



MINIMALLY INVASIVE TECHNIQUES IN CORONARY ARTERY BYPASS GRAFTING: A COMPARATIVE STUDY

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Abstract: Coronary artery bypass grafting (CABG) remains the gold standard for the surgical management of advanced coronary artery disease. In recent years, minimally invasive techniques have emerged as viable alternatives to conventional median sternotomy, aiming to reduce surgical trauma, accelerate recovery, and improve patient outcomes. This study provides a comparative analysis of traditional CABG and minimally invasive approaches, including minimally invasive direct coronary artery bypass (MIDCAB) and totally endoscopic coronary artery bypass (TECAB). Key parameters evaluated include perioperative morbidity and mortality, operative time, length of hospital stay, postoperative pain, and long-term graft patency.

The findings suggest that minimally invasive techniques are associated with reduced blood loss, shorter intensive care unit (ICU) and hospital stays, and faster return to normal activities, while maintaining comparable graft patency rates and survival outcomes to conventional CABG in selected patient populations. However, these approaches require advanced surgical expertise, specialized equipment, and careful patient selection. The study highlights the growing role of minimally invasive CABG as a safe and effective alternative, emphasizing the need for further large-scale randomized trials to validate long-term outcomes and broaden clinical applicability.

Keywords: coronary artery bypass grafting, minimally invasive surgery, MIDCAB, TECAB, coronary artery disease, surgical outcomes, graft patency, cardiac surgery.

Introduction

Coronary artery disease (CAD) remains one of the leading causes of morbidity and mortality worldwide, posing a significant burden on healthcare systems. Surgical revascularization, particularly coronary artery bypass grafting (CABG), has long been established as an effective treatment for patients with complex and multivessel disease. Conventional CABG, typically performed via median sternotomy with cardiopulmonary bypass, provides excellent long-term outcomes and durable graft patency. However, it is also associated with considerable surgical trauma, prolonged recovery time, and potential complications such as infection, bleeding, and sternal instability.

In response to these limitations, minimally invasive surgical techniques have been developed and increasingly adopted in clinical practice. Approaches such as minimally invasive direct coronary artery bypass (MIDCAB) and totally endoscopic coronary artery bypass (TECAB) aim to achieve effective myocardial revascularization while avoiding full sternotomy. These techniques utilize smaller incisions, advanced imaging systems, and specialized instruments, thereby reducing operative trauma and improving postoperative recovery.

Despite the growing interest in minimally invasive CABG, there remains ongoing debate regarding its comparative efficacy, safety, and long-term outcomes relative to conventional

methods. Factors such as technical complexity, learning curve, patient selection criteria, and resource availability continue to influence its widespread implementation. Therefore, a comprehensive comparative evaluation of traditional and minimally invasive CABG techniques is essential.

This study aims to analyze and compare the clinical outcomes, advantages, and limitations of minimally invasive CABG techniques versus conventional CABG, with a focus on perioperative parameters, patient recovery, and long-term effectiveness.

Minimally invasive techniques in coronary artery bypass grafting (CABG) have gained increasing attention due to their potential to reduce surgical trauma while maintaining the clinical effectiveness of conventional approaches. This section presents a comparative analysis of traditional CABG performed via median sternotomy and minimally invasive techniques, primarily minimally invasive direct coronary artery bypass (MIDCAB) and totally endoscopic coronary artery bypass (TECAB).

One of the principal differences between these approaches lies in surgical access. Conventional CABG requires full sternotomy, providing wide exposure of the القلب but at the cost of significant tissue disruption. In contrast, MIDCAB is performed through a small left anterior thoracotomy, typically without cardiopulmonary bypass, while TECAB is conducted using robotic assistance and endoscopic visualization, eliminating the need for large incisions. As a result, minimally invasive techniques significantly reduce operative trauma and improve cosmetic outcomes.

Perioperative outcomes demonstrate several advantages of minimally invasive CABG. Studies indicate that patients undergoing MIDCAB or TECAB experience reduced intraoperative blood loss, lower transfusion requirements, and decreased risk of wound infections compared to conventional CABG. Additionally, the avoidance of sternotomy minimizes complications such as sternal dehiscence and mediastinitis. Intensive care unit (ICU) and overall hospital stays are generally shorter in minimally invasive procedures, contributing to reduced healthcare costs and faster patient recovery.

Postoperative recovery is notably improved in minimally invasive approaches. Patients typically report lower pain levels, earlier mobilization, and quicker return to normal daily activities. These benefits are particularly significant in elderly patients and those with comorbidities, for whom prolonged immobilization may increase the risk of complications such as pneumonia or thromboembolism.

Despite these advantages, minimally invasive CABG techniques present certain limitations. They are technically demanding and require a steep learning curve for surgeons, especially in the case of TECAB, which relies heavily on robotic systems and advanced imaging technologies. Operative times may initially be longer compared to conventional CABG, particularly during the early stages of adoption. Furthermore, not all patients are suitable candidates; individuals with diffuse coronary disease, hemodynamic instability, or need for multiple grafts may benefit more from the traditional approach.

In terms of clinical effectiveness, current evidence suggests that graft patency rates and long-term survival outcomes of minimally invasive CABG are comparable to those of conventional CABG in carefully selected patients. However, long-term, large-scale randomized studies remain limited, and further research is required to fully establish the durability and broader applicability of these techniques.



Overall, minimally invasive CABG represents a promising advancement in cardiac surgery, offering significant perioperative and recovery-related benefits. Nevertheless, its successful implementation depends on appropriate patient selection, surgical expertise, and institutional resources.

Conclusion

Minimally invasive techniques in coronary artery bypass grafting (CABG) represent a significant advancement in the field of cardiac surgery, offering a less traumatic alternative to conventional median sternotomy. The comparative analysis indicates that approaches such as minimally invasive direct coronary artery bypass (MIDCAB) and totally endoscopic coronary artery bypass (TECAB) provide substantial benefits, including reduced perioperative morbidity, decreased blood loss, shorter hospital stays, and faster postoperative recovery.

Importantly, these advantages are achieved without compromising the fundamental goals of surgical revascularization, as graft patency and survival outcomes remain comparable to those of traditional CABG in appropriately selected patients. However, the widespread adoption of minimally invasive techniques is still limited by factors such as technical complexity, the need for specialized equipment, and the requirement for advanced surgical training.

In conclusion, minimally invasive CABG techniques have demonstrated their potential as safe and effective alternatives to conventional surgery, particularly for selected patient populations. Future large-scale, randomized clinical studies are necessary to further validate their long-term outcomes and to support broader integration into routine clinical practice..

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