

ANNOTATION

Dissertation work by Bayterek Bekzat Askaruly

on the topic: «Ересектердегі кардиохирургиялық операция кезінде жалпы көктамыршілік және ингаляциялық анестезияны қолданудың тиімділігін салыстырмалы анықтау»

presented for the degree of Doctor of Philosophy (PhD)

in the specialty 8D10102 – "Medicine"

Introduction:

Anesthetic management during cardiac surgeries significantly influences the intraoperative course and the success of the postoperative period. The traditional methods of anesthesia in cardiac surgery are total intravenous anesthesia (TIVA) and inhalational anesthesia. Numerous studies have shown the superiority of halogenated agents over propofol in myocardial revascularization surgeries [S.G. De Hert, P.J. Van der Linden, S. Cromheecke et al., 2004]. However, high-quality meta-analyses have shown conflicting results [Suryaprakash S, Chakravarthy M., et al., 2013]. Postoperative complications in adults after heart surgery, such as myocardial infarction, low cardiac output syndrome, postoperative cognitive dysfunction, hypoxemia, pneumonia, and acute respiratory distress syndrome, prolong the duration of intensive care unit and hospital stay, and increase mortality rates [Pisano A., Torella, M.; Yavorovskiy, A.; Landoni, G. 2021]. There are several interventions that can improve intraoperative outcomes, one of which is the adequate and safe administration of anesthesia [Stefan, M.; Filipescu, D. 2020]. It is well known that the choice of anesthetic in cardiac surgeries is based on department traditions, personal experience, and so on. However, there is a lack of studies that perform a comparative analysis of the effectiveness of total intravenous anesthesia and inhalational anesthesia during cardiac surgeries. It is known that oxygen consumption and its delivery are sensitive markers for assessing patient protection from surgical stress [Haroun-Bizri S, Khoury S.S., et al., 2001]. Oxygen delivery is considered a more important marker for its transport than blood oxygen saturation. Furthermore, oxygen transport during cardiac surgeries depends on hemodynamic changes [De Hert S, Vlasselaers D., et al., 2009]. However, there is a lack of research on the comparative analysis of the effectiveness of TIVA and inhalational anesthesia on these parameters during cardiac surgeries. Studies using precise, comprehensive metrics—such as cardiac output, systemic hemodynamics, oxygen transport, and energy expenditure—are scarce. The above-mentioned data provided the basis for conducting this research.

Purpose of the Study:

The objective of the study was a comparative analysis of the efficacy of sevoflurane and isoflurane inhalational anesthesia versus total intravenous anesthesia with propofol during cardiac interventions in adults.

Research Objectives:

1. To study the effects of inhalational anesthetics and total intravenous anesthesia with propofol on systemic hemodynamics, oxygen transport and consumption, and energy expenditure during valve prosthesis/plastic surgery under endotracheal anesthesia.

2. To study the effects of total intravenous anesthesia with propofol and inhalational anesthetics on systemic hemodynamics, oxygen transport and consumption, and energy expenditure during coronary artery bypass grafting surgery.
3. To determine the cardioprotective effect of total intravenous anesthesia with propofol or inhalational anesthesia with sevoflurane and isoflurane on myocardial damage during valve prosthesis/plastic surgeries.
4. To examine the effects of sevoflurane and isoflurane inhalational anesthesia and total intravenous anesthesia with propofol on the duration of postoperative mechanical ventilation and patient awakening time.

Study Objects:

The primary material for this study consists of clinical observations and results from specialized examinations of 165 patients who underwent cardiac surgery in the Cardiac Surgery Department of the Medical Center of the Administration of the President of the Republic of Kazakhstan and the multidisciplinary City Hospital No. 2 in Astana. Of the 165 patients, 90 (54.6%) had ischemic heart disease, and 75 (45.4%) had heart valve pathology.

This study includes two patient groups:

- Group 1: 75 patients with heart valve pathology.
- Group 2: 90 patients with ischemic heart disease.

Research Methods:

1. **Stroke volume (SV)** = End-diastolic volume - End-systolic volume (in milliliters).
2. **Cardiac output (CO)** = Stroke volume \times Heart rate (in ml/min).
3. **Cardiac index (CI)** = Cardiac output / Body surface area (in l/min/m²).
4. **CaO₂ (arterial oxygen content)** = $[(1.34 \times \text{Hb} \times \text{SO}_2) + (\text{PO}_2 \times 0.031)] / 100$.
5. **CvO₂ (central mixed venous oxygen content)** = $[(1.34 \times \text{Hb} \times \text{SO}_2) + (\text{PO}_2 \times 0.031)] / 100$.
6. **Arteriovenous oxygen difference (AVDO)** = CaO₂ - CvO₂.
7. Oxygen delivery (DO₂) was determined by the formula: **DO₂ = CI \times CaO₂**.
8. Oxygen consumption (VO₂) was calculated by the formula: **VO₂ = CI \times AVDO** or **VO₂ = CO \times (CaO₂ - CvO₂) \sim CO \times Hb \times 1.34 \times (SaO₂ - SvO₂) / 100**.
9. Oxygen consumption and energy expenditure during anesthesia were measured using indirect calorimetry with a spirometry device (GE DATEX OHMEDA E-CAiOV, USA).

Scientific Novelty

1. A comprehensive and informative study was conducted on cardiac output, systemic hemodynamics, oxygen transport and consumption, and energy expenditure during cardiac surgery to analyze the comparative effectiveness of inhalational anesthesia with halogenated agents (sevoflurane and isoflurane) and total intravenous anesthesia (TIVA) with propofol.
2. A comparative analysis of anesthetic effectiveness during heart valve surgery showed that sevoflurane, isoflurane, and TIVA with propofol do not reduce cardiac output during the surgical stage of anesthesia.

3. For the first time, it was demonstrated that TIVA with propofol in these surgeries is associated with better oxygen transport and lower oxygen consumption compared to inhalational halogenated agents (sevoflurane and isoflurane).
4. It was first shown that TIVA with propofol leads to lower energy expenditure compared to inhalational anesthetics during cardiac surgery.
5. For the first time, it was demonstrated that heart valve repair/replacement procedures are associated with a significant increase in cardiac troponin I, indicating myocardial injury during these interventions. It was also first shown that TIVA with propofol provides better myocardial protection against damage, as postoperative cardiac troponin I levels were lower with this anesthesia method.

Practical Significance

1. It was found that oxygen consumption decreases while oxygen delivery improves during cardiac surgery under TIVA with propofol compared to inhalational anesthesia with sevoflurane and isoflurane. These findings should be considered in clinical practice.
2. Energy expenditure is significantly reduced with TIVA using propofol compared to inhalational anesthesia with sevoflurane and isoflurane. This method optimizes oxygen consumption, which may reduce the likelihood of postoperative complications.
3. TIVA with propofol has a cardioprotective effect on the myocardium. In heart valve repair/replacement surgeries, postoperative levels of the myocardial injury biomarker troponin I were lower compared to those observed with inhalational anesthesia using sevoflurane and isoflurane.
4. Compared to inhalational anesthesia with sevoflurane and isoflurane, TIVA with propofol is associated with prolonged mechanical ventilation and awakening time.
5. Based on our data, TIVA with propofol is the preferred anesthetic method for cardiac surgery, as it reduces oxygen consumption, improves oxygen delivery, and lowers energy expenditure. However, this anesthesia technique is also associated with prolonged awakening and mechanical ventilation in the postoperative period.

Key Findings for Defense

1. During cardiac surgery, inhalational anesthesia with sevoflurane and isoflurane, as well as TIVA with propofol, do not have a depressive effect on the myocardium and do not alter cardiac output.
2. TIVA with propofol in cardiac surgery does not have a depressive effect on the myocardium and exhibits more pronounced cardioprotective and energy-saving effects, as well as better oxygen transport capability compared to inhalational anesthetics.

Conclusions

1. During heart valve replacement or repair surgeries, no differences were observed in cardiac output values between total intravenous anesthesia with propofol and inhalation anesthetics. All three types of anesthetics reduced oxygen transport, oxygen consumption, and energy expenditure. Under propofol anesthesia, oxygen transport decreased by 12.2%, oxygen consumption by 19.8%, and energy expenditure by 10.1%. With sevoflurane and isoflurane anesthesia, oxygen transport decreased more, and oxygen consumption increased compared to propofol anesthesia by 18.1% and 17.3%, and by 9.5% and 12.2%,

respectively. Energy expenditure decreased by 10.7% with sevoflurane anesthesia and by 13.9% with isoflurane anesthesia.

2. During coronary artery bypass grafting (CABG) surgeries, no differences were observed in cardiac output values between total intravenous anesthesia with propofol and inhalation anesthetics. Oxygen transport, oxygen consumption, and energy expenditure decreased with all three types of anesthesia. Under propofol anesthesia, oxygen transport decreased by 13.6%, oxygen consumption by 16.2%, and energy expenditure by 13.8%. With sevoflurane and isoflurane anesthesia, oxygen transport decreased more, and oxygen consumption increased compared to propofol anesthesia by 16.4% and 25.4%, and by 9.1% and 10.8%, respectively. Energy expenditure decreased by 11.3% with sevoflurane anesthesia and by 7.9% with isoflurane anesthesia.
3. During heart valve replacement or repair surgeries, the level of troponin I 12 hours after surgery showed statistically significant differences. After propofol anesthesia, the troponin I level at 12 hours was reduced by 15.1% and 18.5% compared to sevoflurane and isoflurane anesthesia, respectively. Additionally, the average doses of cardiotoxic drugs used with propofol anesthesia were lower than those used with sevoflurane and isoflurane anesthesia, indicating a more pronounced cardioprotective effect of propofol.
4. In the postoperative period, no differences were observed in the effects of propofol and inhalation anesthetics on the duration of mechanical ventilation and the patient's awakening time.

Practical Recommendations

1. TIVA with propofol is associated with lower oxygen consumption and better oxygen delivery. This type of anesthesia is also more energy-efficient compared to halogenated agents (sevoflurane and isoflurane). These factors should be considered in clinical practice during cardiac surgeries.
2. For TIVA with propofol in cardiac surgery, a propofol dose of 4 mg/kg/h is recommended.
3. Compared to inhalational anesthetics sevoflurane and isoflurane, TIVA with propofol has a cardioprotective effect on the myocardium.

Approval of Research Findings

The main findings of the dissertation were presented at the following conferences:

1. IV Congress of Anesthesiologists and Resuscitators of Kazakhstan (Almaty, 2023).
2. "6th International Conference and Exhibition on Pain Management," held on December 4-5, 2023, in Rome, Italy.
3. The First International Scientific and Practical Conference "Astana Medical Forum 2024: Medicine of the Future – Integration of Science, Education, and Practice," dedicated to the 60th anniversary of NAO "Astana Medical University," held on October 14-15, 2024.

Publications on the Dissertation Topic

A total of 5 publications have been produced based on the dissertation research, including:

- **One** article published in a journal indexed in Scopus with a 70th percentile (Q2) CiteScore.
- **Four** articles published in national journals recommended by the Committee for Quality Assurance in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan (KOKSON MON RK):

- *Pharmacy of Kazakhstan*
 - *Journal of Clinical Medicine of Kazakhstan*
 - *Science and Healthcare*
 - *Journal of Clinical Medicine of Kazakhstan*
- Additionally, **one** article was published in a Scopus-indexed journal:
- *Anesthesiology and Pain Medicine*: Vol. 13, Issue 2, e134119. Published Online: March 14, 2023.

Implementation of Research Findings

The results of this study have been implemented and are currently used in the clinical practice of the Departments of Anesthesiology, Resuscitation, and Cardiac Surgery at the Hospital of the Medical Center of the Administration of the President of the Republic of Kazakhstan, as well as in the Department of Anesthesiology and Resuscitation at City Hospital No. 2 in Astana.

Author's Contribution

The author was actively involved in the development of the research concept and design, personally participated in the clinical study, and was responsible for patient selection, examination, and anesthetic management during heart valve replacement/repair and coronary artery bypass grafting surgeries. The author personally conducted postoperative patient monitoring and examinations, maintained electronic medical records, analyzed and interpreted the obtained results, and published the key findings, conclusions, and practical recommendations of the dissertation.

Structure and Volume of the Dissertation

The dissertation consists of an introduction, a literature review, a description of the materials and methods used in the clinical study, a discussion of findings, conclusions, practical recommendations, a list of abbreviations, and references.

The document comprises **123 pages** of typed text, including **26 tables and 14 figures**. The reference list contains **232 sources**.

The structure of the dissertation is as follows:

- Introduction
- Literature review
- Description of materials and research methods
- Two sections presenting the study results
- Conclusion
- Findings
- Practical recommendations
- References