RECENT INNOVATIONS IN MINIMALLY INVASIVE CARDIAC SURGERY (MICS)

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Abstract. *Minimally invasive cardiac surgery (MICS) has significantly transformed modern cardiac surgical practice. Instead of performing procedures through a full median sternotomy, surgeons increasingly use small thoracic incisions, endoscopic cameras, and robotic platforms to access the heart. These techniques aim to reduce surgical trauma, postoperative pain, and recovery time while maintaining the same therapeutic effectiveness as conventional open-heart surgery. Recent technological developments—including robotic mitral valve repair, totally endoscopic coronary artery bypass (TECAB), advanced intraoperative imaging, and hybrid operating rooms—have further expanded the possibilities of minimally invasive cardiac procedures. Clinical studies show that MICS is associated with reduced hospital stays, improved cosmetic outcomes, and faster return to daily activities. This article reviews the most important technological and clinical innovations in minimally invasive cardiac surgery, describes their advantages and limitations, and discusses their potential implementation in developing healthcare systems, particularly in Central Asia and Uzbekistan.*

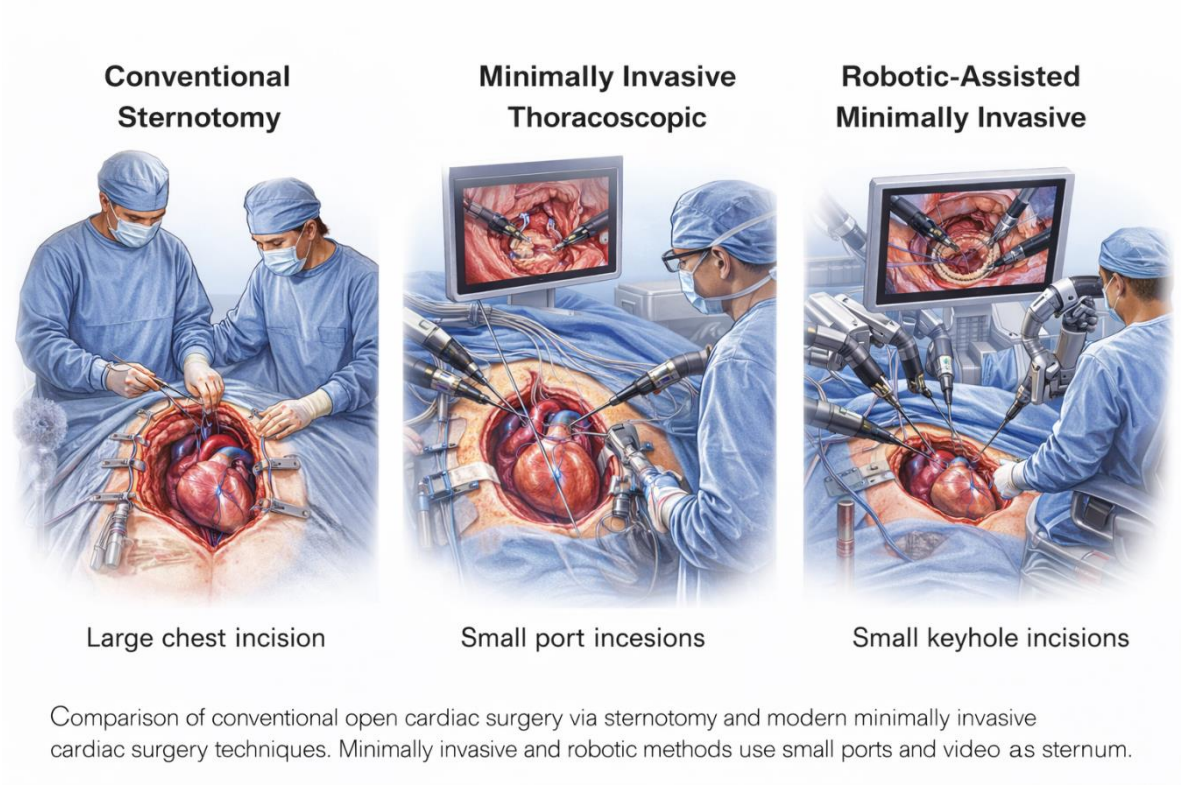
Keywords: *minimally invasive cardiac surgery (MICS); cardiothoracic surgery; robotic cardiac surgery; totally endoscopic coronary artery bypass (TECAB); mitral valve repair; thoracoscopic surgery; robotic surgical systems; cardiovascular innovation; surgical technology; Uzbekistan healthcare development.*

Introduction

Over the past two decades, minimally invasive cardiac surgery (MICS) has become an important development in the field of cardiothoracic surgery. Traditional open-heart surgery typically requires a full median sternotomy, which involves dividing the sternum to access the heart. Although this approach provides excellent exposure for surgeons, it is associated with significant surgical trauma and longer recovery periods. Minimally invasive techniques aim to perform the same cardiac procedures through smaller incisions using specialized instruments, thoracoscopic cameras, and sometimes robotic surgical systems. These approaches reduce tissue damage and help improve postoperative recovery while maintaining surgical safety and effectiveness.

Clinical studies have demonstrated that patients undergoing minimally invasive cardiac surgery often experience reduced postoperative pain, shorter intensive care unit stays, lower infection rates, and faster return to normal activities compared with conventional sternotomy procedures.

Although many advanced cardiac centers in Europe and North America have widely adopted minimally invasive techniques, their implementation in Central Asia remains limited. In Uzbekistan, most cardiac operations are still performed using traditional open surgical approaches. However, growing investment in medical technology and international collaboration may create new opportunities for the adoption of minimally invasive cardiac procedures in the region.



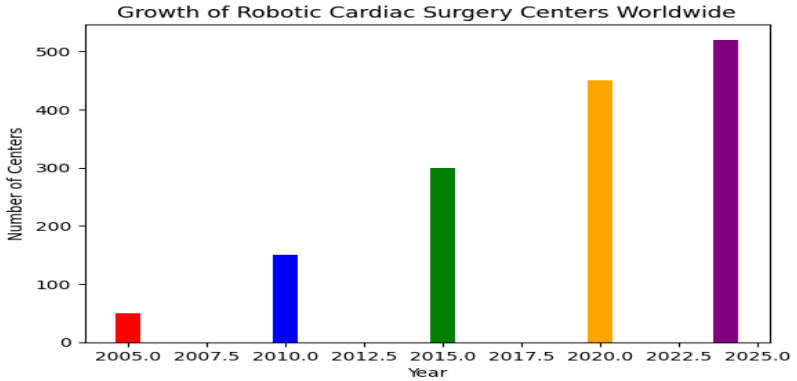
Comparison of conventional open cardiac surgery via sternotomy and modern minimally invasive cardiac surgery techniques. Minimally invasive and robotic methods use small ports and video as sternum.

Epidemiology

MICS has expanded rapidly in many developed countries. Today:

- A large portion of **mitral valve surgeries** in Europe and the U.S. are done using minimally invasive or robotic techniques.
- More than **500 centers worldwide** offer robotic cardiac surgery.
- **Hybrid operating rooms** are becoming standard for advanced cardiac and vascular procedures.

In Central Asia, including Uzbekistan, the use of MICS is growing slowly. The main challenges are equipment cost, limited training, and lack of specialized centers. However, with increasing demand for modern techniques, many hospitals are planning to introduce mini-thoracotomy valve surgery and improved cannulation methods. Recent international studies indicate that minimally invasive mitral valve surgery can reduce hospital stay by approximately **30–40%** compared with conventional sternotomy procedures. Additionally, several large clinical registries report that robotic mitral valve repair has a **success rate exceeding 95% in experienced centers**, with very low operative mortality. These outcomes demonstrate that minimally invasive approaches can achieve results comparable to traditional surgery while improving postoperative recovery.



Innovations in Minimally Invasive Cardiac Surgery

1. Robotic-Assisted Cardiac Surgery

Robotic systems, especially the da Vinci platform, allow surgeons to work through tiny ports with excellent precision. The robot provides:

- A 3D high-definition view
- Very fine instrument control
- Better access to deep structures of the heart

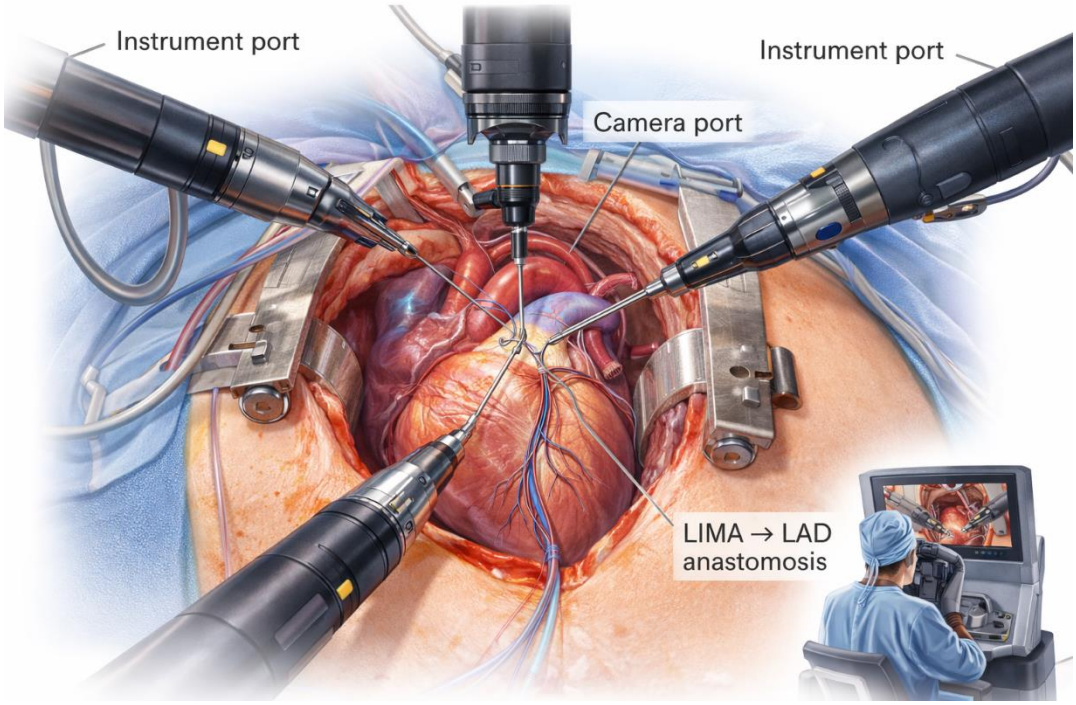
Common robotic procedures include mitral valve repair, ASD closure, and internal mammary artery harvesting. Robotic surgery reduces trauma and improves cosmetic results, but it requires advanced training and a dedicated team.

2. Totally Endoscopic Coronary Artery Bypass (TECAB)

TECAB is one of the most advanced forms of MICS. The entire coronary bypass procedure is done endoscopically, without opening the chest. Benefits include:

- No sternotomy
- Faster healing
- Very small incisions

Although technically demanding, TECAB offers similar results to traditional CABG when performed in experienced centers.



3. Minimally Invasive Valve Surgery

This is currently the most common application of MICS. It includes:

- Mini-thoracotomy mitral valve repair
- Mini-sternotomy aortic valve replacement
- Robotic mitral repair

Patients usually recover quickly, and the risk of wound complications is much lower. Modern imaging—especially 3D echocardiography—helps surgeons achieve precise and durable repairs.

4. Hybrid Operating Rooms

Hybrid ORs combine surgery with real-time imaging such as fluoroscopy, CT, and 3D mapping. This allows:

Combined surgical and catheter-based procedures

More accurate navigation

Improved safety during complex repairs

Hybrid rooms are particularly useful for aortic surgery and structural heart disease.

5. Improvements in Perfusion and Cannulation

To perform MICS safely, surgeons often use **peripheral cannulation** through the femoral or axillary arteries. Other innovations include:

- Mini-circuits that reduce inflammation
- CO_2 insufflation to prevent air embolism
- Better biocompatible materials

These developments make minimally invasive procedures safer and more effective.

6. Advanced Imaging and Navigation

Modern imaging plays a major role in MICS. Surgeons rely on:

- CT scans for preoperative planning
- 3D transesophageal echocardiography during surgery
- Fluorescent imaging to check grafts
- Augmented reality for anatomical guidance

These tools help perform delicate operations through small incisions with high accuracy.

Clinical Presentation and Diagnostic Workup (for MICS Candidates)

Patients considered for MICS usually have:

- Valve diseases (mitral or aortic)
- Coronary artery disease needing bypass
- Atrial septal defects
- Certain congenital heart conditions

Diagnostic workup includes:

- ECG
- Echocardiography
- CT angiography (especially to check peripheral vessels)
- Full lab tests

Patient selection is important. Some patients—such as those with severe aortic calcification or multiple previous heart surgeries—may be better suited for traditional sternotomy.

Management

Intraoperative Management

During MICS, surgeons use:

- Small ports or mini-thoracotomy
- Long-shafted instruments
- Robotic or endoscopic visualization
- Peripheral cannulation for cardiopulmonary bypass
- CO_2 to protect against air embolism

Anesthesia management is also important, especially for single-lung ventilation.

Postoperative Management

After surgery, patients typically experience:

- Faster extubation

- Earlier mobilization
- Less postoperative pain
- A shorter stay in the ICU and hospital

Routine checks include ECG, echocardiography, and blood tests. Complications are less common but can include bleeding, stroke, or arrhythmias.

Conclusion

Minimally invasive cardiac surgery represents one of the most important technological advances in modern cardiothoracic surgery. The development of robotic surgical systems, advanced intraoperative imaging, hybrid operating rooms, and improved perfusion technologies has made it possible to perform complex cardiac procedures through small incisions while maintaining excellent surgical outcomes.

Clinical evidence suggests that minimally invasive techniques can significantly reduce surgical trauma, shorten hospital stays, and improve patient recovery compared with traditional sternotomy-based approaches. Despite the advantages, challenges such as high equipment costs, a steep learning curve, and the need for specialized training still limit widespread adoption. For countries such as Uzbekistan, the gradual introduction of minimally invasive cardiac surgery could play an important role in modernizing cardiovascular care. Continued investment in medical technology, surgeon training, and international collaboration will be essential for expanding access to these advanced surgical techniques in the region.

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