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Original article

Magnetoencephalography using total intravenous anesthesia in pediatric patients with intractable epilepsy: Lesional vs nonlesional epilepsy

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Abstract

Purpose: Magnetoencephalography (MEG) provides source localization of interictal spikes. We use total intravenous anesthesia (TIVA) with propofol to immobilize uncooperative children. We evaluate the effect of TIVA on interictal spikes in children who have intractable epilepsy with or without MRI lesions. *Methods:* We studied 28 children (3–14 years; mean, 6.6). We intravenously administered propofol (30–60 μg/kg/min) to record MEG with simultaneous EEG. We evaluated MEG spike sources (MEGSSs). We compared spikes on simultaneous EEG under TIVA with those on scalp video-EEG without TIVA. *Results:* There was a significant decrease in frequent spikes (10 patients, 36%) on simultaneous EEG under TIVA compared to those (22 patients, 79%) on scalp video-EEG without TIVA ($P < 0.01$). MEGSSs were present in 21 (75%) of 28 patients. Clustered MEGSSs occurred in 15 (83%) of 18 lesional patients but in 3 (30%) of 10 nonlesional patients ($P < 0.05$). MEGSSs were more frequently absent in nonlesional (6 patients, 60%) than lesional (one patient, 5%) patients ($P < 0.01$). Thirteen patients with MRI and/or histopathologically confirmed neuronal migration disorder most frequently showed clustered MEGSSs (11 patients, 85%) compared to those of other lesional and nonlesional patients. *Conclusion:* Propofol-based TIVA reduced interictal spikes on simultaneous EEG. TIVA for MEG still had utility in identifying spike sources in a subset of pediatric patients with intractable epilepsy who were uncooperative and surgical candidates. In lesional patients, MEG under TIVA frequently localized the clustered MEGSSs. Neuronal migration disorders were intrinsically epileptogenic and produced clustered MEGSSs under TIVA. Nonlesional patients often had no MEGSS under TIVA.

Keywords: Magnetoencephalography; Total intravenous anesthesia; Lesional epilepsy; Pediatric patients; Interictal epileptiform discharges; Neuronal migration disorders

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1. Introduction

Magnetoencephalography (MEG) recording, as with magnetic resonance imaging (MRI), requires patients keep still for the precise localization of intracranial epileptic and functional discharges. MEG and MRI fiducial points must exactly correspond for accurate localization of MEG spike sources (MEGSSs) on MRI. Excessive movement with respect to the MEG sensors, which are not directly attached to the patient, distorts the data.

A subset of pediatric patients with medically intractable localization related epilepsy has developmental and/or behavioral problems. Their uncooperativeness renders them difficult to perform immobile MEG and MRI studies for accurate source localization of brain activities. In our facility, we use total intravenous anesthesia (TIVA) with "propofol" and remifentanil to sedate these uncooperative pediatric patients for preoperative evaluation to localize the epileptic foci.

Previous investigators studied the effect and safety of propofol use during EEG [1]. The anticonvulsant effects and inhibition of brain activities of propofol are similar to intravenous diazepam [2] and clonazepam [3]. Although the use of propofol as an anesthetic during MEG did not significantly alter the likelihood of recording interictal spikes compared to recording MEG without anesthesia [4,5], no one has studied the frequency of spikes on EEG recorded with or without TIVA or the characteristics of MEGSSs recorded during TIVA from patients with or without lesions on MRI.

For intractable epilepsy secondary to MRI lesions, resecting the lesion and areas containing clustered MEGSSs treats epilepsy successfully [6]. MEG precisely demarcates the primary epileptogenic zone adjacent to the lesion, which results in its complete removal and seizure control [7]. In particular, we evaluate the effect of TIVA for neuronal migration disorders (NMDs) which are reported intrinsically epileptogenic in patients with intractable epilepsy [7–10]. In view of the increasing number of surgical candidates who have intractable nonlesional epilepsy [11,12], we compare the effect of TIVA on spikes and MEGSSs in patients with and without lesions on MRI.

The purpose of this study is to evaluate the effect of TIVA using propofol during MEG in pediatric intractable epilepsy patients. We hypothesize that, although TIVA suppresses spikes on both EEG and MEG, MEG is still able to define the source of the epileptogenic zone in patients with lesional epilepsy, especially NMDs.

2. Patients and methods

2.1. Patients

Four-hundred seventy-four children with intractable epilepsy underwent MEG at The Hospital for Sick Children from August 2000 to May 2006 for surgical evaluation. Fifty-five (12%) received TIVA for sedation because of uncooperativeness, developmental delay, or behavioral problems. From the 55 patients, we selected and studied 28 who were older than three years and had undergone scalp video-EEG (VEEG) monitoring and MEG. Parents or guardians gave informed consent for all procedures, and the protocols received prior approval from our institutional review board.

2.2. Scalp video-EEG

We recorded scalp VEEG (BMSI 5000, Nicolet, Madison, WI, USA/HARMONIE 5.4, Stellate, Montreal, PQ, Canada) using 19 or 25 scalp electrodes placed according to the International 10–20/10–10 system. A single reference was placed at Oz, Pz' (located 1 cm behind Pz), or FCz. The sampling rate was 200 Hz. Two clinical neurophysiologists (H.O. and A.O.) and a pediatric neurologist (K.I.) reviewed the clinical semiology and EEG findings. Anticonvulsant medications were tapered during scalp VEEG monitoring to capture seizures. We performed scalp VEEG monitoring on a separate admission prior to the MEG study.

We defined "spikes" as spikes, polyspikes and sharp waves [13]. We visually detected the most frequent spikes on scalp VEEG during non-REM sleep. We divided patients according to the frequency of spikes: the "occasional group" had less than 6 spikes per minute; the "intermittent group" had more than or equal to 6 but less than 20 spikes per minute; the "frequent group" had 20 or more spikes per minute.

We analyzed seizure types based on the semiology of seizures captured by scalp VEEG. We diagnosed epilepsy from patients' seizure histories as related by their parents and from the semiology of seizures captured by scalp VEEG.

2.3. MRIs

After MEG, patients were immediately scanned by MR. We replaced the MEG fiducial coils with MRI positive contrast markers (Multi-Modality Radiographic Markers; IZI Medical Products Corp., Baltimore, MD, USA). We performed an axial 3-D fast spoiled gradient T1-weighted volume acquisition using a 1.5T Signa Advantage System (GE Medical Systems, Milwaukee, WI, USA). Slices of 2-mm thickness and spacing were acquired in an axial plane, without angling, with a repetition time of 11 and an echo time of 4. A bandwidth of 15.63–32.15 kHz was used with an acquisition number of two. If a neoplasm was suspected, we injected gadolinium-based contrast intravenously.