

# Relative Localizing Value of Common Tests used in the Preoperative Investigation of Epileptic Patients

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**ABSTRACT:** We have compared the relative localizing value of common tests in the presurgical evaluation of epilepsy in 73 patients with depth electrode (SEEG) confirmed epileptogenic foci and excellent surgical outcome. We found the tests of abnormality (CT, amytal, neuropsychology) to be frequently non-informative and often discordant with SEEG. The EEG was concordant with the SEEG in 38% of cases and provided lateralization in 78%. EEG was less localizing than ictal behavior in frontals but not in temporals. The need for SEEG is rather evident in these results but could become attenuated by the development of the localizing power of scalp EEG.

**RÉSUMÉ:** Valeur localisatrice relative de tests utilisés couramment dans l'investigation préopératoire de patients épileptiques. Nous avons comparé la valeur localisatrice de tests fréquemment utilisés dans l'évaluation préchirurgicale de 73 patients avec foyer confirmé par enregistrement ictal intracérébral (SEEG) et cortectomie avec devenir clinique excellent. On observe une fréquente absence d'information et passablement de discordance dans les tests d'atteintes structurelle (CT) ou fonctionnelle (amytal et neuropsychologie). L'EEG de surface est concordant avec la SEEG dans environ 38% des cas et est latéralisateur dans 78% des cas. L'EEG est moins localisateur que le comportement ictal chez les frontaux mais pas chez les temporaux. L'utilité de la SEEG apparaît évidente. Cependant le développement du pouvoir localisateur de l'EEG ictal de surface pourrait éventuellement rendre moins nécessaire l'utilisation des méthodes invasives.

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Most people interested in epilepsy surgery share the attitude that a preoperative investigation with a large number of concordant tests maximizes the chances of a successful surgery. However, as it is rather rare to have perfect concordance between all tests, it would be useful to have a good estimate of the relative predictive value of individual tests. Some tests may be highly localizing in most cases, some may provide complementary information which may prove very useful on a restricted number of cases, and still other tests may simply add misleading information.

The localization value of a test can only be established relative to a reference. To us, this reference is provided by the most direct measure of epileptic excitability i.e., intracranial focal onset (SEEG). In addition, since SEEG does not lead to a perfect outcome in all cases, only SEEG localizations which have led to excellent outcomes are considered as references.

Previous studies have shown variable correlations between various presurgical tests, generally on a small number of patients.<sup>1-3</sup> Investigation procedures differ greatly from one center to another. Different centers also have different patient selection criteria and different interpretation methods. We have thus

decided to examine the predictive value of the most frequently used tests in a single center in which the investigation methodology has been relatively uniform for more than 15 years (Notre-Dame Hospital, Montreal). This provides a sufficiently large number of patients on which to base comparisons between tests. Here we present preliminary analyses of the correlation between 5 common tests and SEEG.

## METHODS

From 1973 to 1988 inclusive, the epilepsy surgery unit at Notre-Dame hospital has investigated 296 patients of which 128 were treated by cortectomies. Of these, 101 patients had sufficient follow-ups (2 years) and were included in the present analyses. In terms of seizure frequency, patient follow-ups revealed that 70% of the patients showed excellent improvement as defined by Engel's type I and type II outcomes,<sup>4</sup> 20% showed very good improvement (Engel type IIIa, 90% improvement) and 10% showed less improvement (Engel type IIIb or IV).

Different patient groups showed large differences in outcome with 77% of the temporal epileptics, 46% of the frontal epileptics, and 56% of the parieto-occipital epileptics showing excel-

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lent improvement (Engel type I and II). Also, 19% of the temporals and 29% of the frontals showed very good improvement, while 4% of the temporals and 25% of the frontals showed less improvement.

The pre-surgical investigation protocol at Notre-Dame has been described in detail elsewhere.<sup>5,6</sup> The main tests have been used since 1973 except for the addition of CT and MRI scans. In summary, they involve tests of epileptic excitability including interictal and ictal scalp EEG, video recording of ictal behavior, intracranial recording of interictal and ictal brain activity with 6-10 horizontal multi-contact depth electrodes, and electrical stimulation of the depth electrodes. The protocol also involves tests of structural abnormality including arteriography, ventriculography, CT, and MRI, as well as tests of functional deficits including neuropsychological testing and functional testing under sodium amytal. Our core personnel has been constant during this period, so that test interpretation variability is relatively small.

Our preoperative investigation is predominantly based on the intracranial seizure recordings (SEEG). Correlations were made between SEEG ictal onset and every other test in the protocol on the 73 patients (58 temporals, 10 frontals, and 5 parieto-occipitals as determined by SEEG ictal onset) showing excellent outcome as it is in this group that the SEEG localization can best be relied upon.

## RESULTS

Table 1 shows the concordance rates between SEEG ictal onset and other tests in temporal, frontal, and parieto-occipital epileptics with excellent outcome. Concordance was divided in three stages: 1) Correct lateralization and lobe identification (perfect concordance), 2) Correct lateralization, and 3) Correct lobe identification without lateralization.

The table shows high rates of non-localization in the case of the CT scan and in tests of functional deficit such as neuropsychological evaluation and sodium amytal. Neuropsychology provides lateralizing information in only about 40% of cases and discordant information in about 18% of cases. Similarly, amytal testing shows concordance in 41% of temporals but little discordance. CT provides some information in about 31% of temporals and is discordant in 7%.

Scalp EEG (interictal and ictal together) and ictal behavior show negligible discordance with SEEG. Also, these two tests show the highest correlation with SEEG. In temporals the EEG and ictal behavior show about 40% concordance and 30-40% lateralizing information. In frontals however, the EEG is frequently non-localizing while ictal behavior is concordant in 30% of cases and provides lateralizing information in another 50% of cases.

Ictal behavior and EEG do not appear to provide the same localizing information when they do provide information. Indeed, the concordance rate between the joint EEG and ictal behavior tests and SEEG was 22%.

## DISCUSSION

Although they provide information which helps guide depth electrode placement, none of the frequently used preoperative tests appear to be able to provide a degree of localization which can approximate that of intracranial ictal onset. Tests of structural or functional abnormality are frequently non-informative and sometimes discordant with SEEG. Scalp EEG and ictal behavior show less negative results and higher correlations with SEEG than the previous tests of abnormalities but do not appear to be concordant in the same cases.

Compared to ictal behavior, EEG has an inferior lateralizing value in frontals, but is superior in temporals. This reflects the

**Table 1: Rates of concordance between ictal SEEG onset and other tests in the preoperative investigation on patients with good outcome. Concordance is partitioned as: Perfect concordance (Concord.), correct lateralization (Lat.), correct lobe identification (Loc.), discordant localization (Discord.), and non-localizing (Neg.). The number of cases with ictal onset in each lobe is indicated in parentheses.**

		Concord.	Lat.	Loc.	Discord.	Neg.
EEG	T(58)	40%	38%	17%	—	5%
	F(10)	20%	20%	10%	—	50%
	P(5)	60%	40%	—	—	—
Ictal behavior	T(58)	40%	27%	26%	—	7%
	F(10)	30%	50%	10%	—	10%
	P(5)	—	40%	—	—	60%
CT scan	T(51)	12%	19%	—	7%	62%
	F(6)	16%	—	—	16%	67%
	P(3)	67%	—	—	—	33%
Amytal	T(53)	N/A	41%	N/A	2%	57%
Neuro- psychology	T(49)	26%	18%	—	16%	39%
	F(5)	—	40%	—	20%	40%
	P(3)	—	33%	—	—	66%

fact that both the interictal and ictal EEG are more frequently diffuse in frontals than in temporals.

In our hands, EEG lateralizes the epileptogenic zone in 74% of all cases but correctly localizes it in only 38%. These figures represent combined ictal and interictal EEG information. Since the correct craniotomy cannot be specified in 62% of cases on the basis of EEG, we would argue that surgery could not be done with a high proportion of excellent outcome without intracranial ictal recordings or without rejecting a great deal of patients as non-focal epilepsy.

Of course, the tests examined here are never considered alone in the presurgical evaluation and they also serve other functions than localization of the epileptogenic area, such as the identification of lesions or deficits with significant prognostic value and guiding depth electrode placement. None of these tests can therefore be called superfluous. However, their poor individual localizing value suggests that they should be analyzed further to try to establish the relative value of each test in the context of the results of other tests to learn what information to trust and what not to trust and when. These analyses are presently being carried out at our center but analyses from other centers on patients with excellent outcome are also needed.

Ictal and interictal scalp EEG, as it is presently being interpreted, appears better at lateralizing the epileptogenic area than any other test. This suggests that it may be the best measure to be developed and refined as a preoperative investigation technique. Since much of the information of the highly reliable ictal SEEG should also be present in the scalp EEG, future research should be aimed at developing the localizing value of scalp ictal recordings. Suggestions that this may be possible stem from recent developments in quantitative modeling of generators from EEG scalp topographies<sup>7,8</sup> and the rapidly developing devices for the practical clinical use of MEG scalp topographies.<sup>9</sup>

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