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Hippocampus and epilepsy

Imaging memory and predicting postoperative memory decline in temporal lobe epilepsy: Insights from functional imaging

Imager la mémoire et prédire le déclin mnésique postopératoire dans l'épilepsie du lobe temporal : apport des nouvelles techniques d'imagerie fonctionnelle

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INFO ARTICLE

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ABSTRACT

After medial temporal lobe epilepsy (MTLE) surgery, there is considerable individual variation in the extent, nature and direction of postoperative memory change. Before surgery, epileptic patients who are surgery candidates need precise information about the potential cognitive after effects, and particularly in temporal lobe epilepsy, postoperative memory changes. Clinical and neuropsychological data may bring useful information to predict the postoperative memory outcome, but, these data are not always sufficient to replace the Wada test, considered for a long time, as the gold standard to predict postoperative decline following surgery. In any case, numerous studies demonstrate that the Wada procedure can be nowadays reliably replaced by functional MRI (fMRI) activation studies. A vast majority of fMRI studies suggest that it is the functional adequacy of the resected hippocampus rather than the functional reserve of the contralateral hippocampus that determines the extent of postoperative memory decline. In addition, new functional neuroimaging procedures that explore more widespread network disruptions commonly found in MTLE such as diffusion-tensor imaging (DTI) or connectivity studies could in the future constitute a reliable approach combined with fMRI activation studies to significantly improve the prediction of postsurgical memory decline.

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RÉSUMÉ

Le devenir mnésique est une préoccupation essentielle des patients, souffrant d'une épilepsie temporale médiale pharmacorésistante, candidats à une chirurgie de l'épilepsie. Or ce devenir mnésique varie énormément d'un patient à l'autre avec l'observation tout à la fois d'aggravation, de stabilisation, voire d'amélioration des performances en mémoire épisodique. La clinique (notamment le côté de la résection) et les tests neuropsychologiques apportent des renseignements prédictifs fiables mais demeurent parfois encore à l'heure actuelle insuffisants pour remplacer le test de Wada qui a très longtemps été considéré comme le *gold standard* de la prédiction d'un éventuel déclin mnésique postopératoire. Actuellement, de très nombreuses études montrent que le test de Wada peut être avantageusement remplacé par des études d'activation en IRM fonctionnelle. La majorité de ces études suggèrent que c'est la capacité fonctionnelle résiduelle de l'hippocampe à réséquer qui prime sur la réserve fonctionnelle de l'hippocampe controlatéral. En clair, le déclin mnésique est directement lié au fonctionnement préopératoire résiduel de l'hippocampe à réséquer et très peu compensé par le fonctionnement valide de l'hippocampe controlatéral. De surcroît, de nouvelles techniques d'imagerie fonctionnelle, telles que la connectivité ou l'IRM de diffusion montrent une atteinte globale des réseaux sous-tendant la mémoire épisodique. L'étude de ces réseaux couplée à celle du fonctionnement hippocampique en IRM fonctionnelle peuvent constituer des approches complémentaires fiables pour prédire au mieux un éventuel déclin mnésique postopératoire.

1. Introduction

Anterior temporal lobectomy (ATL) is an effective therapy for refractory medial temporal lobe epilepsy (MTLE) [1]. The resection of the anterior temporal pole, the hippocampus and part of the adjacent anatomically related medial structures that play a critical role in episodic memory may cure patients in 60–90% of the patients but may also worsen or damage memory [2]. The challenge in MTLE surgery is thus to completely remove the seizure focus without significantly damaging memory. Obviously, epileptic patients who will undergo surgery for refractory epilepsy need precise information about their postoperative memory evolution: will their memory be stable, worsened, improved after surgery? This information requires a precise knowledge of the organization of episodic memory before and after surgery.

2. Imaging preoperative memory

Historically, the hippocampus belongs to the limbic lobe described by Broca or to the Papez circuit. Its role was first restricted to emotions. The observations that medial temporal lobe (MTL) damage led also to mnemonic dysfunction were derived from studies in brain-damaged patients and in animals. Functional imaging, mainly functional MRI, has helped to change this historical concept. Recent findings have converged on the observation that MTL regions could be consistently activated in verbal or visuospatial episodic memory paradigms. In healthy volunteers, neuroimaging studies have provided support for the broad notion that distinct MTL regions contribute differentially to episodic memory formation [3]. Functional MRI data suggested that perirhinal cortex supports the encoding of the individual elements of an episode, whereas parahippocampal cortex supports the encoding of context information (spatial, emotional, temporal contexts). Finally, the hippocampus supports the relational binding of the individual elements together and/or the binding of these elements to the context of the episode [4]. Furthermore, functional neuroimaging studies have also stressed the importance of the prefrontal and parietal cortical activations in such memory processes. These results show that memory is subserved by a more widely distributed cortical network than expected (Fig. 1).

In MTLE, fMRI studies have shown that patients and controls exhibited different patterns of brain activations during the acquisition and retrieval of episodic materials characterized by decreased MTL activations and increased prefrontal activations in patients (Fig. 2) [5,6]. Sidhu et al. (2013) have demonstrated that patients with left hippocampal sclerosis showed greater right-sided activations both in the temporal neocortex and in the frontal lobe during encoding [7]. Patients with right hippocampal sclerosis similarly showed increased activations both temporally and extra-temporally. Whereas patients with left hippocampal sclerosis showed predominantly right hemispheric increases during encoding, those with right hippocampal sclerosis showed increased activation bilaterally.

3. Prediction of postoperative memory outcome

3.1. *Classical predictors*

Several studies have identified clinical factors that are associated with a significant postoperative memory decline. These factors include surgery in the dominant hemisphere for