

ABSTRACT

Objective : Intraoperative neurophysiological monitoring(IONM), particularly of somatosensory evoked potentials(SSEP) and motor evoked potentials(MEP), is a technique used to predict and prevent neurologic injury during clipping surgery of intracranial unruptured aneurysms. This study was designed to evaluate the effectiveness of applying SSEP with and without MEP monitoring during aneurysm Methods : We retrospectively surgery. reviewed the clinical and intraoperative monitoring records of 94 patients who underwent SSEP and combined SSEP with MEP at our hospital from March 2020 to March 2023. The inhalation anesthesia was SSEP monitoring, and the used for intravenous anesthesia was used for SSEP with MEP monitoring. We compared the clinical outcome, time from drug stop to extubation and economic impact of such monitoring modalities in each patient respectively. Results : There was no significant difference in postoperative deficits, sensitivity, specificity, and accuracy. The time from drug stop to extubation was shorter after the inhalation anesthesia with SSEP(14.87±6.22) compared to the intravenous anesthesia with SSEP and MEP (20.17 ± 7.46) , showing a significant difference (p-value<0.001). Based on IONM time per surgery, in the case of using SSEP monitoring alone, we calculated that each patient saves an average of 131.2 dollars. Conclusion : This study demonstrates that SSEP without MEP after aneurysm surgery lead to shorter time from drug stop to extubation and reduce the cost of treatment without compromising the quality of patients care.

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INTRODUCTION

Brain aneurysm (cerebral aneurysm) refers to the ballooning of the wall of a blood vessel in the brain and the formation of a space within another blood vessel as a result of the impairment and weakening of the internal elastic layer and the medial layer in the internal part of the cerebral artery. Once a ruptured brain aneurysm occurs, the hemorrhage itself stimulates the cerebral meninges and causes symptoms like nausea and vomiting. There mainly are two methods for treating brain aneurysm: brain aneurysm clipping and intravascular coil embolization. Intraoperative neurophysiological monitoring (IONM) refers to the procedures used during surgery for conducting neurophysiological tests to prevent the nervous system from being impaired. However, the preciseness and necessity of IONM in brain aneurysm clipping are debatable.

According to the data on the medical care expenses paid by the insurer announced by the Korean Ministry of Health and Welfare, the medical care expense in cases where only one type of IONM is used is calculated at USD 80.83 per hour, whereas it is calculated at USD 107.68 per hour in cases where more than 2 types of tests are administered simultaneously. This study seeks to compare and analyze the patients' postoperative outcomes in cases (i) where an SSEP test is conducted exclusively and (ii) where an SSEP test and an MEP test are administered simultaneously when performing unruptured brain aneurysm clipping, and to verify the non-inferiority of the exclusive administration of an SSEP test. Additionally, by comparing the economic effects of the two test methods mentioned above on the patients and the duration of postoperative recovery from anesthesia, this study seeks to prove the economic and clinical usefulness of the exclusive administration of an SSEP test.

METHODS AND MATERIALS

Patient

We retrospectively reviewed the clinical and intraoperative monitoring records of 94 patients who underwent surgical clipping under MEP and SSEP monitoring at our hospital from March 2020 to March 2023. The baseline characteristics of the patients and aneurysms are summarized in Table 1. This study was approved by the institutional review board for retrospective review of clinical outcomes. Neurophysiologic Monitoring

MEP was produced by a repetitive train of 5 pulses delivered at 250~400V to C3, C4 sites on the basis of the International 10-20 system of electrode placement. MEP was recorded by twisted-pair needle electrodes at abductor pollicis brevis and abductor halluces muscles. SSEP were elicited by patch electrodes placed at the median and tibial nerves with rectangle pulses. SSEP were recorded via C3/C4 for the upper extremities and Cz/Fz for the lower extremities following continuous interleave stimulation at minimal stimulus intensity.

statistical analysis

All data are presented as mean \pm standard deviation (SD) for continuous variables or number (percentage) for categorical variables. Independent two sample t-test was used to compare differences in continuous variables between SSEP only and SSEP with MEP groups. All statistical analyses were conducted using R software (version 4.1.3; R Foundation for Statistical Computing, Vienna, Austria). The significance level was set at p < 0.05.

Benefit of Intraoperative Somatosensory Evoked Potentials without Motor Evoked Potentials in Unruptured Cerebral Aneurysm Clipping

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RESULTS

variable	SSEP only	SSEP with MEP	p-value
patients, n	47	47	
Sex, n(%)			0.818
Male	12 (25.5%)	14 (29.8%)	
Female	35 (74.5%)	33 (70.2%)	
Mean age±SD (range)	59.6 ± 8.8 (33.0, 75.0)	60.9 <u>+</u> 9.7 (38.0 <i>,</i> 76.0)	0.479
Mean BMI±SD (range)	24.5 ± 2.8 (18.9, 30.8)	24.6 ± 3.8 (18.3, 34.7)	0.871
Location of aneurysm, n(%)			0.007
ICA	14 (28.0%)	3 (6.0%)	
MCA	21 (42.0%)	34 (68.0%)	
ACA	13 (26.0%)	7 (14.0%)	
PCA	2 (4.0%)	6 (12.0%)	
Number of aneurysm, n(%)			>0.999
Single	44 (93.6%)	44 (93.6%)	
Multiple	3 (6.4%)	3 (6.4%)	
Median aneurysm diameter ±SD(range), mm	4.2 ± 1.8 (1.0, 9.1)	4.8 ± 2.4 (1.9, 13.8)	0.200

Table 1. Patient characteristics

n, number; SSEP, somatosensory evoked potentials; MEP, motor evoked potentials; ICA, internal carotid artery; MCA, middle cerebral artery; ACA, anterior cerebral artery; PCA, posterior cerebral artery

RESULTS

Postoperative Outcome and Diagnostic performance

	SSEP only	SSEP with MEP	p-value
post-OP deficits, n(%)	4 (8.5%) - 2 infraction - 2 ischemia	2 (4.3%) - 1 anemia - 1 hyponatremia	0.673

Table 2. Patient outcome comparison with or without MEP SSEP, somatosensory evoked potentials; MEP, motor evoked potentials

	SSEP only	SSEP with MEP	p-value
Sensitivity	0.750 (0.194, 0.994)	0.500 (0.013, 0.987)	0.540
Specificity	0.930 (0.809, 0.985)	0.911 (0.788, 0.975)	0.740
PPV	0.500 (0.118, 0.882)	0.200 (0.005, 0.716)	0.303
NPV	0.976 (0.871, 0.999)	0.976 (0.874, 0.999)	0.986
Accuracy	0.915 (0.796, 0.976)	0.894 (0.769, 0.965)	0.726

Table 3. Diagnostic performance comparison with or without MEP SSEP, somatosensory evoked potentials; MEP, motor evoked potentials; PPV, positive predictive value; NPV, negative predictive value

* However, as the frequency of the occurrence of false positive and false negative was low, there existed no statistically significant difference between the two groups.



Figure 1. Drug stop to extubation time comparison

The extubation time of the group of patients on whom SSEP test was conducted exclusively and sevoflurane inhalation anesthesia was used was 14.87±6.22 (min), while the extubation time of the group of patients on whom SSEP test and MEP test were conducted simultaneously and total intravenous anesthesia (TIVA) was used was 20.17±7.46 (min). There existed a statistically significant difference between the two groups in terms of extubation time (p<0.001).

RESULTS

Economic Effect						
	Cost per hour	Total	Difference			
SSEP only	\$80.83	\$323.32	\$107.40			
SSEP with MEP	\$107.68	\$430.72				

Table 4. Economic summary

According to the data on the medical care expenses paid in South Korea in 2023, the expense for IONM is calculated at USD 80.83 in cases where only one (1) type of test is conducted, and at USD 107.68 in cases where two (2) or more types of tests are conducted simultaneously. While the expense is calculated on a per-hour basis, the calculation is limited to eight (8) hours at the longest. In the case of brain aneurysm clippings conducted at Severance Hospital, the duration of IONM was 246.7 ± 58.6 (min), which is similar to the average duration of IONM per surgery (4.3 hours) that is commonly known. Therefore, out of the expenses for a brain aneurysm clipping that need to be paid by the patient, the expense for IONM was USD 323.32 in cases where SSEP test was conducted exclusively, while it was USD 430.72 in cases where SSEP test and MEP test were conducted simultaneously. Even when the type of surgery was the same, there was a difference of USD 107.40 depending on the type of the test administered during the IONM process.

DISCUSSION

Side effects of MEP test

- 1. Unpredictable movement of the patient caused by electrical stimulation
- Epileptic seizure might take place on very rare occasions
- 3. An electrical burn might also occur
- Patient might bite their tongue due to the contraction of their jaw muscle



Figure 2. (A) Indocyanine green video angiography (B) microvascular Doppler ultrasonography in clipping

In the process of conducting intraoperative monitoring while performing brain aneurysm clipping, in addition to IONM which reflects the patient's electrophysiological condition, the safety of the patient can be better ensured by using microvascular Doppler ultrasonography and indocyanine green video angiography (ICG-VA) that help to identify the blood flow in the parent artery and the main bifurcation.

CONCLUSIONS

- 1. In this study, 94 patients on whom brain aneurysm clipping was conducted from March 2020 to March 2023 at Severance Hospital were divided into two (2) groups as follows: (i) the group of patients on whom SSEP test was conducted exclusively, and (ii) the group of patients on whom SSEP test and MEP test were conducted simultaneously during the IONM process.
- 2. This study identified the clinical usefulness of IONM even when SSEP test is conducted exclusively when performing brain aneurysm clipping, by comparing the differences in drug stop-to-extubation time and medical expenses between cases where SSEP test is conducted exclusively and cases where SSEP test and MEP test are conducted simultaneously.

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