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Modern Halogen-Containing Anesthetics in Anesthetic Management of Thoracic Surgical Interventions

Dmitry G. Kabakov[1*], Margarita A. Vyzhigina[1,2], Dmitry V. Bazarov[1], Svetlana G. Zhukova[1,2], Alexey A. Kavochkin[1], Кулагина Т. Юрьевна[1]

[1]Petrovsky National Research Centre of Surgery, 2 Abrikosovsky Lane, Moscow, 119991, Russia
[2]Federal State Autonomous Educational Institution of Higher Education I.M. Sechenov First Moscow State Medical University of the Ministry of Healthcare of the Russian Federation (Sechenovskiy University), 8/2 Trubetskayast., Moscow 119991, Russia
Kabakov Dmitriy Gennad'yevich - anesthesiologist-resuscitator of the department of anesthesiology and resuscitation - I, Petrovsky National Research Centre of Surgery.
Vyzhigina Margarita Alexandrovna – Doctor of Medical Sciences, Professor, Senior Researcher Department of Anesthesiology and Reanimation, Petrovsky National Research Centre of Surgery, Professor of the Department of Anesthesiology and Reanimatology Federal State Autonomous Educational Institution of Higher Education I.M. Sechenov First Moscow State Medical University of the Ministry of Healthcare of the Russian Federation (Sechenovskiy University).
Bazarov Dmitriy Vladimirovich – Doctor of Medical Sciences, Head of the Department of Thoracic Surgery, Petrovsky National Research Centre of Surgery.
Zhukova Svetlana Grigorievna - Ph.D., anesthesiologist-resuscitator, department of anesthesiology and resuscitation – I, Petrovsky National Research Centre of Surgery, Associate Professor at the Department of Anesthesiology and Resuscitation Federal State Autonomous Educational Institution of Higher Education I.M. Sechenov First Moscow State Medical University of the Ministry of Healthcare of the Russian Federation (Sechenovskiy University).
Kavochkin Aleksey Alekseyevich - anesthesiologist-resuscitator, department of anesthesiology and resuscitation – I, Petrovsky National Research Centre of Surgery.
Кулагина Татьяна Юрьевна – доктор медицинских наук, заведующая лаборатории электрофизиологии и нагрузочных тестов, Petrovsky National Research Centre of Surgery.

ABSTRACT

The global importance of the anesthetic protection in thoracic surgery belongs to the methods of anesthesia and respiratory support, which ensure the optimal level of gas exchange. The paper presents the results of the study of factors and patterns that affect the efficiency of gas exchange in the lungs under anesthesia based on inhaled halogen-containing anesthetics.

The aim of the study is to determine the capabilities of the modern inhaled anesthetics (desflurane, sevoflurane, isoflurane) to affect the effectiveness of gas exchange in the lungs.

Materials and methods: the study included 58 patients of II-IV degree of risk (ASA). Thoracotomy or innovative thoracoscopic access to the surgical field was done. The main anesthetic: desflurane (DF) - 23 patients, sevoflurane (SF) -16 patients, isoflurane (IF) - 19 patients. Were studied the indicators of systemic, pulmonary, intracardiac hemodynamics with the pulmonary thermodilution (PT) method with the analysis of gas exchange and lung metabolism, acid-base balance, gas and electrolytic balance of arterial and mixed venous blood.

Stages of the study: Stage 1 - after induction into anesthesia, under conditions of ventilation of both lungs (ALV-1); Stage 2 – in conditions of surgical pneumothorax and artificial one-lung ventilation OLV); 3 and 4 stages – the main stage of the operation with OLV 60, 80-120 minutes; Stage 5 – the end of the main stage of the operation with both lungs ventilation (ALV-2).

Results: There were identified the influence of DF and SF on gas exchange blood flow in all variants of respiratory regimes (pre- and post-capillary resistance). A significant difference in the total peripheral resistance at stages 1, 3 and 4 with DF was comparable to the IF effect. A higher pump coefficient of the right ventricle was received with DF at all stages of the study, as well as a smaller amount of physiological dead space.

Conclusion: We assume that the systemic vasodilating effect of desflurane extends to the bronchial blood flow, as an integral part of the systemic circulation, as well as to vessels of extracapillary perfusion. Simultaneously, in comparison with SF, a smaller amount of physiological dead space with DF indicates a larger area of the perfused gas exchange surface under conditions of OLV. A higher pump coefficient of the right ventricle with DF at all stages of the study is a sign of its cardioprotective effect.

Keywords: desflurane, one-lung ventilation; thoracic anesthesia; extracapillary perfusion; pulmonary thermodilution; thoracoscpic surgical technologies

Correspondence:
Dmitry G. Kabakov
Anesthesiologist and Emergency Physician, Department of Anesthesiology and Reanimatology I, Petrovsky National Research Centre of Surgery, 2, Abrikosovsky Lane, Moscow, 119991, Russia.
E-mail: docteurmma@yandex.ru.

INTRODUCTION

Anesthetic provision of thoracic surgical interventions provides, as an inevitable component, a stage-oriented alternation of respiratory technologies. This position is decisive in the management of transcapillary mass transfer (TCM) in the lungs (exchange of gases, fluid and protein). On the other hand, the effectiveness of TCM may be influenced by the anesthetic agents themselves. Based on these components of the content of anesthesia, we undertook a study of the possibilities of the latest in a series of modern inhalation anesthetics desflurane (DF), in comparison with the previously more popular IF and SF, to create conditions for the optimal possible gas exchange at the stages of thoracic surgical interventions. The inclusion in the area of interest of the analysis of the interaction between the gas exchange capabilities of the pulmonary and systemic blood flow in the lungs under anesthesia based on desflurane, IF and SF will expand our

understanding of the gas exchange potential of the studied anesthetic technology [5,6]. Analysis of the literature does not contain recommendations for searching for the possibilities of the studied inhalation anesthetics in the formation of gas exchange and metabolic lung function, especially with prolonged exposure to one-lung ventilation in combination with collapse of the contralateral lung [7-11]. Among modern halogen-containing inhalation anesthetic agents (IA): isoflurane (IF), sevoflurane (SF), desflurane (DF) (registered in the Russian Federation 1990; 2004; 2013, respectively). DF has the lowest blood / gas solubility coefficient - 0,42 – 0,52 [12]. The rate of equilibration of concentrations in the inhaled mixture and in the alveoli for desflurane is almost identical to that for N_2O. The minimum alveolar concentration (MAC) is about 6% in oxygen (3% in N_2O) [13], for comparison, sevoflurane 2,1%, isoflurane 1,15%. This allows you to quickly change the depth of anesthesia. A faster increase in the concentration of IA in the alveoli (Fa) corresponds to a proportional increase in the concentration of the anesthetic in the blood and, indirectly, increases the rate of increase in the concentration of IA in the central nervous system. Desflurane metabolism occurs in the same way as isoflurane, because their molecules differ in only one atom. However, due to this difference, only 0.02% of the inhaled dose of desflurane is metabolized. Only a very small amount undergoes defluorination, and after prolonged anesthesia, only a slight increase in the concentration of trifluoroacetic acid in serum and in urine can be detected [14]. All these properties provide great flexibility in intraoperative management and impact on systemic blood flow [15]. In the context of our study, the systemic blood flow should also include those zones of pulmonary hydrodynamics that, along with pulmonary blood flow, under certain conditions are involved in gas exchange: - bronchial and broncho-pulmonary blood flow system, extracapillary perfusion microvessels, lymph flow system. The lymph flow system in the structure of the lung tissue is the main drainage collector of the interstitium and the efficiency of transcapillary diffusion largely depends on its consistency [18]. Separately, it should be noted that the phenomenon of extracapillary diffusion, described in the monograph of pathophysiologists by D.P. Dvoretsky, is highly significant in the participation in gas exchange. and Tkachenko B.I. in 1987 [19,20]. Analyzing the ways of exchange of respiratory gases, it was noted that diffusion O_2 and CO_2 carried out not only through the alveolocapillary membrane. Proof is presented that the intensive transfer of oxygen from the alveoli to the blood occurs through the walls of arterioles and small arteries of the pulmonary circulation [21, 22]. This phenomenon was discovered both for ventilation conditions of the lungs with hyperoxic gas mixtures and for ventilation of the lungs with air of ordinary composition. It was also found that, along with arterioles and small arteries, venules and small veins have a high diffusion capacity. Participation in the field of pulmonary gas exchange of non-capillary microvessels of the pulmonary circulation increases the time during which the blood can undergo oxygenation [19,20]. One of the essential features of the blood supply to the lungs is its two-component organization, which includes vessels of the pulmonary circulation (pulmonary blood flow) and bronchial vessels (systemic blood flow). The functional purpose of both is different: the former is predominantly involved in maintaining adequate pulmonary gas exchange, and the latter mainly provide nutrition to the tissues of the lungs themselves. These two circulation systems are not isolated from each other but have numerous communications at the extracapillary and capillary levels. Such vascular structures carry out extracapillary shunting of blood in a small circle and, if the patient has chronic respiratory failure, are actively included in the gas exchange system [19,20,23,24]. One of the factors in judging the efficiency of gas exchange is the indicator of the *physiological dead space* (VD). VD - this is the volume of all parts of the respiratory system in which gas exchange does not occur. Its value depends on the tidal volume, $PaCO_2$ and $EtCO_2$. This, at first glance, a simple calculated parameter is a worthy alternative to more complex technologies for assessing the effectiveness/inefficiency of breathing [25,26].

In general, the vasodilating effect of desflurane on systemic blood flow is known and described in domestic and foreign literature [16, 17].

We assumed the same high flexibility and efficiency of the reaction of gas exchange blood flow under its action. This assumption became the motivation for the research being performed.

Purpose: to determine the possibilities of modern inhalation anesthetics (desflurane, sevoflurane, isoflurane) to influence the efficiency of gas exchange in the lungs at the stages of thoracic surgical interventions.

MATERIALS AND METHODS

The study included patients of II-IV degree of risk by ASA (2,9 ± 0,1), with a proposed thoracotomy / thoracoscopic intervention, accompanied by artificial one-lung ventilation (OLV) of various duration. Patients with a lower ASA risk were excluded from the analysis; no need for intraoperative one-pulmonary ventilation with the use of respiratory support techniques for the operated lung; suffering from concomitant pathology of liver and kidney function, as well as patients with contraindications to the use of certain components of anesthesia or to the use of invasive monitoring of central and pulmonary hemodynamics. All patients are preliminarily acquainted with the planned method of anesthesia and warned about invasive hemodynamic monitoring. Informed consent was issued for them. All patients underwent general multicomponent balanced anesthesia with mechanical ventilation on a Draeger Primus (Draeger, Germany) and separate intubation of the bronchi with two-lumen endotracheal tubes Carlens and White (Teleflex Medical, Ireland), as a hypnotic component to maintain anesthesia we used the main inhalation anesthetic (desfluranetic Supran, Baxter Healthcare Puerto Rico); Sevoflurane (Sevoran, Eisica Queenborough); isoflurane (foran, "Eisica Queenborough"). The average duration of anesthesia was 392,86 ± 25,04 minutes (from 3 hours 20 minutes to 10 hours). The premedication included midazolam 2,5 mg (dormicum, "F. Hoffmann-La Roche Ltd"), chloropyramine (suprastin, "EGIS ZAO Pharmaceutical Plant") (2,0 ml), atropine (atropine, "Moscow Endocrine Plant FSUE" in weight dosage. For the induction of anesthesia, the following was used: dormicum – 0,07 ± 0,02 mg/kg; fentanyl (fentanyl, Federal State Unitary Enterprise State Plant of Medicines – 2,88 ± 0,14 μg/kg; propofol (Propofol Kabi, Fresenius Kabi Austria) – 1,38 ± 0,13 mg/kg; ketamine (ketamine, "Moscow Endocrine Plant") – 0,82 ± 0,17 mg/kg; cisatracuria besylate (nimbex, "Glaxo Smith Klein S.p.A.") – 0,18 ± 0,01 mg/kg. Anesthesia was maintained with the main inhalation anesthetic and an additional bolus of fentanyl in the most traumatic stages of

anesthesia and surgery (insertion of a catheter into the pulmonary artery, skin incision, surgical pneumothorax, installation of small and large retractors, thoracoscopic ports, manipulations at the root of the lung, installation of drains). In some cases, and additionally, if necessary. The average maintenance dose of fentanyl was 2,29 ± 0,15 μg/kg/h. The adequacy of the use of the concentrations of inhalation anesthetics was controlled by the constant status of central hemodynamic parameters, which did not go beyond the normal range and were comparable between the groups (IF and SF), which is also confirmed in the study Pagel et al. [3]. In the presence of signs of a decrease in cardiac output and hypotension, some patients received an infusion of adrenergic agonists and cardiotonics. The maintenance of muscle relaxation was performed by fractional administration of nimbex (0,05 ± 0,005 mg/kg/h) or pipcuronium bromide (0,02 ± 0,002 mg/kg/h). (arduan, "Gedeon Richter") upon resumption of respiratory activity.

Monitoring. Non-invasive and invasive monitoring was performed using an anesthetic monitor GE Datex-Ohmeda «S5 Anesthesia Monitor» (General Electric Company, USA), which includes the following modules for recording the following parameters: capnography, airway pressure (peak, average, plateau, PEEP), MV, Vt, RR, lung compliance, airway resistance, expiratory oxygen, carbon dioxide, SpO_2, temperature, non-invasive blood pressure, 5-lead ECG, CVP, invasive blood pressure; parameters of pulmonary hemodynamics and cardiac output by pulmonary thermodilution [28]. The radial artery was catheterized with an arterial catheter (B-Braun, Germany), the pulmonary artery with a catheter Swan-Ganz, (Arrow International Inc., USA). Pulmonary thermodilution with fixation of hemodynamic parameters and blood sampling was performed at the stages of anesthesia and surgery. The indicators of monitors were recorded and a computer calculation of indicators of systemic, pulmonary, intracardiac hemodynamics, gas exchange and metabolism were carried out.

To analyze the effect of anesthetics on systemic and pulmonary hemodynamics, in addition to monitoring, calculations were made using the formulas of such indicators as:

Precapillary resistance (Ra): (pulmonary artery pressure means - pulmonary capillary pressure)/cardiac output (mmHg * l-1 * min).

Postcapillary resistance (Rv): (pulmonary capillary pressure - pulmonary artery wedge pressure)/cardiac output (mmHg * L-1 * min).

Right ventricular pumping ratio (RVPR): stroke index of the right ventricle/pressure in the right atrium (g * m * mm-1 * m ^{2}).

Left ventricular pumping ratio (LVPR): left ventricular stroke index / pulmonary artery wedge pressure (g * m * mm-1 * m ^{2}).

Physiological dead space volume (VD), according to Bohr's equation: VD = VT*(PaCO2-PEtCO2)/PaCO2) (ml).

According to the stages of the study, the analysis of CBS, gas and electrolyte composition of arterial and mixed venous (LA) blood was carried out on the device GEM Premier 4000 (IL Headquarters, USA).

Maintaining gas exchange. After intubation, we proceeded to work along a semi-closed circuit in the low-flow mode with a fresh gas flow of 1 l/min and the supply of DP (IF, SF) in an oxygen-air mixture with FiO_2 0,5-0,7 [28, 29]. At the stages of surgical intervention, the fraction of supplied oxygen was regulated according to the data of pulse oximetry and arterial oxygenation (see table).

	1 stage (ALV-1)	2 stage (OLV 30 min)	3 stage (OLV 60 min)	4 stage (OLV 120 min)	5 stage (ALV-2)
FiO_2 (%)					
SF	50,71±5,20	77,07±4,82	83,00±3,07	81,58±2,77	75,33±3,26
IF	56,00±3,74	70,00±3,94	74,00±4,85	68,13±5,85	68,50±4,99
DF	47,19±2,53	76,06±3,84	84,76±3,06	80,28±4,01	63,15±6,08
% MAC					
SF	37,31±7,24	43,93±5,84	44,44±8,31	72,92±7,87	53,67±6,72
IF	28,99±3,35	36,84±2,41	37,18±5,30	32,29±8,09	30,95±5,95
DF	63,33±3,49	76,56±4,69	76,75±3,07	65,79±5,75	66,55±6,67
PaO_2 (mmHg)					
SF	262,91±43,26	153,34±25,77	186,83±26,84	164,95±28,31	258,39±32,72
IF	119,36±24,89	144,72±16,95	194,52±22,59	265,71±31,72	221,88±22,76
DF	156,81±14,07#	117,44±9,41	135,38±16,20#	149,00±16,13#	204,00±36,14
PA-aO2 (mmHg)					
SF	104,39±20,95	350,06±42,25	354,95±42,20	365,40±37,49	233,78±34,40
IF	108,02±19,63	306,12±32,42	286,05±38,26	166,54±50,48	215,85±29,30
DF	130,12±18,27	371,28±26,74	411,93±24,22	366,86±33,55	188,04±40,32
VD (ml)					
SF	157,02±18,28	183,79±13,46	189,24±15,28	208,59±12,32	237,95±46,98
IF	134,57±24,96	143,59±12,00	137,82±14,14	178,53±18,54	156,69±15,64
DF	101,53±13,62	124,70±13,78*	109,40±8,62*	102,41±10,14*#	116,18±17,12*
Ra (mmHg*l^{-1}*min)					
SF	0,99±0,12	0,95±0,12	1,13±0,28	1,18±0,11	1,21±0,20
IF	0,63±0,16	0,59±0,11º	0,64±0,13º	0,94±0,09	0,82±0,15
DF	0,93±0,11	1,04±0,17#	1,16±0,12#	1,00±0,10	0,94±0,09
Rv (mmHg*l^{-1}*min)					
SF	0,66±0,08	0,64±0,08	0,75±0,19	0,79±0,07	0,81±0,13
IF	0,41±0,10	0,39±0,07	0,42±0,08	0,62±0,06	0,54±0,09

DF	0,62±0,07	0,69±0,11	0,77±0,08	0,67±0,06	0,63±0,06
RVPR (g*m*mm ^{1}*m^{2})					
SF	0,89±0,11	0,93±0,10	0,83±0,12	0,94±0,22	0,86±0,08
IF	1,10±0,28	1,02±0,21	0,85±0,05	1,36±0,18	0,95±0,10
DF	1,96±0,48*	1,54±0,22*#	2,36±0,43*#	2,63±0,67*	2,60±0,82*#
LVPR (g*m*mm ^{1}*m^{2})					
SF	5,58±0,96	4,61±0,70	4,39±0,92	5,72±0,98	4,92±0,62
IF	5,17±1,85	4,26±1,02	5,65±1,75	5,68±1,32	3,63±0,51
DF	4,98±0,98	5,81±1,35	5,57±0,71	6,86±1,18	6,09±0,85
SVR (dynes*s*cm^{-5})					
SF	1733,99±171,97	1278,48±158,01	1688,13±275,10	1674,62±177,76	1394,32±117,33
IF	1142,02±118,75º	952,62±56,91	1111,80±85,98	841,02±48,60º	954,11±92,20
DF	1133,14±59,60*	1291,63±89,40	1149,40±74,67	1137,96±99,82*	1071,74±104,89

Effects of sevoflurane, isoflurane and desflurane. Data are presented as Mean±m; ALV - two-lung ventilation; OLV - artificial one-lung ventilation; SEV – sevoflurane; ISO – isoflurane; DES – desflurane; FiO_2 – fraction of oxygen in the inhaled mixture; % MAC – percentage of the minimum alveolar concentration of the inhalation anesthetic; PaO_2 – arterial oxygen partial pressure; PA-aO_2 - alveolar-arterial oxygen difference; VD – physiological dead space; Ra – precapillary resistance; Rv – postcapillary resistance; RVPR – right ventricular pumping ratio; LVPR – left ventricular pumping ratio; SVR – total peripheral resistance; * - reliable difference DF from SF (p<0,017); # - reliable difference DF from IF (p<0,017); º - reliable difference SF from IF (p<0,017)

The concentration of IA was fixed on expiration (IA et); for standardization, % of the minimum alveolar concentration (MAC) was calculated (see table).

Ventilation parameters were selected based on preoperative indicators of external respiration function, intraoperative indicators of pulse oximetry and capnography, monitoring data on airway pressure (peak, mean, plateau, PEEP), MV, Vt, RR, lung compliance data, End tidal O_2 and CO_2, as well as controlled by the results of the study of arterial and mixed venous blood. Research stages. Stage 1. Before the operation, after induction into anesthesia, tracheal intubation, radial artery catheterization, pulmonary artery catheter installation, before the operation. Under conditions of ventilation of both lungs (AVL-1) and maintenance of anesthesia with desflurane. Stage 2. During the installation of trocars and the introduction of surgical instruments in the conditions of surgical pneumothorax (SP) and artificial one-lung ventilation (OLV) lasting 30 minutes. 3 and 4 stages. In the process of performing the main stage of the operation and OLV lasting 60 (stage 3) and 80-120 (stage 4) minutes.
Stage 5. The end of the main stage of the operation when suturing operational defects of the chest wall after extraction of trocars, 20-30 minutes after restoration of ventilation of both lungs (mechanical ventilation) (ALV-2).
Statistical processing of the results was carried out on a PC using the MS Excel365, SPSS 22 software packages, descriptive statistics and methods for small samples (abnormal distribution) were used - nonparametric criteria, Kruskal-Wallis H-Test, confidence level p<0,017.

RESULTS AND DISCUSSION

With ventilation of both lungs *(measurement stage 1, see table)* the level of arterial oxygenation (PaO_2) was in comparable values in all groups and showed an insignificant level of hyperoxia. Alveolar-arterial oxygen difference (PA-aO2) also did not have significant intergroup differences at this stage. The indices of the work of the right and left ventricles were comparable in the three groups and did not have a significant difference when using the studied anesthetics, which corresponds to a sufficient level of anesthetic protection. Statistically significant differences were obtained in total peripheral vascular resistance (SVR): in the SF group there was a significantly higher value in comparison with comparable indicators of the DF and IF groups, which indicates an initially more pronounced constrictor effect on the systemic vascular bed. There was no difference in the effect of gas exchange blood flow (Ra, Rv) between the groups. Thus, the effect of DF on gas exchange blood flow during ventilation of both lungs is similar to the effect of SF. The above observations allow us to conclude that the tone of gas exchange vessels when using modern inhalation anesthetics (DF, IF and SF) in conditions of ventilation of both lungs is comparable between groups and does not have a significant effect on heart performance and oxygenation.
When the operated lung was collapsed *(measurement stage 2, see table)*, arterial oxygenation was sufficient and comparable in all groups, which indicates the safe maintenance of gas exchange. PA-aO2 significantly increased with the previous stage in all groups but did not have statistically significant intergroup differences at this stage. It is important to note the appearance of a significant difference in the physiological volume of the dead space between DF and SF, which in the DF group turned out to be less, which indicates a larger volume of lung tissue included in oxygenation. At the second stage, RVPR DF had a significant difference only with SF, which, possibly, determines the more pronounced cardioprotective property of DF. An increase in Ra DF was observed, which did not exceed the normal value, however, it turned out to be significantly higher than the Ra IF level and comparable with the Ra SF level. Postcapillary resistance (Rv) when the lung was switched off slightly increased with the use of DF and SF, at the same time retained a significantly lower value in the IF group. An increase in the tone of the vessels of the gas exchange blood flow during the period when the lung is switched off indicates that DF has mechanisms of sympathomimetic stimulation of pulmonary blood flow vessels with an increase in vascular resistance in them, which is comparable to the effect of SF [30].
Further on the stages of continuing the *OLV 60 (3 stage) and 80-120 (4 stage) min (see table)* arterial oxygenation in the DF group was sufficient, but significantly lower than in the IF group and comparable to SF. At the same time, the alveolar-arterial oxygen difference naturally had a significant difference with the IF group and retained similarity with the SF group. Despite the observed

difference, blood oxygenation in all groups was sufficient, and the DF group least of all contributed to the development of hyperoxia, which can lead to hyperoxic hypoxia. The indicator of the physiological volume of the dead space was significantly lower in the DF group in comparison with the SF and comparable with the IF group, which indicates the superiority of DF in comparison with SF in the volume of the lung parenchyma capable of oxygenation. At the stage of OLV 60 minutes, there was a statistically significant superiority of RVPR in the DF group in comparison with SF and IF. By 2 hours, OLV RVPR statistically differed from SF, but did not have a significant difference from IF RVPR. This observation indicates a lower load on the right parts of the heart in comparison with the SF group. At this stage of DF measurements, there were significant differences with the IF group in the tone of the gas exchange vessels of the pulmonary MCB; in comparison with SF, the same dynamics was noted, but they were not reliable.

With the duration of the OLV 80 - 120 minutes, there was a restructuring of blood circulation, which eventually led to the restoration of equilibrium between ventilation and perfusion. Arterial oxygenation was sufficient but remained significantly lower in the DF group in comparison with IF and comparable to SF. Alveolar-arterial oxygen difference significantly differed from the IF group and retained similarity with the SF group. The data presented do not have a common conclusion with the study Abe K et al., in which no difference was found [5]. Resistance indices of pre- and postalveolar capillaries did not have a significant intergroup difference, which characterized the end of the process of development of hypoxic pulmonary vasoconstriction. Taken together, this dynamic allows us to conclude that the perfusion of the ventilated lung was fully restored against the background of persisting vasoconstriction in the unventilated lung [31].

The volume of the physiological dead space DF shows stable dynamics at this stage and turned out to be significantly less than SF. Thus, in the period of OLV 60-80-120 min, the resistance of the gas exchange bed did not statistically differ between the groups, however, significant differences in DF in arterial oxygenation and alveolar-arterial oxygen difference with the IF group and the similarity with the SF group allow us to determine that the development of hypoxic vasoconstriction in the collapsed lung is slowed down comparable to SF without signs of pathological load on the right heart. After the ventilation of the operated lung was switched on *(stage 5, see table)*, the macrohemodynamic parameters showed stable dynamics similar to the initial values. Resistance indices of pre- and postalveolar capillaries returned to their original values. Arterial oxygenation and alveolar-arterial oxygen difference returned to baseline values and did not differ between groups. VD at this stage is statistically different between the DF and SF groups, as in the previous stage, DF is two times less than the SF indicator. RVPR DF had a significant difference only with SF, which, despite the presence of persisting shunting blood flow at the previous stages, more favorably reflected the tension of compensatory mechanisms and did not lead to overloads in the right heart.

CONCLUSION

All investigated inhalation anesthetics (desflurane, sevoflurane and isoflurane) meet the safety needs of anesthetic protection and gas exchange during modern thoracic surgical interventions. However, there are certain differences in the mechanisms of their effect on the components of the circulatory system responsible for the effectiveness of TCM, which make it possible to formulate indications for the preferential use of one or another of them.

The study confirmed the identity of such parameters as arterial oxygenation, resistance of pre- and postalveolar gas exchange capillaries at the same level of FiO_2 in comparison of DF and SF. Note separately that in this respect, the effect of DF on pulmonary blood flow corresponds to the effects of SF. This observation is confirmed in a smaller volume of dead space in OLV under the conditions of DF and IF, and thus is evidence of a more efficient gas exchange blood flow when used in comparison with SF. Isoflurane, in contrast to SF, is a more powerful dilator of not only systemic, but also pulmonary blood flow, which provides a higher level of arterial oxygenation with a lower resistance of the pre- and postalveolar parts of the gas exchange bed of the lungs. We assume that the powerful systemic vasodilatory effect of desflurane extends to bronchial blood flow, as well as to vessels of extracapillary perfusion, which are components of the interstitial space of the lungs.

Despite the fact that the effect of DF on the vessels of the systemic blood flow is comparable to isoflurane in terms of SVR levels, which is lower than the level of systemic vasoconstriction in SF, the observation that the main difference between desflurane in comparison with both SF, and especially from IF, is significant. higher rates of pumping ratio of the right ventricle. Both of these factors, together with the dynamics of the volume of the dead space, make it possible to make an assumption about the inclusion in the gas exchange function, in addition to the vessels of the pulmonary blood flow, the vessels of the bronchopulmonary blood flow and extracapillary perfusion under conditions of anesthesia DF. Such a combination of interaction between systemic and pulmonary blood flow, most likely contributes to the improvement of pulmonary lymph flow, which is extremely important, since lymphatic flow is the main drainage collector of the parenchyma, the level of hydration of the parenchyma depends on the efficiency of its functioning, especially when overloaded with volumes. Therefore, despite the comparability in the pulmonary blood flow system with DF and SF, reserves for maintaining gas exchange when using DF have an advantage. Even the cardioprotective function of DF due to the higher RVPR also has an advantage over SF and IF. In conclusion, it should be noted that despite the sufficiently high capabilities of all three anesthetics for patients with limited reserves of the cardiorespiratory system, the use of desflurane as a component of the safety and controllability of anesthesia becomes more justified and expedient.

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