Comparison of heart rate variability with pulse transit time during general anesthesia

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Abstract: - The relation between stiffness of the blood vessel and ANS (autonomic nervous system) is observed by comparing the distribution of the PSD and the change of the PTT appeared the stiffness of the blood vessel at the pre-anesthesia, sevoflurane anaesthesia and intubation after states. In this paper, PSD of the HRV well-known of the index of the ANS activity reflected the ANS activity according to anesthesia stages. Effect of LF during the anesthesia is similar to PTT changes. This means that PTT analysis is useful index reflecting the body state because of well appearing the ANS activity during sevoflurane anesthesia. And this analysis is useful because the calculating method is simple and time is short compare with the method of HRV PSD.

Key-Words: Pulse transit time, Power spectral density, Autonomic nervous system, Heart rate variability, Sevoflurane, anesthesia

1 Introduction

The anesthesia is composed of unconsciousness, analgesia (pain relief), amnesia (loss of memory) and immobilization[1],[2]. This is appeared that anesthetic drugs reach brain through the circulation and block the central nervous system. It has profound effects on a patient's physiology due to the general effects on central nervous system as well as specific effects on all other body systems[3]. Thus, 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.

In order to objectively estimate the awakening, we need to monitor the autonomic nervous activity about external stimulation.

If the sympathetic nerves distributed at heart are exciting, heart rate and the power of muscle extraction will increase. However, if parasympathetic nerves are inhabited, heart rate and the power of muscle extraction will decrease. Autonomic nervous system increase heart rate as a result of sympathetic nerve activation about external stimulation during operation. This is useful information for monitoring patients. Also the assessment of arterial stiffness is clinically significant owing to its association with systolic hypertension and with excess morbidity and mortality during operation[4]. In order to estimate arterial stiffness, we used pulse transit time(PTT)[5]. PTT which is the interval between two pulse waves propagating on the same cardiac cycle from separate arterial sites, is a function of intravascular pressure and the physical characteristics of both the blood vessel and blood.

In this paper, we are intended to estimate the relation between PTT and sympathetic nervous activity of autonomic nervous system. We observed the relation
between arterial stiffness and autonomous nervous system comparing PTT change and power spectral density of heart rate variability (HRV) at pre-anesthesia, maintenance and after intubation[6].

2 Materials and Methods

2.1 Subjects

After obtaining approval by the ethics committee and informed written consent, we studied 12 ASA I or II adult patients. Patients with history of dementia and neurological disorder are excluded. 10 healthy person (ASA I or II) were between the ages of 18 and 63 years (mean 22.5 years). Mean weight was 63.7 kg.

The stage anesthesia is as followed. Pre-operation, Sevo 1.0, Sevo 2.0, Sevo 3.0, Sevo 4.0 and after intubation. Patients were premedicated with glycopyrrolate 0.004 mg/kg and midazolam 0.05 mg/kg, roughly 1-2 hr preoperatively. In this paper, we used a small dose of premedication or none. That means that effect of premedication was excluded.

2.2 Data acquisition and analysis

Continuous three-lead ECG and photoplethysmotraphy (PPG) (obtained from an index finger) data were acquired from Physiolab P400 (Physiolab Co., Korea) Bio-amp. The data were digitized at a sampling rate of 512 samples/s and stored on a PC computer for later off-line analysis PTT and RR interval.

The rPTT and RR-int were calculated off-line from the raw ECG and PPG data using Matlab (version 7.0.1) computational data analysis software. rPTT was measured as the interval between the peak in the R-wave on the ECG to the maximum upslope of the PPG from the same cardiac cycle in Fig. 1. Fig. 1 (a) is ECG signal and (b) is PPG. PTT_{PPG} is interval between R peak of ECG and maximum upslope of the PPG.

Plots of the detected R-wave peaks and PPG upstrokes for each cardiac cycle were superimposed in the ECG and PPG traces for each subject. Visual inspection of these graphs confirmed the accuracy of the R-wave and PPG detection algorithm.

2.3 PSD of HRV

We detected R peak from ECG during pre-anesthesia and operation.

The power spectra of 512 RR intervals were obtained by means of fast Fourier transformation[4]. The direct current component was excluded in the calculation of power spectrum to remove the nonharmonic components in the low-frequency region (<0.04 Hz). The area of spectral peaks within the whole range of 0 to 0.4 Hz was defined as total power, the area of spectral peaks within the range of 0 to 0.15 Hz as low frequency power, and the area of spectral peaks within the range of 0.15 to 0.40 Hz as high frequency power, respectively. The normalized high frequency power (= 100 × high frequency power/total power) was used as an index of modulation of vagal activity; the normalized low frequency power (= 100 × low frequency power/total power) as an index of sympathetic modulation; and the low/high frequency power ratio (= low frequency/high frequency power) as the index of sympathovagal balance[7],[8].

3 Results

Fig.1 showed the result of PTT from patient of sevoflurane anesthesia.

PTT, low frequency (LF), HF (high frequency), LF/HF ratio was calculated at each stage such as pre-anesthesia (Pre.) stage, concentration stage of sevoflurane according to density from 1.0 to 4.0 and after intubation.

Average of PTT on one person is as follow. At Pre. stage, the value is 334.46 ± 14.59, at sevo 1.0 the value is 365.9 ± 5.11, at sevo 2.0 the value is 362.29 ± 4.53, at sevo 3.0 the value is 393.32 ± 3.85, at sevo 4.0 the value is 420.44 ± 7.44, at after intubation the value is 348.42 ± 16.56.

The results of the 10 patients were appeared at the Table 1.
Table 1  Change according to the anesthesia stages

<table>
<thead>
<tr>
<th></th>
<th>Pre.</th>
<th>Sevo. 1.0</th>
<th>Sevo. 2.0</th>
<th>Sevo. 3.0</th>
<th>Sevo. 4.0</th>
<th>Intu. after</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTT</td>
<td>335.71 ± 34.45</td>
<td>374.69 ± 39.42</td>
<td>360.01 ± 52.68</td>
<td>371.78 ± 19.70</td>
<td>420.44 ± 4.21</td>
<td>315.69 ± 34.20</td>
</tr>
<tr>
<td>LF</td>
<td>7.68* ± 1.02</td>
<td>5.55* ± 0.57</td>
<td>6.33 ± 2.43</td>
<td>6.82 ± 1.77</td>
<td>7.39 ± 1.54</td>
<td>7.61 ± 1.54</td>
</tr>
<tr>
<td>HF</td>
<td>1.23 ± 0.62*</td>
<td>3.44 ± 1.90</td>
<td>2.97 ± 1.54</td>
<td>2.56 ± 2.0</td>
<td>2.15 ± 1.48</td>
<td>1.89 ± 1.48</td>
</tr>
<tr>
<td>LF/HF</td>
<td>4.88 ± 3.39</td>
<td>1.07 ± 0.54</td>
<td>4.77 ± 5.28</td>
<td>3.98 ± 3.29</td>
<td>3.42 ± 3.0</td>
<td>5.97 ± 3.40</td>
</tr>
</tbody>
</table>

PTT value is 335.71 ± 34.45 at the Pre. stage, the value is 374.69 ± 39.42 at sevo 1.0, the value is 360.01 ± 52.68 at sevo 2.0, the value is 371.78 ± 19.70 at sevo 3.0, the value is 420.44 ± 4.21 at sevo 4.0, the value is 315.69 ± 34.20 at after intubation. We know that PTT is increased according to density of anesthesia from sevo 1.0 to sevo 4.0. However, PTT is significantly decreased at after intubation stage.

LF value is 7.68 ± 1.02 at Pre. stage, the value is 5.55 ± 0.57 at sevo 1.0, the value is 6.33 ± 2.43 at sevo 2.0, the value is 6.82 ± 1.77 at sevo 3.0, the value is 7.39 ± 1.0 at sevo 4.0, the value is 7.61 ± 1.51 at after intubation stage.

4 Conclusion

If parasympathetic activity is decrease, cardiac disease can occur. Also stress and pain can appear and a state of tension can keep up. A recent study has found evidence that parasympathetic activity tend to be decrease as we grow older.

There are many methods to measure arterial stiffness for health index. In this paper, we examined PTT in arterial stiffness. Fig. 3 shows the result of PTT, LF, HF, LF/HF ratio about 10 persons.

Comparing Pre. with sevoflurane such as Fig. 3, LF is decreased at sevo 1.0, HF is increased. LF/HF ratio appearing the autonomic balance is also decreased(p<0.05). It means that sympathetic nerve activity is decrease and parasympathetic nervous activity is increased comparing with Pre. stage.

PTT is significantly increased comparing with Pre.stage. It means that sympathetic nerve activity which controls cardiovascular system among autonomic nervous system is suppressed. As a result of this, compliance is increased and then the results induce increase of PTT.

According to increasing density of drug of anesthesia, LF is increased and HF is decreased but there is no significance.

Comparing sevo 1.0 and after intubation, LF is significantly increased. HF is decreased but there is no significance. And LF/HF ratio is increased but there is no significance.

Comparing after intubation and sevo 1.0, PTT is significantly decreased(p<0.05). It means that parasympathetic nervous activity is increased at sevo 1.0. And sympathetic nervous activity is increased at after intubation because stimulation is transfer to spinal cord from vasomotor center to peripheral nerve.

The relation between stiffness of the blood vessel and ANS(autonomic nervous system) is observed by comparing the distribution of the PSD and the change of the PTT appeared the stiffness of the blood vessel at the pre-anaesthesia, sevoflurane anaesthesia and intubation after intubation. In this paper, PSD of the HRV well-known of the index of the ANS activity reflected the ANS activity according to anesthesia stages. Effect of LF during the anesthesia is similar to PTT changes. This means that PTT analysis is useful index reflecting the body state because of well appearing the ANS activity during svoflurane anaesthesia. And this analysis is useful because the calculating method is simple and time is short compare with the method of HRV PSD.

References: