Subcortical Mapping Using an Electrified Cavitron UltraSonic Aspirator in Pediatric Supratentorial Surgery

Jonathan Roth[2], Akiva Korn[1], Yifat Bitan-Talmor[1], Rivka Kaufman[1], Margaret Ekstein[3], Shlomi Constantini[2]

■ BACKGROUND: **Intraoperative electrophysiology is increasingly used for various lesion resections, both in adult and pediatric brain surgery. Subcortical mapping is often used in adult surgery when lesions lie in proximity to the corticospinal tract (CST). We describe a novel technique of continuous subcortical mapping using an electrified Cavitron UltraSonic Aspirator (CUSA) in children with supratentorial lesions.**

■ METHODS: **We evaluated the method of subcortical mapping using a CUSA as a stimulation probe. Included in this study were children (<18 years of age) with supratentorial lesions in proximity to the CST in which the CUSA stimulator was applied. Data were collected retrospectively.**

■ RESULTS: **Eleven children were included. Lesions were located in the thalamus (3), basal-ganglia (2), lateral ventricle (1), and convexity (5). Lesions included low-grade gliomas (6), arteriovenous malformation (1), cavernoma (1), cortical dysplasia (1), ependymoma grade II (1), and high-grade glioma (1). Seven patients had positive mapping responses to CUSA-based stimulation at various stimulation intensities. These responses led to a more limited resection in 5 cases. There were no complications related to the mapping technique.**

■ CONCLUSION: **Continuous CUSA-based subcortical stimulation is a feasible mapping technique for assessing proximity to the CST during resection of supratentorial lesions in children. Future studies should be performed to better correlate the current threshold for eliciting a motor response with the distance from the CST, as well as the effect of age on this technique.**

INTRODUCTION

Subcortical mapping is often used to identify motor pathways (corticospinal tract, CST) during resection of intra-axial tumors that are in proximity to these pathways.[1-7] During resection of lesional areas approaching the CST, subcortical stimulation is applied at a sufficient current to activate the CST and evoke an electromyographic response in the contralateral musculature. Several publications have estimated the correlation between the motor threshold and the distance from the CST to be roughly 1–1.8 mA per 1 mm.[1,8-10] Thus direct subcortical mapping, together with motor evoked potentials (MEPs), potentially enable the surgeon to maximize tumor resection while preserving the patient's CST integrity during intra-axial tumor resection.

The main limitation of standard subcortical stimulation is the need to use a separate designated stimulation probe, thus interrupting the surgical workflow, while the actual resection is done with no mapping. To date, 2 publications have suggested modified stimulation methods involving continuous stimulation of subcortical anatomy during resection without the need for interruption. One method uses a modified suction apparatus that can

Key words
- CUSA
- Mapping
- Monitoring
- Pediatric
- Subcortical stimulation
- Tumor resection

Abbreviations and Acronyms
CST: Corticospinal tract
CUSA: Cavitron UltraSonic Aspirator
dcMEP: Direct cortical motor evoked potentials
GTR: Gross total resection
ION: Intraoperative neurophysiology
MEP: Motor evoked potential
STR: Subtotal resection
tcMEP: Transcortical motor evoked potentials

From the [1]Intraoperative Neurophysiological Monitoring Service and [2]Departments of Pediatric Neurosurgery and Anesthesiology and [3]Critical Care, Dana Children's Hospital, Tel-Aviv Medical Center, Tel-Aviv University, Tel-Aviv, Israel

To whom correspondence should be addressed: Jonathan Roth, M.D. [E-mail: jonaroth@gmail.com]

Jonathan Roth and Akiva Korn have equally contributed.

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act as a stimulator[11] while another method describes the use of the Cavitron UltraSonic Aspirator (CUSA) for this purpose.[12] Both publications relate to the feasibility of continuous subcortical mapping in the adult context; the feasibility in the pediatric context remains unexplored.

In the current study, we describe the use of subcortical mapping using the CUSA in resection of supratentorial lesions in children.

METHODS

Following Institutional Review Board approval, we retrospectively collected all pediatric (<18 years of age) patients who underwent resection of supratentorial lesions with the aid of electrophysiologic monitoring. Of 59 eligible cases, we focused on 11 cases in which the CUSA was used for subcortical mapping. Patient and family consent were waived by the IRB.

Collected data included demographics, preoperative motor status, pathology, lesion location, surgical approach, concurrent electrophysiological monitoring dynamics, preoperative and postoperative imaging for assessment of proximity to CST and estimation of degree of resection, and postoperative motor status.

Subcortical Stimulation

The CUSA nosecone is designed to facilitate electrocautery through the CUSA tip during various surgeries such as hepatic surgery.[13,14] The metallic CUSA shaft is not isolated from the CUSA frequency generator. However, the aspiration features of the CUSA are not electrically based, and no electrical current is expected to pass through the CUSA tip other than that delivered by the intraoperative monitoring unit. Dynamic subcortical stimulation is undertaken using an electrified shaft of the CUSA (CUSA Excel Ultrasonic Tissue Ablation System, Integra Life Sciences, San Diego, California, USA). A banana 1.5-mm Touchproof DIN converter (male-to-female, respectively) enables connection to the stimulation system of the intraoperative monitoring unit (Medtronic Eclipse, Medtronic, Dublin, Ireland). Stimulus parameters were identical to those for standard subcortical mapping published earlier by our group.[1] Stimulation frequency was set at 1.2 stimulations per second to maximize the temporal resolution of dynamic mapping while minimizing facilitation effects. Intensity was originally set to 20 mA and was gradually reduced if stimulation yielded motor responses and further resection was desired. Recordings were made in the following muscles contralateral to the side of the tumor: orbicularis oris, tongue, trapezius, deltoid, biceps, abductor pollicis brevis, quadriceps, thenar, and tibialis anterior. The opposite abductor pollicis brevis was used as the control. An "alarm" was defined as an evoked muscle response falling within the expected range of latency for the respective muscle group. Replication of 2 similar traces was not set as a prerequisite for validity of a true response due to the fast dynamic nature of the mapping and ablative features of the CUSA.

Concurrent neurophysiologic monitoring and mapping methodologies consisted of median nerve phase reversal, transcranial and direct cortical MEP monitoring, and electrocorticography to identify after-discharges to cortical and subcortical stimulation.

Anesthesia Protocol

Patients received a standardized general anesthesia protocol following premedication with midazolam. Patients who arrived with intravenous (IV) access were preoxygenated and then given an IV induction with fentanyl and propofol. Patients who arrived without IV access underwent inhaled induction with oxygen, nitrous oxide, and sevoflurane. Once anesthesia was induced, all patients inhaled oxygen and air mixture only. Rocuronium 0.5 mg/kg IV was given before intubation. Anesthesia was maintained with a total IV anesthesia technique of fentanyl 5 mcg/kg for induction, pin placement, and positioning. Next, infusions of 2% propofol 100–250 mcg/kg/min with remifentanil 0.2–0.4 mcg/kg/min were used for maintenance. No additional neuromuscular blockade was used after initial bolus for intubation. Ondansetron 0.15 mg/kg was given as an antiemetic before emergence. Postoperative analgesia was provided with an IV nonsteroidal anti-inflammatory agent mixed with morphine titrated to patient comfort and respiratory rate between 16 and 28 as appropriate for patient age.

Statistics

As this is a descriptive report of a small group, data will be presented with only mean ± standard deviation for numerical variables.

RESULTS

Between January 2015 and December 2016, 11 children (5 girls, 6 boys) ages 1–18 years old (8.7 ± 5) were operated on using CUSA stimulation (Table 1). All children underwent surgery for supratentorial lesions, including 4 pilocytic astrocytomas, 2 gangliogliomas grade I, and 1 each of arteriovenous malformation, cavernous angioma, glioblastoma, cortical dysplasia, and ependymoma grade II. Lesion location included thalamus (3 cases), basal ganglia (2), parietal (3), frontal (2), and lateral ventricle (1). Six lesions were located on the right side, and 5 were left sided. There were no technique-specific related complications.

CUSA-Related Motor Response

CUSA stimulation elicited a motor response in 7 cases (patients 1–7 in Table 1), with an intensity range of 5–15 mA. In 4 cases, no motor response was elicited (patients 8–11 in Table 1).

Patients with a CUSA-Related Motor Response

Gross tumor resection was achieved in 3 of 7 patients, and a subtotal resection (STR) was achieved in 4 patients. The cause of a limited resection in 4 patients (thus STR) was a CUSA-induced motor response at stimulation currents of 5–8 mA, indicating close proximity to the CST. One additional patient had a complete cavernoma resection with a more limited resection of the perilesional gliotic tissue due to a motor response, indicating proximity to the CST. Two patients had a motor response at high stimulation currents (11 and 15 mA), and surgery was not altered.

Of the 7 cases with a CUSA-evoked motor response, 4 had a decline in motor function in the immediate postoperative period. All 4 patients ultimately improved within 2 weeks to 3 months. The stimulation currents eliciting a motor response in these cases