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RESEARCH ARTICLE

Surgical outcome of temporal plus epilepsy is improved by multilobar resection

Carmen Barba[1] | **Sylvain Rheims**[2,3,4] | **Lorella Minotti**[5] | **Laura Grisotto**[6] | **Stéphan Chabardès**[5] | **Marc Guenot**[3,7] | **Jean Isnard**[2,3] | **Simona Pellacani**[1] | **Marc Hermier**[8] | **Philippe Ryvlin**[9] | **Philippe Kahane**[5]

[1]Neuroscience Department, Meyer Children's Hospital–University of Florence, member of the ERN EpiCARE, Florence, Italy

[2]Lyon Neuroscience Research Center, INSERM U1028, CNRS UMR5292, Lyon, France

[3]Department of Functional Neurology and Epileptology, Hospices Civils de Lyon and University of Lyon, member of the ERN EpiCARE, Lyon, France

[4]Lyon 1 University, Lyon, France

[5]CHU Grenoble Alpes, Univ. Grenoble-Alpes, Inserm, U1216, Grenoble Institut Neurosciences, Grenoble, France

[6]Department of Statistics, Computer Science, G. Parenti Application, University of Florence, Florence, Italy

[7]Department of Functional Neurosurgery, Hospices Civils de Lyon, Lyon, France

[8]Department of Neuroradiology, Hospices Civils de Lyon, Lyon, France

[9]Department of Clinical Neurosciences, Vaudois University Hospital Center, University of Lausanne, Lausanne, Switzerland

Correspondence
Carmen Barba, Meyer Children's Hospital–University of Florence, viale Pieraccini 24, Florence 50139, Italy.
Email: carmen.barba@meyer.it

Abstract

Objective: Temporal plus epilepsy (TPE) represents a rare type of epilepsy characterized by a complex epileptogenic zone including the temporal lobe and the close neighboring structures. We investigated whether the complete resection of temporal plus epileptogenic zone as defined through stereoelectroencephalography (SEEG) might improve seizure outcome in 38 patients with TPE.

Methods: Inclusion criteria were as follows: epilepsy surgery performed between January 1990 and December 2001, SEEG defining a temporal plus epileptogenic zone, unilobar temporal operations ("temporal lobe epilepsy [TLE] surgery") or multilobar interventions including the temporal lobe ("TPE surgery"), magnetic resonance imaging either normal or showing signs of hippocampal sclerosis, and postoperative follow-up of at least 12 months. For each assessment of postoperative seizure outcome, at 1, 2, 5, and 10 years, we carried out descriptive analysis and classical tests of hypothesis, namely, Pearson χ^2 test or Fisher exact test of independence on tables of frequency for each categorical variable of interest and Student *t*-test for each continuous variable of interest, when appropriate.

Results: Twenty-one patients underwent TPE surgery and 17 underwent TLE surgery with a follow-up of 12.4 ± 8.16 years. In the multivariate models, there was a significant effect of the time from surgery on Engel Class IA versus IB–IV outcome, with a steadily worsening trend from 5-year follow-up onward. TPE surgery was associated with better results than TLE surgery.

Significance: This study suggests that surgical outcome in patients with TPE can be improved by a tailored, multilobar resection and confirms that SEEG is mandatory when a TPE is suspected.

KEYWORDS

epilepsy surgery, long-term, SEEG, seizure outcome, temporal plus

1 | INTRODUCTION

The concept of temporal plus epilepsy (TPE) was introduced in 2005[1] to indicate a complex epileptogenic zone including the temporal lobe and the close neighboring structures, such as the insula and the suprasylvian operculoinsular areas (temporoperisylvian subgroup [TS]), the orbitofrontal cortex (temporofrontal subgroup [TF]), and the temporoparieto-occipital junction (temporoparieto-occipital subgroup [TPO]). In 2007,[2] the comparison between patients with "pure" temporal lobe epilepsy (TLE) and patients with TPE led to the identification of some ictal clinical manifestations, especially when found in specific clusters, and some interictal and ictal electroencephalographic (EEG) abnormalities suggestive of a possible temporal plus zone requiring further investigation through stereo-EEG (SEEG). Finally, in 2016,[3] TPE was shown to be a hitherto unrecognized prominent cause of temporal lobe surgery failures, with anterior temporal lobectomy insufficient to control seizures.

These findings, taken together, support the hypothesis that most surgical failures after TLE surgery are due to not enough of the epileptogenic focus that extends from temporal into extratemporal regions being resected. However, whether larger resections tailored to SEEG results offer greater chances of seizure freedom in patients with TPE remains to be established.[4]

In the present study, we aimed at assessing whether the complete resection of the temporal plus epileptogenic zone could improve seizure outcome in the short and long term.

Key Points

- The percentage of seizure-free patients with temporal plus epileptogenic zone significantly decreased over time
- TPE surgery was associated with better results than TLE surgery for both Engel IA versus IB–IV and Engel I versus II–IV outcomes
- SEEG is mandatory in patients with suspected TPE to precisely define the extent of the resection

2 | MATERIALS AND METHODS

2.1 | Study design and population

Patients included in this study were selected from the epilepsy surgery cohorts launched in Grenoble and Lyon, France in 1990. Inclusion criteria were (1) epilepsy surgery performed between January 1990 and December 2001, to maximize long-term postoperative follow-up; (2) SEEG defining a temporal plus epileptogenic zone,[2,5] that is, including not only mesial and lateral temporal lobe structures but also the inferior frontal cortex, the suprasylvian operculoinsular cortex or the temporoparieto–occipital junction; (3) either TLE surgery (i.e., temporal lobe resection or disconnection) or (4) TPE surgery (i.e., temporofrontal, temporoperisylvian, or temporoparieto-occipital resections/disconnections), performed according to SEEG results, taking into account anatomical constraints[2]; (5) magnetic resonance imaging (MRI) either normal or showing signs of hippocampal sclerosis (HS); and (6) postoperative follow-up of at least 12 months.[6] Exclusion criteria were as follows: (1) bitemporal epilepsy and (2) evidence on MRI of an epileptogenic lesion other than HS.

2.2 | Presurgical evaluation

Presurgical evaluation was performed according to similar procedures in both centers during the census period, except for fluorodeoxyglucose (FDG)–positron emission tomography (PET), which was performed on a systematic basis only in Lyon. All patients underwent video–scalp EEG long-term monitoring and brain MRI. Noninvasive data were presented at local epilepsy conferences to provide a consensual conclusion regarding the most likely epileptogenic zone and the decision to proceed directly to surgery or to perform an intracerebral (SEEG) procedure. A SEEG study was at that time judged necessary when scalp electroclinical evidence suggested either a possible lateral temporal or extratemporal seizure onset, or an early spread of seizures outside the temporal lobe, that is, involving scalp electrodes other than F7/8, T3/4, T5/6, and, when present, F9/10 and T9/10.[2]

Although placement of SEEG electrodes is by definition individualized to the patient's electroclinical findings and anatomy, common rules were applied to all patients from this series who underwent SEEG to assess a TPE epileptogenic zone. Accordingly, the following regions were more commonly investigated in patients included in the study on the side of suspected ictal onset: hippocampus, amygdala, anterior and posterior aspects of the superior, middle, and inferior temporal gyri, temporal pole, and parahippocampal and fusiform gyri. Extratemporal targets were selected based on the alternative hypotheses formulated regarding the location(s) and extent of the epileptogenic zone(s). The most frequently investigated brain regions were the temporoparieto-occipital junction, frontobasal and orbitofrontal cortex, suprasylvian operculum, and insula, although almost all other cortical areas could be targeted (see Figure S1). The insula was not implanted before 1995 and became routinely sampled thereafter.

2.3 | Surgical treatment

Similar to the decision on whether to proceed to SEEG, the type and extent of surgical treatment was discussed and approved at local epilepsy conferences based on review of available data. During the census period, patients whose SEEG findings fulfilled our current criteria for TPE[1,2] underwent TPE surgery a priori. However, some patients were considered appropriate candidates for TLE surgery either due to functional constraints or because there was a primary involvement of the temporal lobe at seizure onset leading to a unilobar resection to be preferred as the first step. The limited knowledge on the concept of epileptic networks and the role of insula at that time may have influenced our surgical strategy.

2.4 | Outcome assessment

Postoperative seizure outcome was assessed using the Engel postoperative outcome scale[6] at 1, 2, 5, and 10 years, when possible. The delay for seizure recurrence corresponded to the delay between surgery and the first postoperative seizure. When seizures recurred between two follow-up appointments without detail on the exact date, the date of recurrence was taken as the closest follow-up appointment. For all analyses, we assessed both Engel Class I and IA outcomes.

2.5 | Data reviewing

The clinical records of all included patients were reviewed to extract potential preoperative predictors of postoperative seizure outcome, which are detailed further.

All patients in this study underwent SEEG. Their preoperative clinical reports detailing SEEG findings were used to define the extent of the epileptogenic zone to reach a conclusion on the diagnosis of TPE, distinguish TF, TS, and TPO epileptogenic zones, and define the relationship with eloquent areas. The term *epileptogenic zone* referred to the amount of cortex that was considered necessary to be removed to render the patient seizure-free. Particular attention was paid to first clear ictal SEEG change, which was considered as relevant only when it occurred prior to the clinical onset of the seizure, and when it manifested by a fast synchronizing discharge.[2] When possible, we confirmed our conclusions by reviewing original SEEG traces.

Preoperative scans were systematically reviewed to confirm accurate classification of MRI findings. Postoperative MRIs were also reviewed to evaluate the concordance between the operating plan and the tissue effectively resected.

2.6 | Statistical analysis

We performed a descriptive statistical analysis to summarize the variables of interest. Results for quantitative variables are expressed as mean ± SD or median (range). When appropriate, confidence intervals (CIs) were calculated using exact likelihood. Level of significance was set to 5% two-sided. For each assessment of postoperative seizure outcome, at 1, 2, 5, and 10 years, we carried out (1) descriptive analysis and (2) classical tests of hypothesis, namely, Pearson χ^2 test or Fisher exact test of independence on tables of frequency for each categorical variable of interest and Student *t*-test for each continuous variable of interest, when appropriate. Given the exploratory nature of the study, we did not perform any correction for multiple comparisons.

We then carried out an analysis of association between the variables of interest and Engel outcomes other than Class IA and other than Class I, observed at 1 year, 2 years, 5 years, and 10 years of follow-up. Specifically, we investigated the association between Engel I and IA outcomes and the following variables: gender, age at seizure onset, occurrence of focal to bilateral tonic–clonic seizures, evidence of HS or no abnormalities on MRI, age at surgery, epilepsy duration at the time of surgery, type of surgical approach (i.e., TLE or TPE surgery), FDG-PET findings, mean follow-up duration after surgery, and persistence on antiseizure medications (ASMs) at the last follow-up.

Given the longitudinal nature of our data, we carried out an analysis for discrete time data.[7] We performed univariate population average logistic models and included a categorical variable for time in all models to evaluate the time effect. Variables with $p < .05$ in univariate analyses were included in the multivariate population average logistic models, adjusted for possible confounders, that is, from seizure onset to surgery, and age at surgery.

We conducted all statistical analyses using Stata version 16.0 (StataCorp 2016).

2.7 | Data availability statement

The main findings of all statistical analyses are included in the main text, tables, and figures and in the Supporting Material. The authors will make raw data available to any reader upon reasonable request.

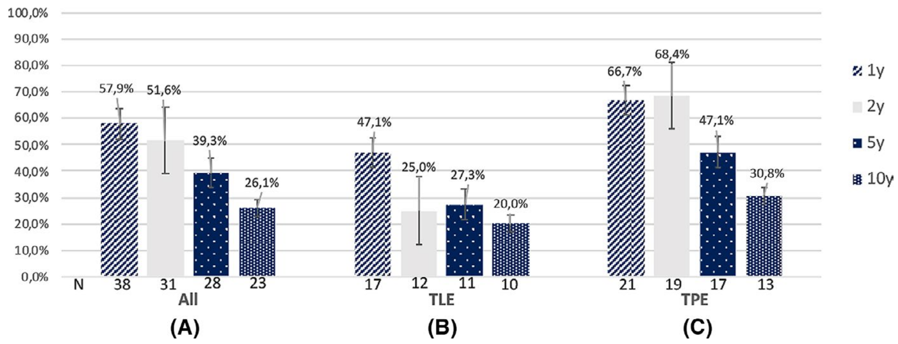

FIGURE 1 Engel Class IA versus IB–IV. Information on seizure outcome was available for 38 patients at 1-year follow-up, for 31 at 2-year follow-up, for 28 at 5-year follow-up, and for 23 at 10-year follow-up. (A) Percentage of seizure-free patients in the whole sample at 1-, 2-, 5-, and 10-year follow-up. (B) Percentage of seizure-free patients 1, 2, 5, and 10 years after temporal lobe epilepsy (TLE) surgery. (C) Percentage of seizure-free patients 1, 2, 5, and 10 years after temporal plus epilepsy (TPE) surgery. The percentage of patients in Engel Class IA after TLE surgery drops sharply in the first 2 years after surgery, then the downward trend is steadier (B). Conversely, the percentage of patients in Class IA after TPE surgery remains stable for up to 2 years; then a sharply downward trend in the rate of seizure-free patients is observed (C)

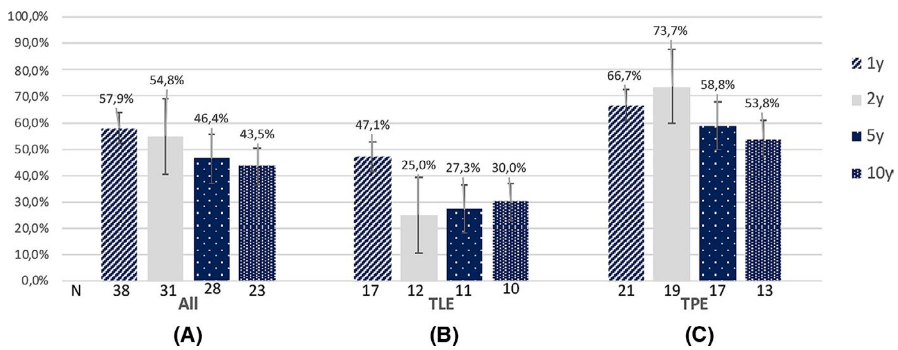

FIGURE 2 Engel Class I versus Class II–IV. Information on seizure outcome was available for 38 patients at 1-year follow-up, for 31 at 2-year follow-up, for 28 at 5-year follow-up, and for 23 at 10-year follow-up. (A) Percentage of patients free from disabling seizures in the whole sample at 1-, 2-, 5-, and 10-year follow-up. (B) Percentage of patients free from disabling seizures 1, 2, 5, and 10 years after temporal lobe epilepsy (TLE) surgery. (C) Percentage of patients free from disabling seizures 1, 2, 5, and 10 years after temporal plus epilepsy (TPE) surgery. The percentage of patients in Engel Class I after TLE surgery significantly decreases in the first 2 years after surgery, then it remains quite constant (B). Conversely, the percentage of patients in Class I after TPE surgery slightly increases in the first 2 years (C), then a steady downward trend is observed

3 | RESULTS

3.1 | Descriptive analysis

The study sample was composed of 38 (21 female) patients, of whom 21 underwent TPE surgery and 17 underwent TLE surgery as defined above. Mean age at seizure onset was 12.2 ± 8.8 years, and mean age at surgery was 33.4 ± 10.6 years. Epilepsy duration was 21.25 ± 9.8 years. Brain MRI revealed HS in 27 patients and was normal in the remaining 11. FDG-PET was performed in 10 patients, of whom five (three TPE, two TLE surgery) showed a temporal, four (two TPE, two TLE surgery) a temporal and extratemporal, and one (TLE surgery) an extratemporal hypometabolism.

SEEG showed that the origin of the discharge was temporal first in 17 patients, extratemporal first in seven, and synchronous in temporal and extratemporal areas in the remaining 14.

TPE surgery was performed in 21 patients subdivided as follows: 13 temporofrontal, four temporoperisylvian, and four TPO resections/disconnections. Twenty-five (65.8%) patients were operated on the right side.

In six (28.5%) of 21 patients undergoing TPE surgery, the resection was incomplete, although extending beyond the boundaries of the temporal lobe, due to functional constraints in different regions (two insulo-opercular, one frontal, two parietal, one calcarine region) and in one (4.8%) due to the incomplete resection of the amygdala. In addition, in one (5.9%) of 17 patients undergoing TLE surgery, a hippocampal remnant was recognized.

Only one of the patients undergoing TLE surgery received a second operation, with no improvement in seizure frequency.

Mean duration of follow-up was 12.4 ± 8.2 years and specifically 10.3 ± 7.7 years after TLE and 9.41 ± 22.8 years after TPE surgery. Information on seizure outcome was available for 38 patients at 1-year follow-up, for 31 (81.6%) at 2-year follow-up, for 28 (73.7%) at 5-year follow-up, and for 23 (60.5%) at 10-year follow-up.

In the whole sample, we found that the trend of seizure outcome over time was influenced by the time from surgery, in particular for the Engel Class IA versus IB–IV outcome. Class IA outcome was observed in 22 of 38 (57.9%) patients at 1-year follow-up, 16 of 31 (51.6%) patients at 2-year follow-up, 11 of 28 (39.29%) patients at 5-year follow-up, and six of 23 (26.1%) patients at 10-year follow-up (Figure 1A). Conversely, Class I outcome was observed in 22 of 38 (57.9%) patients at 1-year follow-up, 17 of 31 (54.8%) patients at 2-year follow-up, 13 of 28 (46.4%) patients at 5-year follow-up, and 10 of 23 (43.5%) patients at 10-year follow-up (Figure 2A). ASMs were withdrawn in seven of 38 (18.4%) patients at last follow-up.

As shown in Figures 1 and 2, the percentages of patients in Engel Class IA and Class I were lower after TLE than after TPE surgery, with a different trend over time in the two groups.

The results of descriptive analysis and classical tests of hypothesis (Pearson χ^2 test or Fisher exact test of independence on tables of frequency for each categorical variable of interest and Student *t*-test for each continuous variable of interest) for each assessment of postoperative seizure outcome, at 1, 2, 5, and 10 years, are detailed in Table 1.

3.2 | Analyses of associations

The only significant variables in univariate models were as follows: seizure outcome at 5 and 10 years (reference = 1 year) and type of surgery (TPE vs. TLE surgery). In the multivariate models including the significant variables in univariate analyses (Tables 1 and 2; Table S1), we observed a steadily worsening trend from 5-year follow-up onward for Engel Class IA versus IB–IV outcome (2-year follow-up: odds ratio [OR] = .65, 95% CI = .40–1.07, *p* = .092 vs. 1-year follow-up; 5-year follow-up: OR = .37, 95% CI = .17–.80, *p* = .012 vs. 1-year follow-up; 10-year follow-up: OR = .24, 95% CI = .09–.65, *p* = .005 vs. 1-year follow-up).

In addition, the multivariate models showed that TPE surgery was associated with better results than TLE surgery for both Engel IA versus IB–IV and Engel I versus II–IV outcomes (Engel Class IA: OR = 4.01, 95% CI 1.04–15.48, *p* = .044 vs. Class IB–IV; Engel Class I: OR = 3.74, 95% CI = 1.09–12.78, *p* = .036 vs. Class II–IV).

TABLE 1 Univariate and multivariate population average logistic models

Engel class IA vs. IB-IV	Univariate models		Multivariate models	
	OR (95% CI)	***p*-value**	**OR (95% CI)**	***p*-value**
Seizure outcome at different FUs (ref. 1 year)				
2 ys	0.70 (0.46; 1.07)	.108	0.65 (0.40; 1.07)	.092
5 ys	0.42 (0.22; 0.79)	**.007**	0.37 (0.17; 0.80)	**.012**
10 ys	0.27 (0.12; 0.61)	**.002**	0.24 (0.09; 0.65)	**.005**
Gender (ref. M)	0.96 (0.28; 3.24)	.950		
Age at seizure onset	1.03 (0.96; 1.10)	.466		
Age at surgery	1.00 (0.95; 1.06)	.923	1.05 (0.96; 1.13)	.246
Epilepsy duration	0.98 (0.92; 1.05)	.613	0.96 (0.89; 1.05)	.366
FU duration	1.04 (0.99; 2.17)	.137		
FtoB tonic-clonic sz	0.34 (0.08; 1.47)	.149		
Brain MRI (ref. normal)				
HS	3.93 (0.74; 20.82)	.108		
Type of Surgery (ref. TLE)				
TPE	4.01 (1.04; 15.48)	**.044**	4.01 (1.04; 15.48)	**.044**

Note: Significant values are in bold.

Abbreviations: CI, confidence intervals; FtoB, focal to bilateral; FU, follow-up; HS, hippocampal sclerosis; M, male; MRI, magnetic resonance imaging; OR, odds ratio; Ref, reference; sz, seizures; TLE, temporal lobe epilepsy; TPE, temporal plus epilepsy; ys, years.

TABLE 2 Univariate and multivariate population average logistic models

Engel class I vs. II-IV	Univariate models		Multivariate models	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Seizure outcome at different FUs (ref. 1 year)				
2 ys	0.80 (0.48; 1.33)	.396	0.76 (0.43; 1.34)	.352
5 ys	0.59 (0.34; 1.02)	.059	0.54 (0.29; 1.01)	.053
10 ys	0.64 (0.28; 1.49)	.304	0.60 (0.23; 1.55)	.292
Gender (ref. M)	0.72 (0.22; 2.30)	.578		
Age at seizure onset	1.00 (0.94; 1.07)	.990		
Age at surgery	0.99 (0.93; 1.04)	.649	1.00 (0.93; 1.08)	.981
Epilepsy duration	0.98 (0.93; 1.04)	.603	0.99 (0.92; 1.07)	.820
FU duration	1.04 (0.99; 1.09)	.140		
FtoB tonic-clonic sz	0.46 (0.12; 1.71)	.246		
Brain MRI (ref. normal)				
HS	3.09 (0.65; 14.76)	.158		
Type of Surgery (ref. TLE)				
TPE	3.74 (1.09; 12.79)	**.036**	3.74 (1.09; 12.79)	**.036**

Note: Significant values are in bold.

Abbreviations: CI, confidence intervals; FtoB, focal to bilateral; FU, follow-up; HS, hippocampal sclerosis; M, male; MRI, magnetic resonance imaging; OR, odds ratio; Ref, reference; sz, seizures; TLE, temporal lobe epilepsy; TPE, temporal plus epilepsy; ys, years.

4 | DISCUSSION

The main result of this study is that the percentage of seizure-free patients with temporal plus epileptogenic zone significantly decreases over time, but with seizure recurrences occurring more often and earlier in patients undergoing TLE than TPE surgery.

Specifically, in the descriptive analysis, we observed a significant negative effect of the time from surgery on both Engel Class IA and Class I outcomes, with a different downward trend in these two groups. Conversely, in the multivariate models, we found a significant effect of the time from surgery only on Engel Class IA, with a steady decrease in the percentage of seizure-free patients from 5-year follow-up onward. Several studies described the worsening of seizure outcome over time after epilepsy surgery at large.[8–10] However, better long-term outcomes (≥5 years) have been reported for temporal versus extratemporal epilepsies.[9–13] In particular, in a meta-analysis including all types of surgical interventions (either curative or palliative),[10] the long-term seizure-free rate following temporal lobe resective surgery was similar to that reported in short-term controlled studies and higher than that after extratemporal surgery and palliative procedures. The stability of Engel Class I outcome over time is confirmed in several retrospective series including only those patients undergoing temporal lobe surgery.[12,14–17] For instance, Elsharkawy et al.[17] found that the probability of achieving Engel Class I outcome was 72.3% (95% CI = 68%–76%) at 2 years and 69.4% (95% CI = 64%–74%) at 16 years postoperatively. Conversely, some authors[14,16,18,19] found that the proportion of adults in Engel Class IA rather decreased over time, in particular in the first 2–5 years after surgery. In Jeha's series,[18] 94% of patients with recurrent seizures relapsed within the first 5 years, with a median timing of 6.6 months postoperatively. Also, with observations lasting up to 18 years,[19] the risk of having any recurrence was 22% during the first 24 months and increased 1.4% per year afterward.

Najm et al.[20] suggested that acute/early postoperative failures (within 1 year after surgery) are due to errors in localizing and/or resecting the epileptic focus, whereas late recurrences are likely due to de novo epileptogenesis. Bartolomei et al.[21] observed, when comparing different subtypes of TLE (including TS epilepsies), a relationship between the duration of epilepsy and the extent of the epileptogenicity, thus suggesting a progressive recruitment of epileptogenic structures in human brain. Conversely, in a series including mainly lesional patients,[22] late recurrences were explained by the presence of epileptogenic networks not detected preoperatively as well by the incomplete resection of the epileptogenic lesion. In a recent study[23] combining clinical variables with brain connectome-derived features to predict seizure outcome, long-term seizure relapse was not specifically related to parameters predicting short-term outcome, thus suggesting different mechanisms of seizure recurrence. The use of different definitions for seizure freedom (Engel Class IA vs. I) may partly explain discrepancies between different series.

In our analysis of associations, we found that undergoing TPE surgery was associated with better seizure outcome in both the short and long term in temporal plus patients. This is in line with a long-term (>6 years) PET study[24] showing that Class IA outcome was associated with a focal anteromesial temporal hypometabolism, whereas non-IA outcome correlated with extratemporal metabolic changes. In a recent small series of six patients with TPE,[25] the resection of temporal and extratemporal structures after SEEG proved effective (Engel Class I) at short follow-up (from 1.3 to 4.7 years). According to some authors, positive predictors of short-term outcome (mean follow-up duration = 5.5 years) do not predict long-term outcome.[18] Conversely, other studies described a high correspondence between predictors of short-term and long-term seizure outcome after TLE surgery,[14,15] possibly due to different designs (longitudinal or cross-sectional) and statistical methods.

We did not find further clinical variables such as the duration of epilepsy and the age at surgery to be associated with seizure outcome. Shorter duration of epilepsy and/or earlier age at surgery have been associated with better outcomes in some studies[16,17,26] but not in others.[27]

Most reports on multilobar resections included patients with severe, often symptomatic epilepsy, showing a favorable postsurgical outcome in 40%–55% of cases.[4] Although noninvasive techniques such as magnetoencephalography seem promising in distinguishing temporal from temporal plus patients,[28] the results of our study underline the relevance of SEEG in patients with suspected TPE not only to confirm the electroclinical diagnosis but also to precisely define the extent of the resection and subsequently improve seizure outcome over time.

4.1 | Limitations

We included in this study a small number of patients, due to the rarity of this type of epilepsy and the need to have a homogeneous sample of patients with a sufficient outcome. However, the use of the population average logistic models allowed us to obtain reliable results and incorporate the missing data.

Another limitation of the study is that the state of the art of neuroimaging and neuropathology in the 1990s may have determined some degree of misdiagnosis. For instance, only a minority of patients underwent FDG-PET scan, which prevents us from drawing definite conclusions on the diagnostic yield of this technique in TPE patients and on its possible role in the decision-making process. In addition, the role of new histopathological entities such as MOGHE[29] might have been underestimated. However, we chose to follow patients with TPE for up to 15 years to assess the natural history of this type of epilepsy after surgery. In more recent years, a greater awareness of the complexity of neuronal circuits of the temporal lobe has made physicians more reluctant to perform temporal lobectomies in patients whose EEG and clinical features may be suggestive of epileptogenic zones with extratemporal involvement,[5,16,21,24,25] thus limiting the possibility of studying a cohort such as the one described in the present study.

Finally, we could not assess the effect of ASM withdrawal on seizure outcome over time for lack of variability. All patients who stopped medical treatment were in Class IA.

5 | CONCLUSIONS

This study responds to the main unanswered question concerning TPE, namely, whether surgical results can be improved by a tailored, multilobar operation, thus optimizing the counseling of TPE patients on possible seizure outcome after surgery. It ends the "trilogy" on this topic, which demonstrated first that TPE patients exhibit different electroclinical features than TLE,[2] then that TPE is a major failure of temporal lobe surgery,[3] and now that performing a tailored multilobar resection leads to a better surgical outcome than removing the temporal lobe only in TPE patients. Our findings underline that the outcome of epilepsy surgery in these patients depends on the epileptogenic area before the surgery and is then influenced by the extent of surgery. In addition, we confirmed that SEEG is mandatory to define the brain area to be removed when TPE is suspected. This study, however, does not end the story of TPE, which has to be reassessed with modern noninvasive tools including FDG-PET scan and whose histopathological substrate has to be determined in correlation with SEEG findings.

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CONFLICT OF INTEREST

None of the authors has any conflict of interest to disclose. We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

ORCID

Carmen Barba https://orcid.org/0000-0001-5445-5842
Sylvain Rheims https://orcid.org/0000-0002-4663-8515
Philippe Ryvlin https://orcid.org/0000-0001-7775-6576

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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