The Role of MEG in Epilepsy Diagnosis and Treatment

Electrophysiological techniques (MEG/EEG) record activity generated by neuronal currents and provide specific information concerning epileptic activity. Their high temporal resolution permits assessment of fractions of milliseconds with magnetic fields being less distorted by different conductivities of tissues (scalp, skull, cerebrospinal fluid, meninges and brain parenchyma) than electric ones. Thus MEG is a reference–free method whilst EEG records tangential and radial components[1]. Whereas MEG selectively detects tangential components of source currents, in clinical practice this does not seem to detract from the utility of MEG because most epileptic spikes have both tangential and radial components. In fact simultaneous EEG and MEG recordings have demonstrated superior sensitivity of MEG especially in neocortical epilepsy[2]. The development of MEG-systems with up to 200–300 channels now permits non invasive, contactless and fast recordings from the whole cortex within one session[3].

The presurgical evaluation of patients with neocortical epilepsy is difficult because of the large extent of the cortex[4], of which the frontal lobe alone comprises 40%. Fast propagation of epileptiform discharges and so-called "silent" areas of the cortex add to the difficulties of the evaluation of these patients[5]. Patients with nonlesional neocortical epilepsies who comprise 20–30% of referrals for presurgical evaluation, pose major problems in the surgical treatment of epilepsies because invasive recordings are always required and even then may not provide sufficient localising evidence to offer patients surgery[6]. It is in these patients where MEG may be able to provide unique localising information[7-10], which may in turn lead to the identification of previously unrecognised MRI lesions[11]. MEG can also be used to optimise the placement of intracranial electrodes as well as define the extent of resection in some of these patients[10].

Indeed MEG helps to define the relationship between the lesion and the epileptogenic cortex such that it can help in the decision as to whether lesionectomy alone can be performed without invasive recordings. On the other hand MEG may reveal extra-lesional cortical involvement and guide invasive electrode placement and the extent of tailored resection, and in some cases it can show extensive abnormalities which preclude invasive monitoring or surgical treatment[10]. In this respect there is a particular difficulty in interpreting scalp-EEG and in performing invasive recording in patients who have undergone previous surgery or cranial trauma, and the non-invasive data provided by MEG may be especially helpful in these circumstances[12]. Cortical dysplasia is increasingly recognised as a cause of neocortical epilepsy, especially in children and the extent of the demonstrated radiological abnormality and the epileptogenic zone are not always concordant, either one may be larger or smaller than the other. MEG has proved helpful in optimising the resection in these cases[13,14] whilst in patients with mesial temporal lobe epilepsy with noncongruent findings from standard presurgical procedures, MEG can again provide useful information for their further management[15,16].

The localisation of sensorimotor cortex and other eloquent cortical areas are required to design neurosurgical strategies and MEG has exquisite sensitivity and reliability for localisation of functional cortex and is used routinely for this purpose[17-19]. The accuracy of these MEG results makes it ideally suited for preoperative planning as well as in intraoperative neuronavigation[18], especially as structural imaging can fail to identify functionally significant areas which may be displaced not only by tumours or edema, but also shifted due to brain plasticity[20].

MEG is a promising new technique with particular applications to the care of patients of all ages with epilepsy. MEG offers unsurpassed temporal and excellent spatial resolution of neurophysiologic data and so provides data that previously could only be obtained by invasive intracranial EEG monitoring.

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