



APPLICATION OF NEW INNOVATIVE METHODS IN CARDIAC SURGERY

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Article history:	Abstract:
<p>Received: August 24th 2025 Accepted: September 20th 2025</p>	<p>Over the past decades, cardiac surgery has become one of the most innovative fields in modern medicine. As cardiovascular diseases remain among the leading causes of death worldwide, there is a growing need to improve surgical techniques and enhance safety levels [3]. In contemporary cardiac surgery, minimally invasive, robot-assisted, transcatheter, and mechanical assistive technologies are being widely implemented [10].</p> <p>Minimally invasive operations are performed through small incisions without opening the chest cavity, which reduces recovery time, minimizes pain, and improves the patient's quality of life. Robotic systems—particularly the Da Vinci Surgical Complex—allow surgeons to perform complex cardiac procedures with exceptional precision [7]. Likewise, the Transcatheter Aortic Valve Implantation (TAVI) technique enables valve replacement without opening the heart or stopping blood circulation, making it especially effective for high-risk patients [2].</p> <p>Mechanical circulatory support devices such as LVAD and ECMO provide temporary or long-term assistance in cases of heart failure [5]. Furthermore, regenerative medicine and stem cell therapies open up new prospects for the restoration of cardiac tissues.</p> <p>This paper analyzes the practical importance, advantages, existing challenges, and future directions of modern technologies in cardiac surgery. The integration of Artificial Intelligence (AI) and digital technologies in surgery has improved the efficiency and precision of operations [6]. AI-based analysis systems model the patient's cardiac performance, identify risk factors, and assist the surgeon in making individualized decisions—reducing the duration of procedures and minimizing postoperative complications.</p> <p>3D visualization and simulation programs make it possible to model complex heart surgeries beforehand, simplifying training for young surgeons. In addition, Virtual Reality (VR)-based learning modules are proving essential in enhancing practical surgical experience [8].</p> <p>Advances in genetic engineering now allow for early detection and prevention of cardiac diseases. By analyzing genetic mutations affecting the heart muscle, individualized treatment strategies can be developed [1].</p> <p>Telemedicine and remote monitoring systems are increasingly utilized in cardiac practice, enabling postoperative patients to be monitored continuously from home. This ensures ongoing communication between doctor and patient [9].</p> <p>Looking ahead, biomaterials and nanoimplants are expected to expand the possibilities of cardiac tissue regeneration, potentially serving as alternatives to heart transplantation [4]. Overall, the deep integration of modern technologies in cardiac surgery marks not only a means of saving lives but also a new era in the fight against heart disease.</p>

Keywords: Cardiac surgery, minimally invasive, robotic surgery, TAVI, LVAD, ECMO, regenerative medicine

MAIN PART Minimally Invasive Cardiac Surgery

This method involves performing operations through small incisions using special instruments instead of large surgical openings. For patients, this approach results in



less pain, reduced blood loss, and shorter recovery periods. Procedures such as valve replacement and coronary artery bypass grafting are successfully performed using minimally invasive techniques.

Robotic-Assisted Surgical Technologies

Robot-assisted cardiac surgery, particularly with the **Da Vinci Surgical System**, enables surgeons to perform delicate and precise movements. Robotic arms eliminate hand tremors, while the high-definition camera expands the visual field. This approach ensures superior aesthetic and clinical outcomes.

Transcatheter Aortic Valve Implantation (TAVI)

This method is used in cases of aortic valve stenosis and allows the implantation of a new valve via catheter without opening the chest cavity.

TAVI is particularly beneficial for elderly or high-risk patients, significantly extending their lifespan and improving life quality.

The implementation of modern technologies in cardiac surgery enhances not only clinical results but also the quality of **medical education, scientific research,** and the overall **healthcare system.**

In the context of Uzbekistan, to successfully introduce these technologies, it is necessary to:

- train specialized professionals;
- study international experiences;
- modernize the technical infrastructure;
- and strengthen cooperation between scientific research centers.

By adopting these measures, cardiac surgery in Uzbekistan can reach a new level, ensuring safe, effective, and innovative treatment for every patient.

Off-Pump Operations

Off-pump coronary artery bypass (OPCAB) surgeries are performed while the heart is still beating, maintaining its natural rhythm. This approach preserves the patient's physiological stability and reduces the risk of complications.

Mechanical Circulatory Support Devices

Devices such as **LVAD, RVAD,** and **ECMO** temporarily support cardiac function. These systems often serve as a "bridge" for patients awaiting heart transplantation.

In recent years, **mechanical ventricular assist devices (MVADs)** have become widely used in the treatment of heart failure. These devices are designed to support the pumping function of the heart, either temporarily or permanently, and are vital for patients with terminal heart failure.

Among these, the **Left Ventricular Assist Device (LVAD)** is the most common. It directs blood from the left ventricle to the aorta, reducing cardiac workload and restoring circulation. Other variants include **RVAD**

(right ventricular), **BiVAD** (biventricular), and the **Total Artificial Heart (TAH).**

Technological advancements have produced compact, energy-efficient, **magnetically levitated LVADs** that operate silently, reduce the risk of thrombosis, and ensure long-term stability.

According to **INTERMACS (USA)** data, over 29,000 patients have received LVADs in the past decade, with a one-year survival rate of 80–86%. In some cases, myocardial recovery allowed device removal altogether. Currently, mechanical assist devices are used in three main ways:

1. **Bridge to Transplantation** — for patients awaiting donor hearts.
2. **Bridge to Recovery** — for those expected to regain cardiac function.
3. **Destination Therapy** — for non-transplant candidates requiring permanent support.

The widespread adoption of such devices represents a new era in cardiac surgery, extending life expectancy and greatly improving patients' quality of life.

Regenerative Medicine and Biotechnology

Stem cell therapy enables the regeneration of cardiac muscle tissue, while **3D bioprinting** allows for the creation of personalized cardiac structures. These innovations hold promise to revolutionize cardiac surgery in the near future.

CONCLUSION

Modern methods in cardiac surgery have become one of the most significant and promising directions in medicine. Compared to traditional open-heart operations, minimally invasive, robotic, and transcatheter technologies offer multiple advantages. These methods are **less painful,** allow **faster recovery,** and provide **safer, more effective treatment** options.

The **aesthetic and clinical outcomes, reduced blood loss, lower tissue trauma,** and **accelerated rehabilitation** are key reasons for the rapid integration of these modern approaches. Robotic systems improve surgical precision and minimize human error, while **TAVI** represents one of the greatest advancements in performing cardiac procedures without major surgical intervention.

At the same time, **mechanical circulatory support devices** play a crucial role in sustaining life in severe cardiac failure cases. In the future, **regenerative medicine, stem cell technologies, genetic engineering,** and **3D bioprinting** are expected to enable cardiac tissue restoration and possibly eliminate the need for transplants.



However, challenges remain—such as a shortage of trained specialists, high equipment costs, and limited research infrastructure. Addressing these issues in Uzbekistan requires strengthening **international collaboration, modernizing clinical facilities, and training young professionals.**

In conclusion, the implementation of modern technologies in cardiac surgery not only saves lives but also significantly improves the **quality of life** and **treatment outcomes** for patients worldwide.

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