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FUNCTIONAL MAGNETIC RESONANCE IMAGING AND SURGICAL PLANNING AND OUTCOME IN EPILEPSY

RESSONÂNCIA MAGNÉTICA FUNCIONAL NO PLANEJAMENTO E RESULTADOS CIRÚRGICOS DA EPILEPSIA

RESONANCIA MAGNÉTICA FUNCIONAL EN EL PLANEAMIENTO Y RESULTADOS QUIRÚRGICOS DE LA EPILEPSIA

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ABSTRACT

Besides mapping eloquent areas such as motor and language cortex for pre-surgical planning, functional magnetic resonance imaging (fMRI) has also been used as a non-invasive technique to predict surgical outcome regarding memory and language deficits. This brief review article will focus on fMRI and the emerging role of electroencephalogram associated to fMRI (EEG-fMRI) in epilepsy surgery.

Keywords: Magnetic Resonance Imaging; Epilepsy; Surgery; Memory; Electroencephalography.

RESUMO

Além do mapeamento de áreas eloquentes, como córtex motor e de linguagem para o planejamento pré-cirúrgico, a ressonância magnética funcional (RMf) também tem sido usada como uma técnica não-invasiva para prever o resultado cirúrgico sobre déficits de memória e de linguagem. Esta breve revisão incidirá sobre a RMf e o papel emergente do eletroencefalograma acoplado a RMf (EEG-RMf) em cirurgia de epilepsia.

Descritores: *Imagem por Ressonância Magnética; Cirurgia; Epilepsia; Memória; Eletroencefalografia.*

RESUMEN

Además del mapeo de áreas elocuentes, como corteza motora y de lenguaje para el planeamiento prequirúrgico, la resonancia magnética funcional (RMf) también viene siendo usada como una técnica no invasiva para prever el resultado quirúrgico sobre déficits de memoria y de lenguaje. Esta breve revisión incidirá sobre la RMf y el papel emergente del electroencefalograma acoplado a RMf (EEG-RMf) en cirugía de la epilepsia.

Descriptores: *Imagen por Resonancia Magnética; Cirugía; Epilepsia; Memoria; Electroencefalografía.*

Language fMRI

When compared to electrocortical stimulation, language fMRI activations revealed a high predictive value for both the presence and absence of critical language function in cortical areas.[1-8] Therefore it has been used as non-invasive method to predict the magnitude of language decline, more specifically naming ability, usually observed in approximately 30-50% [9] of patients submitted to left temporal lobe resections.[9] The increased activation in the left hemisphere (particularly in the left temporal lobe) obtained with semantic decision fMRI task during preoperative investigation, was associated with higher risk of postoperative naming impairment [9].

The high negative predictive value of language fMRI suggested that areas without significant BOLD activity could be excised without electrocortical stimulation; nonetheless the fMRI activation was present in some non-critical language areas, yielding a specificity of 67% and a predictive value for the presence of critical language areas of 51%.[2] A new fMRI protocol based on the role of anterior temporal lobe in semantic integration was designed (story task and arithmetic task) with the purpose of eliciting a contrast (story>math) with strong activation of relevant semantic networks, with higher expectations to be useful for predicting cognitive outcome in temporal lobe surgery.[10]

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Memory outcome

Memory impairment following temporal lobe resections is an important concern for both dominant hemisphere (associated to verbal memory and language deficits)[3] and nondominant temporal lobe (associated to visual memory deficits).[11, 12] One important risk factor associated to memory decline is the level of preoperative memory function, as higher the memory function before surgery, higher the risk of postoperative decline.[13] As fMRI allows the investigation of functional anatomy of cognitive processes such as memory, it has been used to investigate the material specificity of postoperative memory decline[4,5] and with an attempt to predict memory outcome after temporal lobe resection. [9] The activation of contralateral medial TL in fMRI studies of patients with TLE usually predicts a better postoperative memory outcome when compared to patients presenting ipsilateral activations.[5] Some studies showed that preoperative language dominance as determined by fMRI is also associated to postsurgical verbal memory outcome.[9] A paradigm with picture memorization, designed to activate both medial TLs was applied to patients with left TLE and showed that patients showing more activation in the left TL were more likely to present memory decline after surgery than patients with more activation in the right TL. After combining these data with verbal memory scores and knowledge of the seizure focus, verbal memory decline could be predicted in 90% of patients.[6] One study showed that asymmetry of hippocampal activation during a scene-encoding task did not predict verbal memory decline after TL resection[7]. On contrary, the evaluation of visual and verbal memory with material specific paradigm[13] in a group of 72 patients with refractory TLE revealed the predictive value of patterns of hippocampal activation in the postoperative memory outcome. Decline of verbal memory in patients with left TL resections were predicted by stronger left anterior hippocampal activations in response to word encoding task, and decline in design learning after right sided surgery was predicted by a stronger activation of right anterior hippocampus in response to face encoding task.[4]

EEG-fMRI

Simultaneous acquisition of EEG and fMRI (so called EEG-FMRI) have been used to study epileptic network as it provides regions of BOLD changes associated with interictal (IED) and ictal epileptiform discharges.[14] It has proved to be useful for surgical planning, especially when other techniques fail to reveal a clear surgical target.[15] In a group of 10 operated patients, one study[16] showed higher chance of seizure freedom when the area of maximal IED correlated BOLD signal change was concordant with the area of resection; on contrary, in patients who experienced reduction in seizure frequency but did not become free of seizures, the areas of significant IED correlated BOLD signal changes were identified outside the resection.[16] In another study, the IED correlated BOLD signal changes from patients with FCD were compared with seizure onset zone (SOZ, identified with intracranial electroencephalography) and with postsurgical outcome.[17] Good postoperative outcome (>50% reduction in seizure frequency) was achieved when BOLD changes were concordant with SOZ, on contrary, a poor surgical outcome occurred when IED-related BOLD changes were widespread or discordant to seizure onset zone.[17]

Functional connectivity

Synchrony of neural activity among different regions defines Functional connectivity (FC) even when the regions are anatomically distant. Different brain areas are functionally connected when their signal fluctuations are correlated in time.[18] The FC analysis obtained with preoperative resting state fMRI also suggests a possible role in predicting surgical outcome. After defining a seed based on the best overlap between an activation cluster (from the EEG-spike fMRI correlated analysis) with the planned resection area, FC maps were computed and subject to analysis of laterality indices.[19] FC was significantly less lateralized in patients with surgical failure than in seizure-free patients after surgery, suggesting a potential role of preoperative FC as a predictor of surgical outcome.

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