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Interdisciplinary Neurosurgery 12 (2018) 56–58

Contents lists available at ScienceDirect

Interdisciplinary Neurosurgery

journal homepage: www.elsevier.com/locate/inat

Case Report

Effect of sevoflurane on neuronal activity during deep brain stimulation surgery for epilepsy: A case report

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ARTICLE INFO

Keywords:
Thalamus
Deep brain stimulation
Sevoflurane

ABSTRACT

Deep brain stimulation of the anterior nucleus of the thalamus is an effective treatment for patients with refractory epilepsy who do not respond sufficiently to medical therapy. Optimal therapeutic effects of deep brain stimulation probably depend on accurate positioning of the stimulating electrodes. Microelectrode recordings show bursty firing neurons in the anterior nucleus of the thalamus region, which confirms the anatomical target determined by the surgeon. Deep brain stimulation electrodes in epilepsy patients are implanted under general anesthesia. The type and depth of anesthesia might interfere with microelectrode ecordings. Here, we describe our experience of a patient who underwent deep brain stimulation surgery under general anesthesia with sevoflurane, a volatile anesthetic, and its effect on the microelectrode recordings.

1. Introduction

Epilepsy is a common neurological disorder which affects approximately 3 million people in the USA. When conservative treatment with two (or more) anti-epileptic drugs fails, a patient suffers from refractory epilepsy. These patients are evaluated for possible surgical resection, however, only in approximately 55% of patients with medically refractory epilepsy ablation or resection of the epileptogenic area is an option. Deep brain stimulation (DBS) of the anterior nucleus of the thalamus (ANT) offers a novel adjunctive and effective treatment for a subpopulation of these patients [1].

To date, the ANT is defined by pre-operative magnetic resonance imaging and the DBS lead is implanted during stereotaxic surgery. During DBS surgery in general, microelectrode recordings (MER) can be used to confirm the designated target area. In epilepsy patients, DBS surgery is performed under general anesthesia. To date, no studies have been published about the influence of anesthetics on the quality of MER in the ANT in epilepsy patients. Here, we report on the suppression of neuronal activity by sevoflurane.

2. Case report

We report the case of a 26 year-old man with medical refractory epilepsy who was scheduled for bilateral DBS placement. The patient did not receive any premedication except his regular anti-epileptic drugs. In the operating room, standard anesthesia monitoring was applied including a five-lead electrocardiogram, non-invasive blood pressure, pulse oximetry, and a Bispectral Index monitoring system (BIS). BIS is a processed electroencephalogram parameter to measure depth of anesthesia. The numerical values range from 0 to 100 (no cerebral activity to fully awake). A target zone of 40 to 60 is used for general anesthesia. The patient received an intravenous access with Ringer's lactate. General anesthesia was induced with sufentanil (0.2 mcg·kg^{-1}), propofol (2–3 mg·kg^{-1}) and rocuronium (0.6 mg·kg^{-1}). For maintenance sevoflurane (minimal alveolar concentration (MAC) 2.5–3.0%) with continuous intravenous sufentanil 0.2 mcg·kg·hr^{-1} was used. A BIS value of 40 was maintained. The airway was secured with a tracheal tube and positive pressure ventilation was initiated. Then a

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https://doi.org/10.1016/j.inat.2018.01.003
Received 19 December 2017; Received in revised form 16 January 2018; Accepted 20 January 2018

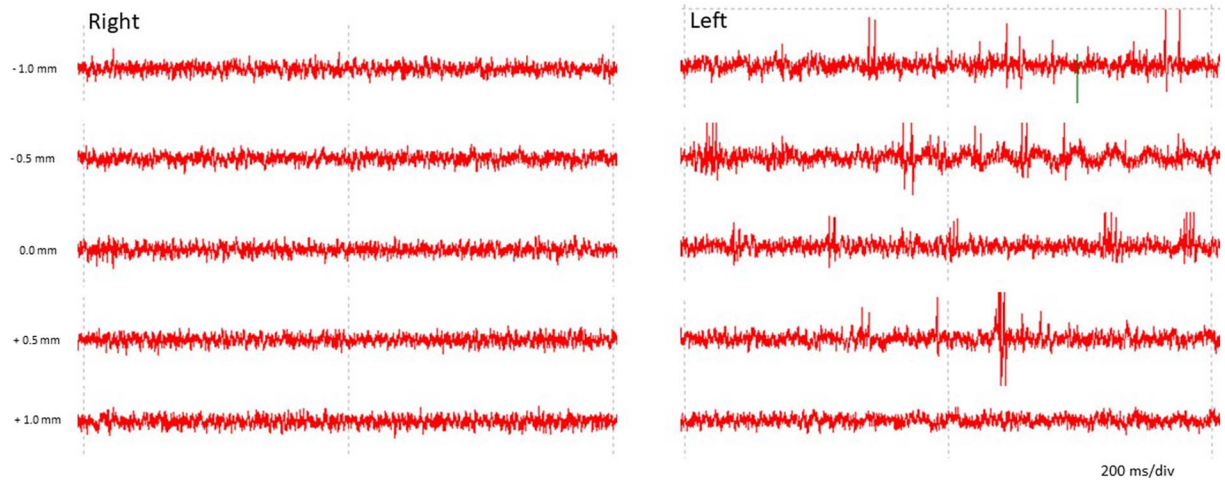

Fig. 1. Example of microelectrode recordings (MER) along the central trajectory. Recordings from −1 mm above until 1 mm below target are presented. Notice the difference between the two sides. As opposed to the right hemisphere, where no spikes were seen, the left hemisphere presented with typical bursts.

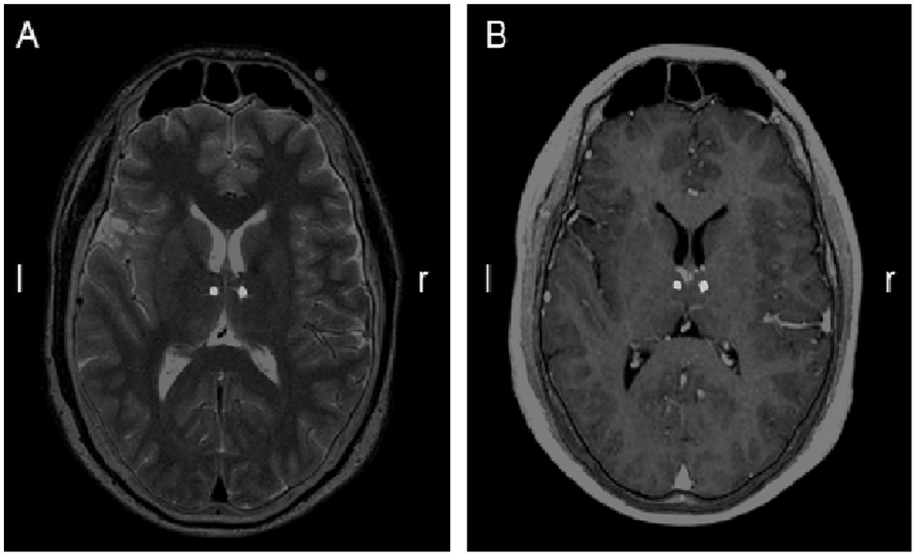

Fig. 2. Pre-operative axial T2 (A) and T1 (B) 3 T magnetic resonance images fused with post-operative CT images showing bilateral DBS lead placement at the predefined anatomical target in the anterior nucleus of the thalamus (ANT).

Leksell stereotaxic frame (Elekta, Stockholm, Sweden) was placed.

The surgical procedure was as follows: along the planned extra-ventricular trajectory to the ANT, as defined on pre-operative T1 and T2 3 T MR images, MER were recorded in both hemispheres. Recordings took place from 10 mm above the target to circa 4 mm beneath the calculated target in 0.5–1.0 mm steps. The electrode signal was bandpass filtered (160–5000 Hz), and sampled at 20/25 kHz (system: InoMed, V3.15, Madison, Wisconsin, USA). During the procedure, standard MER were performed, but no neuronal activity was present in the central trajectory of the right hemisphere (Fig. 1 and Video 1). The type of anesthesia was switched from sevoflurane to propofol before the procedure was started at the left hemisphere. Propofol was given in a dosage of $8\,mg^{-1}{\cdot}kg^{-1}{\cdot}hr^{-1}$ with a BIS target of 40. In the left hemisphere, typical bursty activity was present in the ANT. Peroperatively no complications occurred. A post-operative CT-scan, which was merged with the pre-operative MR, showed that both DBS leads (Medtronic 3389, Minneapolis, USA) were situated in the ANT (Fig. 2). One year after surgery the patient had a reduction of seizure frequency of more than 30%.

3. Discussion

This case shows that the choice of an anesthetic, during an ANT DBS procedure, can have a major impact on MER. Initially, sevoflurane was used but the neuronal activity in the ANT was completely suppressed. After the anesthesia was switched to propofol again a classical bursty neuronal firing pattern was present. We did a retrospective analysis of all of our epilepsy patients who underwent ANT DBS surgery (23 in total). Only in the presented case sevoflurane was used. In all other patients' propofol with opioids were used and even in high dosages of propofol there was no influence on MER.

MER are often used to identify or verify the target area of the DBS lead. Generally, each brain region has its own neurophysiological hallmark which makes it possible to identify the target area. There is not a plethora of quality evidence regarding the utility of MER to optimize placement of the DBS lead for epilepsy patients within the ANT. Recent data however, suggest that MER could possibly help to identify the ANT [2]. To our knowledge, no other reports have been published on the effects of anesthetics on the quality of the MER of the ANT.

Until now, limited studies have been published about the effects of general anesthesia on MER during DBS. Most experience has been obtained in patients with dystonia and Parkinson disease. From these reports, we may conclude that despite small study groups, intravenous and volatile anesthetics, even in low dose seem to interfere with the firing properties of neurons. However, identifying the surgical target based on MER seems not to be influenced by the anesthetic drugs.

In our patient, in which high-dose sevoflurane was used, almost no

neuronal activity was present along the full trajectory. This is in contrast to previous studies. In these studies, minimal effects of volatile anesthetics on MER were seen. The high concentration of sevoflurane used, could be an explanation for the abolished MER signal. A possible explanation could be the difference in MAC value of the inhalation anesthetics. $GABA_A$-receptors in the thalamus play an important role in anesthesia. PET-scan studies showed that volatile anesthetics have a dose-related effect on the $GABA_A$ receptor which could explain the difference in MER [3].

Recently, it has been suggested that assessing depth of anesthesia measured by BIS could be a determinant to obtain good MER [4]. Some case series have been published about DBS surgery under conscious sedation with a positive correlation between BIS and MER registration. Experiences with BIS during DBS under general anesthesia are limited. In our retrospective analysis, seven patients had BIS monitoring during surgery. With BIS levels of 40, no suppression of neuronal discharges were seen. In our case, during sevoflurane anesthesia, with a BIS of 40, no MER registration was possible. An explanation could be the dissociation between cortical and subcortical effects of propofol and sevoflurane. Different studies examined the effect of volatile anesthetics and propofol on brain glucose metabolism and both showed a reduction of cerebral glucose metabolism by 40–55% which is correlated with synaptic activity. They found regional metabolic differences. Propofol had a more pronounced effect on the cortex than on subcortical regions whereas volatile anesthetics caused a specific reduction of regional cerebral glucose metabolism in the thalamus [5].

4. Conclusion

Good quality MER during DBS of thalamic neuronal activity can be obtained during ANT DBS surgery under general anesthesia if propofol is used. Caution should be taken when volatile anesthetics are used, because they may suppress neuronal activity. We advise to use standardized anesthetic protocols during DBS surgery to prevent influence of different anesthesia on the identification and verification of the target region by MER.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.inat.2018.01.003.

Sources of financial support

Department funds only.
No financial disclosures to make.

Conflict of interest

None declared

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