Lateralizing significance of head and eye deviation in secondary generalized tonic clonic seizures. Neurology 1993;43: 1308–1310.
7. Chee M, Kotagal P, Van Ness P, Gragg L, Murphy D, Lüders H. Lateralizing signs in intractable partial epilepsy: blinded multiple-observer analysis. Neurology 1993;43:2519–2525.
8. McLachlan R. The significance of head and eye turning in seizures. Neurology 1987;37:1617–1619.
9. Wyllie E, Lüders H, Morris H, Lesser R, Dinner D, Goldstick L. Ipsilateral forced head and eye turning at the end of the generalized tonic-clonic phase of versive seizures. Neurology 1986;36: 1212–1217.
10. Wöginger S. Clinical semiology of secondarily generalized tonic clonic seizures in patients with focal epilepsy [thesis]. Vienna: Vienna Medical School, Department of Clinical Neurology, 1999.

VIDEO

Asymmetric termination of secondarily generalized tonic-clonic seizures in temporal lobe epilepsy

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Abstract—In patients with secondarily generalized tonic-clonic seizures (sGTCS) an asymmetric termination of the clonic phase can be observed. The authors systematically analyzed this phenomenon in patients with temporal lobe epilepsy (TLE). Thirty-nine sGTCS from 29 patients with TLE who underwent successful epilepsy surgery were analyzed, in addition to a prospectively collected group of 28 patients with TLE who had 35 sGTCS. The clonic phase of sGTCS did not end synchronously in 65.7% of all patients and in 59.4% of all seizures. In 79.3% to 80% this was ipsilateral to the hemisphere of seizure onset, and there was excellent interobserver agreement.

NEUROLOGY 2002;59:1254–1256

Analysis of clinical semiology in medically refractory focal epilepsy may add valuable information for localizing the seizure onset zone during presurgical workup. Various limb motor signs that occur before secondary generalization in focal epilepsies of temporal or frontal origin have been described.[1-4]. A striking asymmetry of limb posture occurs in secondarily generalized tonic-clonic seizures (sGTCS), which has been termed asymmetric tonic limb posturing (ATLP) or *figure 4 sign*.[3,5] ATLP lateralizes reliably to the contralateral seizure focus in temporal and extratemporal epilepsies.[5]

In patients with temporal lobe epilepsy (TLE) who demonstrate ATLP before the generalized tonic-clonic phase, one may notice an asymmetric ending of the clonic phase.[6] We call this phenomenon *asymmetric seizure termination (AST).* We sought to determine the incidence of AST in patients with medically refractory TLE, the association with ATLP, and the value in predicting the hemisphere of seizure onset.

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Patients and methods. We studied 65 patients with medically refractory TLE aged over 17 years and evaluated at the Epilepsiemonitoringeinheit, Universitätsklinik für Neurologie, Innsbruck, Austria, between June 1998 and October 1999 for epilepsy surgery. Patients without superior-quality video recordings were excluded (n = 5). Two patient groups were studied: Group 1 comprised 29 patients successfully treated with selective amygdalohippocampectomy or temporal lobe resections, with a minimum postoperative follow-up of at least 1 year, representing 48.3% of all patients evaluated for surgery during that time period. Three patients operated during that time period were not seizure free and therefore excluded from the study. Group 2 consisted of 28 patients with refractory TLE evaluated for epilepsy surgery who had 35 sGTCS collected prospectively over a 8-month period. They were either awaiting surgery, refused surgery,

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Received January 22, 2002. Accepted in final form July 18, 2002.

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Table 1 *Patient demographics*

Demographic	Group 1, operated patients (n = 29)	Group 2, nonoperated patients (n = 28)
Age at presurgical investigation, y	Median 41 (range 19–61)	Median 41 (range 26–55)
Men/women, n	13/16	13/15
History of complicated febrile convulsions, yes/no, n	9/20	4/24

or follow-up was too short for reliable outcome assessment. All patients underwent intensive video-EEG monitoring with scalp electrodes for an average of 5 days, high-resolution MRI according to a standard protocol, interictal SPECT or PET, and a neuropsychological evaluation including an intracarotid amobarbital test to lateralize speech and memory dominance when feasible. Seizure focus definition was based on concordant findings in these investigations.

We studied 279 seizures in 57 patients (range 1 to 17 seizures per patient); 35 of them showed 74 sGTCS (range one to four). ATLP was defined as striking asymmetry of limb posture during the initial tonic phase of a sGTCS. One arm is rigidly extended at the elbow, whereas the opposite extremity is flexed at the elbow.[5] This is followed by tonic posturing of both upper extremities, which may evolve to the clonic phase. We defined AST when the last clonic jerk was unquestionably unilateral with no movement on the contralateral arm. Asymmetric but synchronous jerking with a higher amplitude on one side was not rated as AST. Two reviewers (G.W., E.T.) examined the seizures individually. The occurrence of each of the lateralizing signs was determined by scoring a sign as present if it was reported by both reviewers. If the two reviewers disagreed, the video was reexamined by a third reviewer (G.B.). The Kappa index was used to quantify interobserver agreement. For each sign the positive predictive value was calculated by the number of patients with the correctly lateralizing sign divided by the total number showing that sign and multiplied by 100. Pearson's χ^2 analysis was used to evaluate the significance of different findings in the two patient groups and to verify the positive predictive value of the described lateralizing signs, assuming statistical difference when $p < 0.05$.

Results. There were 29 patients who were seizure free after epilepsy surgery and had a minimum follow-up of 1 year (Group 1). The prospectively collected Group 2 consisted of 28 patients. Patients' demographics are summarized in table 1. In Group 1 sGTCS were identified in 17 of 29 (58.6%) patients and in 39 of 104 (37.5%) of recorded seizures, whereas in Group 2 18 of 28 (64.3%) of patients and 35 of 63 (55.6%) of seizures (p = not significant). AST was observed in 12 of 17 (70.6%) patients with sGTCS and in 29 of 39 (74.4%) of the recorded seizures in Group 1, whereas in Group 2 AST occurred in 11 of 18 (61.1%) patients (p = not significant) and 15 of 35 (42.9%) seizures ($p < 0.05$). In both patient groups AST occurred more often ipsilateral to the side of seizure focus ($p < 0.001$, $\chi^2 = 17.338$), whereas ATLP was more often contralateral ($p < 0.001$, $\chi^2 = 12.738$). The overall interobserver agreement was excellent, with a kappa index of 0.72 for ATLP and 1.0 for AST. Table 2 shows the incidence and positive predictive value of AST and ATLP in relation to seizure focus lateralization for both patient groups.

Table 2 *Incidence and positive predictive value of asymmetric seizure termination and asymmetric tonic limb posturing in relation to seizure focus lateralization*

	Group 1 (n = 29)		Group 2 (n = 28)		All patients (n = 57)	
Characteristic	Patients	Seizures	Patients	Seizures	Patients	Seizures
sGTCS found in, n (%)	17/29 (58.6)	39/177 (20.9)	18/28 (64.3)	35/102 (34.3)	35/57 (61.4)	74/279 (26.5)
AST, n (%)	12/17 (70.6)	29/39 (74.4)	11/18 (61.1)	15/35 (42.9)	23/35 (65.7)	44/74 (59.5)
Ipsilateral	9/12 (75)	23/29 (79.3)	8/11 (72.7)	12/15 (80)	17/23* (73.9)	35/44* (79.5)
Contralateral	1/12 (8.3)	6/29 (20.7)	2/11 (18.2)	3/15 (20)	3/23* (13)	9/44* (20.5)
Ipsi- and contralateral	2/12 (16.7)		1/11 (9.1)		3/12 (13)	
ATLP, n (%)	11/17 (64.7)	28/39 (71.8)	12/18 (66.7)	24/35 (68.6)	23/35 (65.7)	52/44 (70.3)
Ipsilateral	2/11 (18.2)	4/28 (14.3)	2/12 (16.6)	5/24 (20.8)	4/23† (17.4)	9/52† (17.3)
Contralateral	7/11 (63.3)	24/28 (85.7)	9/12 (75)	19/24 (79.2)	16/23† (69.6)	43/52† (82.7)
Ipsi- and contralateral	2/11 (18.2)	—	1/12 (8.3)	—	3/23 (13)	—
AST without previous ATLP, n (%)	4/17 (23.5)	7/39 (18)	4/18 (22.2)	6/35 (17.1)	8/35 (22.9)	13/74 (17.6)
ATLP without successive AST, n (%)	3/17 (17.6)	6/39 (15.4)	5/18 (27.8)	15/35 (42.9)	8/35 (22.9)	21/74 (12.2)

* χ^2 AST ipsilateral vs. contralateral: $p < 0.001$; $\chi^2 = 17.338$ for all patients, $\chi^2 = 30.727$ for all seizures.
† χ^2 ATLP ipsilateral vs. contralateral: $p < 0.001$; $\chi^2 = 12.738$ for all patients, $\chi^2 = 44.462$ for all seizures.

ATLP = asymmetric tonic limb posturing; AST = asymmetric seizure termination; sGTCS = secondary generalized tonic-clonic seizure.

Discussion. Although it is commonly accepted, that the side of clinical and electroencephalographic seizure onset is critical for a successful outcome following epilepsy surgery, little attention has been paid to the lateralizing value of asymmetric seizure termination. A previous study in a series of 44 patients with 50 secondarily generalized seizures reported an asymmetric ending of the clonic phase in 47.5% of seizures that was ipsilateral to seizure onset in 79%.[6] This is a comparable frequency of AST to the findings in the current study. However, to date there is no systematic analysis of seizure termination in sGTCS. Previous work focused on the electrographic seizure termination in patients undergoing bitemporal depth electrode investigations, with conflicting results on the prognostic implications. In a retrospective study of 50 patients with refractory TLE who had intracranial EEG recordings, 27 of the seizure-free patients following surgery had final electrographic seizure termination more often in the onset location compared to the 23 patients who were not seizure free (67% versus 36%, $p < 0.01$), and less often they had seizure termination outside of the temporal lobe (13% versus 45%, $p < 0.005$).[7] The authors concluded that there may be secondary epileptogenic cortical regions with impaired seizure-terminating capabilities. Another study reported a poor outcome in patients undergoing intracranial EEG monitoring who showed continued ictal electrographic activity contralateral to side of seizure onset following termination of ictal activity ipsilateral to the side of onset.[8] Contrary to these findings in a retrospective analysis of 44 patients with refractory TLE undergoing bilateral subdural and depth electrodes, no correlation of poor outcome and electrographic seizure offset outside the onset zone was found.[9] However, all these studies analyzed the electroencephalographic seizure offset patterns and did not comment on seizure semiology. Moreover, they dealt with a highly selected group of patients with refractory TLE with poorly localized seizure onset or discordant findings in noninvasive techniques demanding implantation of intracranial electrodes. As seizure semiology may add valuable information for patient lateralization in TLE when combined with ictal surface EEG findings,[10] we wished to analyze the seizure termination in TLE. AST can be observed in 65.7% of our patients who had sGTCS and is a useful lateralizing sign. The frequency is comparable to ATLP with a slightly higher positive predictive value (73.9% versus 69.6%) and an excellent interobserver agreement because of the strict definition. In 23.5% of the operated patients showing sGTCS and 22.2% of those who were not operated AST was observed without previous ATLP and may therefore add valuable additional information to correct seizure lateralization. We cannot conclude from our data that AST has prognostic implications because we studied only patients with excellent postoperative outcome. It is likely that AST is the result of the dynamic process of seizure propagation. The hemisphere contralateral to the onset zone is later involved in seizure activity and consequently also seizure suppression occurs later than in the hemisphere ipsilateral to the seizure onset.

Acknowledgment

The authors thank Dr. Hildegard Lukasser and Jürgen Nawratil for their assistance in patient evaluation.

References

1. Kotagal P, Lüders HO, Morris HH, et al. Dystonic posturing in complex partial seizures of temporal lobe onset: a new lateralizing sign. Neurology 1989;39:196–201.
2. Oestreich L, Berg M, Bachmann D, Burchfiel J, Erba G. Ictal contralateral paresis in complex partial seizures. Epilepsia 1995;36:671–675.
3. Bleasel A, Kotagal P, Kankirawatana P, Rybicki L. Lateralizing value and semiology of ictal limb posturing and version in temporal and extratemporal epilepsy. Epilepsia 1997;38:168–174.
4. Werhan KJ, Noachtar S, Arnold S, et al. Tonic seizures: their significance for lateralization and frequency in different focal epileptic syndromes. Epilepsia 2000;41:1153–1161.
5. Kotagal P, Bleasel A, Geller E, et al. Lateralizing value of asymmetric tonic limb posturing observed in secondarily generalized tonic-clonic seizures. Epilepsia 2000;41:457–462.
6. Wöginger S. Clinical semiology of secondarily generalized tonic-clonic seizures in patients with focal epilepsy. Thesis, University of Vienna, Austria, 1999.
7. Spencer SS, Spencer DD. Implications of seizure termination location in temporal lobe epilepsy. Epilepsia 1996;37:455–458.
8. Verma A, Lewis D, VanLandingham KE, et al. Lateralized seizure termination: relationship to outcome following anterior temporal lobectomy. Epilepsy Res 2001;47:9–15.
9. Brekelmans GJ, Velis DN, van Veelen CW, et al. Intracranial EEG seizure offset termination patterns: relation to outcome of epilepsy surgery in temporal lobe epilepsy. Epilepsia 1998; 39:259–266.
10. Serles W, Caramanos Z, Lindinger G, Pataraia E, Baumgartner C. Combining ictal surface-electroencephalography and seizure semiology improves patient lateralization in temporal lobe epilepsy.Epilepsia 2000;41:1567–1573.