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Clinical Study

Transient, symptomatic, post-operative, non-infectious hypodensity around the deep brain stimulation (DBS) electrode

Milind Deogaonkar [a,*], Jules M. Nazzaro [b], Andre Machado [a], Ali Rezai [c]

[a] Center for Neurological Restoration, Department of Neurosurgery, Cleveland Clinic Foundation, 9500 Euclid Avenue, S31, Cleveland, Ohio 44195, USA
[b] Department of Neurosurgery, The University of Kansas Medical Center, Kansas City, Kansas, USA
[c] Department of Neurosurgery, The Ohio State University, Columbus, Ohio, USA

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ABSTRACT

Post-operative edema around a deep brain stimulation (DBS) lead is a rare presentation. Post-operative edema that is symptomatic, self-limiting and not due to infection, in particular, is rarely reported as a separate entity. We aim to discuss the morphological characteristics of post-operative edema around a DBS lead with an insight into possible etiologies and management. We present eight patients with symptomatic, self-limiting peri-electrode edema post-DBS electrode implantation who presented post-operatively with distinct clinical presentations with imaging that revealed a hypodense area in the white matter surrounding the DBS electrode. Local and systemic tests for infection were negative. The edema resolved over time without surgical intervention. The etiology of the edema remains obscure. The transient nature of the edema and benign course with rapid and full resolution in all our patients cautions against any hasty decision to explant the electrode, in the absence of any obvious signs of infection.

1. Introduction

Since the placement of the first deep brain stimulation (DBS) electrode in the thalamus,[1] DBS has become an increasingly common treatment option for disorders such as movement disorders,[2–6] chronic pain disorders,[7] epilepsy,[8] minimally conscious states,[9] psychiatric disorders[10] and is used increasingly for neuropsychiatric disorders such as Gilles de la Tourette's syndrome.[11] An increasing number of targets and indications, variations in surgical techniques and use of microelectrode recordings (MER) can result in an increase in the number and types of potential complications that can occur as a result of DBS placement. The most common complications include device-related failures, infections, hemorrhage and neuropsychologic/psychiatric manifestions.[6,12–14] There are no published reports of transient non-infectious, but symptomatic, brain edema surrounding the DBS electrode that resolved without intervention other than an occasional reference to it as ischemia in published complications.[15,16] The authors discuss eight patients with this edema and hypothesize possible etiologies.

2. Methods

After Institutional Review Board approval, a retrospective chart review of the eight patients who presented with peri-electrode edema was carried out. The patients presented between 2004 and 2009. Seven patients were operated in Cleveland Clinic and one was operated by JMN at an outside institution. Medical records of these patients were reviewed, with particular emphasis on the demographic data, diagnosis, procedural details, time between surgery and appearance of edema, symptoms, diagnostic tests, intervention and days needed for radiological resolution of edema and clinical resolution of symptoms. Statistical analysis was performed using the Student's *t*-test.

2.1. Surgical technique for DBS

Although one patient was operated at a different institution, the basic operating technique was similar. The surgical technique in all patients consisted of stereotactic frame placement, MRI and CT scan acquisition, use of a stereotactic navigation system for anatomic targeting and trajectory planning and micro-electrode recording (MER) for physiological targeting. The basic components of DBS implantation surgery in all patients remained the same as in the last 1000 lead placements done at our center, including frame placement, burr-hole placement, physiological mapping, placement of DBS electrode and in a second stage, placement of implantable pulse generator (IPG). The pre-operative planning was done using pre-operative MRI loaded into a surgical navigation computer and fused with the CT scan done after frame placement. The target of DBS placement was either the subthalamic nucleus (STN) or the globus pallidus internus (GPi). After trajectory

* Corresponding author. Tel.: +1 216 444 5188; fax: +1 216 444 1015.
E-mail address: deoganm@ccf.org (M. Deogaonkar).

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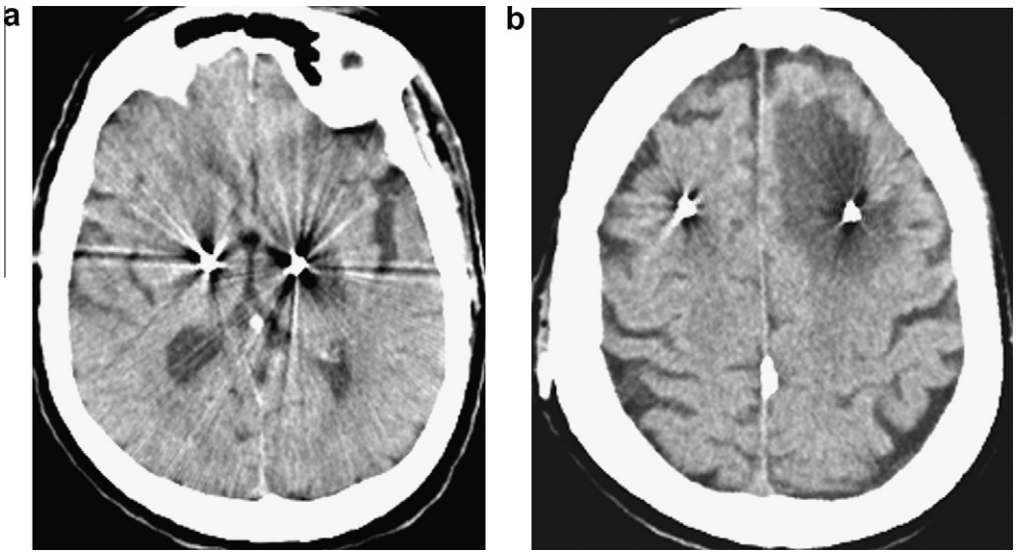

Fig. 1. Axial CT scan without contrast on post-operative day 4 at (a) the tip of the electrode, and (b) the subcortical level, showing a large hypodense area (edema) from the left basal ganglia to the subcortical region around the left deep brain stimulation electrode.

planning, the patient was placed supine on the operating table and the frame attached to the table using an adaptor. Under local anesthesia and intravenous sedation, a parasagittal linear incision was made and a burr-hole placed centered on the entry point. Once the burr hole was made, the intravenous sedation was stopped before starting the MER. Microelectrode mapping was then performed using microelectrodes to accurately define the target structure and to allow for proper placement of the DBS lead. Finally a commercially available DBS electrode (either 3389 or 3387) (Medtronic, Minneapolis, MN, USA) was placed at the final target. Once in place, the distal end of the DBS lead was tunneled to the parietal region and placed in the subgaleal space. In the second stage of the DBS procedure, the IPG was inserted under general anesthesia either on the same day or in a staged fashion. A subclavicular pocket was used for the placement of the IPG, which was then connected to the DBS electrode using an extension wire tunneled from the parietal incision to the pocket.

2.2. Illustrative patients

2.2.1. Patient 1

A 65-year-old right-handed woman with a history of idiopathic Parkinson's Disease (PD) was admitted for the placement of bilateral STN electrodes. She underwent the procedure using local anesthesia and sedation. MER was performed using a micro-electrode attached to the stereotactic frame and advanced through the brain with a calibrated microdrive. Neuronal activity was recorded along each track. Single units were isolated and somatosensory responses were determined. Three tracks of MER were performed on each side to map the anterior and lateral borders of the STN, starting 15 mm above the target, followed by placement of the permanent electrode, model 3389 (Medtronic). The burr holes were sealed with fibrin glue between trajectories to minimize cerebrospinal fluid (CSF) loss and subsequent pneumocephalus during and after the procedure, respectively. An immediate post-operative CT head scan revealed a small amount of pneumocephalus with no parenchymal hemorrhage. The patient was discharged on post-operative day 2 with a normal exam. Her second stage of surgery for IPG implantation was scheduled for a later date.

Four days after her surgical procedure, the patient presented to a local emergency room (ER) complaining of a new headache on the top of her head that would not go away with prescribed pain medications. Because the patient was confused, CT head scan was obtained. This scan revealed a large hypodense area ($4\text{ cm} \times 4\text{ cm} \times 6\text{ cm}$) centered around the left DBS electrode extending from the left basal ganglia to the subcortical region (Fig. 1). Upon admission to the hospital, a small subgaleal fluid collection over the left burr hole was noticed. The patient's exam was otherwise normal. No local or systemic signs or symptoms of infection were present. The subgaleal fluid was aspirated and sent for gram stain, fungal (potassium hydroxide [KOH]) stain and bacterial cultures, all of which were negative. The clinical symptoms improved to baseline over the next 4 days and the patient was discharged home on a short course of oral steroids. Antibiotics were not administered. A 1-week follow-up CT scan showed resolution of the edema.

2.2.2. Patient 2

A 69-year old left-handed male with a history of idiopathic PD was admitted for placement of a right-sided STN electrode. He underwent the procedure using local anesthesia and sedation between episodes of sensory and motor mapping. MER was performed using a platinum iridium micro-electrode attached to the stereotactic frame and advanced through the brain with a calibrated microdrive. Neuronal activity was recorded along each tract. Single units were isolated and somatosensory responses were determined. Three tracks of MER were performed on each side to map the anterior and lateral borders of STN, starting 15 mm above the target, followed by placement of the permanent electrode model 3389 (Medtronic). The burr holes were sealed with fibrin glue between trajectories to minimize CSF loss and subsequent pneumocephalus. Immediate post-operative CT head scans revealed minimal pneumocephalus with no parenchymal hemorrhage. The patient was discharged on post-operative day 2 with a normal examination. His second stage of surgery for implantation of the IPG was scheduled for a later date.

Two weeks after discharge, the patient presented to the emergency room with a history of a single generalized convulsion followed by a brief loss of consciousness. On examination he was orientated and had no focal deficits. A CT brain scan revealed a large hypodense area ($3\text{ cm} \times 4\text{ cm} \times 3\text{ cm}$) centered around the left DBS electrode primarily in the subcortical region and centrum semiovale that did not enhance on contrast administration (Fig. 2). No local or systemic signs or symptoms of infection were present.