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Surgery and Results of Selective Amygdala-Hippocampectomy

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In this article, the surgical techniques and postoperative results of these 100 patients without macroscopic lesions will be presented. Scalp and invasive electroencephalogram (EEG) recording showed a unilateral focus in 82 patients, where surgery is called "causal." In 18 patients, the epileptic focus was outside the temporomediobasal region. The selective AHE was performed in this group as a "palliative" therapy.

After causal selective AHE 69% af the patients were seizure free after 1 year. In a year-to-year classification, 58% are still seizure free after 5 years. In the palliative group, 28% of the patients remained seizure free after 1 year.

CLINICAL MATERIAL AND METHODS

The age and sex distribution are about equal, and details are given in Table 1. The mean age for men was 31 years and for women 32 years. As in previous reports, the patients were divided into two major groups according to the presurgical assessment of seizure origin: group 1, clear-cut unilateral mesial temporal seizure focus, i.e., causal AHE; and group 2, palliative AHE in patients with seizure onset outside the resected structures but with secondary involvement of the hippocampal formation by the ictal discharges.[1,2] It is important to note that although all patients had complex partial seizures as the main seizure type, 49 patients had more than one third of their attacks classified as simple partial seizures, i.e., as isolated areas. On the other hand, 19 patients had more than 10% of their secondarily generalized seizures.

DIAGNOSTIC PROCEDURES

The diagnostic methods have changed considerably during the period from 1975 to 1992. During the first years, most of the patients were evaluated by stereo-EEG, i.e., by means of recording the EEG from stereotactically implanted depth electrodes. As an indispensable precondition, the so-called "repérage," i.e., a neuroradiologic examination under stereotactic conditions, was performed. The repérage consisted of classical neuroradiologic procedures, such as plain radiographs, PEG, and carotid angiography. CT has been used since 1975, and since 1983 MRI has replaced the previously used invasive neuroradiologic methods.[3,4,5,6,7,8]

In some patients, single photon emission computed tomograhpy (SPECT) with hexamethylpropyleneamineoxime (HMPAO) and iomazenil and, since 1988, positron emission tomography (PET) were also performed.[3,4,5,6] As can be seen from Table 2, seizure monitoring with radiotelemetric standard-EEG, stereo-EEG, and foramen ovale electrode recording belongs to the routine assessment of patients suffering from drug resistant temporal lobe epilepsy without obvious neuroradiologic findings. Since the introduction of CT, a regular early postoperative follow-up CT was performed to assess the extent of the resection.[9] Postoperative fol-

Table 1. AGE AND SEX/SIDE DISTRIBUTION

	0-10 years	11-12 years	21-30 years	31-40 years	41-50 years	51+ years	Σ	R	L
♂	1	7	15	15	10	2	50		
♀	–	7	17	14	12	–	50		
Σ	1	14	32	29	22	2	100	55	45
								100	

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low-up CT has been replaced by MRI since 1983.

OPERATIVE APPROACH AND TECHNIQUE

Craniotomy

The approach used in the AHE is a variation of the now standard interfascial pterional craniotomy described previously. A semiellipsoid fronto-parieto-temporal skin incision is performed and turned anteriorly, whereas the temporal muscle is turned laterally. The craniotomy is performed with one burr hole placed 2 cm behind the sphenoid angle of the parietal bone. An ellipsoid shaped bone over the fronto-spheno-temporal region is removed with the craniotome. Using a highspeed electric drill under the operating microscope, the posterolateral orbital roof and posterior ridge of the greater wing of the sphenoid are flattened down to the anterior clinoid process.

Table 2. DIAGNOSTIC PROCEDURES

	No. of Procedures
Long-term seizure montioring	
noninvasively	18
semiinvasively with foramen ovale electrodes alone	47
invasively with stereo-EEG alone	30
invasively with foramen ovale electrodes and SEEG	5
Repérage* alone	2
CT alone	45
MRI alone	30
CT and MRI	18
CT and Repérage	5
PET (18F-FDG)	
Preoperatively	25
Postoperatively (3-5 months)	25
Postoperatively (12 months)	17
SPECT	
Preoperatively	
HMPAO	12
Iomazenil	2
postoperatively	
HMPAO	6
Iomazenil	8
Wada test	25

* Consisted of pneumoencephalography, ventriculography, and angiography under stereotactic conditions and performed as a prerequisite for the implantation of multiple electrodes (stereo-EEG) before the MRI era.

Dural Opening

The dura is opened in a semicircular fashion over the sylvian fissure and arched toward the sphenoid ridge and orbit.

Opening of the Arachnoid

The proximal part of the sylvian fissure is then opened medially or laterally to the sylvian veins using sharp dissection. If the arachnoidal membranes are sufficiently fine, then simply a spreading action with fine forceps is adequate. On the surface, a short length (1.5 cm) forceps is used and exchanged for forceps of increasing length (3.0, 5.0, 7.0, and 9.0 cm) as the dissection of the sylvian fissure proceeds more deeply. Gentle retraction with a fine sucker on a moist cottonoid sponge and, where necessary, division of thickened arachnoid bands with a tenotome or microscissors complete the dissection. The exposure thus is from the carotid bifurcation to the middle cerebral artery bifurcation and some 1.5 to 2. 0 cm beyond, exposing approximately the anterior one third of the insula and 1 to 2 cm of the M2 segments, with the arachnoid between the proximal sylvian fissure down to the internal carotid artery (ICA) and its branches, as well as the position of the oculomotor nerve, tentorial edge, and the medial basal areas of the temporal pole. The lateral branches of the ICA (posterior communicating, anterior choroidal and uncal arteries, and their variations) and the lateral branches of M1 segment (temporopolar, anterior and middle temporal arteries, and their possible variation) are seen as well as the number, position, and course of striate arteries. At the level of the limen insulae, the inferior trunk of the M2 segment curves slightly laterally in the inferior part of the insular sulcus lying just over the inferior insular vein.

Entrance to the Temporal Horn

An incision 12 to 15 mm in length is made at the level of the limen insulae and middle cerebral artery bifurcation, lateral to the inferior trunk of the M2 segment and inferior insular vein. The superior parts of the amygdala are found some few millimeters in depth from the incision line at the base of the superior temporal gyrus (Fig. 1) At this point, it is advisable, using a gentle spreading action with the tips of fine forceps, to advance first in the direction of the inferior horn and to open into it. This will provide a clearer orientation as to the size, direction, and extent of the superior, posterior, and lateral aspects of amygdala. If uncertain of the location of the inferior horn, the amygdala may

first be removed piecemeal both by microrongeur (to provide histologic specimens) and gentle suction.

Removal of the lateral, basal, and cortical nuclei of the amygdala in the superoinferior and medial direction should proceed with great caution until the optic tract has been identified. The most medial parts of the amygdala (especially medial and central nuclei) lying medially to the optic tract and projecting to the claustrum, putamen, and pallidum must remain unresected. After removal of the described parts of the amygdala, the adjacent mediobasal parts of the temporal pole and some part of the anterior parahippocampus are then removed subpially (Fig. 2)

Opening the Pia

After the subpial resection of the most mediobasal areas of the temporal pole, the transparent curtain of pial and arachnoidal membranes adjacent to the lateral part of the carotid cistern and the anterior part of the crural and ambient cisterns may be identified readily anteroinferiorly. On opening the pia, one identifies the uncal and anterior choroidal arteries entering the choroidal fissure along the crural cistern. Medial to this lies the optic tract and laterally the vein of Rosenthal. The cerebral peduncle, P2 segments, and oculomotor nerve also may be seen within the peduncular portion of the ambient cistern. Furthermore, through the delicate arachnoid membranes and fibers between the ocu-

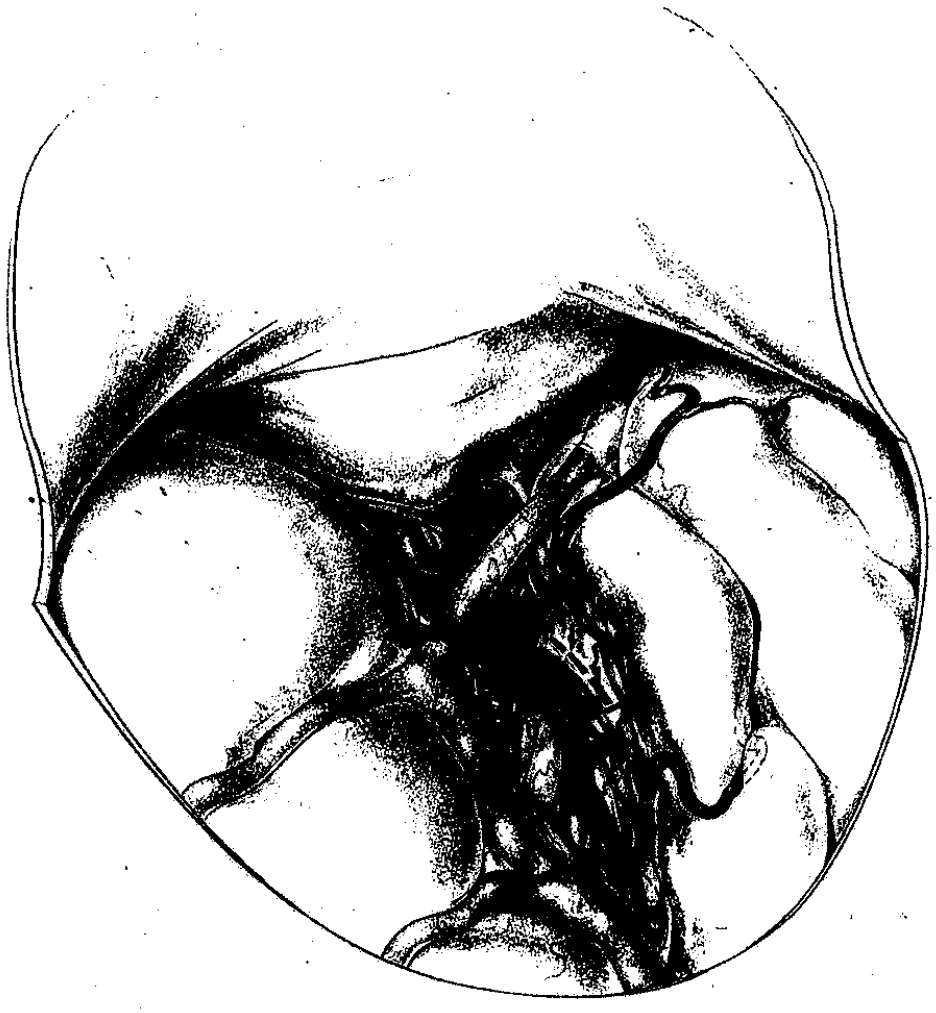

Figure 1. Transsylvian approach to the mediobasal temporal region lateral to the sylvian vein and middle cerebral artery bifuraction and lateral to the inferior insular vein. Dotted line indicates the place of pial incision.

lomotor nerve and posterior communicating artery, the P2 and P1 segments, with their branches, may now be identified within the interpeduncular cistern.

Removal of the Uncus-Hippocampus and Uncus-Parahippocampus

The earlier part of the dissection was directed anteroinferiorly and the surgeon must now turn the microscope posteroinferiorly (Fig. 3) The temporal horn is now opened from its tip in an occipital direction for a distance of about 3 to 4 cm. This gives access from the tip of the horn to the trigone and an excellent view of the choroid plexus and of the pes hippocampus. The choroid plexus may be displaced from medially to laterally to demonstrate the tela choroidea over the choroidal fissure. Through this transparent membrane can be seen the anterior choroidal artery and hippocampal vein and ventricular tributaries of the basilar vein. The choroid plexus is reflected medially and the tela opened with fine forceps or a fine dissector until the taenia fimbriae of the fimbriae hippocampus and the lateral peduncle are entirely visible from anterior to posterior rim. Great attention must naturally be paid to the anterior choroidal artery with its branches running laterally to the anterior one third of the parahippocampal gyrus and uncus. These branches of the anterior choroidal artery must now be coagulated and divided, whereas the main stem of the artery and its medial branches to the peduncle, optic tract, pallidus, internal capsule, thalamus, lateral geniculate body, and choroid plexus must at all costs be preserved. To avoid spasm of these vessels, papaverine is applied locally to the main trunk of the anterior choroidal artery. Attention needs to be paid to a further anatomic vari-

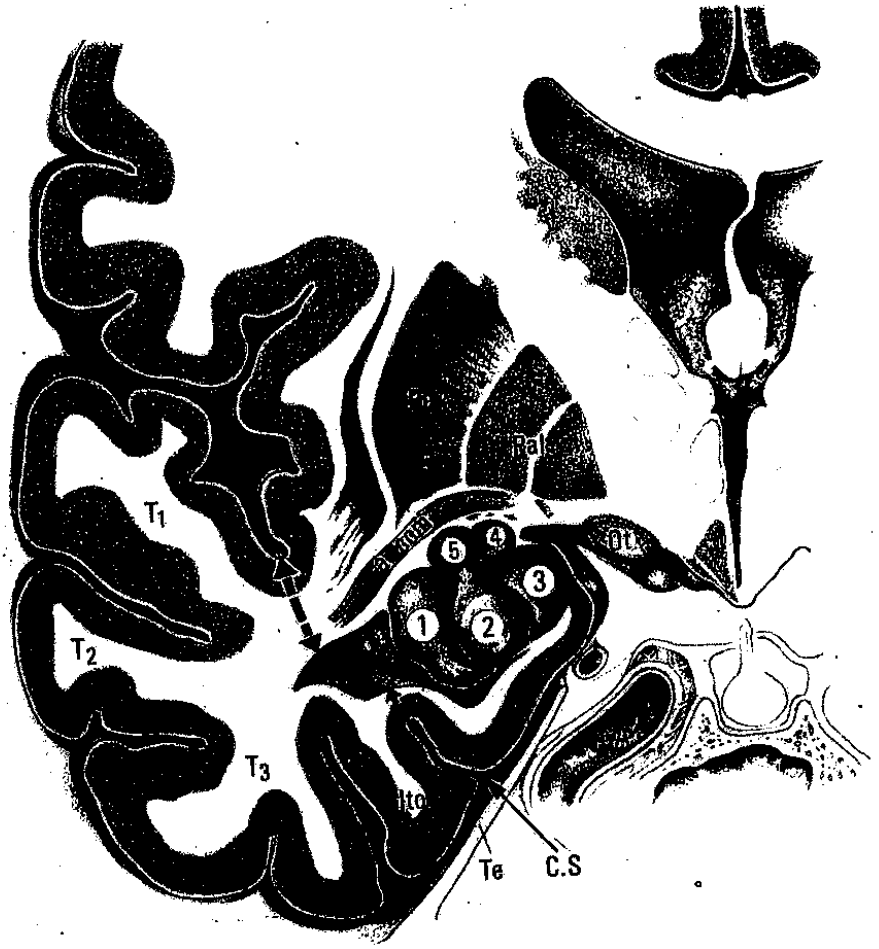

Figure 2. Illustration of the entrance into temporal lobe. Incision (dotted line) through the anterior temporal stem (12-15 mm length and 5-10 mm depth) to the temporal horn. T_1 = superior temporal gyrus; T_2 =middle temporal gyrus; T_3 = inferior temporal gyrus; Ito = lateral temporo-occipital gyrus; Cs = collateral sulcus; a com = anterior commissure; Ot = optic tract; Te = tentorium; ICA = internal carotid artery; A1 = lateral nucleus of amygdala; A2 = basal nucleus of amygdala; A3 = cortical nucleus of amygdala; A4 = medial nucleus of amygdala; and A5 = central nucleus of amygdala.

Figure 3. Illustration of the stages for the removal of uncus, hippocampus, and parahippocampus along the choroidal fissure (1-2), transverse section through the tail of hippocampus (3), lateral incision to the hippocampus and parahippocampus through the collateral eminence (4-5), ending within the area of the previously removed amygdala (6).

ation in which the branches to the uncus and amygdala arise separately and very proximally from the anterior choroidal artery or even originate separately from the lateral wall of the internal carotid artery or from the M1 segment, even from the temporopolar and anterior temporal arteries.

After opening the choroidal fissure, the medial part of the parahippocampus (subiculum) within the lateral wing of the transverse fissure will be seen. The hippocampal and parahippocampal veins (1 to 3) coming out from the hippocampal sulcus and entering into the basilar vein are seen running over the subiculum in a lateromedial direction. These veins have to be isolated from arachnoidal membranes and preserved (Fig. 4).

The so-called "Ammon's horn arteries" lie beneath the described veins and enter into the hippocampal gyrus. These arteries (1 to 4) may originate from the anterior choroidal artery but usually from the P2 segment just proximal to the bifurcation of P3 segments or from the P3 segment itself or from the branches of the P3 segments. The hippocampal arteries must not be coagulated and divided.

Transverse section of the hippocampus-parahippocampus is then carried out at the ascending area of the fimbria and hippocampal tail and parahippocampus (see Fig. 5, dotted line) just at the level of the posterior rim of cerebral peduncle and of the lateral geniculate body, some 1.0 to 1.5 cm before and inferior to the isthmus of cingulate gyrus. The transection through the posterior part of hippocampus-parahippocampus proceeds inferolaterally in the direction of the collateral sulcus and tentorial edge. The dissection with the forceps continues posteroanteriorly along the collateral eminence, in semicircular fashion around the lateral parts of the tail, corpus, and head of hippocampus, entering into the lateral sulcus along its entire length and then into the rhinal sulcus and leaving the uncus and hippocampus-parahippocampus medially in a block. This semicircular incision lateral to the limbic structures extends down to the free edge of the tentorium through the collateral sulcus, leaving the lateral temporooccipital gyrus laterally untouched. The incision is 4 to 5 cm long and 10 to 15 mm deep.

Within the collateral sulcus, the loops and branc-

hes of the temporooccipital arteries arising from the inferolateral trunk of the posterior cerebral artery will be seen. One can observe which branches supply the parahippocampus, which can then be coagulated and divided. The en bloc dissected limbic areas can be reflected laterally to explore the hippocampal veins, again which have to be now coagulated and divided at a proper distance from the basilar vein. Once the circular dissection and mobilization of the parahippocampus-hippocampus and uncus as well as adjacent parts of amygdala is completed, these structures can then be elevated and removed en bloc via the subpial plane. The resected specimen measures approximately 3 to 4 cm in length, 1.5 cm in breadth, and 2 cm in depth (Fig. 5). In the resected area, there remain bleeding points in the bed of the limbic structures from existing small pial veins that require coagulation with bipolar forceps.

Opening the extension of the sulcus collateralis in those cases in which there is no deep mesial herniation, one will ultimately reach the tentorium some 2 to 5 mm from its free edge and in its anterior half. In those cases in which there is herniation of the mesial structures, one must be more concerned about the line of dissection and potential damage to underlying structures. In these instances, provided one stays in the subpial plane, the parahippocampus may be removed en bloc, as the P2 segment with its branches, the superior cerebellar artery, III nerve, and IV nerve (lying below the tentorial edge) will be protected by the pia and a double layer of arachnoid.

At no time during the procedure should retractors be inserted in the small cortical incision. This must be entered only by the sucker and forceps, although the tip of the sucker placed over a moist cottonoid sponge may be used as a gentle temporary retractor. After the amygdala and uncus-hippocampus-parahippocampus are removed en bloc, the superior, middle, and inferior temporal; and medial temporooccipital (lingual gyrus) gyri remain untouched.

Following careful hemostasis around the lines of dissection of M1 and around the internal carotid, anterior choroid and posterior cerebral arteries, and their branches, the dura is closed with a running suture and the bone flap replaced in the normal fashion.

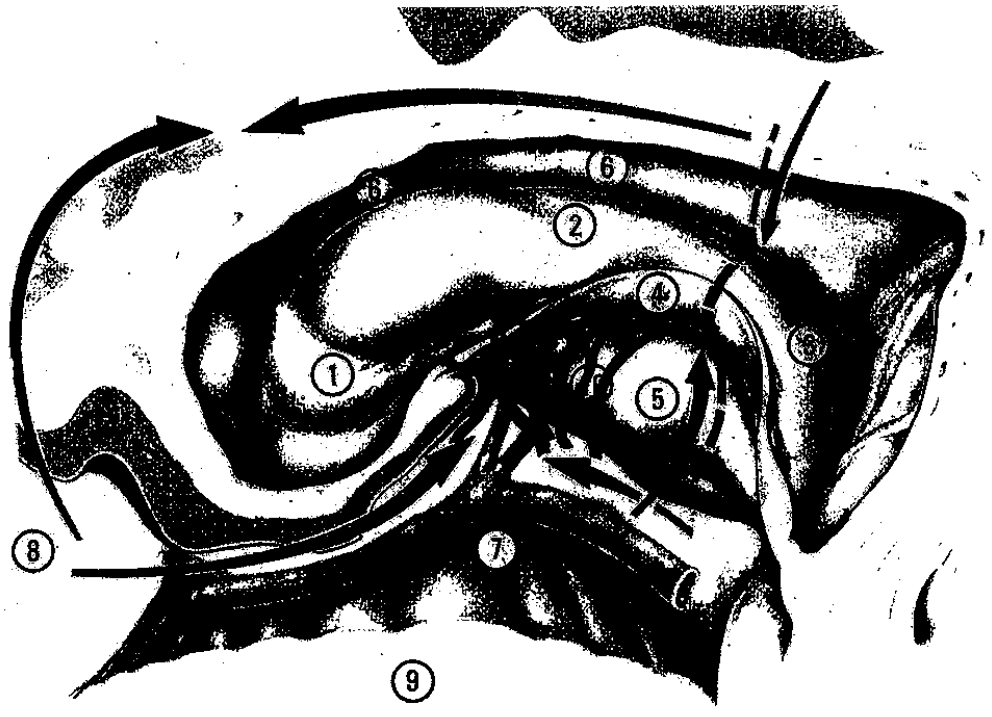

Figure 4. Illustration of the selectively removed parts of hippocampus and parahippocampus: 1 = hippocampal head; 2 = hippocampal body; 3 = hippocampal tail; 4 = fimbria; 5 = subiculum; 6 = collateral eminence; 7 = hippocampal and parahippocampal veins entering into the basilar vein; 8 = arrows indicating the lines of dissection; 9 = peduncle (Crus cerebri) ; and 10 = hippocampal arteries.

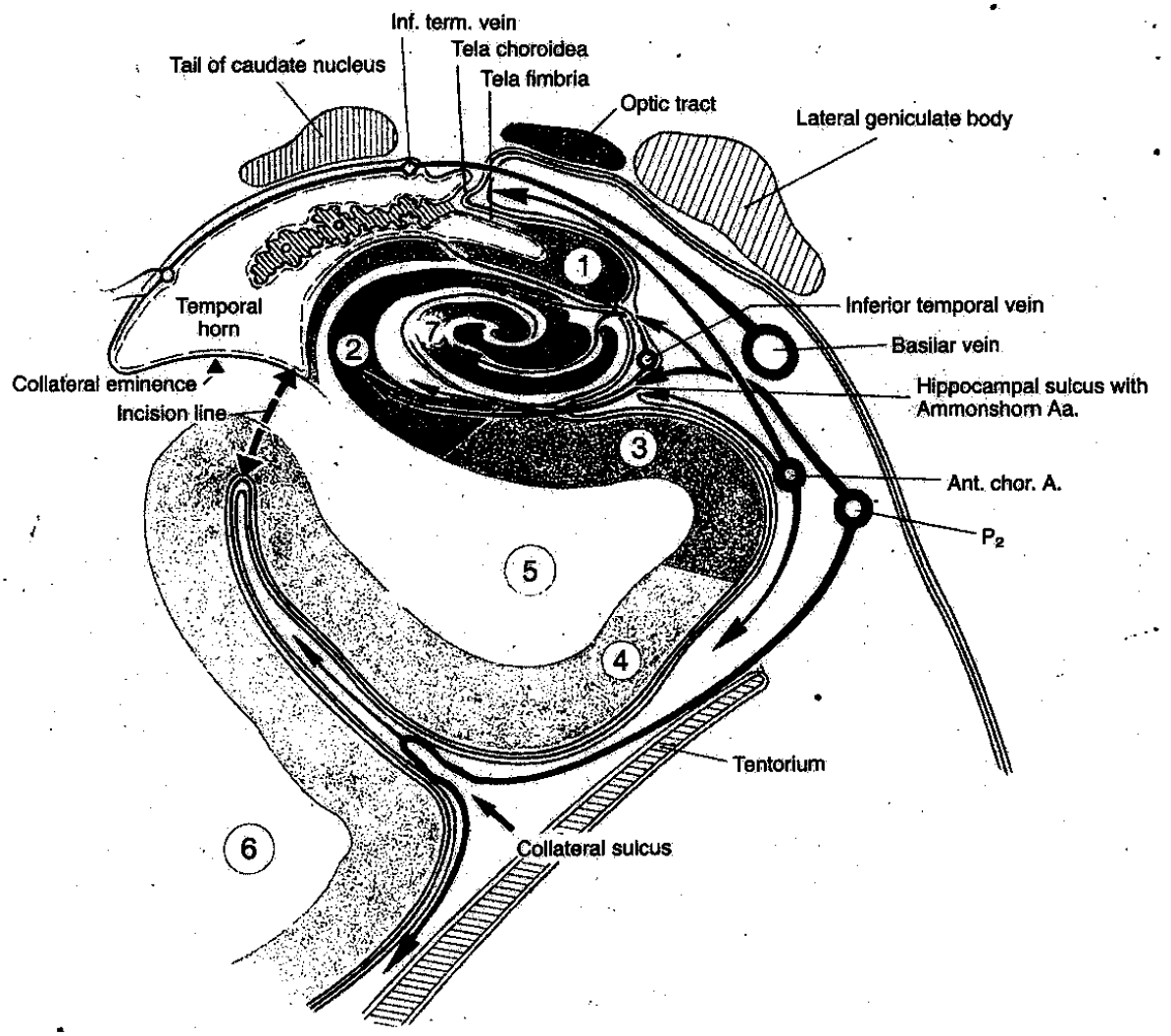

Figure 5. Coronal illustration of selectively removed parts of hippocampus and parahippocampus through temporal horn to collateral sulcus *(dotted line.)* 1 = fimbria; 2 = Ammon's horn; 3 = subiculum; 4 = entorhinal area; 5 = parahippocampal gyrus; and 6 = temporo-occipital gyrus; dentate gyrus.

Problems

The following points should be made regarding specific problems frequently encountered during this procedure.

1. When opening the sylvian fissure, as in all procedures using the pterional approach, dissection is carried out medial to the sylvian vein. Occasionally, however, cases present in which the frontoorbital vein is very large and too many major branches of this vessel would be sacrificed by a medial dissection. On such occasions, dissection must proceed lateral to the sylvian vein along the medial surface of the superior temporal gyrus, in an epipial plane, until the inferior portion of the insular sulcus and the inferior insular vein are reached (see Fig. 1).

2. Variations are frequently encountered in the form and distribution of the lateral branches of the M1 segment.[10,11] The surgeon must find, or by mobilization create, sufficient space to make a 1- to 2-cm incision between the two temporal arteries (see Fig. 1)

3. The possible variation of the vascularisation of the amygdala, uncus, hippocampus, and parahippocampus are shown in figure 6. The major vascular supply shows considerable regular variability.[10,12-47]

4. Removing the amygdala by the use of rongeur

and sucker is not generally a bloody procedure, but on approaching the ventricular wall (particularly medially), one must bear in mind the presence of veins returning from the amygdala within the subependymal layer. These, in turn, run subependymally to the atrial vein of the temporal horn, which runs through the choroid fissure to the basilar vein. Injury to these veins and their branches may result in torrential retrograde venous hemorrhage from the basilar vein and from the vein of Galen. Furthermore, it should be noted that the basilar vein may not run in a semicircular fashion around the cerebral peduncle to drain into the vein of Galen, but instead it may have a diagonal course over the cerebral peduncle from anteromedial to posterolateral in the direction of the tentorial incisure and draining into the superior petrosal sinus. The venous drainage of the insular mediobasal temporal structures, cerebral peduncle, optic tract, and thalamus to the basilar vein (vein of Rosenthal) has been demonstrated precisely and elegantly by H.P. Huang (1976). [33,48-51]

5. The size and form of mediobasal temporal structures (amygdala, uncus, hippocampus, and parahippocampus) can vary considerably.[52-55] In some cases, it is seen to bend only gently around the cerebral peduncle parallel to the optic tract, whereas in others it takes the form of a coiled worm. Preoperative assessment of the configuration of the parahippocampus by CT scan and air encephalography and also by angiography was largely unhelpful. Perhaps the shape of the mediobasal temporal areas is determined in part by the size and configuration of the skull base itself with particular reference to the pterional wing. These variations requ-

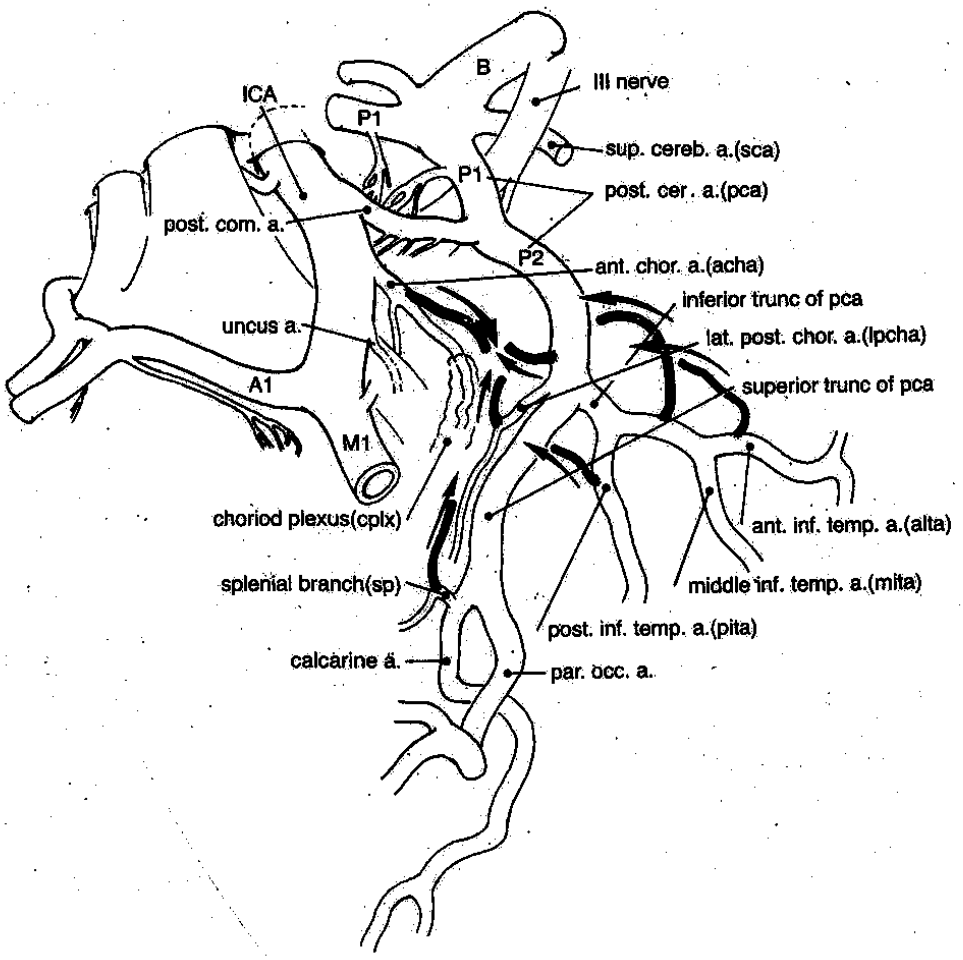

Figure 6. Illustration of the variation of the vascularization within hippocampal and parahippocampal region. Arrows indicate the predominant origin of feeders from anterior choroidal and posterior cerebral arteries and their branches.

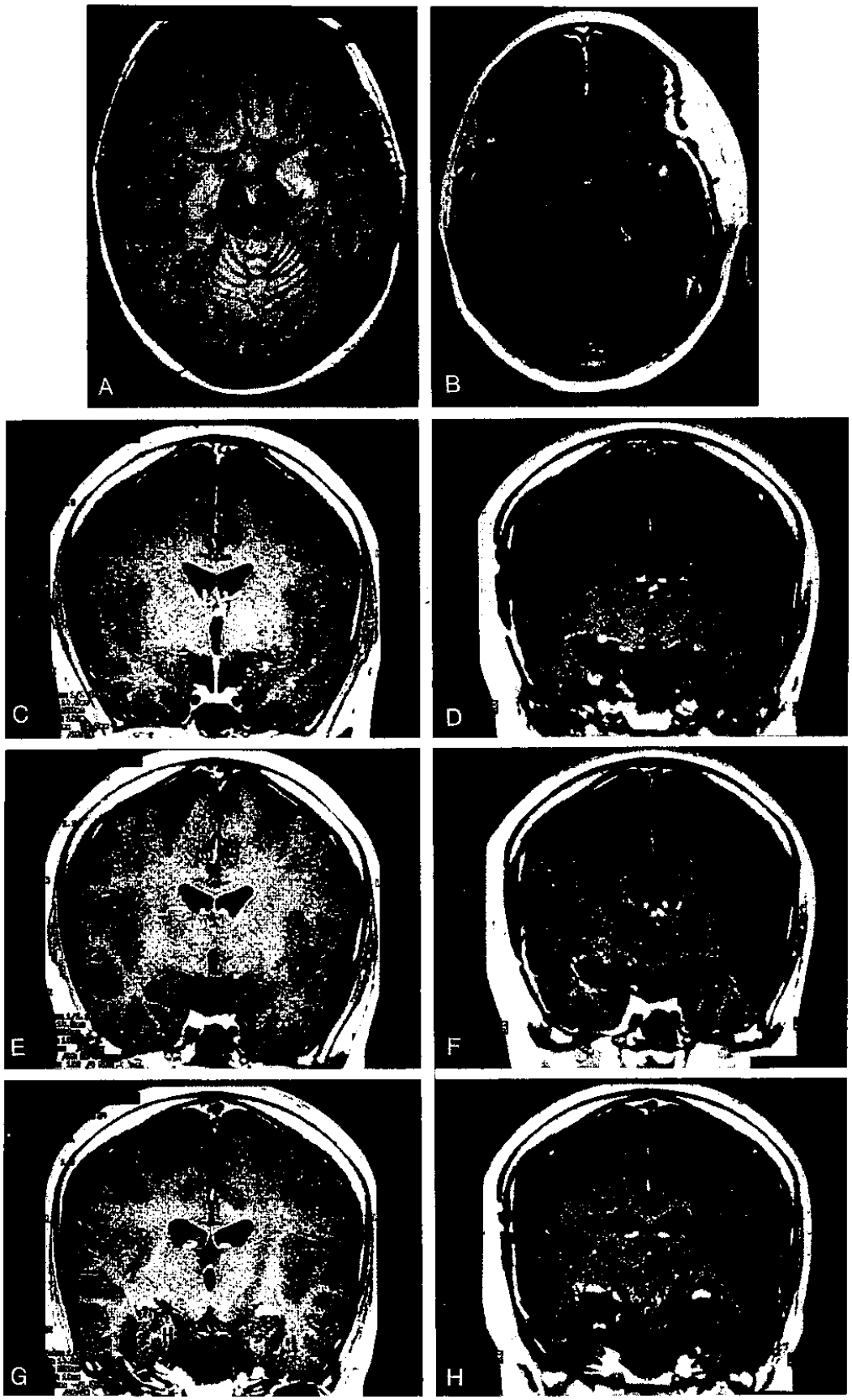

Figure 7. See legend on next page.

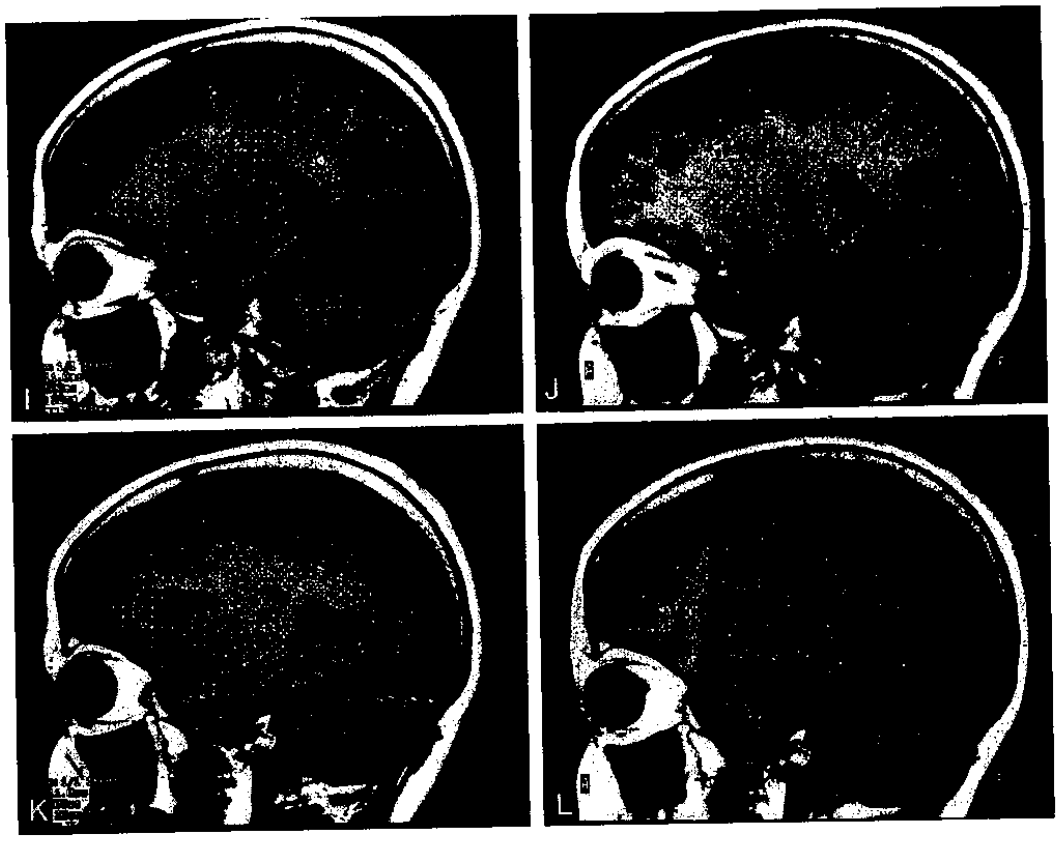

Figure 7. Preoperative (A) and postoperative (B) axial MR images in a case of a 25-year-old woman with temporal lobe seizures without lesional changes. Histology revaled brain tissue (gray and white mater) with gliosis. Preoperative (C) and postoperative (D) coronal MR images at the level of amygdala (A). Preoperative (E) and postoperative (F) coronal MR images at the level of uncus (U), head of hippocampus. Preoperative (G) and postoperative (H) coronal MR images at the level of body of hippocampus (H). Preoperative (I) and postoperative (J) sagittal MR images at the level of uncus (U). Preoperative (K) and postoperative (L) sagittal MR images at the level of lateral amygdala (A) and body of hippocampus (H).

ire further study by anatomists. Current triplanar MRI is of considerable help to study the extension, variations, and exact pre- and postoperative morphology of mediobasal temporal areas (Fig. 7, A-L)

6. The term *"selective" AHE* is rather misleading for several reasons. First, the amygdala is not removed completely,and approximately 10% of its most medial part, where it abuts the striatum, anterior commissure, and tail of the caudate nucleus, remains. Second, the posterior transection of the hippocampus-parahippocampus is generally carried out, respectively, at the level of the posterior rim of the cerebral peduncle at the bifurcation of the P2 segment where it gives the P3 segments, at the level of the ascending tail portion of the hippocampus, and 5 to 10 mm before the isthmus of the cingular gyrus where the anterior part of the medial temporooccipital gyrus lies. But if this is carried too far, there may be damage to the lateral geniculate body or Meyer's loop.

7. Although the operation is safe in terms of inflicting no damage to most parts of the temporal lobe (apart from amygdala, uncus, hippocampus, parahippocampus, and mediobasal temporal pole), there is inevitably some injury to the anterior stem of the superior temporal gyrus in a length of 12 to 15 mm, which is 20% of the total length of the temporal stem (70 to 80 mm). Furthermore, the connection areas of superior, middle, and inferior temporal gyri within the mediobasal temporal pole area will be compromised by subpial suction of amygdala and anterior parahippocampus. Such damage

cannot be well demonstrated with present imaging techniques. Postoperative triplanar MR images have to be examined critically[39]; the volumetric studies may be misleading, measuring only the resection cavity, as the adjacent perserved basal gyri, like the lateral and medial temporooccipital gyri, slide into the surgically created space (Fig. *7, B, D, F, H,. K,* and *L*).

8. By selective AHE, the rest of the temporal lobe, especially the superior, middle, and inferior temporal gyri; the lateral and medial temporooccipital gyri; and 80% of the temporal stem, remains surgically untouched.

9. Serious complications were not common in the presented series of 100 selective AHE operations.[6] Those that might be particularly anticipated are hemiparesis and homonymous field deficits. These may be kept to a minimum if care is taken to avoid damage to the branches of the anterior choroidal artery and branches of the P2 segment. Visual field deficits are more likely to result from damage to or spasm of vessels that supply, the optic tract than to direct injury to Meyer's loop. To avoid arterial spasm, papaverine is locally applied frequently, to the explored arteries.

POSTOPERATIVE FOLLOW-UP AND SEIZURE OUTCOME CLASSIFICATION

Patients were rigidly restudied at least 3 and 6 months after surgery and then at least in 1-year intervals. The follow-up of 86 patients operated on between 1975 and 1990 ranged from 19 months to 15 years. Postoperative seizure outcome was assessed according to the recommendation of the International League Against Epilepsy (ILAE) "Commission for Neurosurgery for Epilepsy (CNE)": I, seizure free; II, rare seizures (not more than 1 to 2 per year); III, worthwhile improvement, i.e., more than 90% reduction of seizures, and improvement in quality of life; IV, unchanged; and V, worse.

RESULTS

Selective AHE was performed on 100 patients without any presurgically demonstrated structural pathology in 55 cases on the right side and in 45 on the left side. The medium age at seizure onset was about 10 years, compared with 25 years in another cohort with structural lesions. The duration of recurrent seizures before surgery was about 20 years, compared with 3 years for the other group with structural lesions, whereas the mean age at operation (31.3 years) did not differ significantly from the patients with structural lesions (29.9 years).

Histologic results are not available for 15 patients, because the surgical specimens had been submitted to other scientific investigations, and the details are given in Table 3. The correlation of the duration of seizure illness (years with recurrent seizures before surgery) with the results of the histopathologic anlaysis revealed an increase in the degree of hippocampal sclerosis with increasing duration of seizures (details are given in Table 4).

Table 5 summarizes the epileptologic outcome in correlation to the duration of postoperative follow-up (year-to year-classification) according to the two different groups ("causal" and "palliative" AHE). Comparing the epileptologic outcome with histopathologic findings, one can see good or even excellent results in patients with hippocampal gliosis and sclerosis of various degrees in about 60% to 70%. A similar good result is achieved in patients without any detectable pathology whereas patients with hamartomas, dysplasia, and infarction show a more scattered distribution between good

Table 3. HISTOLOGY

			Gliosis					Focal		
	Ø	Normal	(+)	+	++	Sclerosis	Hamartia	Scar	Dysplasia	Microinfarct
Causal	10	4	12	25((3)	4	16	4	2	2	2
Palliative	5	4	—	3(1)	1	2	3	—	1	–
	15	8	12	28	5	18	7	2	3	2
Total			(4) oligodendroglia-like foci							100

Table 4. HISTOLOGY AND DURATION OF SEIZURE ILLNESS

Seizure History (years)	Ø	Normal	Gliosis (+)	Gliosis +	Gliosis ++	Sclerosis	Hamartia	Focal Scar	Focal Dysplasia	Focal Microinfarct
0—5	1			1		2	1	1	2	1
6—10	2		2	2	1	3	1			
11—15	1	3	3	6	1	3	1		1	1
16—20	6	1	3	5		3	1			
21–30	2	1	2	8	2	3	4			
31—40	3	3	2	4		4		1		
>40				2	1					
TOTAL	15	8	12	28	5	18	7	2	3	2
										100

and poor results. This outcome does not differ significantly between the first and third postoperative year (Table 6).

DISCUSSION

This updated report demonstrates the excellent epileptologic outcome after selective AHE in highly selected patients with medically refractory seizures of unilateral mesial temporal lobe origin. The epileptologic outcome after AHE is comparable with the outcome after the well-established anterotemporal lobectomy.[1,2,57-62] Other surgical procedures, such as streotactic approaches or subpial transsections, were not applied to seizures of medial temporal origin in Zurich since 1975. Selective AHE avoids lateral cortical damage associated with other resective procedures of the temporal lobe and can be performed without neurologic deficits. Compared with the standard anterior two thirds temporal lobe resection, AHE is followed by a much better neuropsychologic and psychosocial outcome.[63]

Table 5. SEIZURE OUTCOME OF "CAUSAL" AND "PALLIATIVE" AMYGDALOHIPPOCAMPECTOMY (n = 88)

	Year				
Outcome (ILAE-CNE)	1	2	3	4	5
"Causal" AHE (total)	70	61	48	41	33
I	47	34	24	22	19
II	5	10	5	6	2
III	7	6	7	4	3
IV	10	8	8	5	5
V					
Lost	1	3	4	4	4
"Palliative" AHE (total)	18	17	16	13	12
I	2	2	2		
II	5	5	4	3	3
III	4	4	2	1	1
IV	6	6	6	6	6
V					
Lost					
Causal and Paliative AHE	1		2	3	2
	88	78	64	54	45

To reach this aim, besides skillful microsurgical techniques, the exact knowledge of the vascular supply and of the surgical anatomy is essential. The proportion of patients with postoperative complications lies on the lower border of the generally acepted range; particularly anticipated complications are hemiparesis and homonymous visual field deficits in consequence to damage of the vessels of the AchoA and of the P2 segment or damage or spasm of vessels supplying the optic tract. In these series, one transient hemiparesis but no cranial nerve deficits were observed. Surgical problems were one case of osteomyelitis that led to removal of the bone flap and secondary reconstruction and a subacute subdural hematoma that was evacuated without further complications. Two patients in this series died of acquired Creutzfeldt-Jakob disease, but this extraordinary complication has no direct relationship with the AHE procedure.[56]

The surgical results highly depend on selection criteria for resective surgery.[1,2,35,43,62,61-66] Although the surgical results of AHE are slightly better in patients with preoperatively detected structural lesions, this report demonstrates that the group of patients with a syndrome of mesial temporal lobe epilepsy without any gross structural lesions respond equally favorably to AHE as long as the se-

Table 6. OUTCOME VS. HISTOLOGY AFTER 1 AND 3 YEARS (N = 88)

Outcome ILAE-CNE		Normal	Gliosis (+)	Gliosis +	Gliosis ++	Sclerosis	Hamartia	Scar	Focal Dysplasia	Microinfarct
1 year										
I	9	5	6	15	3	8	2	2		
II	1		1	2	1	1	2		1	
III	2	1		12	1	2	1		1	1
IV	2	2		5		4	2			1
V										
Lost	1					1				
Total	15	8	7	24	5	16	7	2	2	2
										88
3 year										
I	3	4	2	10	1	5	1	2		
II	1			3		3				
III	2		1	2		2	1			
IV	2	2	1	3		3	3			1
V										
Lost	2	1		1			1			1
Total	10	7	4	19	1	13	6	2		2
										64

izure origin is unilateral in the mesial temporal lobe.

The histopathologic results are comparable with earlier studies.[67,68] These demonstrate an association between increased severity of gliosis and the duration of seizure illness before operation. In this current report, the same correlation was found. Moreover this report also shows that the more severe the gliosis, the better the outcome.

In conclusion, the good postoperative findings of these "nonlesional" patients demonstrate that selective AHE is a safe microneurosurgical procedure with a favorable chance of success in relieving them from their medically refractory seizures of mesial temporal lobe origin. With the palliative indication, i.e., when seizures originate outside the resected tract but use of the hippocampal formation as a secondary pacemaker structure, this operation is less effective. Even in this group, however, a substantial proportion of patients experienced a good operative result.

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