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# Comparison of Relevance in Patient Status Index (Psi) And Spectral Edge Frequency (Sef) With End-Expiratory Sevoflurane Concentration (Etsev) During General Anesthesia Surgery

**Kai Qin[1], Guanzhu Li[2], Gaofeng Zhao[3], Jinhe Deng[4]***

[1]*Department of Anesthesiology, Guangdong Provincial Hospital of Traditional Chinese Medicine, China.*

[2]*The second affiliated hospital of Guangzhou University of Chinese Medicine, Guangzhou, China.*

[3]*Guangdong Provincial Hospital of Traditional Chinese Medicine, China*

***Corresponding Author**
Jinhe Deng, Guangdong Provincial Hospital of Traditional Chinese Medicine, China

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## Abstract

***Objective***. *To investigate the correlation between PSI, SEF and ETSEV in patients undergoing general anesthesia.*

***Methods.*** *In this study, 26 general anesthesia patients (11 males and 15 females, aged 21-70 years, ASA I-III) underwent lower extremity orthopedic surgery were selected. PSI, SEF, and ETSEV were recorded by Sedline brain function monitor and PHILIPS MP20 monitor, respectively, and the difference between SEF-L and SEF-R ΔSEF was calculated. Spearman correlation analysis was used for the correlation between PSI, SEF and ETSEV, and Bland-Altman was used to analyze the consistency of SEF-L and SEF-R.*

***Results.*** *Spearman correlation analysis showed that PSI (r=-0.401, P=0.001), SEF-L (r=-0.705, P=0.000), and SEF-R (r=-0.635, P=0.000) were all negatively correlated with ETSEV, and SEF was more strongly correlated with ETSEV compared to PSI. Bland-Altman analysis showed that there were 2 points outside the limits of agreement between SEF-L and SEF-R, and SEF-L remained in agreement with SEF-R.*

***Conclusion.*** *Under sevoflurane-maintained general anesthesia, SEF was more responsive to intraoperative depth of anesthesia changes in patients, and left and right brain SEF remained consistent.*

**Keywords:** PSI, SEF, ETSEV, GA

## Introduction

Intraoperative awareness is a serious complication of general anesthesia, and efforts should be made to avoid it. Currently, clinical depth of anesthesia monitoring is mostly performed by using Bispectral index (BIS), auditory evoked potentials (AEP), anesthesia trend index (NI) and patient status index (PSI) to preventintraoperative awareness [1, 2]. However, both BIS, AEP, NI, and PSI have large variability, and some studies have concluded that the above methods of anesthesia depth monitoring have many interfering factors and delayed display of EEG index data, so the anesthesiologists can judge the depth of anesthesia only by the above methods are not completely reliable [3, 4]. At present, the spectral edge frequency (SEF) displayed by the new brain function monitor is the result index after the computer frequency domain analysis processing, and also can display the patient's original brain wave data. It can better reflect the sedative effect of anesthetic drugs and intraoperative maintenance of anesthetic depth, and has good correlation with the blood concentration of many anesthetic drugs and intraoperative anesthetic depth [5]. Therefore, this study intends to investigate and compare the correlation between the state index and spectral rim frequency and the change of sevoflurane concentration at the end of expiration, as well as to analyze the consistency of the left and right brain rim frequencies for clinical reference.

## 1. Materials and Methods

**1.1 General Information** This study was approved by the hospital ethics committee and the patient or authorized family signed an informed consent form. Patients undergoing lower limb orthopedic surgery under general anesthesia from July 2020 to July 2021 at the

Second Affiliated Hospital of Guangzhou University of Traditional Chinese Medicine - Guangdong Provincial Hospital of Traditional Chinese Medicine, who required continuous intraoperative EEG monitoring, were selected, regardless of gender, aged 21-70 years, and ASA class I-III. Exclusion criteria: emergency surgery, cardiothoracic surgery, neurosurgery and brain surgery, patients with a history of psychiatric disorders, brain disorders.

**1.2 Anesthesia Method** BP, ECG, SpO2, and EEG were monitored after admission. Anesthesia induction: anesthesia was induced with sevoflurane. After 10min of baseline (awake) recording, the concentration of end-expiratory sevoflurane was increased and gradually increased to subanesthesia (1.1%), general anesthesia (2.1%), and deep anesthesia (2.8%). After induction, endotracheal intubation was performed under visual laryngoscope. Anesthesia maintenance: the depth of anesthesia was still maintained with sevoflurane at 1.1% to 2.8% concentration before surgical resection. After surgical resection, sevoflurane at 1.1% to 2.8% concentration and reifentanil at 0.1-0.2ug/kg/min. Propofol 2.0-3.0mg/kg/h, Sufentanil (0.5ug/kg) and rocuronium bromide (0.1mg/kg) were added according to surgical requirements.

**1.3 Observation Indicators** ETSEV, PSI and SEF from anesthesia induction to incision.

**1.4 Statistical Analysis** SPSS 25.0 statistical software was used for statistical analysis. The measurement data of normal distribution were expressed as mean ± standard deviation, the measurement data of skewness distribution was expressed as median (interquartile), and the count data was expressed as rate. Spearman correlation analysis was used for the correlation between PSI, SEF and ETSEV, and Bland-Altman was used to analyze the consistency of SEF-L and SEF-R. $P<0.05$ was considered statistically significant.

## 2.Results

**2.1** The study finally included 26 patients undergoing general anesthesia for elective lower extremity orthopedic surgery, of which 10 patients had complete PSI, SEF, and ETSEV at the time of anesthesia induction to surgical skin incision, and the correlation analysis of PSI, SEF, and ETSEV and the concordance analysis of SEF-L and SEF-R were performed on the data of the 10 patients. The general conditions of the patients were as follows (Table 1).

| **Variable** | | |
|---|---|---|
| age | 62±10.75 | |
| gender | male | 42.3% |
| | female | 57.7% |
| comorbidity | non | 61.5 |
| | hypertension | 34.6% |
| | diabetes | 3.9% |
| operation type | TKA | 65.4% |
| | KA | 15.4 |
| | THA | 3.9% |
| | LTS | 15.3% |
| *The continuous normal distribution variables were expressed as mean ± standard deviation, and the continuous skewness distribution data were expressed as median (interquartile distance). Binary variables are expressed as rates. | | |

**Table 1 Demographic data**

**2.2** Spearman's correlation analysis showed that PSI, SEF-L, and SEF-R were all correlated with ETSEV, and SEF was more strongly correlated with ETSEV compared with PSI (Table 2).

| **Variable** | **r** | **p** |
|---|---|---|
| PSI | -0.401 | 0.001 |
| SEF-L | -0.705 | 0.000 |
| SEF-R | -0.635 | 0.000 |

**Table 2 Spearman correlation analysis**

**2.3** Scatter plot of PSI, SEF-L, SEF-R and ETSEV correlation (Figure 1, Figure 2, Figure 3).

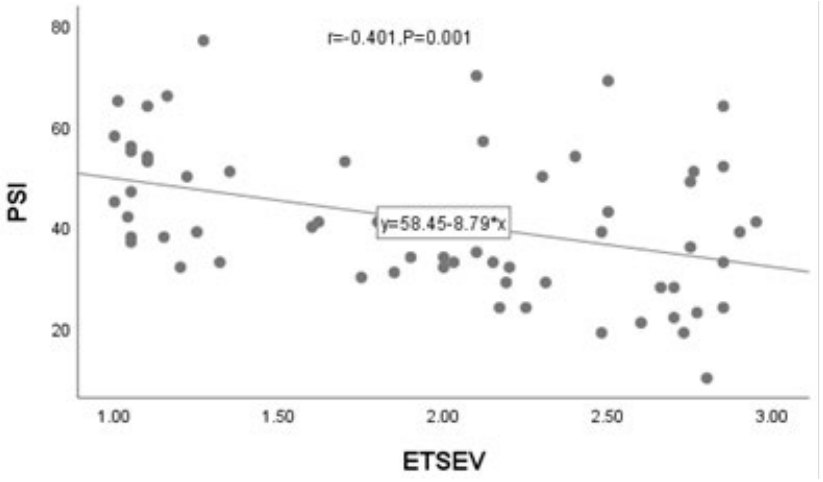


**Figure 1:** Scatter plot of PSI and ETSEV correlation

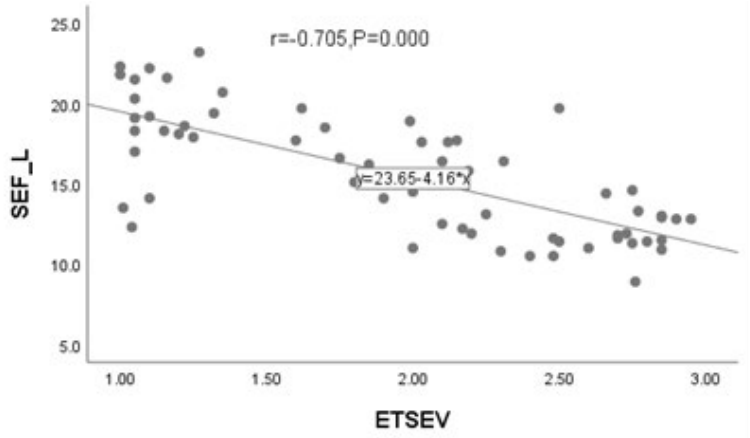


**Figure 2:** Scatter plot of SEF-L and ETSEV correlation

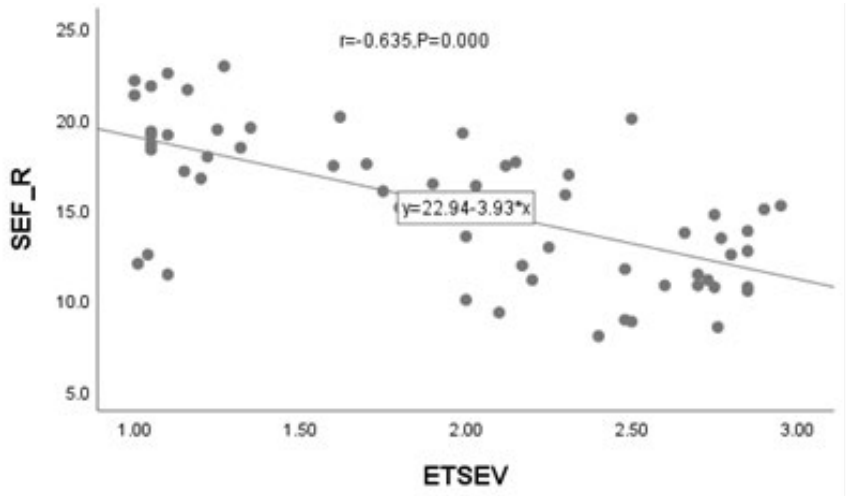


**Figure 3:** Scatter plot of SEF-R and ETSEV correlation

**2.4** Bland-Altman analysis showed that there were 2 points outside the limits of agreement between SEF-L and SEF-R, and SEF-L remained in agreement with SEF-R (Figure 4).

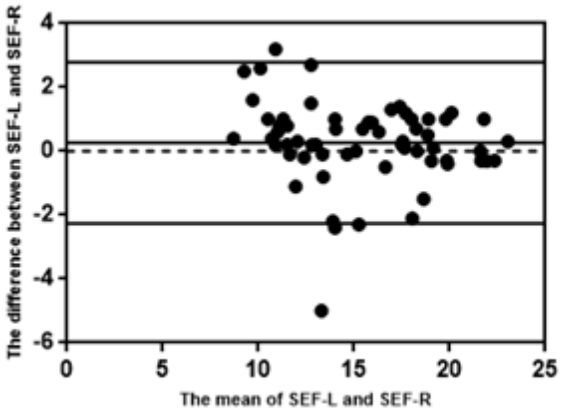


**Figure 4:** Consistency test of SEF-L and SEF-R

## 3.Discussion

The human brain cells can carry out spontaneous, rhythmic, and comprehensive electrical activity. The waveform generated by recording the potential of this electrical activity over time is called an electroencephalogram (EEG) [6, 7]. The dendrites of pyramidal neurons in the cerebral cortex are parallel to each other and perpendicular to the cortical surface, thus facilitating the generation of a large local potential field that can be measured through the skull and scalp, which is the EEG displayed on the brain function monitor in the clinic [8, 9]. EEG data on the scalp shows the status of the cerebral cortex and subcortical structures, so anesthesiologists also often use EEG monitoring to understand the changes in intraoperative brain status, and EEG data also showed changes in the depth of anesthesia [10-12]. The Patient State Index PSI and SEF are also used clinically to monitor the depth of anesthesia intraoperatively.

Human brain cells can carry out spontaneous, rhythmic and comprehensive electrical activity. The wave pattern generated by recording the change of the potential of this electrical activity over time is called electroencephalogram (EEG) [6, 7]. The dendrites of pyramidal neurons in the cerebral cortex are parallel to each other and perpendicular to the cortical surface, thus facilitating the production of a large local potential field that can be measured by the skull and scalp, which is the EEG shown on a clinical brain function monitor [8, 9]. EEG data on the scalp show the state of the cerebral cortex and subcortical structures, so anesthesiologists often use EEG monitoring to understand changes in the state of the brain, and EEG data also showed changes in the depth of anesthesia [10-12]. Currently, patient status index (PSI) and spectral margin frequency (SEF) are also used to monitor the depth of anesthesia during surgery.

The results of this study showed that PSI and SEF both changed with ETSEV. As the ETSEV increased, the values of SEF and PSI decreased, suggesting deeper anesthesia and a negative linear regression relationship with both ETSEV. The results of this study demonstrated that PSI and SEF can respond to the role of the anesthetic drug sevoflurane in intraoperative sedation and maintenance of depth of anesthesia, providing clinical reference for anesthesiologists.

The PSI is only an EEG result generated after time-domain analysis. The PSI ranges from 0-100, and fluctuations in the range of 25-50 are generally normal, so it is possible to assess the depth of anesthesia to some extent. However, some studies have been shown [13,14] that this monitoring index is susceptible to the influence of age and brain development, especially in pediatric patients where the value fluctuates widely and is prone to delay. Therefore, in some specific patients this value does not better reflect the patient's depth of anesthesia.

The SEF is the result of frequency domain analysis on the basis of the original EEG, responding to 95% of the patient's total EEG power below a certain frequency value. Compared to the original EEG, SEF simplifies the form of power variation of various waves in the range of 0-30 Hz. The smaller the value of SEF suggests that 95% of the total EEG power is concentrated in the low-frequency region and the depth of anesthesia deepens, and vice versa [15, 16]. It has been shown that SEF is not influenced by age and brain development, can more accurately and visually reflect EEG changes, correlates with the blood concentration of various anesthetic drugs, and can better reflect the intraoperative role of anesthetic drugs in maintaining the depth of anesthesia [17, 18].

The results of this study showed that both SEF and PSI were negatively correlated with ETSEV, and the absolute value of the correlation coefficient was higher for SEF, demonstrating that SEF is more responsive to sevoflurane than PSI in maintaining depth of anesthesia. Meanwhile, the results of Bland-Altman consistency test showed that the SEF-L and SEF-R were consistent, indicating that there was no difference between the SEF of the left and right brain in indicating the depth of anesthesia of the patients, and both of them could reflect the sedative effect of sevoflurane.

However, there are some shortcomings in this study. Intraoperative anesthesia depth monitoring is influenced by a variety of factors other than age and brain developmental status. And some special surgical patients, such as emergency surgery, neurosurgical brain surgery or patients with psychiatric disorders, can also affect anesthesia depth, so such patients were excluded from this study. Also, the number of cases selected for inclusion in this study was small, and the sample size for statistical analysis as completed data was also small, which may cause a large error in the trial results. Furthermore, only patients with general anesthesia for lower extremity surgery were included in this study, and the type of surgery was relatively homogeneous, which may also lead to test bias

## 4.Conclusion

Under general anesthesia maintained by sevoflurane, SEF is more responsive to intraoperative anesthetic depth changes in patients than PSI, and the left and right brain SEFs remain consistent, which can provide a reference for clinical anesthesiologists to effectively monitor intraoperative anesthetic depth.


## 5.Acknowledgments

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## 6.Statements & Declarations

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## Reference


1. Müller-Putz, G. R. (2020). Electroencephalography. Handbook of Clinical Neurology, 168, 249-262.
2. Purdon, P. L., Sampson, A., Pavone, K. J., & Brown, E. N. (2015). Clinical electroencephalography for anesthesiologists: part I: background and basic signatures. Anesthesiology, 123(4), 937-960.
3. Roche, D., & Mahon, P. (2021). Depth of anesthesia monitoring. Anesthesiology Clinics, 39(3), 477-492.
4. Weyer, C., Prötzl, E., Kinateder, T., Nowak, F., Husemann, C., Hautmann, H., ... & Kreuzer, M. (2021). The strength of alpha oscillations in the electroencephalogram differently affects algorithms used for anesthesia monitoring. Anesthesia & Analgesia, 133(6), 1577-1587.
5. Sawa, T., Yamada, T., & Obata, Y. (2022). Power spectrum and spectrogram of EEG analysis during general anesthesia: Python-based computer programming analysis. Journal of Clinical Monitoring and Computing, 1-13.
6. Jamali, S., & Ross, B. (2013). Somatotopic finger mapping using MEG: Toward an optimal stimulation paradigm. Clinical Neurophysiology, 124(8), 1659-1670.
7. Omejc, N., Rojc, B., Battaglini, P. P., & Marusic, U. (2019). Review of the therapeutic neurofeedback method using electroencephalography: EEG Neurofeedback. Bosnian journal of basic medical sciences, 19(3), 213.
8. Xue, J. (2021). EEG Analysis with Wavelet transform under music perception stimulation. Journal of Healthcare Engineering, 2021.
9. Rokos, A., Mišić, B., Berkun, K., Duclos, C., Tarnal, V., Janke, E., ... & Blain-Moraes, S. (2021). Distinct and dissociable EEG networks are associated with recovery of cognitive function following anesthesia-induced unconsciousness. Frontiers in Human Neuroscience, 15, 530.
10. Lewis, S. R., Pritchard, M. W., Fawcett, L. J., & Punjasawadwong, Y. (2019). Bispectral index for improving intraoperative awareness and early postoperative recovery in adults. Cochrane Database of Systematic Reviews, (9).
11. Chhabra, A., Subramaniam, R., Srivastava, A., Prabhakar, H., Kalaivani, M., & Paranjape, S. (2016). Spectral entropy monitoring for adults and children undergoing general anaesthesia. Cochrane Database of Systematic Reviews, (3).
12. Craik, A., He, Y., & Contreras-Vidal, J. L. (2019). Deep learning for electroencephalogram (EEG) classification tasks: a review. Journal of neural engineering, 16(3), 031001.
13. Wang, E., Wang, L., Ye, C., Luo, N., Zhang, Y., Zhong, Y., ... & eMODIPOD Research Group. (2022). Effect of electroencephalography spectral edge frequency (SEF) and patient state index (PSI)-guided propofol-remifentanil anesthesia on delirium after laparoscopic surgery: the eMODIPOD randomized controlled trial. Journal of Neurosurgical Anesthesiology, 34(2), 183-192.
14. Koch, S., Windmann, V., Chakravarty, S., Kruppa, J., Yürek, F., Brown, E. N., ... & Spies, C. (2021). Perioperative electroencephalogram spectral dynamics related to postoperative delirium in older patients. Anesthesia & Analgesia, 133(6), 1598-1607.
15. Jildenstål, P., Bäckström, A., Hedman, K., & Warrén-Stomberg, M. (2022). Spectral edge frequency during general anaesthesia: A narrative literature review. Journal of International Medical Research, 50(8), 03000605221118682.
16. Fischer, I. W., Hansen, T. M., Lelic, D., Brokjaer, A., Frøkjær, J., Christrup, L. L., & Olesen, A. E. (2017). Objective methods for the assessment of the spinal and supraspinal effects of opioids. Scandinavian Journal of Pain, 14(1), 15-24.
17. Mirra, A., Casoni, D., Barge, P., Hight, D., Levionnois, O., & Spadavecchia, C. (2022). Usability of the SedLine® electroencephalographic monitor of depth of anaesthesia in pigs: a pilot study. Journal of clinical monitoring and computing, 36(6), 1635-1646.
18. Shirozu, K., Nobukuni, K., Tsumura, S., Imura, K., Nakashima, K., Takamori, S., ... & Yamaura, K. (2022). Neurological sedative indicators during general anesthesia with remimazolam. Journal of Anesthesia, 36(2), 194-200.