Editorial

The role of magnetic resonance imaging techniques in the diagnosis, surgical treatment and biological understanding of epilepsy

Gavin P. Winston[1,2]

[1]Epilepsy Society MRI Unit, Chalfont St Peter, Bucks SL9 0RJ, UK; [2]Department of Clinical and Experimental Epilepsy, Institute of Neurology, University College London, London WC1N 3BG, UK

Correspondence to: Dr. Gavin P. Winston. Epilepsy Society MRI Unit, Chesham Lane, Chalfont St Peter, Bucks SL9 0RJ, UK. Email: g.winston@ucl.ac.uk.

Submitted Feb 01, 2015. Accepted for publication Feb 02, 2015.
doi: 10.3978/j.issn.2223-4292.2015.02.02
View this article at: http://dx.doi.org/10.3978/j.issn.2223-4292.2015.02.02

Epilepsy in context

Epilepsy is one of the most common and serious neurological disorders (1). Magnetic resonance imaging (MRI) is the imaging modality of choice especially to investigate seizures with focal onset. Whilst imaging was first used solely to identify a causative lesion, the vast increase in the range and complexity of MRI techniques has led to additional roles in surgical planning and in the understanding of the effects of epilepsy on the brain *in vivo*. Neurosurgical treatment remains a vastly underutilised technique is those with refractory focal epilepsy and imaging is particularly key in this setting. In this special issue devoted to MRI and epilepsy, I have assembled a series of papers that present the role of different techniques in patients with epilepsy.

Structural imaging and surgery

Identification of the epileptogenic zone in patients with focal epilepsy is crucial for planning neurosurgical treatment and outcome but up to 20-30% of patients have normal structural MRI (2). Focal cortical dysplasia (FCD) is one common cause of refractory focal epilepsy that is poorly detected on conventional imaging. A variety of computational approaches are available to localise the abnormality, ranging from voxel-based morphometry and T2 relaxometry to newer computational techniques. Martin *et al*. describe the current state of the art of this area (pages: 188-203).

The main model for epilepsy surgery remains anterior temporal lobe (TL) resection for refractory TL epilepsy (TLE) (3). However, up to 40% of patients undergoing surgery have postoperative seizures by 2 years. Bonilha and Keller explore how quantitative imaging may be able to identify neuroanatomical correlates of postoperative outcome and thus better predict outcome (pages: 204-224).

Epilepsy and cognition

Ongoing seizures are associated with numerous cognitive and neurobehavioural problems. Yoong summarises the imaging correlates of a variety of impairments seen in children with epilepsy, an area that is need of significantly more research (pages: 225-237).

Aside from the impact of seizures per se, antiepileptic drugs may also affect cognition. Functional imaging can be combined with pharmacological manipulation in order to elucidate the impact of such drugs on cognitive networks (pharmaco MRI). Beltramini and colleagues describing the studies performed to date in this emerging field (pages: 238-246).

Diffusion imaging and tractography

Diffusion imaging can be used to investigate both structural integrity of white matter and connectivity within networks and has, like functional imaging, been used to study the basis for cognitive impairment. Leyden and colleagues discuss the role of diffusion imaging in studying language and memory networks in TLE and show that such studies demonstrate structural plasticity within these networks following resective surgery (pages: 247-263).

Diffusion imaging has also been used to show that structural changes exist beyond the epileptogenic zone suggesting that even focal epilepsies are a network disease. A variety of metrics can be derived from diffusion imaging (4) and inferences can be made as to what underlying microstructural changes that these represent. Epilepsy surgery however offers a unique opportunity to correlate preoperative imaging to postoperative histology. Rodriguez-Cruces and Concha illustrate how this might enable us to better interpret abnormalities seen in these parameters (pages: 264-278).

Diffusion imaging is typically analysed using the diffusion tensor model, but it is increasingly recognised that this model is insufficient to fully characterise the underlying tissue microstructure. Several novel diffusion imaging techniques and models have been proposed that may be of utility in surgical planning and the understanding of the microstructural changes in patients with epilepsy. I review three such techniques (pages: 279-287).

Diffusion imaging is also used for tractography, a non-invasive technique to map white matter connections *in vivo*. This is particularly important for surgical planning where the aim is to perform a maximal resection of the epileptogenic abnormality to obtain seizure freedom whilst not causing any new neurological deficit. The optic radiation and visual field deficits following TL resection provide the exemplar for this application (5). Tractography does however have numerous limitations. Lilja and Nilsson review these challenges but also emphasise recent studies showing how imaging can be used intraoperatively in order to reduce the risk of visual field deficits (pages: 288-299).

Other imaging techniques

In patients with epilepsy, the localisation of the seizure onset by imaging is routinely complemented by findings from electroencephalography (EEG). These two techniques can however be combined with simultaneous EEG-fMRI, whereby the haemodynamic changes that accompany electrical discharges can be detected. This combines the high temporal resolution of EEG in detecting epileptic discharges with the superior spatial resolution of functional imaging covering the whole brain. This was initially implemented as scalp EEG-fMRI, but more recently intracranial EEG-fMRI with improved sensitivity to deep structures has become possible. Van Graan and colleagues discuss the role of EEG-fMRI in presurgical evaluation and localisation (pages: 301-312).

Finally, Pan and Kuzniekcy discuss the role that a less commonly used technique, magnetic resonance spectroscopy, may have in informing our knowledge of epilepsy and seizure localisation (pages: 313-322). The rationale is that the evaluation of cerebral metabolism should be helpful in a disorder with underlying altered metabolism.

Other techniques used for seizure lateralisation and localisation, which are not reviewed in this issue, include nuclear medicine techniques such as PET and SPECT. There is the potential however for these techniques to be supplemented by more advanced MRI techniques that are currently being developed. The field of MRI and epilepsy remains a rapidly evolving field.

Disclosure: The author declares no conflict of interest

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Cite this article as: Winston GP. The role of magnetic resonance imaging techniques in the diagnosis, surgical treatment and biological understanding of epilepsy. Quant Imaging Med Surg 2015;5(2):186-187. doi: 10.3978/j.issn.2223-4292.2015.02.02

