Effect of sevoflurane pretreatment on cerebral oxygen saturation, pulmonary compliance and systemic stress response in patients with one–lung ventilation

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ABSTRACT

Objective: To investigate the effect of sevoflurane pretreatment on cerebral oxygen saturation, pulmonary compliance and systemic stress response in patients with one-lung ventilation.

Methods: A total of 70 patients with lung cancer who accepted the selective pulmonary lobectomy in our hospital between January 2012 and December 2015 were collected and divided into observation group and control group (n=35) according to the single-blind randomized control method. After general anesthesia induction, the control group received air/oxygen mixed ventilation, and the observation group received sevoflurane pretreatment for 30 min and received one-lung ventilation after that. Immediately after anesthesia induction (T0), 30 min after sevoflurane pretreatment (T1), 60 min after sevoflurane pretreatment (T2) and at chest wall suture after operation (T3), the cerebral oxygen saturation monitor was used to determine the left and right regional cerebral oxygen saturation (rSO2); end-expiratory airway blocking method and related indexes were used to calculate the contralateral pulmonary static compliance (Cst) and pulmonary dynamic compliance (Cdyn); the RIA method was used to determine serum stress hormone levels.

Results: At T0, differences in cerebral oxygen saturation, pulmonary compliance and systemic stress response were not statistically significant between two groups of patients; at T1, T2 and T3, left and right rSO2 levels of observation group were higher than those of control group, Cst and Cdyn levels were significantly higher than those of control group, and serum epinephrine (E), norepinephrine (NE), cortisol (Cor) and angiotensin II (Ang II) levels were lower than those of control group.

Conclusion: Sevoflurane pretreatment can promote the intraoperative cerebral oxygen saturation and pulmonary compliance, and reduce systemic stress response in patients with one-lung ventilation.

1. Introduction

One-lung ventilation is currently the most common clinical way of ventilation for esophageal and pulmonary surgery, which can not only provide a good static environment for the operation side, but also prevent the pollution of the contralateral lung. But long one-lung ventilation can lead to increased airway resistance and decreased pulmonary compliance, leading to ventilation/perfusion imbalance, the decreased arterial oxygen partial pressure and intraoperative hypoxemia[1,2]. At present, many case reports have shown that there is different degree of postoperative cerebral anoxia in patients with one-lung ventilation, which restricts the clinical popularization and application of one-lung ventilation technology to a large extent. Sevoflurane is the most common clinical inhalation anesthetic, a number of studies have confirmed that it can reduce airway resistance and improve ventilation function, so some scholars recommend the sevoflurane pretreatment application in operation with one-lung ventilation, but there is still not much research report on its exact effect[3,4]. In the study, the effect of sevoflurane pretreatment on patients with one-lung ventilation was preliminarily studied, now reported as follows:

2. Information and methods
2.1 General information

A total of 70 patients with lung cancer who accepted the selective pulmonary lobectomy in our hospital between January 2012 and December 2015 were included, the patients themselves understood the research process and signed the informed consent, and this research was approved by the hospital ethics committee. According to the single-blind randomized control method, the included patients were divided into observation group and control group (n=35). Observation group included 18 male cases and 17 female cases, they were 35-71 years old, the body weight was 48-83 kg and (61.28±9.54) kg in average, and the American Society of Anesthesiologists (ASA) grading was Ⅰ-Ⅱ grade; control group included 19 male cases and 16 female cases, they were 33-72 years old, the body weight was 47-85 kg and (62.82±9.17) kg in average, and the American Society of Anesthesiologists (ASA) grading was Ⅰ-Ⅱ grade. Two groups of patients were not statistically different in gender, age, body weight and ASA grading (P>0.05).

2.2 Inclusion and exclusion criteria

Inclusion criteria were as follows: (1) Diagnosed with early-moderate lung cancer via pathological biopsy; (2) Diagnosed for the first time and never receiving surgery before; (3) With normal contralateral lung function; (4) <80 years old. Exclusion criteria were as follows: (1) With metastatic lung cancer; (2) With primary and malignant tumors of other tissues and organs; (3) With severe heart, liver and kidney dysfunction; (4) With blood coagulation disorders; (5) With the history of sevoflurane anesthesia 1 month prior to admission.

2.3 Anesthesia disposal

Two groups of patients were fasting for solids and liquids for 8 hours before operation, upper-limb peripheral vein was conventionally opened after patients entered the OR, and invasive arterial pressure, blood oxygen saturation, electrocardiogram, bispectral index (BIS), etc were monitored. Anesthesia induction was as follows: patients received TCI propofol 3.5 μg/mL, midazolam 0.05 mg/kg, fentanyl 4 μg/kg and rocuronium bromide 0.5 mg/kg in turn. Double-lumen endotracheal tubes (Tyco in US) were inserted and accurately positioned by fiber bronchoscope (Olympus Corporation in Japan), then the mechanical ventilation began, and the ventilation parameters were set as follows: tidal volume 6-8 mL/kg, ventilation frequency 10-12 times/min, inspiratory/expiratory 1:2 and end-tidal carbon dioxide (PetCO₂) 35-45 mmHg.

After intubation and before one-lung ventilation, control group received regular air/oxygen mixed ventilation, and didn’t receive sevoflurane inhalation. Observation group of patients inhaled sevoflurane for 30 min in advance after the intubation, the minimum alveolar concentration (MAC) was maintained at 1.0, and the oxygenation was quickly conducted for gas exchange after inhalation to keep the sevoflurane MAC at 0 before one-lung ventilation. Both groups of patients received propofol TCI 3.5 μg/mL during operation to maintain anesthesia depth as well as intravenous injection of cis atracurium 0.2 mg/kg every 30 min, and the BIS value was maintained between 40 and 60.

2.4 Observation indexes

Immediately after anesthesia induction (T0), 30 min after sevoflurane pretreatment (T1), 60 min after sevoflurane pretreatment (T2) and at chest wall suture after operation (T3), cerebral oxygen saturation monitor (Beijing Shimao Medical Equipment Trade Co., LTD., model INVOS) was used to determine the left and right regional cerebral oxygen saturation (rSO₂); end-expiratory airway blocking method was used to determine the contralateral pulmonary static compliance (Cst), and pulmonary dynamic compliance (Cdyn) was calculated according to the intraoperative tidal volume (VT) and airway platform pressure (Pplat). Meanwhile, 2 mL of peripheral venous blood was collected from two groups of patients and centrifuged to get supernatant, RIA method was used to detect the stress hormone levels, including epinephrine (E), norepinephrine (NE), cortisol (Cor) and angiotensin I (Ang I).

2.5 Statistical analysis

Data in the study was input in software SPSS 20.0, measurement data was in terms of mean ± standard deviation (x±s), comparison between groups was by t test and P<0.05 indicated statistical significance in differences.

3. Results

3.1 Cerebral oxygen saturation

At T0, T1, T2 and T3, comparison of cerebral oxygen saturation levels between two groups of patients was as follows: at T0, differences in left rSO₂ and right rSO₂ levels were not statistically significant between two groups of patients (P>0.05); at T1, T2 and T3, left rSO₂ and right rSO₂ levels of observation group were significantly higher than those of control group, and differences in left rSO₂ and right rSO₂ levels were statistically significant between two groups of patients at T1, T2 and T3 (P<0.05), shown in Table 1.

3.2 Pulmonary compliance

At T0, T1, T2 and T3, comparison of pulmonary dynamic compliance and static compliance between two groups of patients was as follows: at T0, differences in Cst and Cdyn levels were not statistically significant between two groups of patients (P>0.05); at T1, T2 and T3, Cst and Cdyn levels of observation group were significantly higher than those of control group, and differences in Cst and Cdyn levels were statistically significant between two groups of patients at T1, T2 and T3 (P<0.05), shown in Table 2.
Comparison of serum stress hormone levels between two groups of patients at different points in time (pg/mL).

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>Time points</th>
<th>E</th>
<th>NE</th>
<th>Cor</th>
<th>Ang II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>35</td>
<td>T0</td>
<td>80.34±9.12</td>
<td>173.28±18.95</td>
<td>194.36±27.93</td>
<td>17.48±2.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T1</td>
<td>124.47±13.82</td>
<td>231.85±27.46</td>
<td>312.48±38.29</td>
<td>35.47±4.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T2</td>
<td>137.64±15.88</td>
<td>246.48±29.81</td>
<td>324.56±35.88</td>
<td>42.16±5.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T3</td>
<td>131.65±15.93</td>
<td>230.55±25.47</td>
<td>301.55±34.21</td>
<td>39.74±4.16</td>
</tr>
<tr>
<td>Control</td>
<td>35</td>
<td>T0</td>
<td>79.36±8.23</td>
<td>178.64±19.28</td>
<td>191.53±23.85</td>
<td>18.16±1.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T1</td>
<td>183.25±19.84</td>
<td>374.21±40.09</td>
<td>472.51±50.76</td>
<td>73.82±8.54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T2</td>
<td>195.24±23.77</td>
<td>394.75±45.12</td>
<td>425.07±48.13</td>
<td>82.48±9.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T3</td>
<td>187.62±19.73</td>
<td>342.56±37.15</td>
<td>395.12±46.84</td>
<td>75.48±8.28</td>
</tr>
</tbody>
</table>

Note: compared with control group at T1, *P<0.05; compared with control group at T2, †P<0.05; compared with control group at T3, ‡P<0.05.

3.3 Stress response

At T0, T1, T2 and T3, comparison of serum stress hormones E, NE, Cor and Ang II levels between two groups of patients was as follows: at T0, differences in serum E, NE, Cor and Ang II levels were not statistically significant between two groups of patients (P>0.05); at T1, T2 and T3, serum E, NE, Cor and Ang II levels of observation group were significantly lower than those of control group, and differences in serum E, NE, Cor and Ang II levels were statistically significant between two groups of patients at T1, T2 and T3 (P<0.05), shown in Table 3.

4. Discussion

Intrapulmonary shunt increases and ventilation/perfusion is in disorder during one-lung ventilation, pulmonary oxygenation function declines, and the excessive hypoxia can lead to the suspension of operation. How to increase body’s oxygenation of one-lung ventilation operation and optimize patients’ systemic state is the focus in the current study of clinical anesthesiology[5]. Sevoflurane, as inhalation anesthetic, has been popularized in clinical anesthesia, its characteristics such as small impact on circulation system and relaxing muscle have been clinically recognized, but its role in the patients with one-lung ventilation is less reported. Research shows that sevoflurane has certain dilating effect on pulmonary vessels, and sevoflurane pretreatment for one-lung ventilation can make the contralateral pulmonary vessels dilate to accept more blood perfusion, thereby reduce operation-side intrapulmonary shunt and realize the optimization of pulmonary ventilation/perfusion[6]. Based on the above characteristics, many scholars have currently recommended the sevoflurane pre-ventilation for patients before the start of one-lung ventilation in order to optimize the patients’ overall state during one-lung ventilation.

Regional cerebral oxygen saturation (rSO2) is a noninvasive and sensitive index to reflect oxyhemoglobin/reduced hemoglobin mixed transmission intensity during head closure condition, monitoring rSO2 can early detect the changes of local brain blood flow and metabolism, rSO2 decrease by more than 20% of basic value mostly indicates the possibility of cerebral ischemia, and its current application is common in the management of perioperative patients[8-10]. In the study, the left and right cerebral rSO2 of two group of patients were detected at first to indirectly determine the body’s oxygen supply under one-lung ventilation condition, and it was found that compared with the control group of patients, the observation group of patients were with higher left and right cerebral rSO2 values after one-lung ventilation and before the end of operation, indicating that after sevoflurane pretreatment, patients’ airway function is optimized, the oxygen metabolism efficiency increases, and the cerebral oxygen supply increases eventually.

Declined pulmonary compliance under the one-lung ventilation has been recognized, and its reason is unknown at present and is speculated to be associated with anesthetic application, patients’ position change, etc[11]. Excessively reduced lung compliance can lead to postoperative atelectasis and re-expansion pulmonary edema. The static pulmonary compliance (Cst) and dynamic pulmonary
compliance (Cdyn) compose of lung compliance together, Cst reflects the lung tissue elasticity and Cdyn reflects the dual effects of lung tissue elasticity and airway resistance[12,13]. In the study, Cst and Cdyn levels of two groups of patients were detected at different time points, and it was found that Cst and Cdyn levels were not significantly different between two groups of patients before one-lung ventilation, and at the time points after one-lung ventilation and before the end of operation, the Cst and Cdyn levels of observation group were higher, showing that sevoflurane pretreatment can effectively increase and optimize the intraoperative lung compliance in patients with one-lung ventilation, and this is mainly because that the T MAC sevoflurane dilates the bronchus, reduce the mechanical ventilation resistance and so on.

Surgical trauma, anesthetic effect, etc can all cause intraoperative stress response in patients, pulmonary ventilation/perfusion disorder, the body ischemia hypoxia, etc can all aggravate the stress response, so the patients with one-lung ventilation are often characterized by severe stress state, and it is not conducive to the obtaining of surgery effect as well as patients’ postoperative rehabilitation[14,15]. Stress is mainly in the charge of locus coeruleus-symphatico-adrenomedullary system system as well as the hypothalamus-pituitary-adrenal cortex axis, and its excitement can massively secrete epinephrine (E), norepinephrine (NE), cortisol (Cor), angiotensin II (Ang II) and other stress hormones[16,17]. In the study, the relieving effect of sevoflurane pretreatment on systemic stress response in patients with one-lung ventilation was analyzed at last, and detection of intraoperative stress hormone levels showed that compared with control group of patients, the observation group of patients were with lower serum E, NE, Cor and Ang II levels at different time points after one-lung ventilation, indicating that sevoflurane pretreatment can effectively alleviate the body’s stress response, and this, on the one hand, is associated with the optimized ventilation/perfusion and the enhanced lung compliance after sevoflurane pretreatment, and on the other hand, may be because that sevoflurane deepens the depth of anesthesia and effectively block intraoperative pain transmission. To sum up, it is concluded as follows: sevoflurane pretreatment can promote the intraoperative cerebral oxygen saturation and pulmonary compliance, and reduce systemic stress response in patients with one-lung ventilation, and it’s worth popularization and application in clinical practice in the future.

References