The First Intraoperative EEG Monitoring during a Common Carotid Artery Endoaneurysmorrhaphy in a Philippine Tertiary Government Hospital: A Case Report

Athena Kate D. Antonio, MD*, Maxine Lourraine T. Ty, MD* and Katerina Tanya Perez-Gosiengfiao, MD

Philippine General Hospital, University of the Philippines Manila

ABSTRACT

The surgical treatment of the rare extracranial carotid artery aneurysm can lead to significant thromboembolic events in 4.4% of cases. Intraoperative monitoring has helped detect hypoperfusion and probable ischemic events, but this is not widely available in resource-limited hospitals in the Philippines. This case highlights the use of a portable standard 21-channel EEG machine for intraoperative monitoring in a tertiary government hospital. In addition, it highlights a conception of a protocol for the intraoperative electroencephalogram monitoring of carotid endoaneurysmorrhaphy procedures in a resource-limited setting. During the aneurysmorrhaphy procedure, the authors collaborated with the surgeons and the anesthesiologists to provide feedback about EEG changes during the operation. After a pre-induction baseline was recorded, continuous EEG monitoring was performed until the patient emerged from anesthesia. Mild EEG changes, attributed to relative hypotension, were observed during the procedure. These episodes were responsive to BP augmentation. There were no EEG changes observed during carotid cross-clamping. Shunting was not recommended to the surgical team. No new neurologic deficits were documented postoperatively and on follow-up after six months. This paper illustrates how an intraoperative team was formed, and intraoperative EEG was utilized for a complex carotid endoaneurysmorrhaphy for a patient with ECAA in a tertiary government hospital in the Philippines.

Keywords: resource-limited settings, monitoring, intraoperative electroencephalography, carotid arteries, Philippines

INTRODUCTION

Intraoperative electroencephalographic (EEG) monitoring is critical for assessing cerebral perfusion and neural integrity during vascular surgeries, particularly those involving the carotid arteries. Its primary purpose is to provide real-time detection of cerebral ischemia, thereby enabling timely interventions to prevent permanent neurological deficits.[1]

Intraoperative EEG monitoring is employed in aneurysmal, neurosurgical, and carotid surgeries such as carotid endarterectomy (CEA) to detect cerebral hypoperfusion and reduce the risk of perioperative stroke.[2] By providing continuous feedback on cerebral function, EEG monitoring assists surgical teams in making informed decisions ensuring adequate cerebral perfusion.[3] This has been used for carotid surgeries, specifically during carotid-cross clamping (CCC), where EEG can detect changes in cerebral perfusion.[3]

No preferred treatment method has been identified for rare vascular lesions such as extracranial carotid artery aneurysms (ECAA), defined as a dilatation of the carotid artery greater than 150% of the normal.[4] Treatment options include conservative management, which is usually

Dr. Antonio and Dr. Ty shared first authorship for this manuscript.

eISSN 2094-9278 (Online)
Published: September 15, 2025
https://doi.org/10.47895/amp.v59i13.11227

Corresponding author: Maxine Lourraine T. Ty, MD
Philippine General Hospital
University of the Philippines Manila
Taft Avenue, Ermita, Manila 1000, Philippines
Email: mtty1@alum.up.edu.ph
ORCiD: https://orcid.org/0000-0002-0662-2842

reserved for asymptomatic cases. Invasive approaches such as traditional surgical treatment or endovascular repair are generally used for symptomatic or growing ECAAs, but these have been associated with cranial nerve injury and stroke. These procedures have likewise been associated with a risk for thromboembolic events, with stroke documented in 4.4% of cases.[4]

In the Philippines, there is a scarcity of documented cases of ECAA. An unpublished census by the Department of Surgery at the Philippine General Hospital recorded two cases in the past two years but with no intraoperative neurophysiological monitoring (IONM). In this paper, to the best of our knowledge, we present the first instance of intraoperative EEG monitoring during a common carotid artery endoaneurysmorrhaphy in a patient with documented thrombus in ECCA in a tertiary government hospital in the Philippines.

CASE PRESENTATION

This is the case of a 56-year-old right-handed female presenting with a painless, non-pulsatile right neck mass, continuously enlarging over the past four years. She had no episodes of dizziness, loss of consciousness, or any focal weakness or numbness. However, she had been diagnosed with hypertension three months prior and started on Losartan 50mg once daily. She completed treatment for tuberculous meningitis two years prior with a residual change in visual acuity of 20/400 in both eyes, unchanged by pinhole. She has been maintained on Salmeterol with Fluticasone for bronchial asthma since 19 years of age. Risk factors for stoke included oral contraceptive use for six years. She was not a smoker nor a user of methamphetamines or cocaine. Both of her parents had hypertension, but none of her relatives had an aneurysm. There was a 6 cm x 6 cm non-pulsatile mass in the right supraclavicular area on physical examination. There were no bruits. She was seen awake and oriented, with intact higher cortical function. Otherwise, she had a normal neurologic examination.

Craniocervical CT angiogram (Figures 1A and B) showed a sacculofusiform aneurysm of the right common carotid artery with eccentric thrombus formation. Well-defined hypodense foci were likewise seen in the posterior limb of the left internal capsule and the genu of the right internal capsule (Figure 1C), interpreted as chronic covert infarcts.

Before admission, the thoracovascular surgery team consulted the Neurology service for intraoperative neurophysiological monitoring (IONM) due to a documented thrombus on imaging and the high risk of an embolic event during surgery. However, IONM was not available at the time of referral.

Given the complexity and rarity of the case, our attending neurologists from the stroke, clinical neurophysiology, and epilepsy services discussed whether IONM could be arranged through outsourcing or by utilizing existing equipment. The modalities considered included somatosensory evoked potentials (SSEP) with motor evoked potentials (MEP), electroencephalography (EEG), and transcranial Doppler (TCD). While EEG and TCD were available for routine inpatient and outpatient use, they were not traditionally used for IONM. SSEP and MEP, on the other hand, were not available and would require outsourcing at an additional cost to the patient.

Several logistical challenges were identified, including the absence of a head mount and stabilizer for the TCD machine, the financial burden of outsourcing SSEP and MEP, and the limited availability of a single portable EEG unit, which was typically reserved for routine inpatient monitoring. After thorough discussion, the team reached a consensus to use continuous intraoperative EEG monitoring as the IONM method for this patient.

On the day of the procedure, a 21-channel digital EEG machine was used. Sixteen traditional scalp cup electrodes (ground, reference, F3, C3, T3, T5, P3, O1, Fz, Cz, Pz, F4, C4, T4, T6, P4, and O2) were applied using conductive paste, following the International 10-20 system. Frontopolar and anterior temporal electrodes were omitted to accommodate

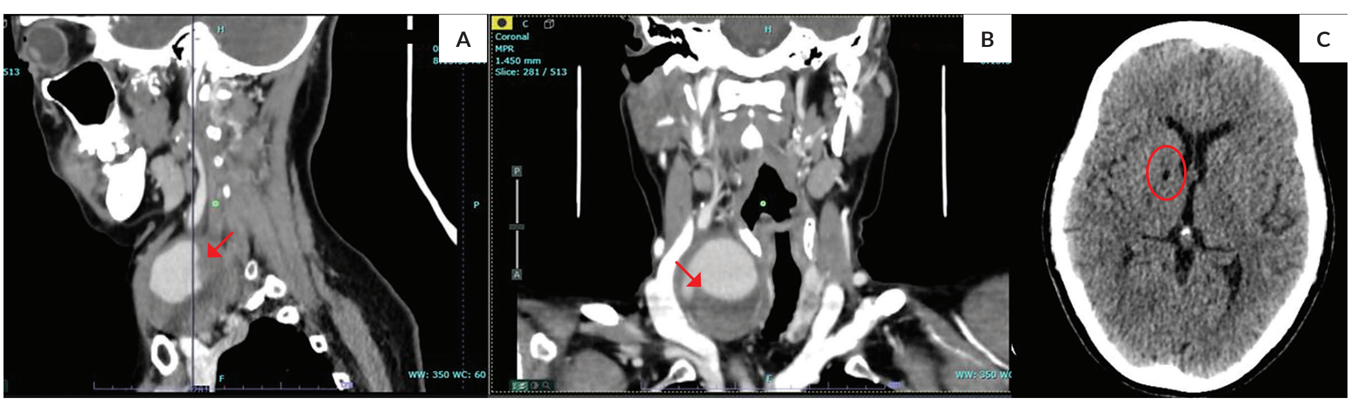

Figure 1. Craniocervical CT Angiogram. **(A)** and **(B)** show the right common carotid artery aneurysm with eccentric thrombus *(red arrows)*, and **(C)** shows the hypodense foci in the genu of the right internal capsule *(encircled)*.

the cerebral oximeter used by the anesthesia team for patient monitoring.

EEG recording was conducted with an impedance of 10 ohms, a sensitivity of 70 μV/cm, a low-frequency filter set at 0.300 Hz, a high-frequency filter at 50 Hz, and a timebase of 30 mm/sec. The Cz referential montage was primarily used, and recording began before anesthesia induction.

The operating room team included an epilepsy fellow, a resident, and a technician, along with three surgeons and two anesthesiologists. The attending epilepsy consultant was available via audio-visual calls and messages through an instant messaging application (Viber©, Rakuten, Tokyo, Japan).

The pre-induction baseline EEG showed low-to-medium voltage posterior-dominant 10–11 Hz alpha waves, with decreased amplitudes over the right centroparietal region (C4-P4). Upon induction, a generalized increase in 10–14 Hz activity was most prominent over the frontocentral regions. This progressed to widespread high-voltage 4–5 Hz theta waves, followed by slower 0.75–1 Hz waves and a burst suppression pattern. Immediately post-induction, the EEG displayed a continuous background of low-to-medium voltage 8–9 Hz activity with superimposed 1–2 Hz slow waves.

A post-induction baseline recording confirmed low-to-medium voltage 9–10 Hz alpha activity before the procedure began. At the start of surgery, vital signs were stable: blood pressure 130/90 mmHg, heart rate 80 bpm, respiratory rate 19 breaths per minute, and oxygen saturation 100%.

However, at the 80th minute, the background frequency decreased to medium-voltage generalized 5–6 Hz theta waves, with intermittent 4–5 Hz theta waves. These changes were mild and diffuse, not meeting Guérit's criteria for impaired brain perfusion. However, the surgical and anesthesiology teams were alerted, as this coincided with relative hypotension (90/60 mmHg from a baseline of 130/90 mmHg). Norepinephrine was administered to restore cerebral perfusion, gradually improving EEG activity to 8–9 Hz alpha waves mixed with occasional 4–5 Hz theta waves. Despite blood pressure stabilization (110–120/70–80 mmHg), the EEG did not fully return to the post-induction baseline. Consequently, a second baseline was recorded before carotid cross-clamping (CCC).

The pre-cross-clamping baseline showed medium-voltage 8–9 Hz alpha waves with occasional 4–5 Hz theta waves (Figure 2A). No further EEG changes occurred during the 45-minute cross-clamping period (Figure 2B). The EEG changes observed earlier responded to blood pressure management with norepinephrine, and since no significant alterations occurred during CCC, intraoperative shunting was not recommended.

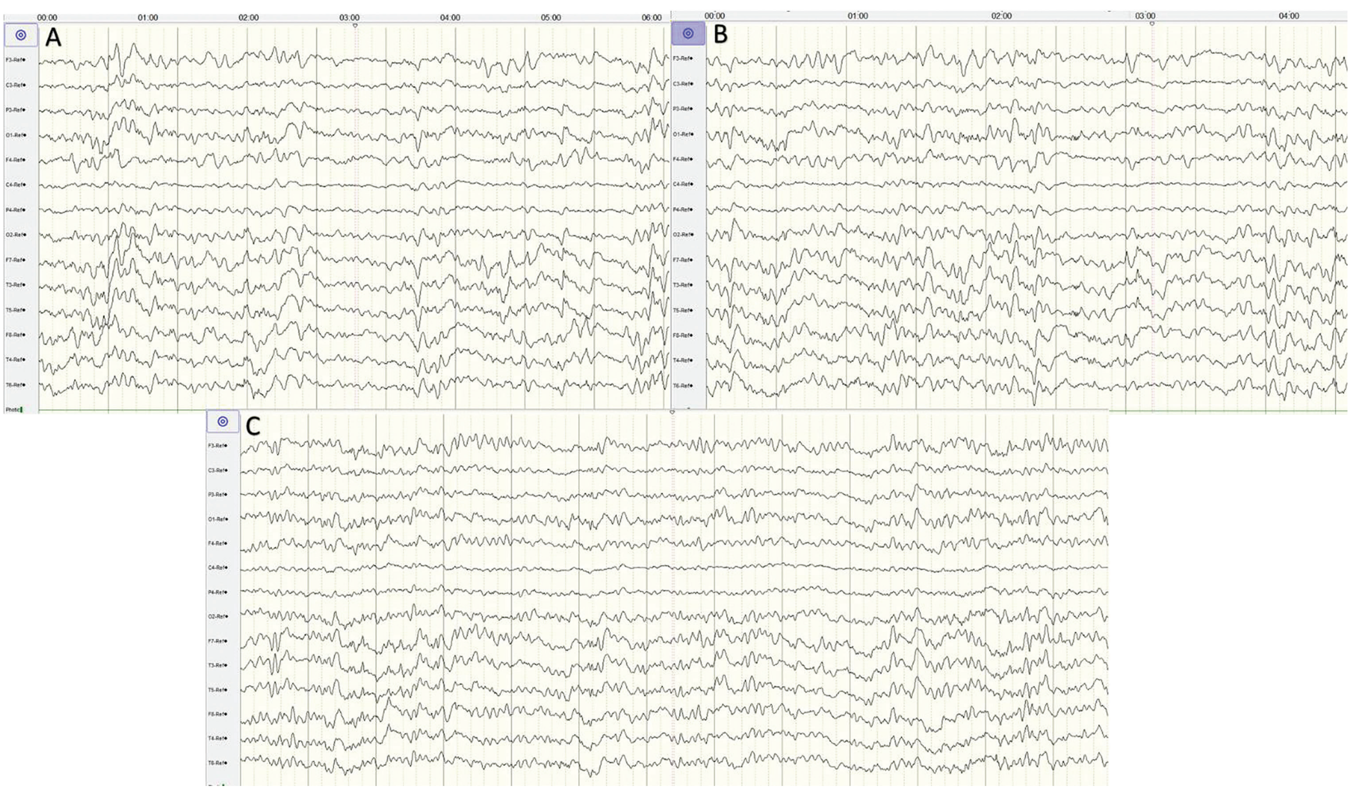

Figure 2. (A) New baseline EEG was recorded before cross-clamping which showed medium voltage 8-9 Hz alpha waves admixed with occasional 4-5 Hz theta. **(B)** EEG during cross-clamping unchanged from the new baseline. **(C)** EEG at 130/90 mmHg post-clamping showing unchanged medium voltage 8-9 Hz activity superimposed with low to medium voltage 4-5 Hz slow waves.

After cross-clamping and once the blood pressure was improved back to 130/90 mmHg, the initial background of low to medium voltage 8-9 Hz activity superimposed with low to medium voltage 4-5 Hz slow waves was again observed (Figure 2C). The procedure was completed after four hours and fifty minutes. After the procedure, a repeat neurologic examination in the OR suite showed no new deficits. On follow-up six months after the operation, slight numbness on the post-op site was noted, otherwise, she did not develop any higher cortical function deficits, craniopathies, weakness, occulosympathetic palsy, or post-operative pain.

DISCUSSION

For carotid artery surgery, one of the most feared neurological complications is stroke.[5] During a carotid artery procedure, this may result from (1) emboli, which may be dislodged during manipulation of the artery, (2) hemodynamic changes, from a drop in systolic blood pressure (BP), most commonly occurring during CCC, or lastly, (3) intraoperative myocardial infarction which may result in cerebral hypoperfusion. The critical event where intraoperative neurophysiological monitoring exerts its most influence is during carotid cross-clamping, wherein IONM data helps decide whether a shunt is needed.[6]

Intraoperative neurophysiological monitoring (IONM) includes various modalities, each with distinct advantages and limitations. Electroencephalography (EEG) has been used for intraoperative neuromonitoring for decades, recording brain electrical activity through scalp electrodes. It provides real-time data on cortical function, aiding in the detection of ischemic events.[1] EEG serves two primary roles in surgery: (1) identifying and preventing new perioperative neurological insults and (2) assessing the depth of sedation and anesthesia.[2,7] Additionally, it offers continuous real-time monitoring of cerebral perfusion and oxygenation, allowing for the early detection of subtle changes and timely intervention. These changes can be addressed through careful arterial manipulation, proper blood pressure management, and selective shunting. However, EEG's sensitivity to anesthetic agents and physiological variables can also limit its utility. Its effective use requires technical expertise and accurate data interpretation.[1,2,8] Moreover, intraoperative EEG cannot determine the cause of reduced cerebral blood flow. In this case, the underlying mechanism behind the patient's relative hypotension remains uncertain.

Somatosensory evoked potentials (SSEPs) monitor the functional integrity of sensory pathways by recording responses to peripheral nerve stimulation, offering continuous feedback on sensory tract viability, while motor evoked potentials (MEPs) assess the motor pathways by eliciting muscle responses following direct cortical stimulation, providing timely warnings of motor tract compromise; their reliability can be affected by anesthetic regimens and neuromuscular blockade.[1,2,8] Similar to EEG, intraoperative machines, technical expertise, and appropriate data interpretation are required for optimal use during surgery.

Transcranial Doppler (TCD) measures cerebral blood flow velocities, aiding in the identification of hemodynamic changes and embolic events, and its ability to detect micro-embolisms; however, it is highly dependent on the user skills and expertise, as well as an appropriate bone window for insonation.[1,2,8]

Stump pressure (SP) monitoring evaluates perfusion pressure in the distal internal carotid artery during cross-clamping, serving as an indirect indicator of collateral cerebral circulation. It is a simple and cost-effective method for assessing collateral flow during carotid artery clamping but offers only a single-point measurement and has low sensitivity in detecting ischemia, and its correlation with actual cerebral perfusion is variable.[1,2,8]

Near-infrared spectroscopy (NIRS) offers non-invasive monitoring of cerebral oxygenation by detecting changes in light absorption, providing continuous data on brain oxygen levels; its depth of penetration is limited, potentially affecting accuracy.[1,2,8]

Awake testing (AT) involves maintaining patient consciousness during surgery to directly assess neurological function through patient responses, allowing immediate detection of deficits; it necessitates patient cooperation and may not be feasible in all surgical contexts as this is done under local anesthesia.[1,2,8]

There is still no consensus as to which modality is best for carotid surgery. Still, a combination of these modalities is used in international centers to optimize the strength of each modality.[6] A recent network meta-analysis comparing these modalities alone or in combination showed that SSEP with MEP had the lowest stroke and mortality rate among all methods for cerebral perfusion monitoring under general anesthesia.[8] Still, AT was better than SSEP with MEP under local anesthesia, and the rest of the modalities (EEG, EEG+TCD, TCD+SP, SP) performed worse regarding stroke and mortality outcomes.[8] Still, these data were inconclusive and did not reach statistical significance.[8] In another meta-analysis, the combined use of EEG and SSEP changes had a specificity of 96.8% (95% confidence interval: 94.1%-98.3%) in predicting perioperative strokes.[9] Thus, a multimodal approach incorporating various neuromonitoring techniques may offer the most comprehensive and reliable intraoperative assessment, as each modality has unique strengths and limitations.[9] A narrative review by Stilo and colleagues summarized these with a proposed algorithm depending on the available modality (i.e., single modality vs multimodality), but more extensive studies are needed to validate the use of this approach.[1]

Although multimodal intraoperative neuromonitoring (IONM) has benefits, its applicability and availability are limited, especially in resource-constrained countries. This challenge is evident in our tertiary government hospital, where specialized technicians for SSEP/MEP and TCD are unavailable, NIRS and SP are not accessible, and AT is not widely applicable due to the use of general anesthesia for these cases.

According to the American Society of Neurophysiological Monitoring guidelines, IONM begins preoperatively with a thorough evaluation of patient-specific factors that may influence waveforms, identification of surgical risks through discussions with the surgical team, and coordination with the anesthesiologist to assess potential anesthetic effects.[10] Intraoperatively, responsibilities include overseeing technical factors in the operating room, interpreting EEG waveforms, formulating differential diagnoses, and promptly communicating findings to the appropriate team—alerting the surgeon if an iatrogenic cause is suspected or notifying the anesthesiologist in cases of anesthesia-related concerns or hypotension.[10] Finally, post-operative responsibilities include reporting, documentation, education, and quality assessment to ensure continuous improvement.[10]

There are no standardized criteria for defining significant EEG changes during intraoperative neurophysiological monitoring (IONM). However, different centers have suggested and adopted various parameters.[7] In this case, we adopted Guérit's classification of mild, moderate, and severe EEG changes, along with its corresponding decision points (Figure 3).[5] The proposed protocol includes a summary of the steps followed in this case.

Meetings were held with the different specialists about their concerns that could arise during the IONM procedure. The surgeons were concerned about how well the improvised IONM would reflect changes in cerebral blood flow during CCC. The clinical neurophysiology team had concerns about how EEG data would be affected by the depth of anesthesia. Similarly, the anesthesiologists were concerned about titrating their anesthetics to avoid burst suppression on the EEG.

The execution of IONM presented several challenges. The first issue was the technical difficulties encountered due

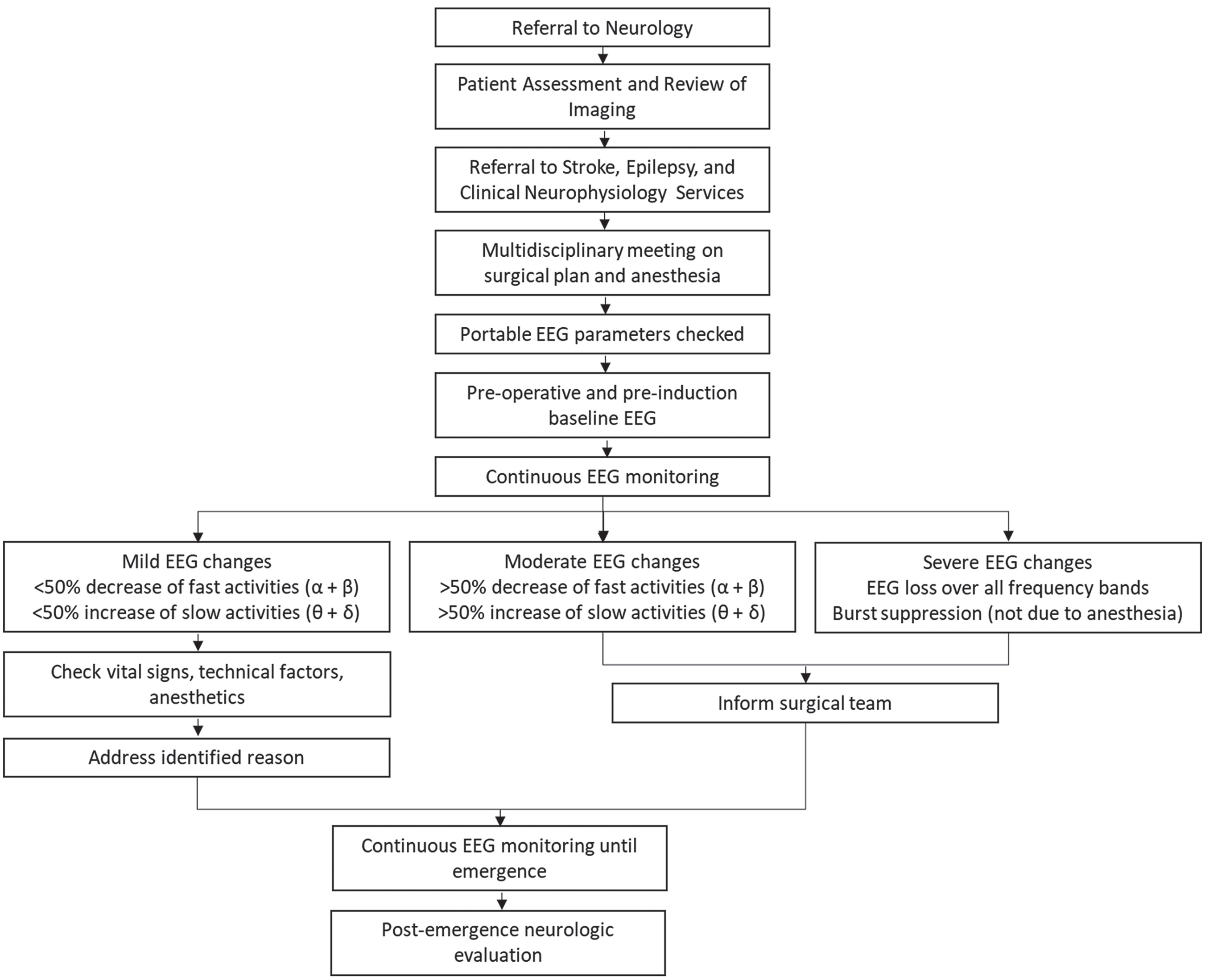

Figure 3. Proposed protocol for intraoperative EEG monitoring for carotid surgery adapted from Guérit.[5]

to this being the first time the EEG machine was brought into the operating room. The intraoperative recording was interrupted multiple times because of electrode dislodgement and amplifier disconnection. The EEG electrodes, which were secured using a conductive paste, became displaced during the procedure. This may have been exacerbated by patient movement, inadequate adhesion, or the absence of additional support, such as a bonnet or skull cap. Proper planning of equipment placement and workspace organization for the surgical and monitoring teams could help preserve the integrity of the EEG system and minimize environmental artifacts in future cases.

Additionally, interference from electrocautery resulted in prolonged periods of unreadable EEG data. While such interference is expected, it raises concerns about delayed recognition of significant EEG changes. A discussion on the effects of bipolar versus monopolar cautery on EEG monitoring may help refine future protocols, but this was not considered in this case.

Separately, lower amplitudes were noted over the right centroparietal region even at the start of the recording. In a patient with prior cerebral insults such as TB meningitis and chronic infarctions, a baseline EEG before surgery would have been ideal for comparison. However, this was not feasible due to institutional constraints—specifically, the limited availability of a single EEG machine.

Despite these difficulties, this case demonstrates the feasibility of intraoperative EEG monitoring in a tertiary government hospital and underscores the need for further refinements to optimize its use in similar environments. We also recognize that this proposed algorithm is for resource-limited settings or hospitals where IONM is unavailable.

CONCLUSION AND RECOMMENDATIONS

This case illustrates how intraoperative EEG monitoring could aid in detecting relative hypotension in a patient undergoing carotid endoaneurysmorrhaphy. The use of intraoperative EEG monitoring may be valuable in preventing neurologic complications following carotid procedures.

International data and guidelines should be adapted to local protocols to standardize intraoperative EEG monitoring in the country. A protocol derived from our experience is proposed, but more studies are needed to uncover evidence that can better guide local practice. Further training of physicians and laboratory personnel, as well as coordination with other specialties regarding the use of intraoperative EEG monitoring, would likewise be beneficial and may improve the availability and use of this modality for patients throughout the country.

Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

All authors declared no conflicts of interest.

Funding Source

None.

REFERENCES

1. Stilo F, Montelione N, Paolini J, Strumia A, Cuccarelli M, Nenna A, et al. Current status of brain monitoring during carotid endarterectomy. JVS-Vascular Insights. 2024;2:100060. doi: 10.1016/j.jvsvi.2024.100060.
2. Ghatol D, Widrich J. Intraoperative neurophysiological monitoring [Internet]. StatPearls. 2025. [cited March 2025]. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30124541. doi: 10.1097/ACO.0000000000000654. PMID: 30124541.
3. Fleseriu CM, Sultan I, Brown JA, Mina A, Frenchman J, Crammond DJ, et al. Role of intraoperative neurophysiological monitoring in preventing stroke after cardiac surgery. Ann Thorac Surg. 2023 Sep;116(3):623–9. doi: 10.1016/j.athoracsur.2023.01.004. PMID: 36634835.
4. de Borst G. Treatment of aneurysms of the extracranial carotid artery: current evidence and future perspectives. J Neurol Neuromedicine. 2016 Sep 1;1(6):11–4. doi: 10.29245/2572.942X/2016/6.1058.
5. Guérit J. Intraoperative monitoring during carotid endarterectomy. In: Nuwer MR, editor. Intraoperative monitoring during carotid endarterectomy, Handbook of Clinical Neurophysiology. Elsevier; 2008. p. 776–90. doi: 10.1016/S1567-4231(07)08057-4.
6. Jahangiri FR, Liang M, Huckabey M, Baloney N, Sharifi S. Carotid endarterectomy surgeries: a multimodality intraoperative neurophysiological monitoring approach. Cureus. 2022 Jul 4. doi: 10.7759/cureus.26556.
7. Isley MR, Edmonds HL, Stecker M. Guidelines for intraoperative neuromonitoring using raw (analog or digital waveforms) and quantitative electroencephalography: a position statement by the American Society of Neurophysiological Monitoring. J Clin Monit Comput. 2009 Dec 16;23(6):369–90. doi: 10.1007/s10877-009-9191-y. PMID: 19757102.
8. Jovanovic A, Jonsson M, Roy J, Eriksson J, Mutavdzic P, Trailovic R, et al. Comparison of methods for monitoring intra-operative cerebral perfusion in patients undergoing carotid endarterectomy with selective shunting: a systematic review and network meta-analysis of randomised controlled trials and cohort studies. Eur J Vasc Endovasc Surg. 2023 Feb;65(2):233–43. doi: 10.1016/j.ejvs.2022.08.025. PMID: 38807326.
9. Thiagarajan K, Cheng HL, Huang JE, Natarajan P, Crammond DJ, Balzer JR, et al. Is two really better than one? Examining the superiority of dual modality neurophysiological monitoring during carotid endarterectomy: a meta-analysis. World Neurosurg. 2015 Dec;84(6):1941-1949.e1. doi: 10.1016/j.wneu.2015.08.040. PMID: 26341440.
10. Gertsch JH, Moreira JJ, Lee GR, Hastings JD, Ritzl E, Eccher MA, et al. Practice guidelines for the supervising professional: intraoperative neurophysiological monitoring. J Clin Monit Comput. 2019 Apr 30;33(2):175–83. doi: 10.1007/s10877-018-0201-9. PMID: 30374759; PMCID: PMC6420431.