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Five-Year Outcome After Epilepsy Surgery in Nonmonitored and Monitored Surgical Candidates

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Summary: *Purpose:* We wished to compare outcome 5 years after temporal lobectomy in 28 patients selected for surgery on the basis of interictal EEG patterns with that in 46 patients who underwent EEG-video monitoring studies as part of their preoperative evaluation during the same era.

Methods: The 28 nonmonitored patients had interictal EEG patterns that demonstrated a consistent, unilateral, anterior-midtemporal epileptiform focus, without discordant findings from other studies. Outcomes were assessed for years 4 and 5 after operation.

Results: Twenty-six of 28 (92.9%) nonmonitored patients were seizure-free or had at least 75% reduction in seizures. Twenty-nine of 46 (63.0%) monitored patients were seizure-free or had at least 75% reduction in seizures. Preoperative interictal EEGs of 29 of these patients showed independently localized bitemporal, extratemporal, midposterior temporal, or diffuse epileptiform patterns. The remaining 17 monitored patients had preoperative strictly unilateral anterior-midtemporal interictal discharges, and their outcome was comparable to the nonmonitored group, with 15 (88.8%) seizure-free or with at least 75% reduction in seizures.

Conclusions: A proportion of candidates for epilepsy surgery can be selected without ictal recordings provided that interictal EEGs demonstrate consistent unilateral anterior-midtemporal epileptiform discharges and that other data are not discordant.

Key Words: Epilepsy surgery—Surgical outcome—Temporal lobectomy—Interictal epileptiform discharges—Electroencephalographic-video monitoring.

Although the modern era of epilepsy surgery began more than a century ago (1), not until the advent of the EEG decades later could epilepsy surgery be utilized in patients who had more than just focal ictal signs and symptoms (often with an obvious physical defect) that suggested a specific site of origin in the brain. The EEG led researchers to realize that focal interictal spikes could identify the site of ictal origin. This in turn led to the recognition of temporal lobe epilepsy and to anterior-temporal lobectomy for treatment of intractable seizures (2–5). Technological advances since the 1960s, including long-term EEG-video monitoring, intracranial EEG recording methodologies, neuroimaging techniques, and improved neuropsychological assessment have expanded the applicability of epilepsy surgery and have resulted in improved operative results.

Although variability exists in selection of appropriate candidates for epilepsy surgery, most investigators favor obtaining ictal recordings as part of the preoperative assessment for all surgical candidates (6), including some who favor intracranial EEG recording most such candidates (6,7). We believe that although ictal recordings obtained through long-term EEG-video monitoring are necessary for most surgical candidates, there exists a group of patients for whom monitoring is not necessary. This group can be selected provided that interictal EEGs demonstrate consistent, strictly unilateral, anterior-midtemporal epileptiform focus and that other imaging and functional tests are not discordant. We report our experience with a group of 28 patients who were so selected, in whom ictal recordings were not obtained, and review the outcome for these patients 5 years after temporal lobectomy. We compared this group with another group of 46 patients who were evaluated and surgi-

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cally treated during the same era but who underwent EEG-video monitoring preoperatively.

METHODS

The 74 patients who constituted the total group of surgically treated patients were part of a prospective study that was initiated in the early 1980s to compare the efficacy of epilepsy surgery for medically intractable seizures with medical management alone. All 74 patients had medically intractable complex partial seizures (CPS), with or without seizures secondarily generalized. There were 38 men and 36 women; mean age at the time of the operation for all patients was 29.6 years (range 18–45 years).

The preoperative evaluation for all patients included history, general and neurological examinations, standard waking and sleep EEGs, computed tomography (CT) studies of the brain, neuropsychological assessment, and cerebral angiography with intracarotid amobarbital procedure (IAP). Forty-six of the 74 patients underwent long-term EEG monitoring with implantation of sphenoidal electrodes; 8 of these further underwent intracranial subdural cortical strip EEG-video monitoring.

The 28 patients (37.8% of the entire group) who did not undergo EEG-video monitoring studies were selected on the basis of standard waking and sleep EEGs that demonstrated consistent, strictly unilateral, spike or sharp wave discharges over a single anterior-midtemporal scalp region. An average of six separate preoperative EEGs was obtained. For most patients, this meant that three pairs of individual waking and sleep EEGs were performed, with each pair performed on different days. Each standard waking or sleep EEG was recorded for a minimum of 45 min (90 min of recording for the pair). Recording procedure followed guidelines developed by the American EEG Society (8). Nasopharyngeal electrodes, as well as additional scalp electrodes, were used for localization purposes (9).

None of the 28 nonmonitored patients had evidence based on CT scanning studies that anatomic abnormalities existed in locations different from that predicted by the EEG. Four of the 28 CT scans among this group demonstrated ipsilateral temporal lobe calcification, atrophy, or cystic lesions; the remaining CT scans were normal. These patients were evaluated before high-resolution magnetic resonance imaging (MRI) was available.

For 29 of the remaining 46 patients the interictal EEGs demonstrated independently localized bitemporal, midposterior temporal, extratemporal or diffuse poorly localized epileptiform patterns. The remaining 17 of the 46 patients had unilateral anterior-midtemporal epileptiform patterns without other discordant data; nevertheless, they underwent EEG-video monitoring at the request of referring physicians, who were not necessarily consistent with each other in the criteria used to select patients for monitoring.

All 74 patients underwent epilepsy surgery between 1982 and 1986. Temporal lobectomy was performed in all 28 nonmonitored patients. The surgical technique was that of a "tailored" resection based on the extent of the epileptogenic zone on electrocorticography (ECoG) and on the intraoperative localization of "eloquent" regions from electrical stimulation mapping (10). The extent of resection involved removal of tissue with epileptogenic abnormalities that did not include eloquent regions. Temporal lobectomy was performed in 41 of the 46 monitored patients, and frontal resections were performed in 5. The surgical technique was the same as that used for the 28 nonmonitored patients, with intraoperative tailoring of the resection.

The patients were graded with regard to seizure control during years 4 and 5 after epilepsy surgery as compared with seizure control in the 2 preoperative years. Any seizure, including simple partial ("auras"), were considered seizures. No seizures were discounted, regardless of circumstances, such as seizures that may have been related to antiepileptic drug (AED) withdrawal or substance abuse. Outcome was graded in one of three categories: (a) completely seizure-free; (b) at least 75% reduction in seizure frequency but at least one seizure in the follow-up period, and (c) <75% reduction in seizure frequency.

RESULTS

The pathology of the resected tissue from the 28 nonmonitored patients was as follows: pilocytic astrocytoma, 1; mixed ogliodendroastrocytoma, 1; ganglioglioma, 1; heterotopia, 2; gliosis and neuronal loss, 23. Of the monitored patients, pathological diagnoses included hamartoma, 2; heterotopia, 1; pilocytic astrocytoma, 1; gliosis and neuronal loss, 42, including all 5 patients who underwent frontal resections.

Overall, 34 (45.9%) of the 74 patients were completely seizure-free 5 years after epilepsy surgery. Twenty-one (28.4%) had at least 75% reduction in

TABLE 1. *Comparison of outcome of nonmonitored and monitored patients*

Outcome	Nonmonitored: unilateral anterior-midtemporal discharges n = 28 (%)	Monitored (n = 46)	
		Unilateral anterior-midtemporal discharges n = 17 (%)	Other interictal patterns n = 29 (%)
Seizure-free	17 (61)	10 (59)	7 (24)
⩾75% reduction in seizures	9 (32)	5 (29)	7 (24)
<75% reduction in seizures	2 (7)	2 (12)	15 (52)

p = 0.0111, Fisher's exact test, monitored versus nonmonitored group.
p = 0.0002, Fisher's exact test, unilateral, anterior-midtemporal interictal discharges versus other interictal patterns.

seizures; 19 (25.7%) had <75% reduction in seizures.

Results for subgroups of patients are shown in Table 1. A statistically significant difference in outcome existed between the nonmonitored patients and monitored patients, with the nonmonitored patients having a more favorable outcome ($p = 0.0111$, Fisher's exact test). However, when patients with unilateral, anterior-midtemporal discharges were compared with those having other interictal patterns, an even more striking difference was evident ($p = 0.0002$, Fisher's exact test). For the subgroup of 17 monitored patients who preoperatively exhibited strictly unilateral anterior-midtemporal epileptiform discharges on EEG, outcome was remarkably similar to that of the nonmonitored patients.

Table 2 shows outcome and pathology data for the nonmonitored and monitored patients, respectively. The number of patients who proved to have structural lesions was small as compared with the number of patients with gliosis or neuronal loss, and no statistically significant differences in outcome existed between "lesional" and "nonlesional" patients.

DISCUSSION

The noteworthy finding in the present study is that ictal recordings are unnecessary for appropriate surgical candidates with unilateral anterior-midtemporal epileptiform patterns on EEG. Such patients do well postoperatively whether they are monitored or not, provided that other data are not discordant.

Although there has been relatively less recent emphasis on the interictal EEG, other investigators have observed the significance of unilateral temporal spikes. In patients who are monitored with intracranial subdural electrode arrays, such discharges invariably predict ictal origin (11,12). If all interictal epileptiform discharges are confined to a single region regardless of location in patients who undergo long-term sphenoidal/scalp EEG-video monitoring, recorded seizures will originate from the region expected (13). In studies that examine the predictors of good outcome after epilepsy surgery, the interictal scalp EEG predictors that correlate best with successful outcome include a single unilateral anterior-midtemporal interictal epileptiform focus (14–16). In patients studied with intracranial electrodes, the best outcome is observed when there is complete lateralization of interictal and ictal discharges to one temporal lobe (17).

Interictal EEG findings must be correlated with other data (18). When the series of patients we report was initially evaluated, CT scanning was the imaging method available. MRI techniques with the potential for identifying focal brain lesions, including hippocampal sclerosis and atrophy, that are not detectable by CT are now available (19–22). We require that no discordance exist between EEG and MRI data if we are to offer surgery without monitoring. Similarly, because a convergence of EEG findings and localization of dysfunction by neuropsychological testing (23,24) IAP (25), and positron emission tomography (26) will more likely result in seizure relief than if such testing lateralizes to the opposite side or is nonlateralizing, monitoring is

TABLE 2. *Pathology and outcome*

Outcome	Gliosis/ neuronal loss	Tumor	Hamartoma	Heterotopia
Nonmonitored (n = 28)				
Seizure-free	15	2	0	0
⩾75% reduction in seizures	7	1	0	1
<75% reduction in seizures	1	0	0	1
Monitored (n = 46)				
Seizure-free	14	1	1	1
⩾75% reduction in seizures	11	0	1	0
<75% reduction in seizures	17	0	0	0

necessary if any of these data are not in accord with data of the interictal EEG.

Ictal recordings are also necessary in patients with independent bitemporal discharges, regardless of the degree of preponderance over one side (13, 27,28). How much interictal EEG recording is necessary to establish with reasonable certainty whether bitemporal discharges exist? We require that at least three pairs of waking and sleep recordings be performed on different days, with 90 min of recording time for each pair, an approach based on observations that additional recordings were not helpful in yielding previously undisclosed bitemporal discharges.

Recently, we showed that in patients who prove to have bitemporal discharges, based on long-term sphenoidal/scalp EEG-video monitoring, 65% of such discharges are apparent after only 30 min of interictal recording and 95% are apparent after 3.5 h of interictal recording (29).

Comparisons of outcomes in the present study with those in other reported series poses some difficulty because most other reported series have a much shorter follow-up (often as little as 1 year), selection criteria differ, and many centers utilize the University of California at Los Angeles (UCLA) classification system (30). The best grade under the UCLA scheme, class 1, does not necessarily mean that the patients are seizure-free, a distinction that is clinically significant (31); in one report, only ~60% of patients graded class 1 were actually seizure-free (31). Moreover, the use of terms such as "worthwhile," "rare," and "significant" in grading outcomes also makes the interpretation of results difficult (32).

Despite these problems, useful information is obtained by comparing outcomes reported in the literature. In one review, 21–65% of patients reported from centers worldwide were seizure-free postoperatively (mainly temporal resection) with follow-up as short as 1 year (33). A review of 282 patients operated on at the Montreal Neurological Institute (34) showed that 55.7% of patients were either seizure-free or had a maximum of three seizures a year at least 1 year after temporal lobectomy; unfortunately, the number of seizure-free patients was not specified. Engel et al. (30) reported that worldwide, at 1 year after temporal resection, 55.5% of patients had class 1 outcome before 1985; by 1990, class 1 outcome was reported in 65–70% of patients. In neither case was the percentage of completely seizure-free patients specified.

Our present findings represent in a sense a "rediscovery" of what earlier pioneers of epilepsy surgery recognized decades ago (4). Yet, this rediscovery may be warranted, because health care resources are not unlimited. At out institution, 1 week of sphenoidal/scalp EEG-video monitoring cost >$15,000 in 1994. Performance of three pairs of awake and sleep EEGs with nasopharyngeal electrodes in the same year cost about one sixth that amount. Long-term EEG video monitoring is a valuable tool in helping to identify many potential candidates for epilepsy surgery and actually may be necessary in many circumstances. However, monitoring is an expensive resource and should be used as judiciously as possible.

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