Chapter 1

Psychological Assessment in Epilepsy Surgery

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Epilepsy surgery has become an excellent option for patients with refractory focal seizures. The majority of these patients have seizures from temporal lobe origin. Extratemporal seizures have in most cases a frontal origin, seizures from parietal or occipital regions are rare. The epilepsies in which commissurotomy can be helpful form a special case.

The road towards the realisation of an operation is long. One of the many assessments the patient undergoes, besides EEG, PET, MRI and psychiatry, is the neuropsychological assessment. It is necessary that the psychological make-up of a patient is thoroughly known before operation. There are many factors that can play a role in the cognitive status of the patient after operation. To unravel the multifactorial outcome, comparisons have to be made between pre- and postoperative level, which requires particular emphasis on retest effects. It is not a rare occurrence that improvement of patients after surgery is reported without carefully controlled test material. It is impossible to use the Complex Rey-Osterrieth Figure twice for instance without knowing what the carry-over effect of the second presentation is.

A patient will not often be rejected from operation on the basis of his neuropsychological performance, although a lower IQ level of 70 is often set. With lower IQs, the chances increase for multiple foci, or diffuse brain damage (Falconer 1973; Van Ness 1992). The neuropsychological outcome (intelligence, memory) after an operation is closely related to the level of performance before operation. There is a close relationship between preoperative neuropsychological impairment, and seizure control and neuropsychological performance after operation. An increase of intelligence test scores after temporal resection for instance is correlated with seizure relief (in combination with EEG signs), and absence of pathology (Lieb et al. 1982). Higher preoperative performances on the memory and language measures are associated with larger decrements in postsurgical scores only among the LTE (left temporal epilepsy) patients (Chelune et al. 1991).

The neuropsychological pre-assessment screening has to include tests in all fields that may be affected by the operation. Neuropsychological confirmation of lateralization or localization of the focus is eagerly wanted by neurologists but not always possible. Evidence for correct localization is sparse (Boon et al. 1991). Often the decision criteria are not clear. The idea that administering a neuropsychological test battery in epilepsy is sufficient to localise the functional deficits is not true. These are highly dependent on the kind of lesion that causes the epilepsy. Seizures caused by tumours for instance often
have more marked effects than seizures without anatomical lesions. The relationship be-
tween functional deficit and anatomical (epileptogenic) lesion must be looked at with
care. A temporal epileptogenic focus may excite the frontal lobe, causing frontal neu-
ropsychological deficiencies (Milner 1975). After removal of the temporal focus the
pathway is disrupted and the frontal effects will then fade away (Bornstein et al. 1987).
Selection for surgery can never be based on neuropsychological tests alone. Only careful
comparison of data between different assessments (surface EEG, depth EEG, PET, MRI
and neuropsychological performance) gives optimal certainty about the site of focus.

An excellent survey of batteries and test(areas) is given by Jones-Gotman et al.
(1993b). It represents the results of a questionnaire received from 82 centres that at-
tended the 1992 Palm Desert II conference.

The list of tests in table 1 is a selection. There is more agreement about fields of inter-
est than about tests used. Jones-Gotman (op.cit.) gives satisfaction-means also. In
tests for adults the range is 3.0 - 4.7 on a scale from 1.0 - 5.0. Thus it seems that all tests
used are satisfactory, a result that appears rather questionable.

In each category only the most important tests are given. As language and memory
are the most vulnerable functions in a frontal or temporal operation, the screening must
include extensive language and memory tests. In TLE (temporal lobe epilepsy) memory
bottleneck structures play an important role (Markowitsch 1995). These are regions in
the brain through which (episodic) information has to pass to become long-term stored
(Papez circuit and basolateral circuit). Subdivisions of memory (episodic, semantic, pro-
cedural) vs. STM (short term memory) and LTM (long term memory) are only partly
mirrored in neuropsychological (epilepsy) tests, because semantic and procedural mem-
ory are almost never affected in epilepsy. The neuropsychological importance of many
classical tests is taken for granted. The WAIS was not intended to be a neuropsychologi-
cal instrument. The Hooper test was made in an era in which organicity wielded the
sceptre. The Seashore Rhythm test alternately points to the left, right or no hemisphere
(Duffy et al. 1984; Sherer et al. 1991). The Wisconsin Card Sorting test should measure
frontal lobe damage (Drewe 1974; Milner 1963), which was subsequently refuted (An-
derson et al. 1991). Dichotic listening is often used to identify patients with possible bi-
lateral or right hemisphere dominance. The methodology however is hard to control.
Task variables can have a huge influence on the outcome of this task. Besides this, a Vi-
sual Half Field task (which is hampered by the same methodological difficulties) can add
to the evidence. Language material exposed to one hemifield, which is at first processed
only in one hemisphere, should be recognized better and faster in the dominant hemi-
sphere.

Efron (1989) points out the multiplicity of external factors which play a role in R/L
asymmetries in visual and auditory modalities in normal subjects. (Table 2)

It is clear that it is impossible to control all these variables in the different cate-
gories. This is why the result of L/R tasks is unstable. One never should conclude to an
atypical speech representation on the basis of a dichotic listening task and/or a visual
half field task alone. The Wada test (explained below) is the golden standard for assess-
ing cerebral dominance. Only when a Wada test is not possible, for instance due to an al-
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ergic reaction to amobarbital, should the results of a dichotic listening task be interpreted without further control. Only performing a Wada test because the results of the dichotic listening task indicate the possibility of altered speech dominance must be strongly discouraged. Unfortunately, dichotic listening tasks and Visual Half Field tasks are often interpreted without a proper awareness of the multiplicity of factors that can influence the result.

On the other hand there are fields lacking in the list, such as olfaction, music, imagery and vigilance. All of these can be subject to damage after neurosurgery and have a tremendous effect on Quality of Life, and appropriate tests should, in future, be included in the battery.

THE WADA TEST

There is widespread agreement about the necessity of performing a Wada test, which thus serves special attention here. Before the use of amobarbital in establishing hemispheric dominance was described (Wada 1949), Gardner (1941) used procaine in two left-handed patients to prove that the suspected left hemisphere was not speech dominant. It was not until 1960 that the first publication about the use of amobarbital was written in English (Wada and Rasmussen 1960). Until then these publications only described the test as a tool for detecting hemispheric dominance. Shortly after this last publication the other major use of the test was described: memory functioning in the hemisphere contralateral to the injection (Milner et al. 1962). Since then the Wada test is used in most centres that perform epilepsy surgery as a standard tool in the presurgical evaluation in patients with intractable (temporal or frontal) epilepsy. It serves primarily as an aid for the neurosurgeon in knowing the relative strength of language and memory functions in the brain hemispheres.

The importance of the knowledge of the representation of language and memory in the brain should be clear. Language areas have to be spared in an operation. Memory assessment is needed because bilateral lesions in mesial structures of the temporal lobe, not only the uncus and amygdala, but also the hippocampus and gyrus hippocampalis cause profound and irreversible amnesia (Scoville and Milner 1957). The same can occur in unilateral temporal lobectomy, if there is an electrographical abnormality in the hemisphere contralateral to the operation. The injection of sodium amytal causes short inactivation (5 - 10 minutes) of one hemisphere, including speech and memory areas, thus serving as a chemical analogue of an operation. The procedure is not standardized, there are even different methods of injecting the drug. Although the Wada test is by far the most valid dominance test, some centres (described in a survey by Jones-Gotman et al. 1993a) have enough confidence in the validity of ‘normal’ outcome of standard neuropsychological assessment not to perform an invasive Wada test. In our series of 368 injections (192 patients) the percentage morbidity is about 1%. During the years, the risk decreased with the experience of the radiologist and careful patient selection.

There is a close relationship between handedness and hemispheric dominance.
The higher incidence of left handedness in an epilepsy population (10% vs. 5% in a “normal” population) is due to the dominance shift in left hemisphere lesions occurring before the age of 5. This goes hand in hand with a higher proportion of right and bilateral hemispheric dominance (both 15%) in left handers (Rasmussen and Milner 1975). Handedness must be known, for instance by a handedness questionnaire (Annett 1970).

An argument against Wada testing in children under age 13 was set by Williams and Rausch (1992), memory scores are lower, especially in left hemisphere foci. The cooperation of the younger patient is often difficult to judge beforehand and sometimes leaves you with uninterpretable results.

**WADA PROCEDURE**

A division can be made between a standard procedure, involving injection in the internal carotid artery, and several forms of selective positioning of the catheter, thereby narrowing or occluding the range of affected brain areas. In all methods the patient must have been fully neuropsychologically screened and prepared for the test the day before. Normally, IQ levels should be above 70-80. In individual cases lower levels may be possible with the test items of the Wada test tailored to the patient. The test has to be recorded on (video)tape with sensitive microphones attached near the head. Normally an angiogram is made before the Wada test and EEG performed during the test. The interpretation that the slowing of contralateral EEG is responsible for speech arrest or aphasia is a difficult one to make, and should be looked at carefully.

In a typical standard Wada, 60-200 mg (in the Netherlands 125 mg) amytal is injected, while the patient is supine. He is asked to count backwards from 100 and move his fingers, while his arms are extended. After injection, the contralateral hand will be-

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**Table 2**
Factors influencing L/R hemisphere asymmetry.

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come paretic. Counting often stops if the dominant hemisphere is injected. In most cases the EEG will show slow waves, but this is sometimes not accompanied by the expected behavioral effects. It is also possible that behavioral effects are present in the absence of EEG effects. Language is then tested by having the patient read words which is the first function which is recovered. If words can be read, objects can often be named, although paraphasic errors and dysarthria can occur. As well as one-syllable objects, one has to choose objects which are more difficult to pronounce in order to elicit errors. A good method is also to show a picture to the patient and have him describe the situation (spontaneous speech).

After this three possible protocols for evaluation of memory can be used:

1. material presented during amytal inactivation and recognition after the effects have disappeared (Montreal procedure).
2. presentation of material during amytal inactivation and recall within the inactive state (Seattle procedure).
3. presentation of material within the inactive period and recall afterwards (interview method).

Unpublished data by Dodrill (Jones-Gotman et al. 1993a) suggest an agreement between these three methods of 64% for classifying patients as either “passing” or “failing” the memory tests. A cut-off score of 50% is used then for passing/failing the test. We follow the Montreal procedure. Two and a half minutes after injection, the patient is presented with five items, three pictures, the name of a country and a proverb. These have to be recalled 15 minutes after injection. Immediately after this presentation a story has to be recalled which has been told before injection. Quantitative scoring reflects the retrieval process. Paraphasic errors can also be noted as the patient retells the story, an activity which prevents the patient from rehearsing the presentation. A modified Token test with 5 items can now give additional information about language problems. After 15 minutes, the 5 test items have to be recognized in multiple-choice format with three foils.

RELIABILITY AND VALIDITY

The reliability and the validity of the Wada test are much in debate. The reliability of the test seems to be reasonable (McGlone and MacDonald 1989). There are several data from centres which suggest that a failure on the Wada test does not always indicate a risk for postoperative amnesia (Loring et al. 1992; Novelley and Williamson, 1989). It has been claimed that true positives exist (Rausch et al. 1993). This was because patients (a number of 6 had been identified) had been operated after a Wada prediction of amnesia, and the amnesia in fact occurred after operation. False negatives have also been described (Dasheiff et al. 1993).
In our sample of 215 only 14 patients (6.5%) failed the test. They all passed a subsequently performed superselective Wada. No global amnesia was found after operation. Evidence for a lower Wada memory and corresponding neuronal CA3 cell loss was found (Sass et al. 1991). The extent to which medial area is removed, is also negatively correlated with retention of memory material (Katz et al. 1989). These important findings support the idea that the Wada memory test is measuring real memory deficiency and that patients who fail to show memory contralateral to the focus side have to be excluded for operation.

**ALTERNATIVE METHODS**

Several alternatives for the identification of functional areas have emerged. Electrical stimulation mapping has already been used for a long time (Brekelmans 1999). Because the language areas are often very localized with on/off boundaries of 0.5 cm, it is important that electrodes are placed accurately. New techniques make this possible. fMRI is one of the most promising new methods. It has the potential to be a standard tool for investigating language dominance in a non-invasive way (Binder et al. 1996; Benson et al. 1999). However, the number of patients in these studies is still low, which poses validity problems, particularly in cases of right hemispheric dominance.

**TESTING DURING OPERATION**

If an operation is needed in the dominant hemisphere, stimulation during operation can be valuable. This technique requires that the patient does not panic and is mentally strong enough to maintain quite a long period of consciousness while the neurosurgeon is operating. By stimulating discrete parts of the eloquent cortex and at the same time showing the patient pictures which he has to name, paraphasias can be elicited. Even memory can be tested in this way. The value of this technique however is limited (Ojemann et al. 1993).

One suspected area for language has emerged recently, the basal temporal area. Although it is claimed there are no lasting language deficits after the resecting of this area (Lüders and Awad 1992), other publications warn against operation in this area (Lüders et al. 1986; Burnstine et al. 1990; Schäffler et al. 1994). It is advisable to try to map these areas during operation.

**NEUROPSYCHOLOGICAL EFFECTS OF EPILEPSY SURGERY**

The presurgical neuropsychological performance serves as a baseline against which postsurgical results can be compared. The moment of testing and how often testing occurs after operation is important. Testing too early gives results which are blurred by the short-term after effects of the operation. Waiting too long is unacceptable for the patient and the other disciples. The Dutch Collaborative Epilepsy Surgery Program in the Netherlands follows the patient at three times: 6 months, 2 years and 6 years after operation.
Auditory verbal learning difficulties which exist after dominant temporal lobe excision tend to last only for three to five years (Blakemore and Falconer 1967). Permanent recovery is possible, but is negatively correlated with age and the ongoing occurrence of seizures. This makes a neuropsychological assessment before six years after operation not a true reflection of a steady state and must be interpreted with care. Most institutions stop follow up after 1 year. This gives an incomplete, distorted reflection of patients’ future abilities.

Intelligence changes after temporal lobectomy can be divided in short term (1 month post) postoperative decline (Meyer 1959; Blakemore and Falconer 1967; Milner 1975; Powell et al. 1985) and recovery on a longer time basis. Short term effects on intelligence are caused by temporary edema of the brain tissue and are thus not of importance in describing the situation of the patient. Effects after 1 year seem to yield an overall picture of slightly better results after nondominant than after dominant resection (Rausch and Crandall 1982; Novelly et al. 1984; Warrington et al. 1986; Olivier 1988; Leonard 1991). The increase of the IQs mostly stay below the expected retest increase of 3.5 for the VIQ and 9.8 for the PIQ (Seidenberg et al. 1981) and must in fact be regarded as a decrease. An important finding is that if no pathology is found in the resected tissue, the IQ tends to be lower (Lieb et al. 1982). It is probable that functional tissue has been removed too.

Damage to the temporal lobes does not normally result in a deficit in immediate memory span (Milner 1965). However, deficits have been shown depending on the nature of the task. Sequential presentation puts more “work load” on the right hemisphere than simultaneous presentation (Tucker et al. 1986).

Material specific loss of memory after unilateral temporal lobectomy has been extensively described (Milner 1975; Taylor 1979; Katz et al. 1989). This holds for anterograde memory as well as retrograde amnesia (Barr et al. 1990). Verbal memory declines after dominant lobectomy, visuo-spatial memory declines after nondominant lobectomy. This pattern can be refined. The same as holds for intelligence, can be seen in memory. If the removed tissue is functional, ipsilateral deficits occur. If the tissue was pathological, contralateral improvement can be seen (Milner 1975). Postoperative seizure reduction is an important factor in improvement (Novelly et al. 1984). Most improvement can be seen after nondominant resection, probably because the dominant temporal lobe has a higher potential to cope with verbal and nonverbal memory (Cavazutti et al. 1980; Rausch and Crandall 1982; Ivnik et al. 1987). Early onset of seizure disorder can cause a crowding effect, an anomalous representation of function: Saykin et al. (1989) found that figural memory after left temporal lobectomy of early onset patients worsened.

The correlation of the extent of the resection with memory decrement was studied by Katz et al. (1989). Due to small numbers of patients (n=20) and high numbers of correlations, none of the correlations was significant.

An attempt to describe different task sensitivity of the hippocampal area vs. lateral neocortex was done by Rausch (1992). Performance on unrelated word-pairs could be impaired in hippocampal damage, while recall of logical prose is sensitive to lateral tem-
poral lobe regions, however defects are not often found.

Language ability tends to be lower preoperatively in patients with dominant tem-
poral lobe epilepsy (Hermann and Wyler 1988). This group showed improvement in re-
ceptive language comprehension and associative verbal fluency after operation. Lan-
guage problems can occur after operation if the resection edge lies near the eloquent cor-
tex. A function more ascribed to the frontal lobe as word fluency tends to be affected in
patients with TLE (the strongest effect seen in anterior TLE) in both hemispheres (Mar-
tin et al. 1990). These often resolve over time.

Frontal lobe resections normally have little effect on intelligence or memory such
as found in temporal excisions. Still, frontal lobectomy gives rise to a multiplicity of dis-
orders. Well known are the aphasias, poor associative learning, poor temporal memory
and disorders of planning. In planned epilepsy surgery Broca’s area is normally spared, so
that dysphasia seldomly occurs. Spatial (Milner 1982) and paired (Owen et al. 1995) as-
sociative learning was found to be decreased. Subtle motor effects often can be shown
(tapping). For example, deficits of stimulus (motor) response compatibility are seen after
frontal lobectomy (Konorski et al. 1972).

Olfaction is a function that deserves more attention in the neuropsychological
screening. Sometimes a patient complains about change in taste. The importance of the
orbitofrontal cortex in olfactory discrimination has been shown (Jones-Gotman and Za-
torre 1988; Zatorre and Jones-Gotman 1991). Temporal lobe excisions can disrupt the
pathways to the orbitofrontal cortex and thus have an disconnecting effect on olfactory
discrimination.


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Tucker, D.M., R.A. Novelly, W. Isaac, and D. Spencer: Effects of simultaneous vs sequential stimulus...


