Multi-Modality Monitoring in Carotid Surgery: The Importance of Reliable Readings

R.W.M. Keunen MD PhD, D.L. Tavy MD, B. Knippenberg, MD PhD
Dept. of Neurology,
Haga Teaching Hospitals, The Hague, Netherlands

Introduction. Electroencephalography (EEG) and Transcranial Doppler (TCD) are established monitoring instruments during carotid endarterectomy (CEA) procedures.[1,2] However, EEG is often time consuming and can only be of value if the EEG shows bilateral symmetry prior to the arterectomy. TCD monitors both the cerebral hemodynamic and cerebral embolism, but the procedure can only be applied if the patient has patent temporal windows. Moreover, due to the fact that the Doppler probe is liable to unintended dislocation throughout the surgical procedure, alternative monitorings instruments could be of value especially when they provide stable and consistent readings. Both technologies add layers of cost and complexity to a case. This case report illustrates the complexities that can exist while monitoring CEA patients.

Anamnesis. Male patient, 76 years old was admitted into the hospital for left CEA. The contralateral side (right) showed signs of stenosis, but it was decided to do a single-sided CEA of the left side. Significant prior medical history included a traumatic brain injury 23 years prior and recent history (<6 months) transient ischaemic attack (TIA). The patient reported complete clinical and functional recovery from the traumatic brain injury.

Pre-operative. Planned neurologic monitoring included 16 lead EEG, Transcranial Doppler and NIRS cerebral oximetry. Cerebral oximetry monitoring was conducted using Nonin Medical's EQUANOX™ 7600 NIRS Regional Oximetry System with two 8000CA sensors. The latest advancement in cerebral oximetry, this system is based on EQUANOX rSO_2 technology that utilizes dual-emitter dual-sensor architecture, enhanced signal processing and computational algorithms that deliver quicker, more consistent and accurate measurements than traditional cerebral oximetry products.

Abnormalities in the EEG monitoring, including significant bilateral discrepancies pre-operatively were noted due to the patient's significant prior medical history. A neurologist consult was requested for interpretation of the EEG findings. Given the underlying bilateral discrepancies at baseline, the neurologist determined that EEG would not provide appropriate information for this patient and it was discontinued.

Prior to intubation or interventions, the 8000CA sensors were installed on the patient's forehead. Basic skin preparation of an alcohol swab and a brief 15 seconds of drying prior at the site of the sensor application assured secure adhesion of the sensor throughout the case. Pre-intubation measurements were established at 69% (Channel 1: Right – Contralateral Side) and 68% (Channel II: Left – Operative Side). The anesthesiologist set the reference baseline to 70% for both sides and deemed the intervention threshold to be 62%. These parameters were input into the Model 7600 display to provide visual and audible alarms if the threshold was met. The compact pods were secured to the bed away from the surgical field with Kocher's forceps. The generous length of trunk cable allowed for the cable to be directed from the pods away from the head with the ventilator tubing to avoid additional accessories in the work space of the surgeon and anesthesiologist.

Peri-operative. The EQUANOX 7600 and TCD monitors were easily installed together on one small bedside cart in the surgical suite. *(Figure 1)* The neuromonitoring technician monitored the cerebral oximeter and TCD simultaneously under the supervision of the anesthesiologist. Cerebral oximetry provided a continuous, real-time assessment of trending cerebral oxygenation.


Figure 1

Surgical endarterectomy of the left carotid artery was performed under general anesthesia. Strict control of the blood pressure was maintained to keep the carotid inflow as stable as possible.

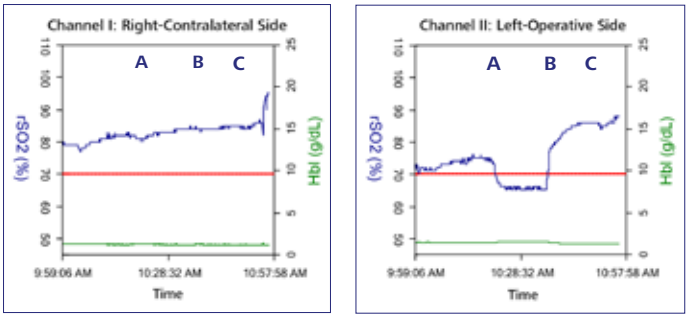
Approximately 15 minutes into the procedure, the TCD signal was lost. Despite the technicians attempt to find the underlying cause, the TCD signal could not be reestablished. At this point in the surgery, TCD became ineffective, resulting in NIRS cerebral oximetry being the sole neuromonitoring available to the clinical team for the remainder of the surgical procedure.

The surgeon and neurologist decided to defer to the reading from the Nonin EQUANOX 7600 cerebral oximeter as the indicator for need for intervention during the clamping of the carotid artery. The decision

to shunt would thus be based on the intervention threshold of 62% that was determined by the clinical team. A decrease in oxygenation on the operative side to below 62% would lead the team to use a shunt, while maintenance above this level would result in the case continuing without shunting.

The EQUANOX rSO_2 technology was sensitive to changes throughout the procedure, including a notable decrease in the operative side during carotid clamping. *(Figure 2)* However, the value remained stable at 65% and did not reach the predetermined threshold for intervention. Therefore, no shunting was performed. A firm atherosclerotic plaque with a soft center was removed after definitive clamping. As the internal carotid artery was relatively wide (5 mm) no patch was used to close the artery after endarterectomy. Upon clamp release, the rSO_2 of the surgical side returned to the pre-surgery baseline and increased slightly due to revascularization and hyperperfusion of the region. Total clamping time was 15 minutes.

Figure 2: Cerebral Oximetry During Clamping



A: Clamping anterior carotid **B:** End clamping, blood flow to brain **C:** End of surgery

Post-operative. The patient was stable during recovery and had no signs of neurocognitive defects at 24 hours post-operative. The patient was discharged from the facility on post-operative day two with no signs or symptoms of neurologic insult.

Discussion. We present a case report which is exemplary for problems that physicians face during carotid endarterectomies. Three modes of neuromonitoring were planned for patient safety and two modes failed and were not continuously available. Interpretation of the EEG reading was complicated due to severe asymmetry in the EEG preoperatively as a result of a prior stroke. Secondly, and perhaps more distressing, the TCD probe dislocated during the procedure and signal restoration was not possible. Thus, the Nonin EQUANOX 7600 cerebral oximeter was the only reliable monitoring instrument available continuously during the case. Had the cerebral oximetry monitor not been available in this case, we would have faced the decision to continue the surgery without monitoring; abort the surgery or continue with a prophylactic shunting.

Although the majority of patients do not have severe asymmetry of EEG reading at baseline, this mode of monitoring still has limitations for use in such cases. Unlike NIRS cerebral oximetry, EEG is not a real-time monitor but rather has an approximate delay for processing of five minutes.

In general, TCD provides an indirect measure of blood flow to the brain and is used to decide whether or not to shunt during carotid endarterectomies. Moreover, TCD detects both ongoing cerebral embolization and cerebral hyperperfusion during the peri-operative and post-operative phase of surgery. NIRS cerebral oximetry provides a measure of brain oxygenation that can be thought of as the balance between oxygen supply and demand. A change in either oxygen supply or oxygen demand of the brain will result in a change in cerebral oximetry.

Both EEG and TCD require a skilled technician to monitor the systems throughout the case. Personnel resources for a dedicated technician increase costs for facilities. As noted in this patient, even the most skilled technicians may not be able to maintain the TCD probe placement appropriately to provide uninterrupted monitoring.

The importance of having a reliable mode of monitoring cannot be under estimated. NIRS cerebral oximetry proved to be reliable, providing stable and consistent measures when both alternative methods of monitoring failed. Limited resources are required to integrate NIRS cerebral oximetry into the procedure as a dedicated technician is not required for monitoring the device which displays numerical and graphic findings directly. By incorporating predetermined thresholds for intervention, alarms can be set to allow for both visual and audible indicators to the anesthesiologist when a significant event occurs. From the current literature there is no absolute threshold determined for selective shunting during carotid endarterectomy. However CABG studies show that brain ischemia is likely to occur if the brain saturation drops more than 20% from baseline.[3] Therefore, the team decided to be conservative and set the threshold for intervention at 62%.

The Nonin EQUANOX 7600 cerebral oximeter gave full information of the severity of the brain oxygenation throughout the case with no loss of signal. The cerebral oximetry reading allowed the surgery to be completed safely while providing the clinical team confidence that the patient was maintaining adequate oxygenation.

References

[1] Cheng MA, Theard MA, Tempelhoff R. Anesthesia for carotid endarterectomy: a survey. *J Neurosurg Anesthesiol*. 1997 Jul;9(3):211-6.

[2] Martinelli O, Benedetti-Valentini F. Transcranial Doppler: value in clinical practice. *Int Angiol.* 2009 Aug;28(4):249-53.

[3] André Denault, Alain Deschamps and John M. Murkin. A Proposed Algorithm for the Intraoperative Use of Cerebral Near-Infrared Spectroscopy. *Semin Cardiothoracic Vasc Anesth* 2007; 11; 274

Nonin Medical, Inc.
13700 1st Avenue North, Plymouth, MN 55441-5443, USA
Phone: +1 763.553.9968 | Toll Free: 800.356.8874 | Fax: +1.763.553.7807 | Email: info@nonin.com

EQUANOX™
www.nonin.com

M-9009