Seizure and memory outcome following temporal lobe surgery: selective compared with nonselective approaches for hippocampal sclerosis

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Object. The aim of this study was to compare seizure and memory outcome in patients with medically refractory mesial temporal lobe epilepsy due to hippocampal sclerosis (MTLE/HS) treated using an anterior temporal lobectomy (ATL) or a selective amygdalohippocampectomy (SA).

Methods. Surgical outcome data were prospectively collected for 2 to 11 years in 161 consecutive patients with MTLE/HS. Eighty patients underwent an ATL and 81 an SA. Seizure control achieved with each technique was compared using the Engel classification scheme. Postoperative memory testing was performed in 86 patients (53%). At the last follow up, 72% of the patients who had undergone an ATL (mean follow up 6.7 years) and 71% of those who had undergone an SA (mean follow up 4.5 years) were seizure free (Engel Class IA). Estimated survival in patients in Engel Classes I, IA, and I and II combined did not differ between the two surgical techniques. Preoperatively, 58% of the patients had verbal memory scores one standard deviation (SD) below the normal mean. One third of the patients with preoperative scores in the normal range worsened after surgery, although this outcome was not related to the surgical technique. In contrast, one third of those whose preoperative scores were less than −1 SD experienced improvement after surgery. Nine (18%) of the 50 patients whose left side had been surgically treated improved their verbal memory scores by more than one SD. Seven (78%) of these nine underwent an SA (p = 0.05).

Conclusions. Both ATL and SA can lead to similar favorable seizure control in patients with MTLE/HS. Preliminary data suggest that postoperative verbal memory scores may improve in patients who undergo selective resection of a sclerotic hippocampus in the dominant temporal lobe.

KEY WORDS • temporal lobe epilepsy • epilepsy surgery • amygdalohippocampectomy • anterior temporal lobectomy • memory outcome • survival analysis

THE syndrome of MTLE/HS is the most common medically refractory epilepsy syndrome in adolescents and adults seen in epilepsy surgery programs. Excellent surgical results in terms of seizure control and psychosocial rehabilitation have proven that MTLE/HS is a surgically remediable disorder. Note, however, that the increasing ability to visualize the sclerotic hippocampus on MR imaging and the evolving knowledge about the pathogenetic bases of MTLE/HS have raised questions about the best surgical approach to treat patients with refractory seizures. Particularly, it has been questioned whether the epileptogenic zone comprises both neocortical and mesial temporal structures or whether the latter are sufficient to generate the recurrent seizures in this disorder.

Uncertainties regarding this issue have led to the development of different surgical strategies in which the temporal neocortex is included in the resection or spared in favor of more selective techniques that focus the resection on the mesial structures. Supporting selective resection are the hippocampal site of the pathological entity and the evidence from depth electrode studies that the ictal onset zone is usually related to these mesial structures whenever TLE is associated with HS. On the other hand, the consistent recording of neocortical epileptiform spikes on acute electrocorticography has been seen by many as an indication for tailoring resection of the temporal neocortex.

As is the norm in the field, most epilepsy centers follow a single preferred surgical strategy, and comparisons can only be made among patients who undergo surgery at different centers, with unavoidable selection and technical biases. To our knowledge, there are only two studies in which different techniques for temporal lobe resection are specifically compared. Both consist of a limited number of patients who had variable profiles of abnormalities in the mesial structures, including the presence or absence of MR

Abbreviations used in this paper: AED = antiepilepsy drug; ATL = anterior temporal lobectomy; CI = confidence interval; EEG = electroencephalography; CI = confidence interval; IED = interictal epileptiform discharge; MR = magnetic resonance; MTLE = mesial temporal lobe epilepsy; MTLE/HS = MTLE due to HS; SA = selective amygdalohippocampectomy; SD = standard deviation.
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Imaging features suggestive of unilateral HS. In Porto Alegro, we performed surgery in 161 consecutive patients with medically refractory MTLE/HS through either an ATL or an SA. Patients were uniformly evaluated,11,34 had a very homogeneous clinical picture, and were surgically treated by the same surgeon (El.P.). Our findings in comparing these two techniques are the subject of the present report.

Clinical Material and Methods

Inclusion Criteria

Included in the study were patients in whom clinical features were characteristic of MTLE,16,32,36 interictal scalp/sphenoidal EEG recordings had unilateral or bilateral independent anteromesial temporal epileptiform discharges, at least one electroclinical seizure on scalp/sphenoidal video-EEG monitoring was recorded, and MR imaging or histopathological findings were characteristic of HS.3,7 The MR imaging criteria included the presence of at least two of the following: hippocampal atrophy, decreased intrahippocampal signal on T1-weighted images, or increased intrahippocampal signal on T2-weighted and fluid-attenuated inversion-recovery images. Histopathological studies positive for HS were based on qualitative evidence of neuronal loss3,7 in at least one of the hippocampal subfields CA1 or CA3 or in the dentate gyrus.

Patient Population

Surgical outcome was analyzed in 161 consecutive patients who had undergone surgery for MTLE/HS between January 1992 and March 2002. These individuals were drawn from a total of 569 patients who had undergone surgery for intractable epilepsy during the same period, in the temporal lobe in 285. Among these patients with TLE, 161 (56.5%) had HS, 58 (20.5%) low-grade gliomas, 11 (3.8%) nonspecific gliosis, 12 (4.2%) cavernomas, nine (3.2%) dysgenetic lesions, and 34 normal MR imaging and pathological study results.

Patient age at seizure onset ranged from 1 to 35 years (mean 7.3 years), and the age at operation ranged from 8 to 62 years (mean 31.3 years). Only five patients were younger than 15 years and four were older than 50 years at surgery. Eighty-eight patients were male, and 93 patients (57.8%) underwent surgery on the left side. Epilepsy duration ranged from 3 to 60 years (mean 24 years). Data regarding clinical, neurophysiological, and surgical variables in patients who had undergone each technique are listed in Table 1, which shows that both groups did not significantly differ in any of these variables except in the duration of follow-up.

Electroencephalography Studies

Prolonged video-EEG via scalp/sphenoidal electrodes was performed to record seizures and interictal spikes during wakefulness and sleep in patients receiving the usual and reduced dosages of AEDs. The last 24 hours of video-EEG recordings were analyzed to quantify interictal epileptiform discharges. Specific subgroups of electrical abnormalities were defined according to the side-to-side ratio of the anterobasal temporal IEDs. Thus, discharges were classified as having a greater than 90% predominance of one side or a less than 90% unilateral predominance. In all patients except three, extratemporal IEDs were not present in the EEG samples obtained for analysis. The ictal scalp/sphenoidal EEG findings were classified as being unequivocally localized to one temporal lobe, being lateralized to one hemisphere, or having uncertain lateralization.

Neuropsychological Test Battery

Patients were evaluated with a standardized neuropsychological test battery, focusing on verbal and nonverbal memory domains, consisting of the Wechsler Memory Scale–Revised, the Rey Auditory Verbal Learning Test, and the Rey Visual Design Learning Test.17,25 Patients in whom there were uncertainties about the memory reserve provided by the hemisphere contralateral to the epileptogenic zone underwent a unilateral sodium amobarbital test.22 Postoperative neuropsychological testing of memory function was performed in 86 randomly selected patients (53% of the total sample) between 12 and 36 months after surgery by using parallel versions of the preoperative test battery. Fifty patients had undergone left and 36 right temporal lobe surgery. The difference between pre- and postoperative memory scores was used to define changes in memory function. We focused our analysis on results regarding the verbal memory domain. For the purpose of correlating with the side of surgery, we assumed verbal memory to be dependent on the left side, except in patients in whom the sodium amobarbital test indicated a reversed dominance. In accordance with the standardization proposed by Wechsler,22 we considered as significantly abnormal those memory perfor-

<table>
<thead>
<tr>
<th>Variable</th>
<th>ATL</th>
<th>SA</th>
</tr>
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<tbody>
<tr>
<td>no. of patients</td>
<td>80</td>
<td>81</td>
</tr>
<tr>
<td>male/female ratio</td>
<td>43:37</td>
<td>45:36</td>
</tr>
<tr>
<td>mean age (yrs) at surgery</td>
<td>31.9</td>
<td>30.7</td>
</tr>
<tr>
<td>mean epilepsy duration (yrs)</td>
<td>22.8</td>
<td>25.1</td>
</tr>
<tr>
<td>side of surgery (lt/rt)</td>
<td>42/38</td>
<td>51/30</td>
</tr>
<tr>
<td>mean FU (yrs)</td>
<td>6.7</td>
<td>4.5</td>
</tr>
<tr>
<td>yrs of FU (no. of patients)</td>
<td>37</td>
<td>3</td>
</tr>
<tr>
<td>no. of patients w/ verbal memory test (lt/rt)</td>
<td>42/38</td>
<td>51/30</td>
</tr>
<tr>
<td>postop</td>
<td>27/19</td>
<td>25/17</td>
</tr>
<tr>
<td>no. of patients w/ seizure frequency (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;1/day</td>
<td>22 (27.5)</td>
<td>22 (27.2)</td>
</tr>
<tr>
<td>1–7/wk</td>
<td>46 (57.5)</td>
<td>53 (65.4)</td>
</tr>
<tr>
<td>&lt;1/wk</td>
<td>12 (15.0)</td>
<td>6 (7.4)</td>
</tr>
<tr>
<td>no. of patients w/ IED ratio (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;90% unilat</td>
<td>62 (77.5)</td>
<td>65 (80.2)</td>
</tr>
<tr>
<td>&lt;90% unilat</td>
<td>18 (22.5)</td>
<td>16 (19.8)</td>
</tr>
<tr>
<td>no. of patients w/ ictal EEG (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>temporal</td>
<td>59 (73.8)</td>
<td>63 (77.8)</td>
</tr>
<tr>
<td>uncertain</td>
<td>21 (26.2)</td>
<td>18 (22.2)</td>
</tr>
</tbody>
</table>

* FU = follow up.
TABLE 2
Postoperative Engel outcome class at the last follow up in 161 patients with MTLE/HS

<table>
<thead>
<tr>
<th>Engel Class</th>
<th>No. of Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ATL</td>
</tr>
<tr>
<td>I</td>
<td>73 (91.3)</td>
</tr>
<tr>
<td>A</td>
<td>58 (72.5)</td>
</tr>
<tr>
<td>B</td>
<td>5 (6.3)</td>
</tr>
<tr>
<td>C</td>
<td>7 (8.8)</td>
</tr>
<tr>
<td>D</td>
<td>3 (3.8)</td>
</tr>
<tr>
<td>II</td>
<td>3 (3.8)</td>
</tr>
<tr>
<td>A/B</td>
<td>3 (3.8)</td>
</tr>
<tr>
<td>D</td>
<td>3 (3.8)</td>
</tr>
<tr>
<td>III</td>
<td>3 (3.8)</td>
</tr>
<tr>
<td>IV</td>
<td>1 (1.3)</td>
</tr>
<tr>
<td>lost to FU</td>
<td>0 (0)</td>
</tr>
<tr>
<td>total</td>
<td>80 (100)</td>
</tr>
</tbody>
</table>

Imaging findings indicative of HS were identified preoperatively in 152 (94%) of 161 patients. All nine patients with normal findings on MR imaging were evaluated using the 0.5-tesla unit and were included in the study based on post-resection histopathological confirmation of HS.

Twenty-seven patients were evaluated using bitemporal subdural electrodes (Ad-Tech, Racine, WI) inserted through temporal bur holes.

Surgical Procedure

Eighty patients had undergone an ATL during which the anterior 2 to 3 cm of the first and 3 to 4 cm of the second and third temporal gyri were resected, as were the mesial structures. The latter were excised beginning with aspiration of the amygdala, followed by en bloc resection of both the anterior 2 to 3 cm of the hippocampus and the para-hippocampal gyrus extending posteriorly to the midmesencephalic level. The extent of resection was the same, regardless of the side of operation. The other 81 patients had undergone an SA during which the mesial structures were removed according to the technique originally described by Niemeyer. The temporal horn of the lateral ventricle was reached through a 2- to 2.5-cm incision in the second temporal gyrus. The amygdala and uncus were then aspirated, preserving the pia and arachnoid membranes overlying the vascular and neural cisternal structures. Finally, following identification of the fimbria, the hippocampus and parahippocampal gyrus were resected en bloc. The posterior limit of this resection extended 1 to 1.5 cm posterior to the inferior choroidal point, thus amounting to a total hippocampal resection of 2.5 to 3 cm.

Between 1992 and 1997, 57 patients underwent an ATL and 55 an SA. Between 1998 and 1999, 16 had an ATL and 33 had an SA. During the last 3 years included in the study, seven patients had an ATL and 43 an SA. The surgical procedure was not randomized.

Hippocampal tissue adequate for histopathological examination was obtained in 142 (88%) of the 161 patients. The diagnosis of HS was based on the qualitative assessment of the pattern of cell loss and gliosis in hippocampal...
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subfields CA1, CA3, and endofolium and in the dentate gyrus and followed published guidelines. All operations were performed by the same neurosurgeon (El.P.).

Postoperative Course

Patients were discharged while receiving therapeutic dosages of at least one first-line AED. Follow up was performed every 6 months in the 1st year (and yearly thereafter), either through outpatient visits or telephone interviews. Outcome was assessed independently by the neurological and neurosurgical teams. Patients and relatives were instructed to report seizure recurrences by telephone between scheduled outpatient visits, and these data were entered onto a structured outcome data sheet. Interviews for follow-up purposes involved questioning patients or relatives about the recurrence of symptoms previously associated with auras; episodes of transient alteration of consciousness; and signs suggestive of complex partial, partial motor, or generalized tonic–clonic seizures. This information was complemented by data regarding AED dosages and any modifications thereof between each visit or telephone contact. Attempts were made to maintain therapeutic dosages of a first-line AED for at least 2 years after surgery, when slow discontinuation was begun in patients who were seizure free. The temporal relation of recurrent auras or other types of seizures to reductions in the AED dosages was noted. We considered seizures related to the withdrawal of or a reduction in medication as only those occurring within 1 week of such modifications; any of these seizures were thereafter fully controlled by resuming the previous AED regimen. Patients with an Engel Class I seizure outcome at the last follow up were evaluated according to whether they were taking no medication, using less than 50% of the preoperative dosage of a first-line AED, or taking between 50 and 100% of the preoperative dosage of a first-line AED.

Outcome in relation to seizure control was based on the Engel classification, using all 13 subclasses. Engel Class I includes patients who are free of disabling seizures; Class II, those who have rare disabling seizures; Class III, patients with worthwhile improvement; and Class IV, those in whom surgery did not result in a worthwhile improvement in seizure frequency. The subclass IA specifically refers to patients who have been completely seizure free since surgery, including complete control of simple partial seizures (auras). Outcome was analyzed at the last follow up (Table 2), and survival analyses were performed to determine the probability of a patient remaining over the years in Engel outcome Class I (A, B, or D), IA, and I or II combined (Kaplan–Meier curves; Figs. 1 and 2) and to estimate retention in each of these outcome classes when comparing the two surgical techniques. Excluded from Engel Class I survival curves were all patients who had experienced any postoperative complex partial or generalized seizure, except when it occurred within 1 week of a reduction in the withdrawal of AEDs (Engel outcome Class ID).

The mean survival time in each outcome class and the 95% CIs were calculated for each surgical technique, complemented by tests for equality of survival distributions comparing both techniques. In addition, a t-test, contingency tables, and the Fisher exact test were used to correlate seizure control with clinical, neurophysiological, preoperative neuropsychological, imaging, and histopathological variables as well as to compare results obtained with each surgical technique. A logistic regression model was used to evaluate the association between the selective surgical technique and a favorable outcome in terms of an improvement of more than one SD in postoperative verbal memory scores. Included as covariates in the model were duration of postoperative follow up and side of surgery. Significance was established at a probability level less than 0.05 by using a commercially available statistical package (SPSS, version 11; SPSS, Inc., Chicago, IL). Acute postoperative complications with regard to hematomas, infections, motor or language deficits, global amnesia, and psychosis were noted.

Results

One (0.6%) of the 161 patients with MTLE/HS was lost to follow up. All others were followed up for 2 to 11 years (mean 5.59 years).

Surgical Outcome at the Last Follow Up

After a mean follow-up period of 5.8 years (range 24–132 months), 143 patients (88.8%) had an Engel Class I outcome, 116 (72%) had a Class IA outcome, and 111 (93.7%) had either a Class I or II outcome. Fifty-eight (72.5%) of the 80 patients who had undergone an ATL (mean follow up 6.7 years) and 58 (71.6%) of the 81 patients who had undergone an SA (mean follow up 4.5 years) continued to be completely seizure free since surgery (Engel Class IA). Results concerning the other outcome classes are shown in Table 2. There were no significant differences in the results obtained with each surgical technique in regard to the Engel outcome class or subclass, except for Class IB. Five (6.5%) of the 80 patients who had undergone an ATL still reported auras at the last follow up (Engel Class IB) despite being free of complex partial seizures, whereas none of the 81 patients who had undergone an SA experienced only auras at the last follow-up visit (p = 0.03).

Survival Analysis of Engel Outcome Classes I, IA, and I and II Combined

Analyzing the entire series of 161 patients, the probabili-
ty of a given patient remaining in the Engel outcome Class IA after 1, 2, 6, and 11 years postsurgery was 84, 76, 71, and 65%, respectively. The mean survival time in patients in this outcome class was 8.03 years (95% CI 7.22–8.84). Furthermore, the probability of survival in patients in Engel Class I (A, B, or D) at the same postoperative time points was 88, 85, 83, and 80%, respectively, with a mean survival time of 9.23 years (95% CI 8.57–9.89). Finally, the probability of survival in Engel Class I or II at Years 1, 2, 5, and 10 after surgery was 96, 94, 94, and 91%, respectively (mean survival time 10.26 years, 95% CI 9.8–10.73).

The probability of survival associated with Engel Classes I and IA after 1, 2, and 6 years following either surgical technique and at 11 years post-ATL is shown in Table 3 and Figs. 1 and 2. Tests for equality of survival distributions comparing both techniques in outcome Classes I, IA, and I and II combined were not significantly different at any point in time.

Magnetic Resonance Imaging and Histopathological Data

A diagnosis of HS was rendered in all 161 patients based on either MR imaging features or histopathological data. Histopathological information was available in 146 patients (90.7%), and a diagnosis of HS was confirmed in all, including the nine patients in whom the 0.5-tesla MR unit did not reveal HS. Thus, of the 161 patients, 137 (85%) had both MR imaging and histopathological evidence of HS, 15 had MR imaging evidence only (tissue was not available for examination), and nine had histopathological evidence despite normal results on 0.5-tesla MR imaging studies.

Surgical Complications

Death, intracranial hematomas, and motor deficits did not occur in this series. In addition, there were no infectious complications affecting the central nervous system.

Postoperative Neuropsychological Evaluation

There was no instance of overt dysphasia or global amnesia, although mild naming difficulties were reported by five patients who had undergone surgery in the left hemisphere. Fifty (58%) of the 86 patients retested postoperatively had preoperative verbal memory scores below one SD of the normal mean in age-matched control volunteers. Postoperatively, 44 patients (51%) had this same degree of memory abnormalities. In evaluating postoperative verbal memory based on scores crossing the threshold (that is, the criterion for defining significant memory deficit), among 36 patients whose preoperative verbal memory scores were considered to be within normal limits, 11 (30%) demonstrated postoperative scores that not only crossed the threshold but also were more than one SD below the normal mean (that is, their memory performance significantly worsened). Of these patients, six had undergone an SA (five left sided and one right sided), and the other five an ATL (four left sided and one right sided). The other 25 patients (70%) remained without significant memory deficit. Surgical techniques did not differ in this regard. In contrast, of 50 patients in whom preoperative verbal memory scores were already more than one SD below the mean, indicating significant preoperative memory deficit, 17 (34%) experienced improvement; that is, their scores crossed the one-SD line from the bottom up. Of these patients, eight had undergone an SA (six left sided and two right sided), and the other nine an ATL (three left sided and six right sided). The other 33 patients (66%) continued to suffer from their preoperative deficits (Table 4).

The other criterion used to analyze postoperative memory performance was related to the quantitative assessment of the variation in memory scores, that is, whether the postoperative performance worsened or improved more than one SD compared with the preoperative scores (Table 5). The postoperative verbal memory scores in 60 (70%) of the 86 patients tested did not vary more than one SD. On the other hand, the scores in eight patients (9%) worsened more than one SD, and the remaining 18 (21%) demonstrated improvement of more than one SD in comparison with preoperative scores. Of the eight patients whose memory performance worsened, only one underwent right-sided surgery. The association between left-sided temporal lobe surgery and the level of worsening in memory performance

### TABLE 3

<table>
<thead>
<tr>
<th>Yrs of Survival</th>
<th>I (A, B, or D)</th>
<th>IA (A right, B, or D)</th>
<th>I + II (A left, B, C, or D)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>90.0</td>
<td>86.2</td>
<td>83.7</td>
</tr>
<tr>
<td>2</td>
<td>88.7</td>
<td>81.7</td>
<td>78.6</td>
</tr>
<tr>
<td>6</td>
<td>87.4</td>
<td>77.6</td>
<td>74.2</td>
</tr>
<tr>
<td>11</td>
<td>84.7</td>
<td>NA</td>
<td>67.3</td>
</tr>
</tbody>
</table>

* NA = not applicable.

### TABLE 4

<table>
<thead>
<tr>
<th>Surgical Technique/Side of Surgery</th>
<th>No. of Patients</th>
<th>Below Threshold</th>
<th>Performance Score Subgroups†</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>No. of Patients</td>
<td>Below/Below</td>
<td>Above/Below</td>
</tr>
<tr>
<td>SA/lt</td>
<td>24</td>
<td>14 (58.3)</td>
<td>13 (54.2)</td>
</tr>
<tr>
<td>ATL/lt</td>
<td>26</td>
<td>16 (61.5)</td>
<td>17 (65.4)</td>
</tr>
<tr>
<td>SA/rt</td>
<td>17</td>
<td>7 (41.2)</td>
<td>6 (35.3)</td>
</tr>
<tr>
<td>ATL/rt</td>
<td>19</td>
<td>13 (68.4)</td>
<td>8 (42.1)</td>
</tr>
<tr>
<td>total</td>
<td>86</td>
<td>50 (58.1)</td>
<td>44 (51.1)</td>
</tr>
</tbody>
</table>

* Threshold was defined as one SD below the mean verbal memory performance score.
† See Neuropsychological Test Battery for definitions of subgroups.
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Discussion

Few surgically remediable epilepsy syndromes can be treated with two clearly distinct approaches, as in MTLE/HS. Over the years, it has been shown that both ATL and SA are effective and safe procedures in patients with intractable epilepsy, although the former procedure is used to remove anterolateral neocortical tissue whereas the latter is not. In theory, more conservative procedures are preferred over more extensive ones, provided that efficacy is similar between the two. Note, however, that one major caveat to concluding that ATL and SA are equally effective for seizure control in patients with MTLE/HS is the fact that each treatment center usually performs one preferred procedure. Thus, comparisons usually rely on results reported on by different centers, which evaluate and perform surgery in patients based on different protocols. To our knowledge, authors of only three studies have attempted to compare both procedures at a single center. One study included patients with different types of pathological entities in the temporal lobe, and an ATL was performed in the majority of cases. This surgical procedure was found to be more effective in terms of seizure control (60 compared with 21%), although the heterogeneous origins may explain the different rates of seizure control. The authors of a second study compared both techniques in patients in whom surgery was performed by different surgeons at a single institution. In this analysis were patients with and those without MR imaging—demonstrated HS, and seizure freedom rates were similar after either surgical procedure and correlated with the presence of HS. Follow up was limited in many patients, and outcome was determined based on results from the last available follow up. In a large series of patients with TLE due to a variety of causes, Clussmann and colleagues reported findings that were similar to ours. There was no difference in terms of seizure control, whereas patients who had undergone an SA demonstrated a better verbal memory outcome. To our knowledge, we are the first to compare ATL and SA in a homogeneous, relatively large cohort of patients with MTLE who were evaluated using a single preoperative protocol, had a single pathological entity, were surgically treated by the same surgeon, and whose outcome was assessed through a long-term survival analysis.

Note that the choice of the procedure in our patients was not randomized. In the first 5 years of our epilepsy surgery program, almost all patients underwent an ATL. Because initial resection of the temporal neocortex allows clearer identification of the vascular and neural structures surrounding the amygdala and the hippocampus, ATL is generally the preferred strategy in the 1st years of an epilepsy surgery program. In contrast, during the last 5 years the majority of our cases were treated with an SA (Table 1). This change of approach was based on the realizations that the bulk of the epileptogenicity in MTLE/HS was localized to the mesial structures and that even acute epileptiform discharges over the temporal neocortex recorded on electrocorticography could be safely disregarded without compromising the surgical results. Furthermore, the surgeon became more comfortable over the years with selectively resecting the mesial structures and sparing the neocortex. There are two main strategies in selectively resecting the mesial temporal structures: through the second temporal gy-
rus (proposed by Niemeyer29) or through the sylvian fissure (described by Yaşargil, et al.,48 and Wieser, et al.49). In the present series we chose the approach favored by Niemeyer to avoid manipulation of the sylvian artery37 and to prevent disconnection of the anterior portion of the temporal stem,43 which results from the transsylvian technique.

Virtually all patients (99.4%) were properly followed up. At the last follow up a mean of 6 years after surgery, 143 (88.8%) of 161 patients had an Engel Class I seizure outcome, regardless of the type of surgical procedure performed (73 ATL and 70 SA; Table 2). Moreover, the rates of complete seizure freedom since surgery (Engel Class I A) and of surgical failure (Engel Classes III and IV) were similar with either technique. These findings suggest that in patients with unilateral MTLE/HS, resection of the anterolateral temporal neocortex does not aggregate value in terms of surgical failure (Engel Classes III and IV) were similar with either technique. These findings suggest that in patients with unilateral MTLE/HS, resection of the anterolateral temporal neocortex does not aggregate value in terms of seizure control.

Ojemann and colleagues30 have shown language interference on electrical stimulation of the anterior third of the dominant temporal neocortex, particularly the superior temporal gyrus. We systematically spared the first temporal gyrus when performing an ATL and did not observe significant language abnormalities. Visual fields were not formally tested after surgery. Through clinical neurological examination, however, we found no significant abnormalities, regardless of the surgical technique performed.

The debate over whether to advocate an SA or an ATL in MTLE/HS relates to postoperative memory function. Both medial and neocortical temporal lobe structures have specific roles in the acquisition, consolidation, and retrieval of material-specific information.24,28 and, theoretically, an SA should lead to fewer postoperative memory abnormalities than an ATL. Some aspects should be considered, however. Information enters the hippocampus through the entorhinal cortex, which is resected during both techniques and may be the primary cause of postoperative memory changes. Nevertheless, commissural pathways connecting the neocortical temporal regions through the corpus callosum and anterior commissure may transfer information processed in the neocortex of the temporal lobe whose medial structures were resected into the contralateral medial structures. This possibility would be indirectly supported if consistent differences in memory performance were demonstrated between selective and nonselective techniques. Note also that selective techniques differ in respect to white matter tract disconnection, particularly the plane through which the temporal stem fibers are reached. Via the transsylvian route one approaches the ventricle transecting the bulk of the anterior temporal stem fibers perpendicular to their main axis, whereas use of the transcortical route may spare a portion of this fiber tract because one approaches the ventricle in parallel to the tract’s main projection. (This is a similar concept to that involved in approaching spinal cord tumors.) Should reorganization of memory circuits through commissural pathways prove relevant, sparing the temporal stem is likely to be beneficial.

We analyzed postoperative changes in memory function based on the Wechsler Memory Scale—Revised,43 whose memory tests are standardized to an index of 100, which represents the performance of an average individual, with an SD of 15. One SD below this mean represents a deficient performance. Thus, we set the deficit threshold line at one SD below the mean and analyzed the individual performance of our patients in two different ways: crossing the deficit threshold line and varying performance by more than one SD in either direction. In the first type of assessment, patients could cross the deficit threshold line irrespective of the absolute magnitude of gains or losses in scores. This approach assumes that any score above or below one SD has clinical relevance. A major limitation, however, is the lack of a quantitative measure of the changes. What matters is crossing the line. To circumvent this limitation, we also analyzed the data by considering the absolute variations in pre- and postoperative scores, regardless of whether the deficit threshold line was crossed. We again chose one SD as the quantitative threshold to consider a gain or a loss, because it reflects the changes in raw scores for Logical Memory II (delayed recall) that physiologically occurs from the ages of 25 and 44 years to 70 and 74 years (see Table C-5 in Wechsler, 1987). Thus, any loss of a magnitude greater than one SD represents a surgically induced decrease in function (Fig. 3).

Approximately one third of the patients with no significant preoperative deficit in verbal memory demonstrated scores that crossed the threshold deficit line, but the other two thirds did not. There was no correlation of these findings with the surgical technique performed. Although there was an apparent predominance of worse verbal memory scores with left-sided operations (Table 4), this trend did not reach statistical significance (p = 0.09). Furthermore, only 9% of the patients had verbal memory performance scores worsened by more than one SD, and 70% had scores that did not vary by more than one SD in any direction (Table 5 and Fig. 3). On the other hand, one third of those patients with a significant preoperative verbal memory deficit had scores that crossed the threshold line from the bottom up, thus demonstrating improvement in verbal memory performance postoperatively.

Our data concur with those from a recently reported series of similar patients, which showed a degree of improvement in material-specific memory functions postoperatively with the use of selective approaches.19 In our series, nine (18%) of the 50 patients who had undergone surgery on the left side as well as pre- and postoperative testing showed an improvement of more than one SD in postoperative verbal...
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memory scores. Seven of these had undergone an SA and only two an ATL. Focusing only on these patients who underwent left-sided surgery, 29% of those who underwent an SA and only 8% of those who had an ATL improved significantly in verbal memory (Table 5). This difference reached significance in a $2 \times 2$ statistic, and the association between a more favorable outcome in postoperative verbal memory performance in patients undergoing an SA was also suggested by results of the logistic regression model. If confirmed, these findings may favor the choice of selective procedures, particularly transcortical SA, in patients with left-sided MTLE/HS. At present, however, these findings should be seen as preliminary because postoperative memory evaluations were not performed in all patients presented in this study.

In the recent publication of Gleissner and colleagues, gains in verbal memory function were reported in approximately 8 to 10% of the individuals who had undergone a left-sided SA. This quantitative discrepancy could be due to the fact that German patients were treated via a transsylvian approach, during which the temporal stem is usually disconnected to a larger extent than during the transcortical SA we used. Irrespective of its magnitude, improvement in verbal memory function was not observed in a recently published metaanalysis of postoperative memory outcome following ATL. On the other hand, 25% of our patients who had undergone surgery on the right side as well as postoperative testing showed improvement of more than one SD in verbal memory performance. Such improvement was somewhat expected. The fact that other authors have reported much greater gains in verbal memory following a nondominant temporal lobe resection may be related to the threshold we established to accept an improvement in scores as significant.

Our data do not allow a firm conclusion on the role of selective compared with nonelective surgical techniques on the feasibility of reducing or discontinuing AEDs. Changes in AED dosages were only considered after the 3rd postoperative year in seizure-free patients. As shown in Table 1, the mean duration of follow up in patients who had undergone an ATL was 6.7 years, whereas in those who had undergone an SA the mean was 4.5 years. Thus, more definitive data concerning the feasibility of AED changes according to surgical technique must await longer-term follow up data in the group who underwent an SA. Nevertheless, the initial results presented in Table 6 suggest that a reduction in or the discontinuation of AEDs is feasible in many patients who undergo either technique. Results of a recent review demonstrated that one third of seizure-free patients who discontinue AEDs after temporal lobe surgery experienced seizure recurrence.

Conclusions

We have shown that both ATL and SA can lead to similar favorable seizure control in patients with MTLE/HS. Approximately 70% of patients who had undergone either surgical procedure were entirely seizure free at the last follow up, and both techniques were similarly associated with high degrees of estimated survival in Engel outcome Classes I, IA, and I and II combined for up to 11 years. Thus, seizure freedom is likely not to be a decisive factor in favoring one technique over the other. In addition, our findings suggest that a transcortical SA in patients with dominant MTLE/HS who already demonstrate a significant decrease in preoperative verbal memory scores may lead to better chances of postoperative memory improvement.

References

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