Development of anesthesia depth index using SEF, BDR and BTR

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Abstract—Monitoring of depth of anesthesia is an ongoing problem in anesthesia. In this paper, using SEF, BDR, BTR parameters which is calculated by power spectral density. EEG data were obtained from 7 patients (ASA I, II) during general anesthesia with sevoflurane. The anesthetic depth evaluation index algorism was embodied to obtain a quantified index with the scale of 0 to 100. Then quantified index could be obtained from the patients under analysis: the average was 86.05, 36.98, 15.33 and 87.72 for the states of pre-operation, induction of anesthesia, operation and post-operation, respectively.

The results show that when evaluating the depth of anesthesia, more quantified information can be provided for anesthesia doctors, rather than depending solely on their subjective evaluation, achieving the effect of establishing safer environment for surgery.

Key- Words: Anesthesia, monitoring, power spectral density, EEG

1 Introduction
Anesthesia is essential to prevent pain or distress in patients. But some patients are inclined to have uncomfortable experience due to the awakening with or without pain during anesthesia. It is indispensable to evaluate the depth of anesthesia during a surgical operation not to be influenced from it. There have been immense researches in medicine, especially in the field of an anesthesia to seek the safe anesthetic level. EEG and esophagus contraction was used for depth of anesthesia. However, objective method has not been developed. Therefore, development of standardized index is necessary for discovered in the early awakening.

In this study, we want to develop the depth of anesthesia index using the SEF, BTR, BDR used each frequency power-spectrum phases.

2 Method of research

2.1 Data Acquisition
After obtaining approval by the ethics committee and informed written consent, we studied 12 ASA 1 or 2 adult patients.

We measured the EEG signal of patients who had a short time operation and in inhalation in Gynecology, Pusan national university hospital. We also were approved by them about this experiment. The average age of the patients was 47.7 ± 9.1 years, the average weight was 70.7 ± 10.5 kg. To acquiring EEG signal, we used the measurement of bio-signal, that is PhysioLab 400 and electrode attachment method at frontal lobe for measuring EEG signal.

2.2 Development of anesthesia depth index using power spectrum analysis
To transform EEG data to frequency domain using the PSD during operation, fast fourier transform(FFT) was performed. Main frequency band concentrated energy among EEG bands is from 1 to 35Hz. A various component ratio of EEG energy bands was calculated. In clinical, the EEG includes the characteristic of various signals. In order to analyze this data for estimation of anesthesia index, we find anesthesia parameters and check the parameter's data and compare. Parameters of this study are SEF, BTR and BFR. We estimated anesthesia depth parameters using these parameters. SEF, BTR and BDR obtain expression is shown below.

\[ BTR = \frac{\beta \text{ ratio}}{\theta \text{ ratio}} \times 100 \]

TP(total power) is amplitude of total PSD of EEG, 95% SEF is the frequency below 95% of the total power.

\[ 95\% \ SEF > \frac{TP}{100} \times 95 \]

BTR showed the correlation between beta ratio and theta ratio.
\[ \text{BDR} = \frac{\beta \text{ ratio}}{\delta \text{ ratio}} \times 100 \]  

(3)

BDR showed the correlation between beta ratio and delta ratio.

2.3 Depth of anesthesia index classifier

The structure that estimates anesthesia depth using SEF, BTR, BDR showed fig. 1. At first, set the TH1 and TH_1 of SEF. Next set the TH2 and TH_2 of BTR. Finally set the TH3 and TH_3 of BTR. We obtained index value of A, B and C applied these three phases. In order to calculate final anesthesia depth index, we multiply 40%, 30% and 30% of App. Ratio values each index value. The depth of anesthesia index consists of 0-100 step value.

![Fig. 1. Structure of anesthesia depth classifier.](image)

3 Result

EEG data were performed to anesthesia depth classifier and the results were showed at Fig. 2 and Fig.3.

![Fig.2. Anesthesia index of the patient A according to time.](image)

Results of experiment of EEG data obtained from 7 patients appear in Table 1. In pre-operation, It is between maximum index 98.14 and minimum index 72.71. The average is 86.05. In anesthesia induction, it is widely between maximum index 78.96 and minimum index 17.79. The average is 36.98. We think that this phenomenon is complexed data after perfect anesthesia because the EEG measurement time which is within 5 min is so short. When the anesthesia induction, it is through to complexed phenomenon about reflex response and compensatory hyperfunction of an autonomic nervous system through the input of drugs and intubation.

In operation, the other words perfect anesthesia, it is between maximum index 41.99 and minimum index 3.37. The average is 15.33. Therefore, in operation, estimate the depth of anesthesia index change is a little wide. But the index which is under 42 can separate other estimate the depth of anesthesia index of anesthesia steps. In awaked, it is between maximum index 75.53 and minimum index 25.13. The average is 50.88. This result of anesthesia induction and each patient is different. But almost similar distribution. This result is influenced by estimate the depth of anesthesia index because anesthetic drugs block and tension of neural-muscle after extubation and reflex response is increase. Also Beta wave of EEG signals increasing is reason. In post-operation, it is between maximum index 98.20 and minimum index 61.45. The
average is 87.72. This patient's change aspects is different. But it is almost similar distribution to pre-operation.

4 Conclusions

We insert parameters of SEF, BTR, BDR into the estimated depth of anesthesia index and find estimated depth of anesthesia index each anesthesia steps. We implement the analyzer of the estimated depth of anesthesia index using 0-100 steps. For verifying analyzer of the estimated depth of anesthesia index, we found the estimated depth of anesthesia index each steps using EEG signals that obtained by 7 subjects. The result average of pre-operation is 86.05. In post-operation, the average is 87.72 and 36.98 in anesthesia induction and 15.33 in operation and 50.88 in the recovery of anesthesia. If index value is over 80 by the estimated depth of anesthesia index analyzer, we can think awakening. In operation index is around 10~20 and around 25~40 in anesthesia induction and around 25~70 in the recovery of anesthesia.

5 Acknowledgment

This work was supported by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government(MOST)(No. R01-2007-000-20260-0).

References: