**ORIGINAL RESEARCH**

The role of anesthesiology in modern cardiac surgery: overview of key techniques and issues

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**Abstract**

Anesthesiology plays a key role in modern cardiac surgery, ensuring the safe conduct of surgical interventions on the heart and blood vessels. The paper provides an overview of the main techniques and problems in the field of anesthesiology in cardiac surgery. The first section is devoted to the basic methods of anesthesiological provision of cardiac surgery. He describes the various types of anesthesia used in cardiac surgery, including general anesthesia, epidural and spinal anesthesia, as well as combined methods. The advantages and disadvantages of each of them are considered, as well as the specifics of their application, depending on the type of operation and the patient's condition. The second section examines the key problems faced by anesthesiologists in cardiac surgery. This includes managing hemodynamic parameters during surgery, monitoring heart and respiratory function, ensuring adequate analgesia, and preventing possible complications such as myocardial ischemia, arrhythmias, hypothermia, and thromboembolic events. Special attention is paid to solving problems related to patients with concomitant diseases such as hypertension, diabetes mellitus, chronic obstructive pulmonary disease, etc. The article discusses the features of the use of cardiothoracic anesthesia in cardiac surgery, as well as emerging problems and prospects in this area. An overview of the use of anesthesia in the field of cardiac surgery is presented, both current challenges and problems in this area are highlighted. The current state of anesthesia in cardiac surgery is analyzed and a number of problems faced by anesthesiologists during cardiac surgery, including problems of cardiothoracic anesthesia, are highlighted. This includes difficulties with controlling the depth of anesthesia, ensuring safety while maintaining artificial circulation, managing fluid balance, and monitoring cardiac function during surgery. The article reveals the relevance and importance of the work of anesthesiologists in cardiac surgery and the problems they face, as well as reveals the prospects for the development of anesthesia in cardiac surgery. This will help anesthesiologists and cardiac surgeons better understand the specifics of anesthesiological care in cardiac surgery and effectively solve emerging problems, ensuring maximum safety and comfort for patients.

**Keywords**

Anesthesiology, Cardiac surgery, Modern techniques, Cardiothoracic anesthesia, Problems of anesthesia in surgery, Safety of anesthesia, Cardiothoracic anesthesia, Treatment of cardiovascular diseases, Problems of anesthesia in cardiac surgery.

Imprint


**INTRODUCTION**

Modern cardiac surgery is one of the most complex and technically advanced areas of medicine, requiring not only high surgical skill, but also precise anesthetic support. Anesthesiology in cardiac surgery plays a key role in ensuring the safety and effectiveness of surgical interventions on the heart and blood vessels. Advances in cardiac anesthesia have led to the identification of knowledge gaps that require a focus on perioperative care, including long-term outcomes.

The use of different types of data, new analytical methods and innovative approaches to research will ultimately benefit patients.
With the advent of minimally invasive cardiac surgery (MICS), dose minimization of opioids and ultrasound-guided regional anesthesia for pain relief have made accelerated recovery from cardiac surgery (ERACS) possible.

With the development of technologies and techniques for the surgical treatment of cardiovascular diseases, the possibilities of intervention have significantly expanded, which has led to an increase in the complexity of operations and increased requirements for anesthesiological support. This creates the need for continuous improvement of anesthesiology methods and solutions to emerging problems.

Medical treatments such as dilators and diuretics have made a significant contribution to reducing mortality and exacerbations of heart failure [1]. Some aspects such as regional analgesia, new drugs and technologies, artificial intelligence in cardiocarotid surgery, advances in imaging, MICS and anesthesia that have influenced clinical practice are described in detail.

Anesthesiology plays a key role in modern cardiac surgery, ensuring the safe conduct of surgical interventions on the heart and blood vessels. Cardiovascular surgery is one of the most difficult and technically demanding in medical practice, and the anesthetic support of these interventions plays a critical role in the success of the operation and the well-being of the patient.

Cardiothoracic anesthesia may seem to be one of the most “traditionalist” specializations among anesthesiologists: cardiothoracic anesthesiologists intubate almost everyone, perform little locoregional anesthesia (especially in cardiac surgery), they are still far from the fashionable concept of “non-opioid anesthesia”, and are among the few who still use a pulmonary artery catheter [2].

Cardiovascular diseases remain one of the leading causes of death in the world, and for many patients, surgical treatment is the only way to survive or improve their quality of life. However, performing cardiovascular surgery involves high risks associated with the intervention itself, as well as the general risks inherent in any surgical procedure.

Someone will say that this is an old method, doomed to disappear, like cardiac surgery itself, but it cannot be further from the truth. Cardiothoracic anesthesia is one of the oldest and at the same time, it is the most advanced of all types of anesthesia. Most often, this type of anesthesia is applied to patients with serious illnesses, so further study of this area will allow us to reach a new level of medicine.

On the one hand, improvements in perioperative hemodynamic management and intensive care procedures, as well as the availability of increasingly sophisticated and effective mechanical circulatory support devices, make it relatively safe to perform complex invasive cardiothoracic surgery in elderly patients and in patients with poor systolic myocardial function [3].

On the other hand, minimally invasive and hybrid cardiothoracic procedures are becoming more widespread [4]. Accordingly, cardiothoracic anesthesiologists and intensive care specialists will have to cope with all this in order to simultaneously face both less invasiveness and greater complexity and risk level.

Anesthesiology in cardiac surgery includes not only the selection and use of anesthetics, but also the maintenance of vital body functions such as respiration, blood circulation, and ensuring the stability of hemodynamics during surgery. In addition, the anesthesiologist must take into account the characteristics of each patient, their concomitant diseases, allergies and reactions to anesthetics.

The main objective of the work is to study the basic methods of anesthesiology used in cardiac surgery, as well as to identify the key problems faced by anesthesiologists in this field. Consideration of modern methods of anesthesiological support and analysis of problems will allow us to better understand the specifics of the work of anesthesiologists in cardiac surgery and develop strategies for optimizing anesthesiological care to improve the results of surgical treatment of cardiovascular patients.

We will look at the main aspects of anesthesiological provision in cardiac surgery, including the techniques and technologies used, as well as the key problems faced by anesthesiologists in this field. Understanding these aspects will help to ensure maximum safety and effectiveness of surgical treatment of cardiovascular diseases.

The purpose of the work is to consider the features and problems of the use of cardiothoracic anesthesia in cardiac surgery.

MATERIALS AND METHODS

In the process of writing the paper, an array of articles and monographs were analyzed within the framework of the research topic. These materials in-
cluded the characteristics of various cardiac surgical procedures and techniques used in surgical practice, as well as the study of the principles of working with cardiothoracic anesthesia. Also, the studies reviewed concerned the study of specific applications of robots in the medical field, such as surgery, rehabilitation, diagnostics, etc. As noted in the literature, despite the studied issue of anesthesia in cardiac surgery, there are still a number of problems that need to be solved. In the process of creating the article, a systematic analysis of scientific articles, review articles and meta-analyses on the role of anesthesiology in cardiac surgery was used. Clinical recommendations and guidelines on cardioanesthesia issued by leading medical organizations were studied, as well as a review of national and international standards and protocols on anesthesia in cardiac surgery.

The study identified the key techniques used by anesthesiologists in cardiac surgery, as well as the problems they face in the process of providing cardiothoracic anesthesia. The article discusses these problems in detail and suggests ways to solve them.

RESULTS

In cardiac surgery, various types of anesthesia are used depending on the characteristics of the operation, the patient’s condition and the preferences of the anesthesiologist. The main types of anesthesia include: general anesthesia, epidural, spinal and combined methods.

General anesthesia is the most common method of anesthesia in cardiac surgery. The patient is in a state of deep unconscious sleep and does not feel pain. To achieve general anesthesia, inhaled anesthetics (e.g., isoflurane, sevoflurane) and/or intravenous anesthetics (e.g., propofol) are used. General anesthesia allows anesthesiologists to fully control breathing and the depth of anesthesia, which is especially important during cardiac surgery requiring cardiopulmonary bypass.

Epidural anesthesia is preferred in some cases, especially during operations on the thoracic aorta. During epidural anesthesia, the anesthetic is injected into the epidural space, which leads to a blockage of sensitivity in a certain area of the body. This anesthesia provides good analgesia and reduces the dose of general anesthetics, which is especially important for patients at high risk of cardiovascular complications.

Spinal anesthesia, like epidural anesthesia, provides analgesia and blocks sensitivity in certain areas of the body. Unlike epidural anesthesia, with spinal anesthesia, the anesthetic is injected directly into the spinal canal, which provides a faster onset of action and a more pronounced blockade.

Combined anesthesia methods are often used in cardiac surgery, especially in heart and lung operations. For example, a combination of general anesthesia with epidural or spinal anesthesia may be used to achieve better control of analgesia and stability of hemodynamic parameters during surgery.

It is important to note that anesthesia is used in particular in cardiothoracic surgery. In this type of surgery, general anesthesia is most often used, which includes inhalation anesthetics, intravenous drugs and muscle relaxants to maintain complete anesthesia and respiratory control. This allows surgeons to perform complex operations on the heart, lungs and other organs in the chest cavity without pain and discomfort for the patient.

The advantages of general anesthesia in cardiothoracic surgery. A deep level of analgesia and amnesia, which allows the patient not to feel pain and not to remember the operation. Control over breathing and the depth of anesthesia, which allows surgeons to safely perform procedures. Rapid onset of action and rapid disappearance after discontinuation of the anesthetic [5].

The disadvantages of general anesthesia include the risk of adverse reactions and complications, such as allergic reactions, impaired heart and lung functions. The possibility of postanesthetic nausea and vomiting after surgery. Possible problems waking up after anesthesia, including drowsiness, dizziness and disorientation.

However, modern anesthesia methods and constant monitoring ensure a high level of safety and comfort for patients [6].

Mortality and the incidence of serious complications after cardiothoracic surgery have decreased in recent decades due to improvements in both surgical techniques and perioperative care (including, as already mentioned, the availability of increasingly sophisticated monitoring devices). However, mortality remains significant (on average about 2%) even for the simplest procedures and increases sharply with combined or more complex interventions [7]. Moreover, cardiothoracic surgery is still associated with a relatively high risk of severe complications such as low cardiac output syndrome (LCOS), neurological
complications, acute kidney injury (AKI), pulmonary complications, and major bleeding [8].

Despite intensive clinical research, many aspects of cardiothoracic anesthesia still remain rather “empirical”, without convincing randomized evidence clearly defining clinical strategies and therapeutic choices [9].

In the latest edition of a series of international “democracy-based” consensus conferences, the aim of which was to report on all “auxiliary” (i.e. non-surgical) interventions that are widely believed to significantly affect survival in perioperative and critical condition, according to at least one randomized controlled trial (RCT), only four interventions related to cardiothoracic surgery have been identified: inhaled anesthetics, levosimendan for postoperative SSC syndrome, the use of leukocyte-depleted erythrocytes, and the rejection of aprotinin [10]. Of these, the use of leukocyte-depleted erythrocytes for blood transfusion is currently considered the best practice in most Western countries, while the “unsolved case” of aprotinin may possibly be resumed in the future after its re-introduction into use [11].

Volatile anesthetics and levosimendan are undoubtedly two hot topics of modern clinical practice and research in the field of cardiothoracic anesthesia [12].

In several single-center studies and meta-analyses, volatile anesthetics have been shown to have a cardioprotective effect (anesthetic preconditioning). Accordingly, their use in anesthesia during cardiothoracic procedures is suggested or recommended by current guidelines and is also widely used as primary maintenance therapy during cardiopulmonary bypass (CPB) in countries such as the USA, Great Britain, Belgium and the Netherlands [13]. At the same time, a recent multicenter MYRIAD RCT did not confirm the beneficial effect of inhaled anesthetics compared with total intravenous anesthesia on overall survival among 5,400 patients who underwent isolated coronary artery bypass grafting (CABG) [14].

Currently, studies are underway to study the possible role of inhaled anesthetics in preventing damage to other organs in patients who have undergone cardiac surgery: the multicenter RCT DELICATE is aimed at studying the effect of inhaled anesthetics on the incidence of postoperative delirium in elderly patients; the APLICS study examines the effect of sevoflurane compared with propofol on lung damage and pulmonary complications [15].

**DISCUSSION**

Levosimendan is the most studied inotropic drug in its history and the only one for which there are data (mainly obtained from meta-analysis) on reducing mortality in cardiac surgery patients [16]. Although three large studies published in 2017 did not reveal a statistically significant beneficial effect of levosimendan on clinically significant outcomes after cardiac surgery, when prescribed either before surgery in patients with reduced left ventricular ejection fraction of LICORN and LEVO-CTS studies, or after surgery. The ongoing WEANILEVO study is aimed at studying the effectiveness of levosimendan in improving the rates of successful discontinuation of treatment (and mortality among other secondary outcomes) in adult patients who are shown to cancel VA-EKMO [17].

Hemodynamic goals (e.g., mean blood pressure), administration of inotropic drugs and calcium, parameters to be monitored, use of “targeted therapy” or “targeted perfusion” protocols, and monitoring. The devices to be used during and after cardiothoracic surgery vary widely in different centers around the world and are chosen rather empirically [18].

Among the pharmacological interventions that can improve neurological outcomes after cardiac surgery, the most promising and deserving of further research is intraoperative dexmedetomidine infusion, which was shown in a 2020 meta-analysis and in a subsequent single-center study to possibly reduce postoperative delirium in patients undergoing heart surgery.

The use of neuromuscular blockers and ventilation strategies in cardiothoracic surgery (including during cardiopulmonary bypass) are gradually changing, although there is still no evidence that the abandonment of neuromuscular blockers or any ventilation strategy can affect postoperative pulmonary outcomes [19].

Although neuroaxial and deep regional (such as paravertebral blockades) anesthesia methods have long become a reality in thoracic surgery, in which even lung resections are increasingly performed without general anesthesia and single-lung artificial ventilation. Their use in cardiac surgery is still quite limited due to fears of possible serious complications (especially neurological consequences due to the formation of hematomas).

To date, research in the field of myofascial blockades is relevant. These blockades may have an even greater justification, given the growing spread of less invasive (for example, mini-thoracotomy) methods of
cardiac surgery. In the near future, it will certainly become a thriving area of clinical research in the field of cardiothoracic anesthesia.

Cardiothoracic anesthesia is developing rapidly, especially with the advent of new methods, technologies and other devices that expand the boundaries of possibilities for better diagnosis, research and treatment of heart diseases. One of the cutting-edge new technologies in this area is the development of the Aveir silent pacemaker.

Aveir was developed to prevent complications of traditional transvenous pacing systems, namely heart perforation, tricuspid valve damage, infectious endocarditis, electrode fractures, central vein thrombosis, etc.

Big data analytics and artificial intelligence will be crucial in the future of cardiac surgery for predictive communication, customized treatment options and research. Numerous studies have demonstrated the superiority of AI models for predicting mortality over more traditional methods such as logistic regression analysis and forecasts by anesthesiologists [20].

Tsch. Junior and other experts evaluated the ability of various predictive artificial intelligence models to predict the mortality of individual patients after congenital heart surgery based on large amounts of data. They proposed a random forest model to predict individual mortality after heart surgery. A machine learning algorithm has also been developed that can reliably predict the need for red blood cell transfusion during cardiac surgery. The predictive capabilities of these artificial intelligence algorithms can help anesthesiologists accurately assess the risk of hemorrhages and the need for blood transfusion for planned cardiac intervention. Other important applications of AI in cardiac surgery include evaluating the effectiveness of a team or individuals, predicting the time of surgery, continuous monitoring of cardiac output, analysis of heart rate variability, delayed closure of the sternum during congenital heart surgery, predicting the cessation of artificial ventilation, the occurrence of delirium, etc.

Before relying on AI for interpretation, several issues should be considered. The interpretation of AI associated with rare clinical circumstances, such as intraoperative awareness, is not reliable. In these scenarios, big data-based approaches can be used to address data scarcity issues.

Even with an ideal AI algorithm, interpretation will be poor if the input data is of poor quality. Since there is a possibility of errors, doctors should always be vigilant to identify machine malfunctions. Despite its drawbacks, artificial intelligence applications should be widely integrated into routine perioperative patient management in order to improve personalized patient care and improve outcomes.

CONCLUSIONS

Modern cardiac surgery requires a high level of anesthesiological support to ensure the safety and effectiveness of surgical interventions on the heart and blood vessels.

Anesthesiology plays an extremely important role in modern cardiac surgery. It provides safety and comfort for patients during operations. The key methods of anesthesiology in cardiac surgery are intubation and ventilation, monitoring of the cardiovascular system, control of blood pressure and depth of anesthesia. Specialists face a number of challenges, including managing hemodynamic parameters, monitoring heart and respiratory function, ensuring adequate analgesia and preventing complications such as myocardial ischemia, arrhythmias, hypothermia and thromboembolic events. One of the main problems in anesthesiology is maintaining hemodynamic stability during heart surgery.

During the work, it was revealed that general, epidural, spinal anesthesia and their combinations are used depending on the type of operation, the patient’s condition and the preferences of the anesthesiologist. Each method has its advantages and disadvantages, which must be taken into account when choosing.

The article emphasizes the importance of continuous training and advanced training of anesthesiologists, as well as the development of new anesthesia techniques in cardiac surgery. It is worth noting that the technological aspect also affects the quality of anesthesia in cardiac surgery, so it is important to develop this area to improve the efficiency and safety of operations.

To solve the problems stated above, comprehensive approaches are needed, including monitoring of vital parameters, the use of appropriate medications, ventilation management, adequate analgesia and prevention of complications.

Cardiothoracic anesthesia, as part of cardiac surgery, is a complex and responsible type of anesthesia used in operations on the heart, lungs and other organs in the chest.
In general, high-quality anesthetic care plays a crucial role in the success of cardiac surgery and the well-being of patients. Continuous improvement of anesthesiology methods, innovative technologies and collaboration between anesthesiologists and surgeons are key aspects in achieving the best results and reducing risks for patients.

Cardiothoracic anesthesia requires special training of anesthesiologists who know the features of this type of anesthesia. In the process of cardiothoracic anesthesia, various methods of monitoring the patient are used, such as invasive blood pressure, ECG, pulse oximetry, etc. Cardiothoracic anesthesia may be associated with the risk of complications related to the cardiovascular system and respiration, therefore constant monitoring and maintenance of homeostasis is required.

The correct choice of medicines, adequate control of respiration and blood circulation, and timely detection and treatment of complications are key aspects of successful cardiothoracic anesthesia.

REFERENCES