EDITORIAL

Clinical fMRI: A Pre-Surgical Test in Patients with Medically Intractable Epilepsy

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Epilepsy is a common neurological disorder that affects between 0.5% - 1% of the general population[1]. About 30% of the patients with localization-related epilepsy develop medication resistance and may benefit from surgery to improve their outcome. Anterior temporal lobectomy (ATL) is superior to medical therapy in patients with medically intractable temporal lobe epilepsy (TLE), which is the most common form of partial epilepsy[2]. Favorable surgical outcome depends on proper selection of the patients on clinical basis, accurate localization of the epileptogenic focus with the electroencephalogram (EEG), and sparing of the important cognitive functions with the neuropsychological testing and other ancillary tests. Improvements in the magnetic resonance imaging (MRI) technology and its widespread availability have had a remarkable impact on the pre-surgical planning in epilepsy. High resolution anatomical MRI and quantitative analyses of the MRI findings are currently used to identify subtle epileptogenic lesions such as malformations of the cortical development and low grade tumors or focal brain atrophy that would have otherwise gone unnoticed[3].

Lateralization and localization of the language functions are of paramount importance for ATL as the distance from the language area to the resection boundary is the most important predictor of developing postoperative language deficits[4]. Invasive tests such as the intracarotid amobarbital test (IAT, a.k.a. Wada test) and electro-cortical stimulation (ESM) mapping have long been considered as the "gold standard" pre-surgical and intra-operative tests for lateralization and/or localization of the language functions, respectively[5,6]. However, IAT and ESM are associated with inherent limitations and risks (Figure). While IAT test provides reliable lateralizing information for language function, it provides no localizing information within the involved cerebral hemisphere. ESM mapping, on the other hand, is a highly localizing test but it is limited to the assessment of the exposed cortical surface during the surgery. Non-invasive neuroimaging techniques have reduced the need for reliance on such procedures on a routine basis in most comprehensive epilepsy centres. Functional MRI (fMRI) has emerged as an alternative tool to complement and replace these invasive procedures for pre-surgical planning of the patients with medically refractory partial epilepsy[7].

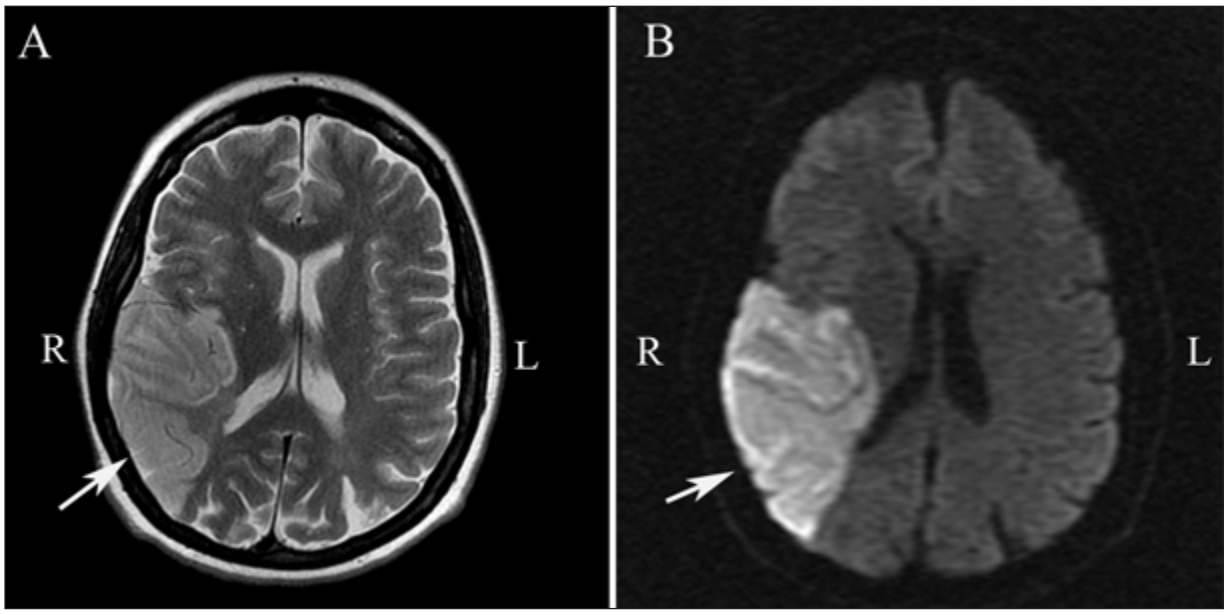

Figure: *Axial T2 (A) and axial diffusion-weighted (B) images of a patient with medically intractable temporal lobe epilepsy who experienced an acute ischemic stroke in the territory of the right middle cerebral artery (white arrows) from a traumatic dissection of the right internal carotid artery during the intracarotid amobarbital test that led to the cancellation of her planned left anterior temporal lobectomy to improve her seizure outcome.*

In this issue of the journal, Beers and Federico review the basics of fMRI and provide a comprehensive overview of the previous studies comparing fMRI to IAT and ESM for language mappings in the cerebral cortex[8]. They also discuss the role of fMRI in studying brain plasticity for language functions after temporal lobectomy (TLY) as well as its utility to study the memory, sensory-motor, and visual functions plus the resting state networks and simultaneous EEG-fMRI.

In IAT, each cerebral hemisphere is selectively anesthetized, allowing the function of the other hemisphere to be assessed. Therefore, it is essentially a "lesion" study which requires selective catheterization of the internal carotid arteries with a small but real risk of stroke and other complications. The IAT more importantly assesses the functional integrity of memory structures in the mesial temporal lobes (Figure), particularly hippocampi even though the carotid circulation does not directly supply most of the mesial temporal lobe structures. Functional MRI has increasingly been used to predict cognitive decline after TLY. The high concordance of fMRI with IAT (~ 90%)[9] and ESM[10] in language mapping has made it the diagnostic modality of choice in pre-surgical mapping of the language functions in most comprehensive epilepsy centres while its role in clinical assessment of the memory functions remains unsettled and it has shown a variable degree of promise in its other clinical applications. fMRI has also been used to examine plasticity in language functions in patients with epilepsy before and after TLY[10].

Functional MRI can be used to map sensory-motor and visual function of the cerebral cortex that is helpful to predict postoperative functional deficits in the extra-temporal resections. Integrated approaches, such as coupling fMRI with diffusion tractograghy or EEG are helpful to localize the epileptogenic zone and predict surgical outcome. Simultaneous EEG - fMRI can aid in localizing the seizure focus and further characterize the interictal and peri-ictal states. More recent advances in fMRI pertain to the study of the intrinsic spontaneous coherent fluctuations of neuronal activity and coupled hemodynamic response[11], which could be used to assess cortical networks associated with various cognitive tasks in patients that are otherwise unable to perform “cognitive” to activate those areas. Alternatively, resting state fMRI can be used to assess the network connectivity in the inter-ictal, pre-ictal, and ictal states[12]. Moreover, the effect of anti-epileptic drugs on the resting state network connectivity can be assessed.

In summary, fMRI has become an indispensable clinical tool in the routine pre-surgical evaluation of patients with medically intractable epilepsy. Beers and Federico's comprehensive review in this issue of the Canadian Journal of Neurological Science[8] should draw greater attention to this valuable, easily accessible, and non-invasive diagnostic tool and pave the way for its day to day use in all comprehensive epilepsy centres around the world, particularly Canada. It is noteworthy that clinical fMRI has been accessible to the patients and the clinicians in the United States of America as of January 1st, 2007 when the American Medical Association (AMA) proposed a series of Current Procedural Terminology (CPT) codes for it[13]. A responsible use of such billing codes by the trained professionals is essential to avoid over interpretation of the results.

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