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Effects of stellate ganglionic block on hemodynamic changes and intrapulmonary shunt in perioperative patients with esophageal cancer

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Abstract. – OBJECTIVE: The aim of this study was to observe the effects of stellate ganglion block (SGB) on hemodynamic changes and intrapulmonary shunt during one-lung ventilation (OLV).

PATIENTS AND METHODS: Thirty ASA class I-II patients undergoing elective esophageal surgery were randomly divided into two groups: general anesthesia group (group N, n=15) and general anesthesia combined SGB group (group S, n=15), patients in group S were received left SGB before induction. Radial artery was cannulated for arterial blood pressure (ABP) monitoring and blood sampling and Swan-Ganz catheter was position in the pulmonary artery via right internal jugular vein under local anesthesia. ECG, MAP, HR, CVP, continuous cardiac output (CCO) index and BIS were continuously monitored during anesthesia. General anesthesia was induced with propofol 1.5-2.0 mg/kg, sufentanil 0.4 μg/kg, and Rocuronium 0.6-0.9 mg/kg. Endobronchial occluder was placed blindly after tracheal indubation and the correct position was verified by auscultation and fiberoptic bronchoscopy. The patients were mechanically ventilated. The ventilation conditions were Fio_2=100%, V_T = 8-10 ml/kg, I: E = 1:2 and respiratory rate was adjusted to maintained $P_{ET}CO_2$ at 35-45 mmHg during both two-lung ventilation (TLV) and OLV. Anesthesia was maintained with continuous infusion of propofol 4-10 mg/kg·h, sufentanil 0.2 μg/kg·h, vecuronium o.1 mg/kg·h, BIS was maintained at 45-55. Blood samples were taken from radial artery and S-G catheter for blood gas analysis at following intervals: during spontaneous breathing when the patient was awake (T_0), 1 min after tracheal indubation (T_1), 1 min after patient was placed in lateral position (T_2) and 15 min after it (T_3), 1 min after ribs was braced (T_4), 30, 60, 120 min during the course of OLV (T_5, T_6, T_7), the two lungs were ventilated again for 30 min (T_8) and Qs/Qt was calculated.

RESULTS: SVRI, MAP, HR in group N increased significantly at T_1, T_2, T_4 compared with group S ($p < 0.05$). Qs/Qt was significantly increased after patient was placed in lateral position and increased further during OLV; the calculated Qs/Qt values were highest at T5· PaO_2 was significantly lower after OLV was started and reached the lowest level at T6 then was gradually increasing. There was no significant difference in Qs/Qt and PaO_2 at all time points between two groups.

CONCLUSIONS: SGB before induction effectively suppress the stress response work as stable blood dynamics and does not affect Qs/Qt and arterial oxygenation during OLV, SGB is a safe technique of anesthesia for general thoracic surgery.

Key Words:
Stellate ganglionic block, One-lung ventilation, Intrapulmonary shunt, Hemodynamic.

Introduction

Due to great surgical trauma in thoracotomy, postural restriction during the surgery, sudden changes in intrathoracic pressure, one-lung ventilation and other characters, intraoperative hemodynamic perturbation in patients is often evident. Hemodynamic stability is not only related to the safety of patients during perioperative period, but also affects the postoperative outcome. How to maintain the stability of the circulation in patients undergone a series of noxious stimulation, it is a problem faced by the anesthesiologist. Stellate ganglion, owning to the certain inhibition on the sympathetic-adrenal system, is widely used in the treatment of the autonomic nervous system dysfunction in recent years. Whether stellate ganglion block (SGB) in the thoracic surgery can reduce hemodynamic fluctuation and influence intrapulmonary shunt during one-lung ventilation (OLV) after sympathetic inhibition or not, it has not been reported yet. In this study, L-SGB was applied to esophageal cancer radical surgery under general

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anesthesia, to observe the changes of the indexes such as blood dynamics and intrapulmonary shunt in perioperative period, in order to better guide clinical anesthesia.

Patients and Methods

General Information

The study was approved by the hospital Ethics Committee. Thirty ASA class I-II patients, 50-65 years old, weight 55-70 kg, who would undergo elective esophageal radical surgery, were selected in this study. The patients contained 16 males and 14 females. Patients with preoperative moderate or severe cardiovascular, liver, kidney disease, anemia, abnormal pulmonary function tests, or FEV_1/FVC ratio < 65% were excluded.

Anesthetic Methods

Patients were injected with atropine (0.5 mg, i.m.) and sodium pentobarbital (100 mg, i.m.) 30 minutes before the surgery. After entering operating room, the peripheral vein was open and treated with midazolam (2-3 mg, i.p.). Under local anesthesia, radial artery was cannulated and Swan-Ganz catheter was position in the pulmonary artery via right internal jugular vein. The patients were randomly divided into two groups: general anesthesia group (group N, n=15) and genaral anesthesia combined L-SGB group (group S, n = 15). Patients in group S were received L-SGB 10 minutes before induction and the local anesthetic is 1% lidocaine (0.12 ml/kg). The sign of success was the presence of Horner sign in the block side (Horner sign was judged as positive by presence of more than three characteristics among facial adiaphoresis, facial flushing, narrowed eye fissure, enophthalmos and miosis), or the case was excluded from this study.General anesthesia was induced in turn with propofol (1.5-2.0 mg/kg), sufentanil (0.4 μg/kg) and rocuronium (0.6-0.9 mg/kg) by mainline in two groups. Endobronchial occluder was placed blindly after tracheal indubation was viewed clearly via mouth and the correct position was verified by fiberoptic bronchoscopy. Connected with the ventilator, the patients were mechanically ventilated. The ventilation conditions were V_T = 8-10 ml/kg, Fio_2 = 100%, I: E =1:2 and respiratory rate was adjusted 10-12 times/min to maintain $P_{ET}CO_2$ at 35-45 mmHg during both two-lung ventilation (TLV) and OLV. Anesthesia was maintained with continuous infusion of propofol (4-10 mg/kg/h), sufentanil (0.2 μg/kg/h) and vecuronium (0.1 mg/kg/h), and BIS was maintained at 45-55 during the surgery.

Monitoring Indicators

ECG, HR, MAP, CVP, MPAP, CCO, SVPI and SpO_2 were continuously monitored during the operation and BIS were used to monitor the depth of anesthesia. Blood samples taken from radial artery and mixed venous blood samples were used for blood gas analysis at a volume of 1.5ml respectively at following intervals: during spontaneous breathing when the patient was awake (T_0), 1 min after tracheal indubation (T_1), 1 min after the patient was placed in lateral position (T_2) and 15 min after it (T_3), 1 min after ribs was braced (T_4), 30, 60, 120 min during the course of OLV (T_5, T_6, T_7), the two lungs were ventilated again for 30 min (T_8). The intrapulmonary shunt fraction was calculated, according to the formula $Qs/Qt = (Cc'O_2\text{-by } CaO_2)/(Cc'O_2\text{-Cv } O_2) \times 100\%$ among which $CaO_2 = (Hb \times 1.31 \times SaO_2) + (PaO_2 \times 0.003)$; $CO_2 = (Hb \times 1.31 \times S\ O_2) + (P \text{ of } O_2 \times 0.003)$; when the air was breathed, $Cc'O_2 = (Hb \times 1.31 \times SaO_2) + (149\text{-}PaCO_2/0.8) \times 0.003$; when 100% O_2 was inhaled, $Cc'O_2 = (Hb \times 1.31 \times SaO_2) + (713\text{-}PaO_2/0.8) \times 0.003$. ($Cc'O_2$: pulmonary capillary blood oxygen content; CaO_2: arterial oxygen content; CO_2: mixed venous oxygen content; SO_2: mixed venous oxygen saturation; SaO_2: arterial oxygen saturation; PO_2: mixed venous oxygen partial pressure).

Statistical Analysis

All measurement data were expressed as mean ± SD. SPSS13.0 statistical software (SPSS Inc, Chicago, IL, USA) was applied to statistical treatment. At each time point the parameters within the group were compared using two-factor analysis of variance. The parameters between the two groups at each time point were compared by single factor analysis of variance and q test. *p* values < 0.05 were considered significant.

Results

There was no significant difference in general situation before the surgery between two groups. The results were shown in Table I.

As shown in Figure 1, compared with group N, Systemic Vascular Resistance Index (SVRI) in group S decreased significantly at T_1, T_2, T_4 (p <

Table I. A comparison of preoperative general situation between two groups (n=15, $\bar{x} \pm s$)

Items	S Group (n=15)	N Group (n=15)
Height (cm)	167 ± 8	165 ± 8
Weight (Kg)	60 ± 13	62 ± 11
Gender composition ratio (mile/female)	10/5	9/6
Age (years)	56 ± 10	55 ± 9
FEV1 (%predicted value)	115 ± 26	110 ± 31
FVC (%predicted value)	120 ± 21	118 ± 27
FEV1/FVC (%)	78 ± 13	78 ± 5
PaO_2 (mmHg)	82 ± 10	86 ± 9
PCO_2 (mmHg)	35 ± 3	37 ± 3
PeakTLV (cmH_2O)	16.7 ± 3.1	17.1 ± 2.9
PeakOLV (cmH_2O)	20.4 ± 2.5	21.3 ± 2.0

FEV_1: Forced expiratory volume in one second; FVC: Forced vital capacity; PeakTLV: Inspiratory peak pressure in airway during TLV; PeakOLV: Inspiratory peak pressure in airway during OLV.

0.05). The difference between SVRI at T_1, T_2, T_4 and SVRI at T_0 in group N heightened significantly compared with group S ($p < 0.05$).

There was no significant difference in Qs/Qt before the operation between two groups, and Qs/Qt were all within the normal range. Intrapulmonary shunt was significantly increased after patient was placed in lateral position during TLV ($p < 0.05$). Qs/Qt increased further during OLV, and the calculated Qs/Qt values were highest at T_5. But there was no significant difference in Qs/Qt after OLV between two groups ($p > 0.05$). The results were shown in Figure 2.

MAP, HR in group S lowered significantly at T_1, T_2, T_4 compared with group N ($p < 0.05$). The difference between MAP, HR at T_1, T_2, T_4 and MAP, HR at T_0 in group N heightened significantly compared with group S ($p < 0.05$). Hemodynamic fluctuation was not manifest after T_5. MPAP, CVP increased significantly after the patients were mechanically ventilated ($p < 0.05$), but there was no significant difference between two groups ($p > 0.05$). PaO_2 was significantly lower after OLV was started ($p < 0.05$) and reached the lowest level at T_6 (PaO_2 in group S and group N were 172 mmHg and 181 mmHg, respectively) then was gradually increasing. There was no significant difference in PaO_2 at all time points between two groups ($p > 0.05$) (Table II).

Discussion

The study was based on continuously monitoring CCO, MPAP, CVP and maintaining the same depth of sedation, to observe the effects of gener-

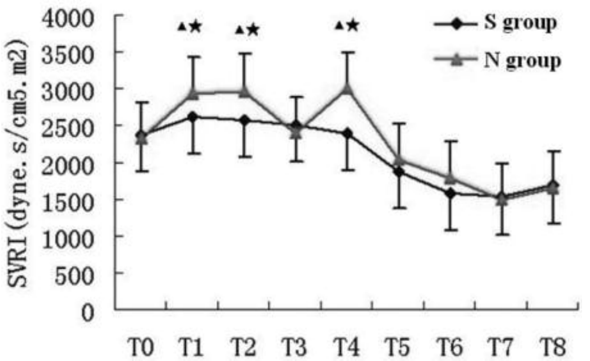

Figure 1. A comparison of SIVR at each time points between two groups. Compared with group N, $^*p < 0.05$; Compared with the difference between SVRI at T_1, T_2, T_4 and SVRI at T_0, $^\blacktriangle p < 0.05$.

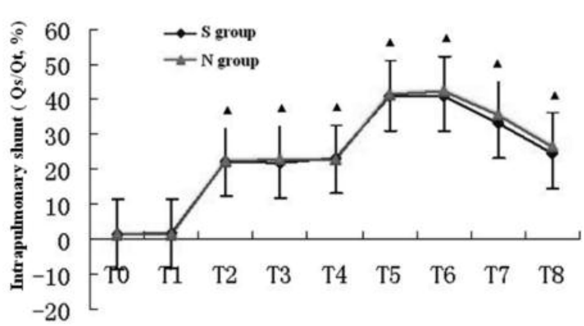

Figure 2. A comparison of Qs/Qt at each time points between two groups. Compared with group N, $^*p < 0.05$; Compared with the difference between SVRI at T_1, T_2, T_4 and SVRI at T_0, $^\blacktriangle p < 0.05$.

Table II. A comparison about blood dynamics and respiratory parameters between two groups (n=15, $\bar{x} \pm s$).

Items	Gro-up	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
MAP	S	90 ± 8	103 ± 12*▲	99 ± 20*▲	94 ± 8	105 ± 18*▲	94 ± 12	85 ± 17	78 ± 14	81 ± 12
(mmHg)	N	88 ± 14	115 ± 15▲	113 ± 16▲	90 ± 10	122 ± 16▲	101 ± 16▲	94 ± 11	76 ± 20	78 ± 16
MPAP	S	17.2 ± 2.5	16.9 ± 2.4	18.4 ± 3.6	19.1 ± 2.1	19.3 ±.7	21.0 ± 4.6▲	21.3 ± 2.8	22.2 ± 5.1	20.7 ± 4.1
(mmHg)	N	16.3 ± 1.9	16.6 ± 3.1	19.9 ± 3.8	19.8 ± 4.1	19. 9± 4.3	22.2 ± 5.7▲	21.9 ± 4.9	23.1 ± 4.2	21.0 ± 3.3
HR	S	65 ± 14	78 ± 12*▲	82 ± 10*▲	72 ± 11	85 ± 13*▲	73 ± 18	70 ± 17	65 ± 12	68 ± 18
(times/min)	N	64 ± 13	96 ± 8▲	96 ± 10▲	73 ± 9	102 ± 19▲	80 ± 14▲	77 ± 13	73 ± 19	69 ± 20
CVP	S	6.9 ± 1.7	8.2 ± 2.4	9.0 ± 2.6	9.1 ± 2.5	9.4 ± 1.8	9.8 ± 2.7▲	9.4 ± 3.1	9.3 ± 2.3	9.1 ± 2.8
(cmH2O)	N	7.1 ± 2.3	9.0 ± 1.8	9.0 ± 3.1	9.4 ± 2.1	9.2 ± 2.7	9.9 ± 1.7▲	9.5 ± 3.8	8.9 ± 3.2	8.9 ± 2.3
CI	S	2.8 ± 0.6	2.9 ± 0.5	2.7 ± 0.9	2.7 ± 0.9	3.2 ± 0.4	3.6 ± 0.8▲	3.8 ± 0.2▲	3.6 ± 0.3	3.7 ± 0.6
($L.min^{-1}.m^2$)	N	3.0 ± 0.5	3.3 ± 0.7	3.1 ± 0.9	3.1 ± 0.9	3.5 ± 0.8	3.9 ± 0.6▲	4.2 ± 0.3▲	4.4 ± 0.6	4.6 ± 0.7
PaO_2	S	82 ± 10	225 ± 85▲	412 ± 74▲	407 ± 66▲	419 ± 53▲	186 ± 85▲	172 ± 62▲	228 ± 87▲	357 ± 62▲
(mmHg)	N	86 ± 9	230 ± 76▲	420 ± 58▲	418 ± 60▲	422 ± 65▲	192 ± 69▲	181 ± 73▲	219 ± 96▲	343 ± 79▲
Qs/Qt (%)	S	1.4 ± 0.7	1.6 ± 0.3	22.3 ± 5.5▲	21.9 ± 4.3▲	23.1 ± 3.6▲	43.7 ± 7.4▲	41.1 ± 8.7▲	33.4 ± 7.6▲	24.4 ± 5.7▲
	N	1.3 ± 0.9	1.2 ± 0.8	22.1 ± 5.8▲	22.7 ± 6.4▲	22.7 ± 5.7▲	42.1 ± 6.2▲	41.4 ± 9.6▲	35.5 ± 4.9▲	26.3 ± 3.0▲
SVRI	S	2374 ± 51	2615 ± 468*▲	2571 ± 517*▲	2515 ± 328	2390 ± 342*▲	1871 ± 260	1591 ± 39▲	1526 ± 467▲	1684 ± 235▲
($dyne.s.cm^5.m^2$)	N	2317 ± 465	2946 ± 391▲	2971 ± 354	2397 ± 326	3002 ± 423▲	2026 ± 343	1781 ± 40▲	1482 ± 391▲	1641 ± 257▲

Compared with group N, $^*p < 0.05$; Compared with the difference between SVRI at T_1, T_2, T_4 and SVRI at T_0, ▲$p < 0.05$.

al anesthesia and general anesthesia combined L-SGB on intraoperative hemodynamic changes and intrapulmonary shunt. The results showed general anesthesia combined L-SGB was propitious to maintain stable blood dynamics during perioperative period, and did not affect intrapulmonary shunt and arterial oxygenation during OLV.

Surgical trauma and pain as strong stress stimulation had an impact on perioperative circulation, respiration, metabolism and other various aspects by stimulating the pituitary – adrenal cortex system and sympathetic – adrenal medullary system of patients[1,2]. Appropriate perioperative anesthesia could make stress response moderate. Rational use of various anesthetic techniques and drugs could effectively control the harmful stress response and maintain hemodynamic stability. In this work, the result of SVRI indicated that the body had been at a relatively high degree of stress state when the patient entered the operating room, and stress response was more present in patients after endotracheal intubation under induction of general anesthesia and postural changes. Hemodynamic indicators changed significantly, and reached the peak after ribs was braced by the rib spreader then tended to stable. It showed that the surgical noxious stimulation could still cause a strong stress response under the appropriate depth of anesthesia, resulting in great hemodynamic fluctuations. If we blindly deepened the depth of anesthesia and increased the dose of intravenous anesthetics or the concentration of inhaled anesthetics to suppress the stress response, it would be very confined and dangerous, and even increased the risk of myocardial ischemia for some patients[3]. In this study, L-SGB was applied to esophageal cancer radical surgery under general anesthesia, to observe the effect on hemodynamic indicators. The results showed that the hemodynamic indicators MAP, HR, SVRI in group S lowered significantly compared with group N during endotracheal intubation a change of position and rib braced under the anesthesia and surgical operation. The difference was statistically significant; indicating that group S had a relatively stable blood dynamics compared with group N during this period. The mechanism might be associated with the systemic response produced during the periods when SGB blocked the sympathetic nerves leading to the heart, lungs and ascending conduction of nerves in the position of surgical stimulation, to decrease excitability of sympathetic nerves, and general anesthesia inhibited relative excitability of vagus. The perioperative systemic stress response was regulated effectively, thus contributing to maintain hemodynamic stability.

OLV resulted in the presence of pathophysiological responses such as an abnormal Qs/Qt during perioperative period and a further increase in intrapulmonary shunt, which was the main reason for intraoperative hypoxemia[4]. Hypoxic pulmonary vasoconstriction (HPV) was compensatory protection mechanism to maintain appropriate Qs/Qt during OLV. Animal experiments showed that HPV had a role in making the proportion of blood flow volume in the collapsed lung in cardiac output reduced from 40%-50% to about 25%[5].

Stellate ganglion was fused by posterior cervical sympathetic ganglion and first thoracic sympathetic ganglion. The partial sympathetic postganglionic fibers were distributed in the pulmonary vascular smooth muscle and inner cortex, to regulate pulmonary vascular contraction and relaxation[6]. Previous studies had reported[7] that SGB had an effect on the peripheral vascular expansion, to reduce elevated pulmonary vascular resistance and pulmonary artery pressure. This was contrary to HPV and increased pulmonary artery pressure after OLV was started, and in theory, SGB had an inhibitory role in HPV. However, in this study, the find that there was no significant difference in Qs/Qt and PaO_2 during OLV between two groups indicated SGB did not increase intrapulmonary shunt and had no significant inhibition of HPV. The mechanisms were considered as follows: (1) Although most of people thought HPV was the direct effect of hypoxia on pulmonary vas, hemodynamic changes in pulmonary vas were not only influenced by their own pulmonary vascular tone, but also affected indirectly by the change of circulation. While reducing the ipsilateral sympathetic tone and pulmonary vascular expansion, SGB produced a certain degree of inhibition on the heart, vascular smooth muscle and cardiac conduction system, marked by a decline in CI, SVI and HR. Thoracotomy due to intrathoracic pressure changed from negative to positive, unilateral lung collapse and bilateral pulmonary ventilation switched to be borne by the unilateral lung, it led to an increase in CVP and pulmonary artery pressure and a decrease in CCO and PO_2. The comprehensive effect was a decrease in CCO and PO_2, which then enhanced HPV, reduced intrapulmonary shunt and served as one of the indicators reflecting the role of HPV at the same time. The changes in pulmonary vascular resistance were correlated positively with the role of HPV, and elevated pulmonary artery pressure, to some extent, reduced the intrapulmonary shunt. (2) Because of unilateral SGB, it could only reduce the sympathetic tone of the block side, and the role was limited. At the same time Mullenheim et al[8] found that, under the case of stress, unilateral SGB could increase bilateral artery blood flow. To a certain degree, this increased pulmonary blood flow in the ventilation side, improved Qs/Qt, decreased intrapulmonary shunt and improved oxygenation; (3) Humoral factors also had a certain influence on intrapulmonary shunt during OLV. Yang et al[9] found *in vitro* and *in vivo*, pulmonary artery pressure and pulmonary vascular resistance were increased accompanied by significantly elevated serum thromboxane B2 (TXB2) during exposure to hypoxia. According to another report[10], SGB could reduce the synthesis and release of prostaglandin (PG) by inhibiting the release of norepinephrine. An increase of TXB2 and a decrease of PG were all conducive to the contraction of the pulmonary vascular resistance, to reduce intrapulmonary shunt. It was still under further study what changes humoral factors produced and what impacts on intrapulmonary shunt OLV had after SGB. In addition, the factors such as preoperative pulmonary function, surgical approach, the modes of mechanical ventilation, acid-base balance and hemoglobin content all could affect HPV and intrapulmonary shunt. In this work, the above parameters between the two groups were considered no significant difference and, therefore, their interferences were excluded.

Conclusions

General anesthesia combined SGB was conducive to maintain stable blood dynamics and hardly affected intrapulmonary shunt and arterial oxygenation during OLV, so it was a safe technique of anesthesia for general thoracic surgery.

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Conflict of Interest

The Authors declare that there are no conflicts of interest.

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