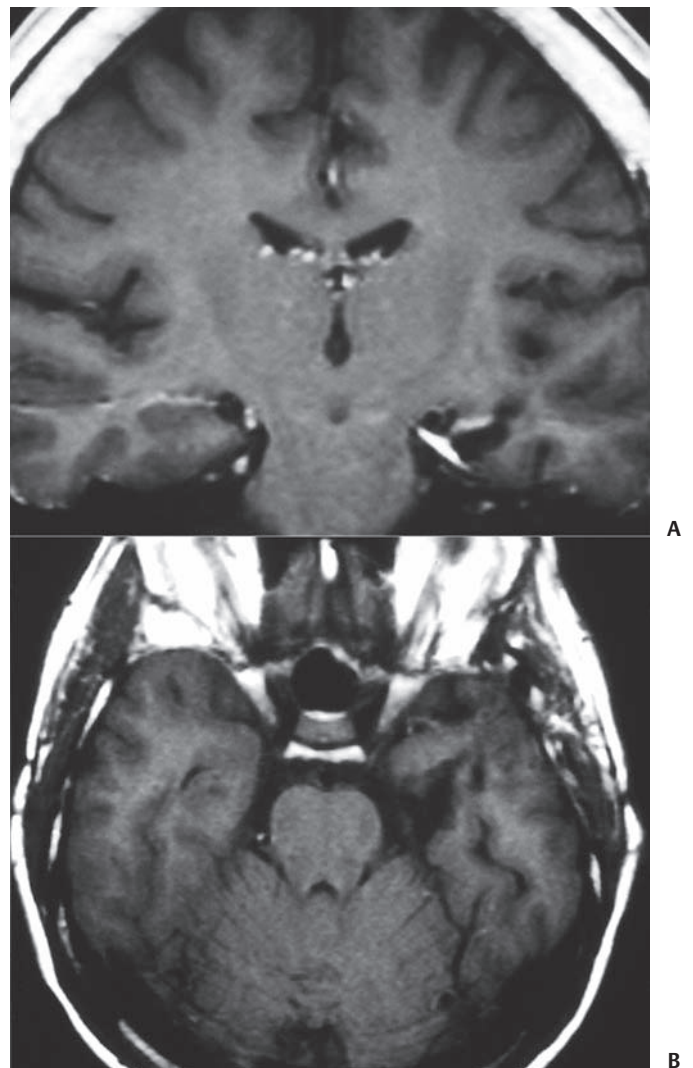


Fig. 2.7 Postoperative magnetic resonance imaging 6 months after selective hippocampectomy. **(A)** Coronal T1-weighted image along the plane of the transinsular-temporal stem dissection. **(B)** Axial image showing the resection bed.