Vertebral Artery Reconstruction Using Microanastomosis and Intraoperative Neuromonitoring: A Case Report from Santiago, Chile

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ABSTRACT. Jorge Mura, M.D. performed the microsurgery presented in this report on August 22, 2006 at the Institute of Neurosurgery Asenjo in Santiago, Chile. Intraoperative neuromonitoring was conducted throughout the procedure. Following resection of the tumor and completion of the microanastomosis, somatosensory evoked potentials were improved from baseline potentials. Motor function was stable throughout the procedure. A post operative computerized tomography (CT) angiogram showed that the reconstructed artery was normal and three times the size of the right vertebral artery. The patient had no post operative deficits. The preliminary result of the biopsy was an angiofibroma.

KEY WORDS. Anastomosis, basilar artery, intraoperative neuromonitoring, microanastomosis, vertebral artery.
INTRODUCTION

The patient presented with quadrantanopia. A magnetic resonance imaging (MRI) scan was performed, which revealed several infarctions of the posterior circulation including the occipital lobe/visual cortex and cerebellum. A magnetic resonance angiogram (MRA) showed an occlusion in the lower of the basilar artery. The basilar trunk developed a reverse filling by the posterior communicating arteries, so the patient had no brainstem compromise. The MRI also showed a left sided, highly vascular epidural mass between C1 and C2 in close proximity to the vertebral artery. Angiography confirmed that this was a vascular tumor. Preoperative endovascular embolization was contraindicated because of the risk of secondary occlusion of the vertebral artery and possible stroke or death. The patient presented with a congenital anomaly of only having one functional vertebral artery. The functional vertebral artery was on the left side, the site of the tumor. The right vertebral artery mainly filled the right PICA territory. The preoperative discussion was mainly focused on the tumor as the cause of the occlusion of the basilar artery. A suboccipital far lateral approach was performed along with an opening of the transverse foramen of C1 in order to free the vertebral artery proximal to the tumor. Then, the tumor was completely resected off of the vertebral artery. Additionally, the tumor was within the interior walls of the vertebral artery. Therefore, the vertebral artery had to be transected and the tumor had to be removed from within. Finally, a vertebral artery reconstruction using a microanastomosis was made between the proximal and distal end of the artery where it was initially surgically transected to remove the tumor.

The IONM of this case involved the assessment of motor and sensory function as well as continuous electromyography (EMG). Transcranial electrical motor evoked potentials (TCeMEPs) and somatosensory evoked potentials (SSEPs) are specifically important because they offer the surgeon indications about cortical perfusion. TCeMEPs are more sensitive than SSEPs to an ischemic event and can alert the monitoring team to an ischemic event almost immediately upon occurrence, and in time for operative reversal. This response time is due to the fact that the anterior (motor) tracts of the spinal cord are more heavily myelinated than the posterior (sensory) tracts. These more heavily myelinated tracts require more oxygen and are thus better indicators of decreased blood perfusion. In fact, the corticospinal tract arises in the cerebral cortex and is the largest descending tract. It is composed of over 1 million fibers, with 700,000 of these fibers being myelinated and 90% of them having a diameter of 1 to 4 μm (Gondim and Thomas 2007).

This case report covers the resection of a vascular tumor from a patient’s only functional vertebral artery. The intraoperative neuromonitoring was used to assist the surgeon throughout the case via repetitive testing and updates. Therefore, the monitoring team could inform the surgeon that the patient’s motor and sensory functions were intact and the cranial nerves were free of irritation due to mechanical
manipulation. Additionally, the monitoring team was able to identify improved amplitude and decreased latency in sensory potentials post resection, indicating the increased likelihood for patient symptom improvement post operatively. Therefore, IONM serves as a tool for surgeons by offering real time assurance of their patient’s neurological pathway status in attempts to avoid perioperative damage.

**MATERIALS AND METHODS**

Multimodality monitoring was used with the following electrode setup:

**SSEP Stimulation sites:**
- Bilateral median nerves at the wrist
- Bilateral tibial nerves at the ankles

**TCeMEP muscle recording sites:**
- Bilateral adductor pollicis brevis
- Bilateral abductor digiti minimi
- Bilateral tibialis anterior
- Bilateral abductor hallucis
EMG recording electrode sites:

- Bilateral soft palate (for CN IX)
- Bilateral vocal cords (for CN X)
- Bilateral trapezius muscle (for CN XI)
- Bilateral tongue (for CN XII)

RESULTS

Prior to the start of the tumor resection, TCEMEPs were tested. TCEMEPs were tested by introducing between 296 V and 356 V to the scalp corkscrew electrodes. Upper and lower TCEMEPs were present bilaterally from the abductor digiti minimi and adductor pollicis brevis muscles for upper TCEMEPs as well as from the tibialis anterior and abductor hallucis muscles for lower TCEMEPs. Following resection of the tumor and upon complete reconstructive anastomosis of the vertebral artery, upper and lower extremity TCEMEPs showed no significant deviation in amplitude from baseline. Baseline amplitude remained consistent throughout the case, indicating perfusion to the cortex was not compromised.

Upper and lower SSEPs were recorded throughout the procedure. Prior to resection, median nerve SSEPs showed a slight asymmetry with the left cortical
evoked potential being slightly diminished in amplitude although close to synchronous in latency with the right cortical evoked potential. Tibial nerve SSEPs were bilaterally symmetric in amplitude and latency.

As the tumor resection began, a dramatic and impressive decrease in latency for both median and tibial SSEPs was noted. Additionally, the left median nerve SSEP that was diminished in amplitude in comparison to the right at the start of the resection gradually increased in amplitude. This decreased latency and increased amplitude could potentially be attributed to the removal of the very vascular tumor. As the tumor was resected, less of it was available to participate in the “steal phenomenon,” allowing more blood to perfuse the cortex and, therefore, the sensory homunculus, leading to larger and earlier responses. The theory of steal phenomenon describes how a highly vascularized tumor can lead to focal hypoperfusion. Neoplastic malformations have been shown to lead to a steal phenomenon in the brain as well as other locations in the body (Hamvas et al. 1990, Kanko et al. 2006).

It is important to note one further point about the results of testing the evoked potentials. Throughout the case, all other influential factors such as anesthesia and blood pressure remained consistent. Total intravenous anesthesia (TIVA) was employed for sedation. The monitoring team closely worked with the anesthesiologist during the case to prevent any bolus of anesthetic from being administered, to prevent any agent from being adjusted that could cause a false negative or false positive, and to maintain communication among the team. Additionally, bandpass filters were not adjusted and stimulation intensities were maintained throughout the case. Upper SSEP stimulation remained at 20 mA and lower SSEP stimulation remained at 40 mA.

Table 1 shows the numerical values for left upper N20, P23, and subcortical (SC) responses followed by the right upper N20, P23, and SC responses, the left lower P37, N45, and N34 responses, and the right lower P37, N45, and N34 responses. Some values are not visible on the actual copies from the case and are, therefore, omitted from this table. However, it is evident that from this data and from the accompanying figures of the tracings printed during surgery, there was an overall decrease in latency bilaterally for upper and lower SSEPs and this decrease in latency continued as the tumor was resected and removed, and the vertebral artery anastomosis completed. Additionally, the left upper cortical SSEP that began as slightly diminished in amplitude in comparison to the right upper cortical SSEP gained amplitude as the tumor was resected. When the tumor was finally removed, the amplitude of the left upper cortical SSEP matched the amplitude of the right upper cortical SSEP.

Upper SSEPs were recorded with bilateral asynchronous stimulation at the median nerve at the wrist and recorded from C4′-FPz for the left and C3′-FPz for the right upper cortical SSEPs (N20) and (P23). Upper subcortical SSEPs (SC) were recorded from A1-FPz. While the montage of C5 to a reference point such as Erbs point
Table 1. *Somatosensory evoked potential (SSEP) peak values throughout the case. SC – subcortical.*

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<th>N20</th>
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<tr>
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<td>23.9</td>
<td>12.9</td>
<td>21</td>
<td>24.1</td>
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<td>38.4</td>
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<td>27.5</td>
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<td>SSEPs AFTER REMOVAL OF INFARCT ANASTOMOSIS COMPLETE</td>
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<td>22.8</td>
<td>14.1</td>
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<td>13.8</td>
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contralateral (EPc) is often utilized for recording subcortical potentials, the surgical approach created a situation where C5 and EPc would not have been as readily accessible as A1 during surgery if there was a complication with the leads. A1-FPz was utilized for recording subcortical potentials and studies show SSEPs recorded from the neck area and referenced to FPz reflect an interaction between spinal-generated and brainstem generated potentials (Blackburn et al. 1999).

Lower SSEPs were recorded with bilateral asynchronous stimulation at the tibial nerve at the ankle and recorded from CPz’-FPz for upper cortical SSEPs (N45) and (P37) and A1-FPz for lower subcortical potentials (N34) (Legatt and Soliman 2006).

The authors recognize a slight issue with the upper subcortical peak labels in Figure 3. To avoid confusion, the peaks are referred to simply as “SC” or subcortical potentials. The authors did not adjust the pre-set peak labels already programmed in the recording instrument’s montage. The authors could have removed the P22 labels from the subcortical channels and relabeled the N13 as N14.

Figure 4 shows the TCeMEPs done post resection of the tumor.

FIG. 3. Somatosensory evoked potentials (SSEPs) post resection. Left tracings from top to bottom: upper left cortical, left subcortical, right cortical, right subcortical. Middle tracings from top to bottom: lower left cortical, left subcortical, right cortical, right subcortical. Right tracings from top to bottom: free running EMG shown for Cranial Nerves IX, X, Left XI, Right XI, XII.
DISCUSSION

The cranial nerves at risk during this surgery were cranial nerves IX through XII. They were monitored with free running electromyography (EMG). The only noted EMG activity during the case was some sustained low amplitude EMG activity from the soft palate that lasted approximately ten to fifteen seconds on two separate occasions. The surgeon was informed, waited until the EMG activity subsided, and adjusted his approach accordingly, making sure to ask for notification if the EMG activity returned.

The glossopharyngeal nerve, CN IX, “emerges from the medulla of the brainstem as the most rostral of a series of rootlets that emerge between the olive and the inferior cerebral peduncle” (Moore and Dalley 1999). The brachial component of CN IX innervates the stylopharyngeus muscle. CN X, the vagus nerve, including its
The recurrent laryngeal nerve branch, has visceral sensory and motor as well as autonomic functions. The vagus nerve “emerges through the jugular foramen and lies within the same dural sheath as cranial nerve eleven” (Moore and Dalley 1999). CN XI, the spinal accessory nerve, innervates the sternocleidomastoid muscle and the trapezius muscle. The hypoglossal nerve, CN XII, has somatic motor function and supplies all of the intrinsic muscles of the tongue, which control the shape of the tongue. Also, CN XII innervates three out of four of the extrinsic muscles of the tongue. Any damage to cranial nerves IX through XII could result in deleterious effects on swallowing, speech, shoulder/neck movement, and tongue control.
A review of the Circle of Willis and the overall blood supply to the brain facilitates understanding how crucial these vessels are. The internal carotid arteries arise from the common carotid arteries and are differentiated from the external carotid arteries easily because the external carotid arteries have no intracranial branches. The internal carotid arteries have terminal branches called the anterior and middle cerebral arteries. The anterior cerebral arteries perfuse the interhemispheric portion of the cerebral hemispheres. The middle cerebral arteries perfuse “most of

FIG. 6. Operative view of the left sided, highly vascular and large tumor. The arrow points directly to the golf-ball sized tumor.
the lateral surface of the cerebral hemispheres” (Gondim and Thomas 2007). Together, “the internal carotids and their branches are often referred to as the anterior circulation of the brain” (Gondim and Thomas 2007). Additionally, the internal carotid arteries join the posterior cerebral arteries via the posterior communicating arteries. The posterior cerebral arteries perfuse the inferior aspect of the cerebral hemisphere as well as the occipital lobe and the posterior communicating arteries perfuse the thalamus, internal capsule, cerebral peduncle, and optic tract.

These arteries and branches together make up the cerebral arterial circle or Circle of Willis (Figure 5). The posterior communicating arteries are the terminal branch of the basilar artery, which is in turn, is the terminal branch of the unified vertebral arteries. The vertebral arteries come from the subclavian artery. The basilar artery perfuses the brainstem, cerebellum, and cerebrum while the vertebral arteries that form the basilar artery perfuse the cranial meninges and the cerebellum. Just as the
internal carotids and the branches of the internal carotids create the anterior circulation of the brain, the vertebrobasilar arterial system and respective branches compose the posterior circulation of the brain. Interestingly, “the two vertebral arteries are usually unequal in size, the left being larger than the right” and “the transversarial parts of the arteries pass through the transverse foramina of the first six cervical vertebrae” (Gondim and Thomas 2007).

Figure 6 is the operative view showing the highly vascularized, golf ball sized tumor. Figure 7 is the operative view post tumor resection, pre-anastomosis. Importantly, this patient presented with a congenital anomaly of only having one functional vertebral artery. That functional artery was the left artery, in which the tumor was located. The microanastomosis was performed in 15 minutes. Figure 8 is the postoperative view of the vertebral arteries. Figure 9 is a postoperative picture of the patient.
CONCLUSION

Intraoperative neuromonitoring, including TCeMEPs, SSEPs, and free running EMG is a tool for surgeons and can provide important patient status information, especially during complicated cases.
ACKNOWLEDGEMENTS

The authors of this paper are grateful for the skilled surgical team at the Neurosurgery Institute in Santiago, Chile; NeuroMatrix, a generous company; and the chance to use this specific technology for patient safety.

REFERENCES


