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Clinical Article

Temporo-mesial epilepsy surgery: outcome and complications in 100 consecutive adult patients

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Summary

Background. We studied the surgical outcome, and the complications in a group of 100 consecutive adult patients with medically refractory epilepsy arising from the temporo-mesial structures.

Methods. Hundred patients were treated surgically between 1994 and 2003 for drug-resistant epilepsy involving the temporo-mesial structures. All of them underwent a comprehensive noninvasive presurgical evaluation. Fourty-eight of them underwent depth electrodes recordings (according to the Talairach's StereoElectroEncephaloGraphic (SEEG) methodology) because the noninvasive investigations were not congruent enough to identify the epileptic zone. The patients presenting with any space-occupying lesion, or with a cavernoma, or with a strictly lateral neocortical epileptic focus, were excluded. The MRI-examination was abnormal in 87 cases, displaying a hippocampal atrophy in 69 cases. The extent of temporal resection was planned according to the results of the presurgical investigation in each particular patient. Consequently, this ''tailored'' resection varied from selective amygdalo-hippocampectomy (6 cases), to anterior temporal lobectomy (76 cases), or to total temporal lobectomy (18 cases).

Findings. The mean post-operative follow-up period was 53 months. 85 patients were found to be in Engel's class I post-operatively (free of disabling seizures), among them 74 were in class Ia (totally seizure free). Nine patients were in Engel's class II and six were in Engel's class III or IV (failures). There was no surgical mortality. Three patients had a postoperative hematoma; two patients required a shunt insertion; in three patients meningitis occured; and two patients had postoperative ischaemia of the anterior choroidal artery territory, which resulted in a mild permanent hemiparesis. Neuropsychological complications are not addressed in detail in this article.

Conclusions. These data indicate that ''tailored'' resective surgery for temporo-mesial epilepsy can be performed with a low rate of morbidity, and is highly efficacious. The use of invasive presurgical investigation (SEEG) may explain this high rate of success.

Keywords: Epilepsy surgery; temporal lobe epilepsy; surgical results; mesial sclerosis; depth electrode recordings; SEEG.

Introduction

During the past decades, surgery for intractable epilepsy has been increasingly performed. Surgery may provide not only relief from seizure, but also functional improvement and increased quality of life [22]. This is particularly true for temporal lobe epilepsy, of which surgical outcome is known to be the most satisfying, especially if the temporo-mesial structures are involved [5, 14, 17, 33]. Despite the recent elaboration of the mesial temporal lobe epilepsy syndrome (MTLE), there are few papers in the literature dealing specifically with its surgical outcome and complications, as some of them tend to mix data from MTLE with data from neocortical temporal lobe epilepsy. Etiological data are also sometimes difficult to compare, as tumor, or cavernoma-related epilepsies do not have the same features as a MTLE due to mesial sclerosis. Also, there are few papers dealing with cases of MTLE with the benefit of invasive presurgical electrophysiological recordings for planning the extent of the temporal lobe resection outside the amygdalo-hippocampal structures, namely the temporal pole and the lateral neocortical areas. In this report, we focus on the surgical outcome and complications after ''tailored'' temporal surgery involving the whole temporo-mesial structures and a variable extent of the pole and the lateral neocortex, defined according to the data given by the presurgical investigation.

Material and methods

Patients

The series includes 100 consecutive patients with medically refractory temporo-mesial epilepsy treated surgically between 1994 and 2003 in the Department of Stereotactic and Functional Neurosurgery of Lyon, France. There were 58 females and 42 males; the mean age was 34 years (from 18 to 58).

Patients with cavernomas were not included; they were treated by lesionectomy and perilesionectomy of the surrounding gliotic and hemosiderinic tissue only. Patients with low-grade astrocytomas or oligodendrogliomas, even though mesial temporal epilepsy was the revealing feature of the disease, were also excluded; as a matter of fact, extent of resection was decided according to the tumor extension and not on epilepsy considerations. In contradistinction, when dealing with dysembryoplastic neuro-epithelial tumors (DNET) or gangliogliomas, surgery was performed on a more standardized basis, i.e. lesionectomy associated with temporomesial resection; therefore these lesions were not excluded from the series.

On another hand, patients in whom the presurgical investigation showed a strictly neocortical, but not mesial, temporal onset of the seizures, were also excluded. Patients with cortical dysplasia, hamartoma, micro-cystic, gliotic or ischemic lesions were included. A majority of the other retained patients suffered from hippocampal sclerosis, as shown in the section on ''results'' (Table 2).

Presurgical investigations

All patients underwent a comprehensive noninvasive presurgical investigation, including a neurological evaluation, neuropsychological testing, imaging studies, and prolonged video-EEG recordings. Fluorodeoxyglucose-Positron Emission Tomography (PET) scans and/or Single Photon Emission Computerised Tomography (SPECT) were also performed. The intracarotid amobarbital procedure (Wada test) was done in the 73 cases in whom laterality for language had to be ascertained. When the Wada the test confirmed that the dominant side for language was same hemisphere as epilepsy, neocortical resection spared the T1 as well as the posterior part of the T2 gyri when indicated.

In fourty-eight of our patients, data from these noninvasive presurgical investigations were not sufficiently congruent for localizing reliably the epileptogenic area. The noninvasive presurgical investigations were considered as congruent as soon as the clinical, electrophysiological and MRI data were those expected in the MTLE syndrome as described in the literature [33], and pointed clearly at the temporo-mesial structures on one side. The high percentage (48%) of patients without insufficient congruence among data from the noninvasive investigation is explained by the fact that a number of ''complex'' cases were referred to our center from other centers not having facilities to perform the depth electrode SEEG method (StereoElectroEncephaloGraphy). This was performed by implanting depth electrodes according to the methodology of Talairach, described in the 60's by Talairach and Bancaud [30]. Principles and methodology of SEEG have been reported in detail in previous publications [6, 12, 21]. Briefly, SEEG consists of stereotactic implantation of depth electrodes in an orthogonal plane, using superimposition of both MRI and angiography. The sites of implantation depend, for each particular patient, upon the outcome of prior noninvasive presurgical investigations. Because MRI is coupled with angiography, each electrode can reach its implantation site without injuring cerebral vessels. The electrodes are left in place for up to 21 days, or until sufficient information is obtained on localization of seizure onset and propagation. Intracerebral recordings of spontaneous seizures were thus undertaken before the surgical decision in 48 patients. Because of the use of the SEEG in complex and/or noncongruent cases, for those cases we did not have recourse to subdural grids, or electrodes inserted through the foramen ovale prior surgery, or intra-operative electrocorticography (EcoG).

Surgical procedures

The operations were carried out by the first two authors together (MS and MG). The policy was to perform tailored temporal resections according to the data given by the presurgical investigation [27]. Six patients, who demonstrated, by means of SEEG, strictly limited temporo-mesial epilepsy, i.e. epileptic foci and fast propagation to the mesial structures only, were submitted to selective unco-amygdalo-hippocampectomy (which included by definition the parahippocampal gyrus). On the other hand 18 patients, also having undergone SEEG procedure, with epilepsy quickly propagating to the entire temporal lobe in addition to the temporo-mesial structures, had a total lobectomy, which of course respected language areas on the dominant side. In the other 76 patients, in whom the presurgical investigation demonstrated mesial temporal lobe epilepsy with only partial involvement of the neocortex at the temporal pole, the resection included the mesial structures and a polectomy involving 2 to 3 cm of the neocortex from the tip of the pole.

The left side was involved in 43 cases, and the right side in 57 cases.

The surgical procedure performed in our patients used a transsylvian transventricular approach – derived from the one learnt during the training of the senior author in Yasargil's department in Zurich [35] – combined with a medial cisternal approach along the anterior choroidal artery within the crural and the ambient cisterns on the medial side of the temporal lobe. The technique has been described in detail in previous publications [27, 28].

After excision, the tissue was given to the neuropathological department for histological examination.

Postoperative outcome was assessed one year or later (up to ten years) after surgery (mean: 53 months). Results on epilepsy were graded using (a slightly simplified) Engel's classification (Table 1).

Complications

Postoperative complications which do not resolve completely after the first ten days following surgery were rated as follows. Persistent superior homonymous quadranopia after total temporal lobectomy was not quoted as a complication, but as a side-effect. Superior homonymous quadranopia occured systematically if the extent of neocortical resection was 6 cm or more from the tip of the pole, it never occured if the extent of neocortical resection was 2 cm or less from the tip of the pole (see Ref. [13]). Neuropsychological and psychiatric transient side-effects are not addressed in detail in this study. Only the severe and durable postoperative behavioural changes will be considered as complications and mentioned. Short-lasting (2 to 4 weeks) postoperative mnesic or behavioral impairments will be mentioned as side-effect.

Table 1. *Simplified Engel's classification of postsurgical outcome, used in our series*

Engel's class	Epileptological outcome
Ia	Completely seizure-free since surgery
Ib	Non-disabling simple partial seizures (infrequent auras)
Ic	Some immediate post-operative seizures only
Id	Recurrence of seizures on drug withdrawal only
IIa	Initially seizure-free but still has rare seizures
IIb	At least 90% decrease of seizure frequency
III	50% to 90% decrease of seizure frequency
IV	Less than 50% decrease of seizure frequency or worsening

Statistical analysis

Chi-square-statistics were applied to correlate dichotomized aspects of preoperative findings to outcome; $p < 0.05$ was considered as significant.

Results

Presurgical investigation

By definition, the extra and/or intracranial recordings of all the patients showed that the primary epileptogenic focus involved the temporo-mesial structures (amygdala, hippocampus, parahippocampal gyrus). MRI examinations showed structural abnormalities in 87 cases, of which 69 were hippocampal atrophy (Table 2).

Neuropathology

The histopathological findings are also summarized in Table 2. Hippocampal sclerosis was found in 69 cases. The histopathological examination did not find any specific abnormality in 13 cases.

Table 2. *Neuropathological findings, with corresponding pre-operative MRI findings and outcome*

Type of lesion on histopathological examination (Nb of patients)	Visible on MRI	Outcome (Engel's class I)
Hippocampal sclerosis (69)	69	91.3%
DNET, ganglioglioma (7)	7	100%
Cortical dysplasia (5)	5	60%
Hamartoma (3)	3	66.6%
Cystic, gliotic, or ischemic lesion (3)	3	66.6%
No visible lesion (13)	0	60%
Total (100)		

Surgical outcome

Surgical outcomes are summarized in Table 3. Overall, 85 of the patients were postoperatively in Engel's class I (85%); among them, 74 were in Engel's class Ia, 5 in class Ib, 4 in class Ic, and 2 in class Id. Nine patients were in Engel's class II (9%). Six patients (Table 4) were in Engel's class III or IV (6%).

The anti-epileptic drugs were left unchanged for at least six months postoperatively. They were then progressively decreased according to patients, leading to an off-medication state in 2 to 5 years postoperatively in 34 of the patients.

Prognostic factors

There was no significant correlation between outcome on epileptic seizures and age, side or type of temporal resection. Difference in terms of surgical outcome was significant according to the presence or the absence of an abnormality on MRI; the percentage of patients in Engel's class I was 87% in the group with a structural abnormality versus 77% only in the group without abnormality. There was a significant difference in outcome according to the presence or not of histological abnormalities ($p < 0.001$). 60% of the patients with no abnormality, versus 91% with a hippocampal sclerosis and 100% with a DNET, were in Engel's class I. The finding of a cortical dysplasia was associated with a less favourable outcome; only 60% were in Engel's class I after surgery.

Complications

There was no surgical mortality.

Table 3. *Surgical outcome*

Engel's class	Ia	Ib	Ic	Id	IIa	IIb	III	IV	
Number of cases	74	5	4	2	6	3	2	4	100
	Class I: 85				Class II: 9		Class III–IV: 6		100

Table 4. *Baseline characteristics of Engel's class III and IV patients in our series*

#	Gender	Age	SEEG	Surg.	Side	Histology	F.U.	Outcome	Explanation of failure
1	F	36	yes	TTL	R	H. Scl	69	IV	insular involvement
2	F	43	yes	ATL	R	normal	72	III	unknown
3	M	52	yes	TTL	R	normal	77	IV	orbito-frontal involvement
4	M	41	yes	ATL	L	H. Scl	89	III	orbito-frontal involvement
5	M	39	yes	ATL	R	H. Scl	90	IV	hippocampal remnant
6	M	25	yes	ATL	L	hamartoma	101	IV	unknown

F Female, *M* male; *Surg*. type of temporal resection, *TTL* total temporal lobectomy, *ATL* anterior temporal lobectomy; *R* right, *L* left; *F.U.* follow-up, in months; *H. Scl* hippocampal sclerosis.

Table 5. *Postoperative complications*

Type of complication	Complications		Long-term evolution
	Major*	Minor*	
Contralateral motor deficit	2		mild spastic hemiparesis
Postoperative haematoma (reoperated)		3	no sequelae
Hydrocephalus (shunted)	2		no sequelae
Third nerve deficit (transient)		5	no sequelae
Bacterial meningitis		3	no sequelae
Pulmonary embolism		1	no sequelae
Durable depressive state	3		partial recovery
Total	19		

* The severity of a complication is graded according to Rydenhag and Silander [25] as minor if it resolved within three months and major if it lasted longer than three months.

Complications are summarized in Table 5. In three patients a haematoma was found in the excision cavity the day after surgery on the post-op CT control, which was evacuated without any sequellae in all three. A bacterial meningitis appeared in three patients; they all were treated medically and cured without sequelae. Pulmonary embolism occured in one patient; outcome was favourable. Surgery was followed by a contralateral hemiparesis in two patients, which was due to ischaemia in the anterior choroidal artery territory as demonstrated by postoperative MRI-scans. In both cases, the deficit recovered well, leaving only a mild, non disabling, spasticity so that the two patients could resume their previous work after three months of rehabilitation and physical therapy. Third nerve palsy was noticed in 5 patients, all transient. This transient dysfunction was attributed to the dissection of the third nerve from arachnoidal adhesions sticking the uncus to the nerve at the level of the crural and ambient cisterns; the purpose was to free the anterior choroidal artery and the P2 segment of the posterior cerebral artery so as to identify their collaterals to the hippocampal and parahippocampal gyri. Two patients required a shunt insertion some weeks after surgery due to secondary hydrocephalus. Persisting, although transient (lasting less than three months), post-operative neuropsychological impairment was noticed in 17 cases. Among them, verbal amnesia was noticed in 7 cases, all having had surgery on the left (dominant) side. Behavioral dysfunctions were noticed in 7 patients; the right side was involved in six of them. Severe and lasting post-operative depressive states developed in three more patients; the right side was involved in two of them, and the left in one.

It has to be noticed that there was no correlation between age, side or extent of surgery and the occurence of a surgical, neurological, or neuropsychological complication.

Three complications occured after SEEG procedures. It was a localized subcutaneous infection in one case, which was treated medically without sequelea. The enlargement of a previously known thin chronic subdural haematoma was noticed in another case, that was operated on three weeks after the removal of the electrodes. A fracture of one of the electrodes occured in a third patient. The remaining intracranial part of the electrode was removed from under the skull vault under local aneasthesia.

Discussion

Most of the patients included in this study (i.e. 94%) benefited from surgery; 85% had Engel's class I and 9% Engel's class II outcome, with a postoperative morbidity rate relatively low and a mortality nil. According to the literature data (see reference 11 for review: 145 references cited) 50 to 93% of adult patients (68% on average) are free of disabling seizures (Engel's class I) after temporal lobe surgery [3, 7, 9, 10, 18, 20, 23]. One randomized controlled study [31] concluded that 58% of the patients surgically treated became seizure-free (Engel's class Ia), compared to only 8% in the group of patients who did not receive surgery. Our results compare favourably with those reported in the literature. This can partly be explained by the non-inclusion in our study of the patients presenting with low-grade epileptogenic gliomas or cavernomas and also the strong contribution of the invasive part of the presurgical investigation, namely the SEEG recordings. As a matter of fact 48 patients had SEEG, especially those who had (at least some) discrepancies between clinical, imaging, and videoEEG data on preoperative investigation; furthermore, recordings were performed using a large number of electrodes and contacts (8 to 15 electrodes, 11 on average, and 5 to 15 contacts per electrode). For each single case, the sites of implantation of the electrodes depended upon the information obtained from the noninvasive presurgical investigation. Implantation sites were chosen in order to be precise: either the side of the onset of seizures, or the uni- or multilobar feature of them, or a possible operculo-insular propagation from a temporal onset. Also, by using direct electrode stimulation, the method served for functional mapping

especially in the vicinity of speech or motor area. Generally speaking, the use of SEEG in the ''difficult'' cases of our series helped to choose between selective amygdalohippocampectomy, amygdalohippocampectomy plus polectomy, and total lobectomy, that is to delineating ''tailored'' resective operations. We estimate that SEEG, when performed, has pushed to enlarge the resection to the pole and more or less to the lateral neocortex in some 90% of the patients in the series, on the basis of the early implication of those structures in the epileptic propagation. One patient in the series had additional resection of the inferior insula together with the infrasylvian opercula, and another one of the temporo-occipital junction on the data harvested from the SEEG recordings. On the other hand and it is important to mention it, in 9 patients in the series SEEG allowed one to propose resective surgery whereas this appeared disputable on the sole noninvasive investigation. Also, thanks to SEEG, 11 patients were excluded from the series, that is from resective surgery, in spite of presenting with appearently classical temporal lobe epilepsy, because of bilateral or bilobar foci or foci located in the speech area.

As previously reported [1, 2, 8], surgical outcome in our study was correlated to the presence of a structural abnormality, especially mesial sclerosis at histological examination [16, 24]. The finding of an ipsilateral mesial sclerosis is known to be an excellent prognostic factor in mesial temporal lobe epilepsy (MTLE) syndrome [24]. MR and histological findings of a dysembryoplasic neuro-epithelial tumour (DNET) or a ganglioglioma share a good prognosis with those of mesial sclerosis. By contrast, cortical dysplasias result in less beneficial seizure outcomes. This was reported in previous papers [15, 19] which argued that cortical dysplasias, the definition of which is still a matter of discussion, are known to be accompanied by widespread changes in neuronal structure and function.

Our definition of a complication may be open for discussion, as some postoperative disturbances have been considered as acceptable side-effects, and not as complications if they resolved completely within ten days. Thus, for example, dysnomia, or mild hemiparesis, lasting a couple of days and generally linked to post-operative focal ''brain oedema'', were considered as simple transient side-effects. Furthermore, some permanent visual field defects were also not classified as complications, because considered as unavoidable; as a matter of fact, homonymous superior quadrantanopia occurs constantly if the extent of the temporal resection reaches 4 to 6 centimeters from the tip of the pole [13]. In this series, the overall rate of complications lasting more than ten days amounted to 19%, which is well in the range of those from the literature [4, 25, 26, 32]. The most severe neurological complication was contralateral motor deficit due to impairment of the pyramidal tract at the level of the internal capsule. It amounted to 2%. Fortunately in these

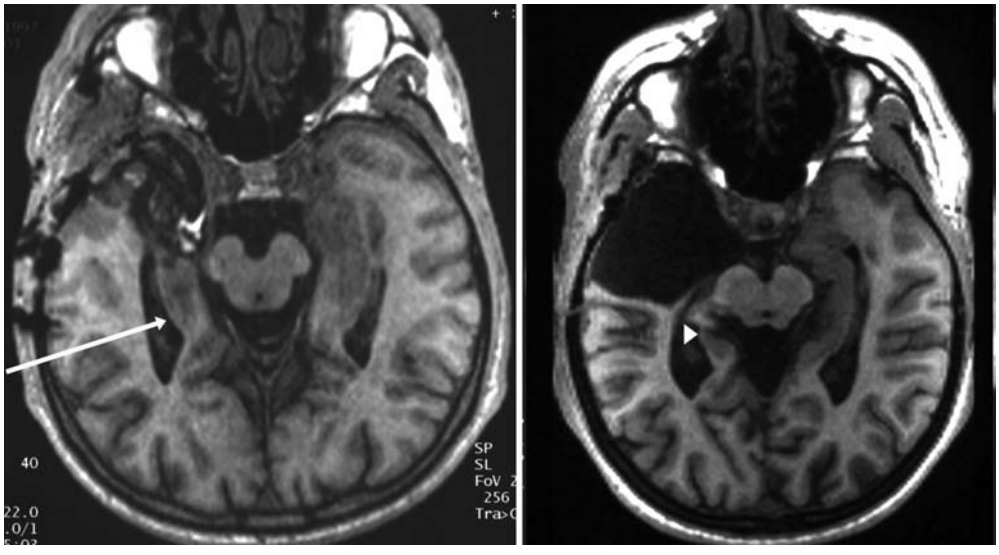

Fig. 1. Examples of hippocampal and parahippocampal removals. The one on the right part of the figure can be considered as ''complete''; its posterior limit reaches the frontal plane passing at the level of the tectal plate. The one on the left part of the figure can be considered as incomplete; Arrow: significative hippocampal remnant; Arrowhead: ''complete'' hippocampectomy

two patients the deficit was reversible within a few weeks, with only mild spasticity persisting; working status could be resumed.

Six of the patients in this series (Table 4) were found to be postoperatively in Engel's class III or IV, which corresponds to failure. In three of these six cases, the bad outcome can be explained by the early involvement of the insular or the orbito-frontal regions, that were intentionally not removed in spite of their detection by the SEEG recordings; the reason was that they were erroneously considered as ''secondary'' epileptogenic zones. In another case who failed, postoperative MRI-scan showed an incomplete removal of the hippocampus, leaving more than one-third of its length behind (Fig. 1). Although not being totally proved due to lack of randomized studies, some data in the literature are in favour of a correlation between seizure outcome and extent of hippocampal resection [29, 34]. In the two remaining cases who failed, the cause of the bad surgical outcome remains unclear.

In conclusion, our data, as others, confirm that temporal resection is a safe and efficacious treatment for drug-resistent MTLE, especially in the presence of hippocampal sclerosis. Also, patients with DNET or ganglioglioma, if resection is complete, have good outcome. The high percentage of patients seizure-free after surgery in our series indicate that ''tailored'' resective surgery constitutes a good surgical policy. This requires the use of depth electrode recordings (SEEG in our practice) each time the noninvasive investigations are not concordant enough to clearly identify the epilepogenic zone [12]. It allows one to include patients who can benefit from surgery in spite of not totally concordant pre-surgical investigation criteria, as well as to exclude from the selection process patients with multilobar or bilateral foci.

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