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Presurgical evaluation in refractory epilepsy secondary to meningitis or encephalitis: bilateral memory deficits often preclude surgery

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ABSTRACT – We investigated the clinical features and surgical outcome of 17 patients with refractory epilepsy secondary to CNS infection who were referred to a tertiary center for presurgical evaluation. Six patients had a history of meningitis and 11 patients had a history of encephalitis. Median age at infection was three years (40 days-40 years). Time to seizure onset was shorter in the encephalitis group (median of 0.9 years *versus* 5.9 years in the meningitis group). MRI showed unilateral mesial temporal sclerosis (MTS) in all but one patient with meningitis (5/6). MRI in the encephalitis group showed unilateral MTS (four patients), bilateral MTS (three), porencephalic cysts (one) or no significant findings (three). Seizure semiology, following analysis of 127 seizures, included automotor seizures, complex motor/hypermotor seizures, dialeptic seizures and bilateral asymmetric tonic seizures. Neuropsychological assessment in patients with MTS frequently showed bilateral memory impairment (7 out of 12 MTS-patients), even in 4 patients with unilateral MTS, precluding epilepsy surgery. Six patients (two meningitis and four encephalitis patients) underwent a temporal lobe resection. All patients are either seizure-free (Class 1a) or are having only auras after surgery. One patient from the meningitis group underwent functional hemispherectomy and he is also seizure-free. In our series, MTS was the most common finding in refractory epilepsy after CNS infections. Bilateral memory deficits were often encountered in patients with MTS, even when unilateral, these deficits being a limiting factor for surgery. Good surgical outcome can be expected in selected patients with unilateral MTS and congruent memory deficits.

Key words: refractory epilepsy, meningitis, encephalitis, memory deficit, surgery, mesio-temporal sclerosis

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It is well known that a history of meningitis or encephalitis is strongly associated with the subsequent development of recurrent, unprovoked seizures (Annegers *et al.* 1988, O'Brien *et al.* 2002). Previous epidemiological studies have shown that the risk of developing epilepsy ranges from 1.7% by a year, to 6.8% by 20 years after the CNS infection, mostly as focal seizures (Annegers *et al.* 1988). Cerebral insults, such as CNS infections, birth injury, hypoxia, and traumatic brain injury can predispose to mesial temporal sclerosis (MTS) and temporal lobe epilepsy (TLE) (Diaz-Arrastia *et al.* 2000, Mathern *et al.* 1995). It has been hypothesized that the mesial temporal region is particularly vulnerable to epileptogenic damage following a relatively minor insult early in life (Marks *et al.* 1992). However, it remains unclear why meningitis (and less often encephalitis) is frequently associated with mesial temporal lobe epilepsy secondary to MTS. It has been suggested that the initial responsible insult may have been the result of seizures experienced during the infection, fever related to the illness, direct damage from the encephalitic or meningitis illness, or a combination of these factors (Trinka 2004).

Previous studies have shown that patients who develop unilateral mesial temporal lobe epilepsy (MTLE), irrespective of the type of infection, are suitable for epilepsy surgery with a successful seizure outcome comparable to patients with cryptogenic MTLE (Lee *et al.* 1997, O'Brien *et al.* 2002, Trinka *et al.* 2000, Trinka 2004). It seems that seizure semiology in these patients is similar to those who develop MTLE of unknown origin (Marks *et al.* 1992). The aim of this study was to investigate the clinical features, presurgical assessment and surgical outcome of patients with refractory epilepsy secondary to CNS infections, referred to a tertiary center for presurgical evaluation.

Patients and methods

Seventeen patients (11 men, six women) with a history of meningitis (n = 6) or encephalitis (n = 11) were identified from a retrospective chart review of patients admitted to our Epilepsy Monitoring Unit for presurgical evaluation between 1995-2004. All patients underwent a comprehensive presurgical evaluation consisting of complete neurological examination, long-term video-EEG monitoring – including monitoring with foramen ovale electrodes in two patients – a high-resolution MRI, neuropsychological testing, and bilateral carotid sodium amytal testing if needed.

The diagnosis of viral encephalitis or bacterial meningitis was based on history and medical records consistent with CNS infection (acute or subcaute onset of headache, fever, signs of meningeal irritation and impairment of consciousness in association with typical inflammatory CSF abnormalities). Patients with brain abscess, prolonged febrile convulsions with neither typical inflammatory-CSF abnormalities nor signs of CNS parenchymal involvement, chronic encephalitis, post-infectious or post-vaccination encephalitis were excluded.

The following clinical and demographic variables were collected *(table 1)*: sex, age, age at CNS infection, history of acute symptomatic seizures during infection, latent period before non-provoked seizures, age at seizure-onset, seizure semiology, inter-ictal and ictal EEG data, neuroradiological findings, side of surgery and pathology. Surgical outcome with respect to seizures was assessed by retrospective chart review according to Wieser's classification (Wieser *et al.* 2001). Seizure semiology was obtained after reviewing videotapes from inpatient, long-term video-EEG monitoring and from chart reviews looking for previous auras or seizure types not present at the moment of the presurgical evaluation. Patients were examined during and after the seizure by trained EEG technicians, who assessed the level of consciousness. We reviewed 127 seizures from 17 patients. Investigators reviewing the videotapes (A.D, M.C., R.A.) were blinded to the patients' EEG and neuroimaging data. Each seizure was analyzed by the authors independently, and classified according to the semiological seizure classification (Luders *et al.* 1998). If disagreement occurred between the reviewers, the videos were re-evaluated in presence of the three primary reviewers (A.D, M.C., R.A.), and consensus was obtained.

As a part of the preoperative assessment, a comprehensive neuropsychological examination was performed, including intelligence and memory tests. We included certain subtests (Logical Memory and Visual Reproduction) of the Wechsler Memory Scales (WMS, WMS-R and WMS-III), which are among the most commonly used tests for neuropsychological assessment in surgical centers for epilepsy (Jones-Gotman, 1992). Premorbid intelligence was tested by the Vocabulary subtest of the Wechsler Adult Intelligence Scales (WAIS and WAIS-III). For statistical analysis of neuropsychological variables, normalized "z" scores were computed using mean and standard deviations of the raw scores of the general population. Verbal and visual memory scores were compared with vocabulary scores individually. We consider the subjects as memory-impaired if more than one subtest z score was one standard deviation (SD) below the general level of intelligence (vocabulary), as proposed by Lezak (Lezak and Gray 1984).

Six patients (two meningits and four encephalitis patients) underwent a temporal lobe resection. In five patients, an anterior temporal lobectomy was performed, which consisted of removal of the anterior part of the temporal lobe; extending backwards 3-3.5 cm from the temporal pole in the dominant hemisphere and 3.5-4 cm in the non-dominant hemisphere, sparing the posterior half of the superior temporal gyrus. A standarized, anatomical resection, which consisted of removal of the anterior part of the temporal lobe, extending backwards 6.5 cm from the temporal pole in the non-dominant hemisphere, was performed in one patient with atypical seizure semiology. In every case, the mesial structures (amygdala and hippocampus) were included in the resection. One patient with an extense porencephalic cyst over the left fronto-

Table 1. Results of presurgical evaluation and outcome after surgery in patients with refractory epilepsy secondary to CNS infections.

Patient	Age/ gender	Age at Infection	CNS infection/ Acute seizures	Sz onset	EEG interictal	EEG ictal	Sz semiology	Neuropsycology	MRI	Surgery/Pathology/ sz outcome
1	58/M	3 y	- Meningitis	39 y	SW R ant T	Regional R T	Aura abdominal and psychic→ Automotor sz	Visual memory deficit	R MTS	R ant. T Lobect (including mesial structures)/ MTS/ Sz free
2	34/F	14y	- Meningitis	20y	SW L and R T	F.Ovale: focal L mesial T	Aura(unspecific sensation in the right hand) →Automotor sz	Not valuable	L MTS	
3	46/M	3 y	- Meningitis - CGTCs	18 y	SW R ant/mid T SW L T	Reg R T	Hypermotor sz (rowing and pedaling) sz.→L Head versión→ GTCS	Verbal memory deficit	R MTS	R T anatomic lobect/ MTS/ Sz free
4	39/M	8 m	- Meningitis - Parcial motor SE (L Face clonic)	1y	SW R T SW L T	Reg R F-T	Aura→ Dialeptic sz→ L facial clonic→ clonic gen sz.	Verbal and visual memory deficit	R MTS	
5	58/M	13y	- Meningitis (TBC)	13y	SW L ant T	Reg L T	Aura→Hypermotor szs	Verbal and visual memory deficit	L MTS assoc. to L T atrophy	
6	32/M	40d	-Meningo-encephalitis (N. Meningitidis) - Focal szs (R Hemibody)	6y	Slow SW complexes gen (max R F-C)	Generalized	R hemibody Somato-S aura→ BAT sz→ R arm clonic sz (Sound/ startle reflex epilepsy)	Attention deficit; Psicomotor slowing; Learning disabilities; Visuo-man coord deficit	Porencephalic cyst over the L F-T region	L functional hemispherectomy Sz free
7	29/F	22y	-Encephalitis -GTCs	22y	SW R T SW L T	Reg R post T	Automotor sz→ GTCS	Verbal memory deficit	R MTS	
8	61/F	32y	-Viral Encephalitis -CGTs	32 y	SW L ant. and mid. T	Reg L F-T Reg R F-T BiTemp.	Psychic aura → Dialeptic sz→R head clonic sz	Verbal and visual memory deficit	Bilateral MTS	
9	21/M	3y	-Meningo-encephalitis (VVZ)	14y	-SW R F -SW L P-O -SW C-P	Generalized	1. Dialeptic sz→ L head clonic sz→ clonic gen sz. 2. Hypermotor sz →L head clonic sz→clonic gen sz	Attention deficit; Verbal and visual memory defict	Normal	
10	28/F	20m	-Viral encephalitis (Measles)	2,5y	SW R ant. and mid. T	Reg R T	Abdominal aura→ Automotor sz	Verbal and visual memory deficit	R MTS	R Ant T Lobect/ (including mesial structures) MTS/ Seizure free
11	32/M	15m	-Viral Encephalitis	4y	-SW L F-T -SW generalized -SW R F-T	Generalized	BAT	Learning disabilities (verbal> visual)	L F porencephalic cyst	
12	23/M	6y	-Meningo-encephalitis -Focal szs (L hemibody) and GTCs	6y	-SW L mid. T	Reg R T	Aura → Automotor sz → L head version→GTCS	Mild visual memory deficit	Normal	R Ant T Lobect/ (including mesial structures) MTS / Rare auras
13	46/M	40y	-Viral Encephalitis -Non-convulsive SE	40y	-SW R and L post. T	Reg R T Reg L T	Psychic aura →Automotor sz.→ R head versive→ GTCS	Verbal and visual memory deficit	Bilateral MTS	
14	39/M	6m	-Viral encephalitis	16y	-SW R and L T	Reg L T	Aura→ Hypermotor sz →R head version→ GTCS	Verbal and visual memory deficit	L MTS	L Ant T Lobect (including mesial structures)/ MTS/ Seizure free
15	25/F	18 m	- Viral Encephalitis	3y	-SW L T	Reg L T	Aura abdominal→ Automotor/dialeptic sz	Verbal memory deficit	L MTS	L Ant T Lobect/ MTS and neocortical gliosis / Rare auras
16	34/F	12y	- Encephalitis -Generalized SE	18y	-SW L and R T	Reg Bitemporal F.Ovale: L and R T	Dialelptic sz→ complex-motor/ hypermotor sz→ GTCS	Verbal and visual memory deficit	Bilateral MTS	
17	41/M	19y	- Encephalitis - Generalized SE	19y	No SW	Obscured	Aura→ R arm Tonic sz → R hemibody tonic sz → GTCS	Attention deficit; Learning disabilities	Normal	

Abbreviations: M: male, F: female, y: year, m: month, d: days, SW: sharp wave, L: left, R: right, T: temporal, Bitemp: bitemporal, F: frontal, F-C: fronto-central, P: parietal, O: occipital, Ant: anterior, Mid: middle, Post: posterior, MTS: mesial temporal sclerosis, Lobect: lobectomy, BAT: bilateral asymmetric seizure, GTCS: generalized tonic-clonic seizure, Gen: generalized, TBC: tuberculous meningitis, SE: status epilepticus.

temporal region after post-natal meningo-encephalitis underwent a functional hemispherectomy. All patients were operated on by the same neurosurgeon (JR) between 1996 and 2005.
Postoperative follow-up data were collected at three month intervals in the first year and every six months in the following years in all patients. Mean follow-up time was 4.1 years, ranging from 12 months to 7 years. Surgical outcome was classified according to Wieser's classification (Wieser *et al.* 2001). Long-term follow-up of those patients deemed to be inappropriate surgical candidates was also performed.

Results

Median age at CNS infection was three years, ranging from 40 days to 40 years. Median age for the meningitis group was three years (range: 40 days to 14 years) and six years for the encephalitis group (range: six months to 40 years). The latent period from the initial CNS infection to the onset of recurrent seizures ranged from immediately after the CNS insult to 36 years afterwards. The latent period was shorter in the encephalitis group (median 0.9 year; range 0 to 15.5 years) compared with the meningitis group (median 5.9 year; range 0 months to 36 years). However, this difference did not reach statistical significance (median 0.9 *versus* 5.9 years, $p > 0.05$, Mann-Whitney U test), probably because of the small sample size. All patients from the meningitis group experience bacterial meningitis; one of them was TBC meningitis. From the encephalitis group, the etiology was measles encephalitis in one, VVZ encephalitis in one, and viral encephalitis of undetermined etiology in nine patients.
Acute symptomatic seizures were developed by three patients in the meningitis group. One of them experienced focal motor status epilepticus consisting of clonic movements of the left hemiface, one experienced right hemibody focal motor seizures and the third experienced generalized motor seizures. In the encephalitis group, six patients developed acute symptomatic seizures. Three of them experienced generalized motor seizures, one had focal motor seizures involving one hemibody, two had generalized motor status epilepticus and one of them developed non-convulsive status epilepticus.
Acute neurological sequelae consisted of right hemiparesis and moderate dysarthria in one encephalitis patient, and bilateral neurosensorial hypoacusia in one patient of each group.

Neuroradiology findings

All but one patient in the meningitis group had mesial temporal sclerosis (MTS) on MRI. This was associated with severe, neocortical basal and lateral atrophy over the ipsilateral temporal lobe in one patient. There was only one patient in this group who displayed a porencephalic cyst over the left fronto-temporal region. In contrast, neuroradiological findings in the encephalitis group were more varied, and included unilateral MTS (four patients), bilateral MTS (three patients), porencephalic cyst (one patient), and no significant findings (three patients).

Seizure semiology

Seizure semiology in the meningitis group was characterized by automotor seizures (complex partial seizures with automatisms) in two patients, dialeptic seizures (complex partial seizures with loss of awareness but without obvious motor components) in one patient, bilateral asymmetric tonic seizures mainly triggered by sudden and unexpected stimuli such as noise ("startle epilepsy") in one patient, and complex motor/hypermotor seizures in two patients. The complex motor/ hypermotor seizures were characterized by violent and predominantly proximal limb movements such as rowing or bicycling in one patient and by grimacing associated with unilateral flailing arm movements in the other. Five patients reported auras (abdominal and psychic auras in one, right hemibody somato-sensory aura in one, and non-specific auras in three – dizziness and nauseous sensation, non-specific tingling sensation in the right hand and cephalic sensation).
With regard to the encephalitis patients, we divided them into two groups depending on the presence of MTS on the MRI scan. Seizure semiology in those who had MTS (seven patients) was characterized by automotor seizures in four patients, dialeptic seizures in two patients and hypermotor seizures in one patient. Hypermotor seizures were characterized by violent and proximal unilateral flailing arm movements and vocalizations. Epileptic auras were present in five patients. These were described as abdominal aura (two patients), psychic aura (two patients) and non-specific cephalic aura (one patient). Dystonic arm posturing during seizures was seen in three patients.
Among those encephalitis patients who did not display MTS on MRI studies, one patient had an extensive porencephalic cyst over the frontal region. His seizures were characterized by bilateral asymmetric tonic posturing. Three patients did not show any abnormalities on MRI studies. Seizure semiology in this group was characterized by automotor seizures (one patient), right arm tonic seizures (one patient), dialeptic seizures and hypermotor seizures (one patient). Epileptic auras such as dizziness and right leg movement illusion occurred in two patients with normal MRI scans.

Interictal and ictal EEG

Interictal epileptiform activity in the meningitis group was located mainly over the temporal region and was often bilateral; three out of five patients with MTS showed bi-temporal, independent sharp waves. In the encephalitis group, interictal epileptiform activity was temporal in nine (bi-temporal in four), frontal in one, parieto-occipital in one and generalized in two patients. Multiregional spikes were seen in one patient. The distribution of the temporal sharp waves in the encephalitis patients was more widespread than in the meningitis patients, involving the anterior, middle and posterior temporal region (see *table 1* for more detailed data).

Scalp-recorded ictal activity in those patients with a history of meningitis and MTS was located over the temporal region and was congruent with the MTS location in all but one patient, who required foramen ovale electrode placement to correctly lateralize seizure-onset, also congruent with the location of the MTS. The patient from the meningitis group who had a porencephalic cyst over the frontotemporal region displayed a diffuse, electrodecremental pattern as an ictal EEG finding. In the encephalitis group, ictal EEG seizure activity was temporal in eight patients, being bilateral independent in three. The ictal EEG pattern was generalized in three patients (generalized paroxysmal fast activity), and obscured in another patient.

Neuropsychology

Neuropsychological assessment in the meningitis group was performed in all patients but one, who had a severe, bilateral hypoacusia that interfered significantly with the neuropsychological evaluation. The results revealed a decline in both visual and verbal function in two patients, a decline in memory function congruent with the location of MTS in one patient and non-congruent in the other one. In the encephalitis group, those patients who displayed unilateral MTS (four patients) showed several patterns of memory impairtment; two of them showed a decline in both verbal and visual memory function, one had a decline in memory skills congruent with the MRI lesion and the other one had a decline in memory skills which was non-congruent with the location of the MRI lesion. Patients who exhibited bilateral MTS showed a decline in both visual and verbal memory function. Those patients who had porencephalic cysts or did not show a lesion on MRI scans tended to display a more widespread cognitive impairment including memory and attention deficits, learning impairment and global psychomotor slowing (for more details see *tables 1* and *2*).

The Wada test was performed in four patients, two with left MTS, to verify functional reserve of the right hippocampus, and two with right MTS (one with bilateral memory deficit and the other with a predominantly verbal memory deficit).

Surgery and postsurgical follow-up

One patient from the meningitis group and four patients from the encephalitis group underwent an anterior temporal lobectomy. All of them showed unilateral MTS (three right temporal). Seizure outcome was excellent, as three patients were rendered seizure-free (Class 1a) after surgery and two of them are free of disabling seizures, having exclusively rare auras (Class 2). One meningitis patient, who had a right MTS, severe neocortical atrophy and somewhat atypical seizure semiology underwent a temporal standardized anatomical resection. He has been seizure-free (Class 1a) since then. The most important limiting factor for epilepsy surgery in patients with MTS was concern about memory decline in patients with non-congruent or bilateral memory deficits. One meningitis patient underwent a functional hemispherectomy and he has been seizure-free since then (Class 1a). Three patients (all of them from the encephalitis group) were not considered suitable for surgery because of multifocal or non-

Table 2. Neuropsychological test results.

Patients	Estimated IQ	Logical memory immediate recall	Logical memory delayed recall	Visual reproduction immediated recall	Visual reproduction delayed recall
1	50	0.70	1.00	-1.30	-1.00
2	Not performed	---	---	---	---
3	47	-1.45	-1.10	0.58	-0.62
4	47	-1.20	-1.32	-1.68	-2.87
5	43	-1.00	-2.30	-0.30	-2.30
6	33	1.00	0.40	0.70	0.70
7	57	-0.40	-1.40	0.30	0.30
8	47	-1.69	-2.38	-1.43	-2.12
9	53	-1.00	-1.00	-0.34	-0.97
10	47	-1.08	-1.27	-0.36	-1.32
11	47	-0.76	-0.45	0.93	0.30
12	37	0.60	0.10	0.60	-0.80
13	63	-1.43	-1.34	-1.21	-1.93
14	57	-1.08	-1.56	-0.80	-3.02
15	50	-1.74	-1.86	1.27	1.36
16	50	-0.69	-1.29	-0.28	-1.07
17	47	0.30	0.00	0.60	-0.40

Results are presented as a *Z* scores (mean = 0; Sd = 1) except for verbal IQ scores presented in *T* scores (mean = 50; SD = 10).

localizable epileptic focus. Those patients who underwent a temporal lobe resection had in common, the presence of a unilateral MTS in the preoperative MR scan, unilateral seizure-onset, latent period extending over several years (except one who developed recurrent seizures immediately after the CNS infection), and, in addition, all of them suffered from a CNS infection before the age of four (except one who developed an encephalitis at the age of six).

Postoperative memory decline was seen only in one meningitis patient who showed preoperatively, a deficit of verbal memory, non-congruent with the location of MTS (right side). However, he displayed an apparently good functional reserve in the left hippocampus during the Wada test. He underwent a right temporal lobectomy and became seizure-free, but displayed a decline in verbal and visual memory function which prevented him from carrying out his previous occupational activities.

No other postoperative deficits were seen in our population of patients.

Long-term follow-up of those patients deemed to be unsuitable surgical candidates ranged between two to 11 years (median: five years). None of them was seizure-free at the time of follow-up. Furthermore, a reduction in seizure frequency of more than 50% was not observed in any patient from either the meningitis or encephalitis groups.

Discussion

All our patients with refractory epilepsy following meningitis, had seizures with semiology similar to those patients with MTLE without a known etiology, including automotor and dialeptic seizures preceded by abdominal, psychic and non-specific auras. However in some patients, complex motor/ hypermotor seizures were observed. This has been previously reported in patients with temporal lobe epilepsy, probably due to a fast spread of the epileptic activity from the mesial temporal structures to the anterior cingulate gyrus or to the dorsolateral frontal region (ACC) (Bartolomei *et al.* 2002, Carreno *et al.* 2005, San Pedro *et al.* 2000).

In contrast to the meningitis patients, those with refractory postencephalitis epilepsy exhibited a more varied seizure semiology, reflecting the fact that extratemporal epilepsies were included in this group. This is in agreeement with previous studies (Annegers *et al.* 1988, Free *et al.* 1996, Lancman and Morris III 1996, Lee *et al.* 1997, Marks *et al.* 1992, O'Brien *et al.* 2002, San Pedro *et al.* 2000, Trinka *et al.* 2000, Trinka 2004).

In the current study, the most common lesion found was MTS. Several studies have shown that bacterial meningitis can cause damage at the cerebral cortex and the hippocampal formation, especially in the dentate gyrus (Bifrare *et al.* 2003, Bogdan *et al.* 1997, Leib *et al.* 1996, Leib *et al.* 2000, Leib *et al.* 2001, Pfister *et al.* 1992, San Pedro *et al.* 2000). In those patients with a history of meningitis, the MTS was unilateral in contrast to those with a history of encephalitis, who showed bilateral MTS in three out of seven cases. This is in agreement with previous studies that showed, using normalized volumetric analysis, that bilateral hippocampal volume loss is more often detected in patients with a history of encephalitis (Free *et al.* 1996). Patients with a history of encephalitis and MTS showed, compared to the patients with meningitis, more EEG signs of diffuse disease, such as lateral and posterior temporal interictal epileptiform discharges or bi-temporal, independent seizure-onsets. In addition, patients with a history of encephalitis not showing MTS, frequently showed extratemporal interictal epileptiform discharges and generalized EEG ictal patterns. These results are in agreement with previous studies (Marks *et al.* 1992).

An interesting finding of our study was the result of the neuropsychological testing. Patients with a history of meningitis or encephalitis and MTS often showed a decline in both visual and verbal memory function, even those patients with unilateral MTS on the MRI scan. This was the main limiting factor for epilepsy surgery in those patients, since it is well known that in the presence of a poor, baseline bi-lateral memory performance, any decline in memory after a temporal lobe resection may be a considerable risk to significant functional memory disabilities (Martin *et al.* 2001).

Although memory deficits are common in patients with previous CNS infections, they had not been related to the existence of hippocampal atrophy on MR scans (Schmidt *et al.* 2006). In addition, those studies dealing with refractory epilepsy patients after CNS infections associated with mesial temporal sclerosis (Lee *et al.* 1997, O'Brien *et al.* 2002, Trinka *et al.* 2000, Trinka 2004) did not comment on presurgical neuropsychological findings. Therefore, we feel that the presurgical neuropsychological results found in our group of patients with MTS are clinically relevant; on one hand, because the existence of bilateral memory deficits in patients with a history of CNS infection and MTS had not been previously reported, and on other hand because it was the most important limiting factor for epilepsy surgery in our study population.

It is important to point out that the only patient who underwent surgery with a non-congruent memory deficit had a postoperative memory decline that prevented him from carrying out his previous occupational activities, in spite of an adequate memory performance during Wada test; it is well known that the ipsilateral hippocampus may not be inactivated during the Wada test, making the memory testing unreliable (Setoain *et al.* 2004). So it should be emphasized that all patients with refractory epilepsy after CNS infection considered for epilepsy surgery, should undergo detailed neuropsychological evaluation, the Wada test if needed and counselled about possible postsurgical memory decline.

Our post-ATL seizure-outcome results are in agreement with previously reported, favorable seizure-outcome factors, including occurrence of CNS infection before the age of four, remote history of meningitis, presence of MTS in the preoperative MRI, longer latent period to the onset of epilepsy and seizure-onset localized to one temporal lobe (Lancman and Morris III 1996, Lee *et al.* 1997, O'Brien *et al.* 2002, Trinka *et al.* 2000). In these selected patients, an excellent surgical outcome can be expected. Conversely, in those patients who had no focal lesion on MRI, a short latency period, late age at the time of CNS infection, history of encephalitis or a neocortical origin of their seizures, poor seizure outcome should be expected (Annegers *et al.* 1988, Lancman and Morris III 1996, Lee *et al.* 1997, Marks *et al.* 1992, O'Brien *et al.* 2002, Trinka *et al.* 2000, Trinka 2004). Interestingly enough, none of those patients deemed to be inappropriate surgical candidates was either seizure-free or experienced a reduction seizure frequency of more than 50%, showing that these patients are in fact strongly resistant to the current antiepileptic drugs.

Our study has some limitations, including its retrospective nature and the fact that the diagnosis of CNS infection was often dependent on the information provided by the patients and their families. However, this is often the case in series dealing with this type of patient. Another potential limitation is the small number of patients included in the meningitis group. However, we feel that it may provide interesting information to those dealing with patients with refractory seizures after meningitis or encephalitis and who are being evaluated for epilepsy surgery. □

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