

# Neurosurgical perspectives on temporal lobe epilepsy

**Karl Schaller, Margitta Seeck**

Departments of Neurosurgery and Neurology, University of Geneva Medical Centre, Faculty of Medicine, University of Geneva, Switzerland

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## Relevance and clinical manifestation of temporal lobe epilepsy in an epilepsy surgical programme

Pioneers of epilepsy surgery, such as Wilder Penfield, Percival Bailey, Murray Falconer, Paolo Niemeyer and Gazi Yasargil, recognised decades ago that temporal lobe epilepsy (TLE) responds well to surgical procedures. Even today, approximately two thirds of resective epilepsy surgical procedures are carried out on the temporal lobe. The fact that chronic pharmaco-resistant TLE responds better to surgery than extra-temporal epilepsies might have to do with the fact that the temporal lobe is a rather confined anatomical structure, in comparison with the frontal or the parietal lobe for example. There are specific patho-anatomical pre-conditions, which render it useful to distinguish between mesial TLE, mainly caused by mesial temporal lobe sclerosis (MTLS, or – synonymously – hippocampal sclerosis), and lateral (neocortical) TLE. Seizure semiology is different from that of other regions as well, with most patients suffering from mesial TLE presenting with simple partial seizures (patients remain aware of themselves and their surroundings) and/or complex partial seizures. They are frequently preceded by an aura, which may consist of strange feelings in the abdomen (epigastric aura), gustatory, or olfactory, psychic or autonomic phenomena. Depending on hemispherical dominance this may include speech disturbance as well. This may be followed by loss of contact, automatisms, or secondary generalised seizures.

In addition to MTLS, there are a number of pathologies which can be found as a frequent source of lesional TLE: Dysembryoplastic neuro-epithelial tumours (DNT), Gangliogliomas, and malformations of cortical development, such as focal cortical dysplasias (FCD). For example, especially in young patients ectopic neurons may also be found in the temporal pole. However, even if the MRI is normal, the post-operative outcome can be as good as in lesional epilepsy [1]. In their seminal study, Wiebe et al. proved the superiority of anterior temporal lobectomy (ATL) over drug therapy in chronic TLE [2]. The goal of detailed pre-surgical evaluation

is to develop a hypothesis about the underlying (structural) cause of TLE and the extent of the surrounding epileptogenic zone. The existence of the so-called irritative zone, the zone of potential functional deficit (e.g., the temporomesial and the language areas), and the eloquent zone must be taken into account. In a more recent study, the superiority of surgery has been shown even in early onset mesial temporal lobe surgery [3].

## Pre-surgical planning

As the outcome following TLE surgery cannot be judged on the basis of seizure control alone, because good epileptological results should not be achieved on the expense of neuropsychological and neurological functioning, the goal for further surgical improvement relates to individualised planning of TLE surgery. This includes strict adherence to a pre-surgical work-up protocol which nowadays includes not only high-resolution structural imaging and high temporal resolution EEG, but a combination of imaging and electrophysiological techniques, including metabolic and functional imaging. Signal analysis and methods for meaningful and robust co-registration of these techniques is mandatory for individual surgical planning [4]. Some groups are working on new concepts for determination and visualisation of the individual brain, for example by radioactive marking, and it is quite possible that such techniques might be also used for the further understanding of the epileptogenic mechanisms in TLE in the future.

Apart from standardised approaches, epilepsy surgeons have to apply intra-operative navigation for adequate planning, to avoid unnecessary disconnection of functionally relevant fibre tracts for example, such as Meyer's loop, or the uncinate fasciculus (fig. 1).

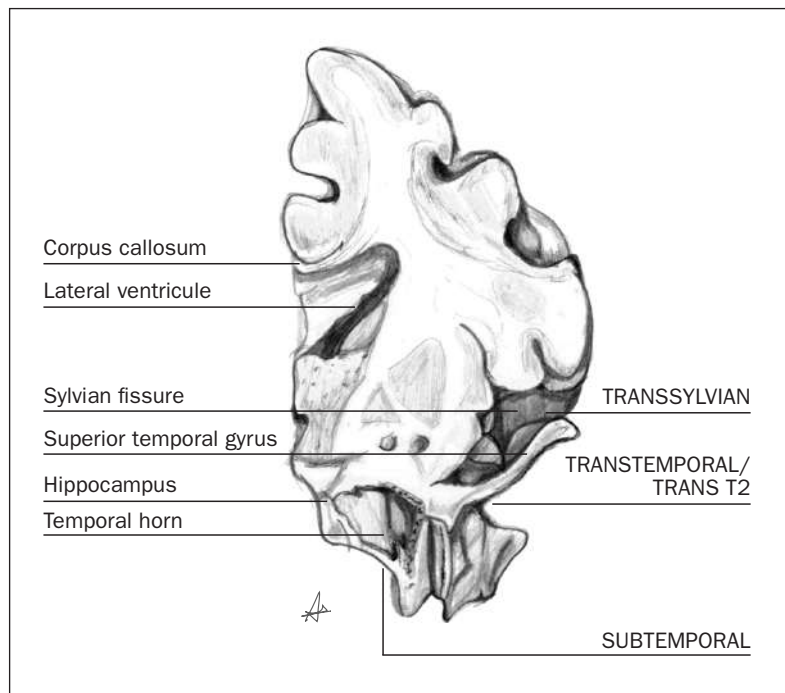
## Outcome following TLE surgery

Regardless of the application of more selective approaches, such as in selective amygdalohippocampectomy or of standard ATL, seizure control rates are between 60 and 80%. It seems that more selective approaches in MTLS (SAH) versus more global approaches (classic ATL) lead to better neuropsychological outcome. Quality of life (QOL) is clearly an issue in TLE surgery as well, as good QOL is clearly correlated with good outcomes according to the Engel grading scale, which ranges from grade I (seizure-free) to

### Correspondence:

Professor Karl Schaller, MD  
Departments of Neurosurgery and Neurology  
University of Geneva Medical Center  
Faculty of Medicine, University of Geneva  
Rue Gabrielle-Perret Gentil 4  
CH-1211 Genève  
Switzerland  
karl.schaller[at]hcuge.ch

**Figure 1** Different approaches to the temporo-mesial region: transsylvian, transtemporal (mostly through the middle temporal gyrus), or subtemporal. Other, less common, alternatives include the suboccipital transtentorial approach. For some approaches intra-operative neuronavigation is indispensable. (Illustration provided by Alister Rogers, MD.)



grade IV (no worthwhile improvement), with subscales in order to better appreciate more complex outcomes [5].

Mortality is close to zero in TLE surgery, whereas permanent neurological morbidity is in the range of 2–5% [6]. TLE surgery can be performed with limited surgical risk which has been shown in a large nationwide study from the United States of America, comprising of approximately 20% of all TLE surgical procedures between 1988 and 2003 [7]. Post-operative morbidity in 677 patients was 8% only, with 24 patients (3.5%) requiring permanent assistance [6]. There are intrinsic risks, such as the integrity of the visual field, which are not necessarily considered as a postoperative complication but rather a to-be-expected deficit if a larger resection needs to be carried out. Recent advances in surgical planning include fibre tracking of Meyer's loop in order to minimise this side-effect for the visual pathways in TLE surgery with good results. Moreover, the sub-temporal approach to the mesial temporal lobe may be an alternative to the commonly used transsylvian approach for SAH in MTLS [8].

Pre- and post-operative neuropsychological testing should be part of TLE surgery, as collateral damage due to the surgical approach may cause decline in verbal or figural memory [9, 10]. Concerning neuropsychological outcome, the results are somewhat equivocal. An effect of TLE surgery on cognition has been shown: in some patients it seems to have a beneficial effect, in others it has a pejorative effect. It is most important to avoid so-called double losers: patients who won't be seizure-free following surgery and who will show neurological and/or cognitive deterioration in addition. The reasons for failure of TLE surgery may be manifold:

Incomplete resection of the epileptogenic zone, bilateral seizure onset which had gone unnoticed, dual pathology which was not diagnosed appropriately, pseudo-failure due to psychogenic seizures or fits of other origin [11]. Resection length or resection volume of the temporo-mesial structures alone are not decisive for good epileptological outcome, however, according to a randomised multi-centre study, the rate of seizure control may be related to disconnection of a critical mass of efferent and afferent axons rather than to length or volume of the resected tissue alone [12].

### Surgical challenges and alternative surgical strategies

Alternative and emerging surgical techniques are radiosurgery, and deep brain stimulation (DBS), respectively. These have only been tested in very small numbers of patients and need further evaluation and validation in larger randomised studies [13]. Unilateral or bilateral depth electrodes have been placed – either in the hippocampus, or in the anterior nucleus of the thalamus. The success rates are in the range of 50% reduction of seizure activity in approximately 50% of patients, with a tendency for improvement over months and years. This trend is similar to what is found with vagal nerve stimulation and differs from the usual drug effect, which is mostly related to a *decrease* of efficacy over time [14].

Radiosurgery for MTLE seems very much dose-dependent (>20/24 Gy to hippocampus and amygdala) with the optimal safe and effective dosage remaining yet to be determined. It takes months to become effective, and seizure control rates are in the range of only 60%. There are also non-responders to treatment [9], as well as treatment-related complications such as intracerebral cysts becoming apparent on long-term follow-up. Appropriate target planning and dosage calculation in radiosurgery are thus equally important as appropriate definition of the target and of stimulation parameters DBS.

So far, resective surgery remains the most established neurosurgical treatment of pharmaco-resistant TLE, already exhibiting its effect the day after surgery. However, DBS and radiosurgery emerge as alternative treatment options, which need further definitions of optimal stimulation parameters and/or patient cohorts. Randomised trials between the different surgical approaches are missing [7].

**Key words:** temporal lobe epilepsy; pre-surgical evaluation; temporal lobe epilepsy surgery; radiosurgery and deep brain stimulation in TLE

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