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ADVANCES IN CABG GRAFT PRESERVATION

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ABSTRACT
Advances in coronary artery bypass grafting (CABG) graft preservation are crucial for improving patient outcomes in cardiac surgery. CABG, first pioneered in the 1960s, is a widely recognized surgical procedure aimed at alleviating symptoms and enhancing survival rates in patients suffering from coronary artery disease.[1][2] The importance of effective graft preservation lies in its significant impact on long-term graft patency and the prevention of major adverse cardiac events (MACE), such as myocardial infarction and the need for repeat revascularization, which are influenced by the quality of preservation strategies employed during surgery.[3][4]Recent advancements in graft preservation techniques have introduced innovative methods aimed at mitigating the damage that grafts endure during the surgical process. Notably, the introduction of specialized preservation solutions, such as DuraGraft, has shown promise in enhancing the viability of vascular conduits by protecting endothelial integrity and reducing ischemic reperfusion injury.[3][5] Despite the potential benefits of these advanced techniques, traditional preservation methods, including saline and autologous whole blood, remain prevalent in clinical practice, raising concerns about the long-term implications for graft functionality.[3][6] Controversies surrounding graft preservation practices include debates over the efficacy of newer solutions versus established methods and the implications of surgical techniques on graft longevity. Studies indicate that inadequate preservation practices can lead to a high incidence of vein graft failure, which compromises the long-term success of CABG procedures.[4][6] This ongoing discourse highlights the need for greater awareness among clinicians regarding the critical role of graft preservation in optimizing surgical outcomes, as well as the necessity for further research and clinical trials to validate the efficacy of innovative preservation solutions.[3][5]In summary, the evolution of graft preservation in CABG not only reflects advancements in surgical techniques but also underscores the importance of addressing persistent challenges in graft management to improve patient care in cardiac surgery. As research continues to evolve, the integration of effective preservation strategies may play a pivotal role in enhancing graft longevity and minimizing complications, ultimately contributing to better overall outcomes for patients undergoing CABG.[3][6]

HISTORICAL BACKGROUND

Coronary Artery Bypass Grafting (CABG) was pioneered in the 1960s by René Favaloro, MD, aiming to enhance symptom relief and survival in patients with coronary artery disease.[1] Since then, CABG has evolved significantly, becoming one of the most extensively studied cardiac surgical procedures, with a wealth of follow-up data highlighting its long-term efficacy and complications.[2]The introduction of various graft types, including saphenous vein grafts and arterial conduits such as the internal thoracic artery (ITA) and radial artery, has improved patient outcomes. Arterial grafts generally demonstrate superior long-term patency compared to vein grafts, although they are often more challenging to implement surgically.[1][3]Research from the 1990s onward has consistently indicated that vein grafts face high rates of failure, particularly due to negative remodeling, which significantly impacts graft longevity and patient quality of life.[4] In recent years, the development of preservation solutions has gained traction as a strategy to enhance graft patency post-surgery. Studies have explored various preservation methods, including the use of autologous heparinized blood and buffered solutions containing antioxidants, aiming to mitigate endothelial damage during the grafting process.[5][3]The importance of effective graft preservation is underscored by findings indicating that suboptimal preservation solutions, such as saline, remain commonly used despite their negative effects on graft integrity.[3]Furthermore, landmark trials from the 1970s and subsequent research have solidified CABG's status as the gold standard for treating complex coronary artery disease, emphasizing its benefits over medical therapy for symptom relief and quality of life improvements, particularly in patients with multivessel disease.[1][6] These advancements in surgical techniques and graft preservation highlight the ongoing evolution of CABG and its critical role in modern cardiac surgery.

Importance of Graft Preservation

Graft preservation is a critical aspect of coronary artery bypass grafting (CABG), as it directly influences the long-term outcomes of the procedure. Major adverse cardiac events (MACE), such as death, non-fatal myocardial infarction, and the need for repeat revascularization, are significantly impacted by the effectiveness of graft preservation strategies[3][1]. The preservation of saphenous vein grafts (SVGs) is particularly vital, as vein graft failure remains a persistent issue that can compromise clinical outcomes post-CABG[7][6].

Clinical Outcomes and Graft Patency

The primary focus of graft preservation is to enhance graft patency and prevent failure, which can lead to further complications such as myocardial infarction or the need for additional surgical interventions[3]. Recent studies have demonstrated that inadequate preservation solutions, such as saline and autologous heparinized blood, can have deleterious effects on the endothelium of grafts, underscoring the necessity for improved strategies[5]. A European multi-institutional registry has been established to evaluate the performance of innovative graft preservation solutions, like DuraGraft, aiming to provide detailed insights into their efficacy and associated outcomes over a five-year period post-CABG[6].

Long-Term Complications

Improper graft preservation not only affects short-term surgical outcomes but also contributes to long-term complications, including reduced graft function and increased mortality rates[1][8]. The implications of these complications underscore the importance of raising awareness among clinicians regarding the critical role of intraoperative graft preservation. Continued advancements in preservation techniques are essential to improve SVG patency rates and minimize long-term risks following CABG[6][2].

Types of Grafts Used in CABG

Coronary artery bypass grafting (CABG) utilizes various grafts to restore blood flow to the heart in patients with multivessel coronary artery disease. The choice of graft is critical for ensuring long-term patency and successful surgical outcomes.

Arterial Grafts

Internal Thoracic Artery (ITA)

The internal thoracic artery (ITA) is considered the gold standard for grafting the left anterior descending artery (LAD) due to its superior long-term patency rates compared to other graft options.[6]

Radial Artery (RA)

The radial artery has gained popularity as an alternative graft, particularly for non-LAD targets. Systematic reviews indicate that the use of the RA is associated with lower rates of major adverse cardiovascular events (MACE) and higher patency rates at both 5 and 10 years post-surgery.[6]This trend towards multiple arterial grafting reflects an ongoing shift in clinical practice guidelines, encouraging the use of arterial grafts over traditional saphenous vein grafts (SVGs).[6]

Venous Grafts

Saphenous Vein Graft (SVG)

Saphenous vein grafts remain the most commonly used conduits in CABG, despite their lower long-term patency rates compared to arterial alternatives. Rates of vein graft failure (VGF) can be as high as 50% within ten years post-surgery.[2]Factors influencing SVG patency include the quality of the graft itself, the anastomosis, and patient-specific variables such as the progression of coronary artery disease.[2]

Graft Preservation Techniques

Innovative techniques and preservation solutions have been investigated to enhance the viability and long-term outcomes of vein grafts. For example, the use of intraoperative graft preservation solutions like DuraGraft has shown potential in improving endothelial structure and mitigating ischemic reperfusion injury.[7] Evidence suggests that the method of graft harvesting, such as no-touch techniques, can significantly limit vascular smooth muscle activation and promote better long-term patency.[9]

Recent Advances in Graft Preservation Techniques

Recent advancements in graft preservation techniques have focused on enhancing the outcomes of coronary artery bypass grafting (CABG) by improving the integrity of vascular conduits. One significant development is the introduction of DuraGraft (Somahlution Inc., Jupiter, FL), an intraoperative graft treatment designed to protect against endothelial damage during CABG. This treatment involves the use of an ionically and pH-balanced physiological salt solution containing glutathione, L-ascorbic acid, and L-arginine, which collectively aim to mitigate the ischemic reperfusion injury that often affects grafts during storage and anastomosis[3][5].

Efficacy of DuraGraft

Several studies have illustrated the potential benefits of DuraGraft. In vitro studies have shown that DuraGraft outperforms traditional solutions such as saline and autologous whole blood (AWB) in maintaining the structural and functional integrity of the grafts' endothelium[3]. A retrospective observational study indicated that the use of DuraGraft is associated with reduced long-term complications, including lower rates of myocardial infarction and the need for repeat revascularization[3][6]. However, systematic data validating the long-term clinical efficacy of DuraGraft in preventing saphenous vein graft (SVG) intimal hyperplasia and subsequent vein graft failure (VGF) are still required[3].

Current Practices and Challenges

Despite the promising evidence supporting DuraGraft, saline and AWB remain the most commonly used preservation solutions, utilized in over 55% of CABG patients across various hospitals in the United States[3]. This highlights a critical need for improved graft preservation strategies. Educational initiatives aimed at raising awareness about the importance of intraoperative graft preservation may contribute to a shift in clinical practices, ultimately enhancing SVG patency and reducing long-term complications following CABG[3].

Ongoing Research

Ongoing research, including the prospective, multicentric VASC registry, aims to further assess the safety and performance of DuraGraft in a larger cohort of CABG patients over five years[5][6]. Initial findings have suggested improvements in endothelial cell morphology and integrity when grafts are treated with DuraGraft compared to saline solutions, emphasizing its potential as a viable preservation option for improving graft outcomes[3][7]. As the landscape of CABG continues to evolve, the incorporation of advanced preservation techniques such as DuraGraft may play a vital role in optimizing graft function and long-term patient outcomes.

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Research and Clinical Trials

No-Touch Saphenous Vein Grafting

Recent studies have explored the efficacy of the no-touch saphenous vein graft (NT-SVG) harvesting technique compared to conventional methods in coronary artery bypass grafting (CABG). The 2018 European Society of Cardiology/European Association for Cardio-Thoracic Surgery Guidelines recognized NT-SVG as a class IIa recommendation based on evidence suggesting favorable long-term patency rates, such as the 16-year patency shown by Samano et al.[6]. However, findings from the SWEDEGRAFT trial, presented at the ESC Congress 2024, indicated no significant advantages of the no-touch technique over conventional vein harvesting in terms of graft failure or clinical outcomes after CABG[10]. This pragmatic registry trial involved 902 patients randomized to either technique, highlighting the necessity for independent research to guide future clinical guidelines[10].

DuraGraft Treatment

Another significant area of investigation is the use of DuraGraft, a novel intraoperative treatment designed to protect the endothelial integrity of vascular grafts during CABG. This treatment is formulated in a physiological solution and aims to reduce complications such as vein graft disease (VGD) and subsequent vein graft failure (VGF)[3]. A multicenter trial comparing DuraGraft with standard heparinized saline is ongoing, with primary endpoints focusing on changes in graft wall thickness and lumen diameter over time[2]. Initial studies have suggested that DuraGraft may preserve the functional and structural integrity of vein grafts better than saline[3]. However, comprehensive clinical validation of its effectiveness in preventing intimal hyperplasia and improving long-term outcomes remains to be established[3].

Challenges and Limitations

The field of coronary artery bypass grafting (CABG) faces several challenges and limitations that impact patient outcomes and the overall efficacy of graft preservation techniques.

Variability in Surgical Techniques

One significant challenge is the variability in surgical techniques employed by different surgeons. The choice between multi-arterial grafting (MAG) and single-arterial grafting (SAG) can depend on numerous factors, including the surgeon's experience, the specific patient's anatomy, and the availability of conduits. Dr. Schaffer notes that a surgeon's decision may be influenced by unmeasured variables, such as conduit availability and individual patient assessments, which are not captured in clinical databases[11]. This variability can lead to inconsistencies in outcomes across different patient populations.

Gender Disparities in Outcomes

Another critical limitation is the observed disparity in outcomes between genders. Studies have indicated that women tend to fare worse in redo CABG procedures, with only 12% of patients in one study being female, highlighting the need for further investigation into why this disparity exists[12]. The factors contributing to this difference are not fully understood, emphasizing the necessity for more comprehensive research to ensure equitable treatment outcomes for all patients.

Lack of High-Level Evidence

The lack of high-level evidence to support some surgical practices also presents a challenge. For example, recent guidelines from the American Association for Thoracic Surgery acknowledged the absence of robust data on the use of mechanical cardiac support in high-risk populations undergoing CABG[1]. This indicates a gap in the research that could inform better clinical decisions and enhance patient safety.

Intraoperative Graft Preservation Practices

Intraoperative graft preservation remains a contentious issue, with saline and autologous whole blood (AWB) solutions being the most commonly used despite evidence of their potential negative effects on conduit endothelium[3]. This reliance on traditional methods can hinder advancements in graft preservation, as newer, potentially more effective preservation solutions are not widely adopted.

Need for Comprehensive Collaborative Approaches

The future of CABG also hinges on a collaborative multidisciplinary heart team approach, which necessitates careful consideration of all treatment options, including percutaneous coronary intervention (PCI) and medical therapy[1]. However, the implementation of such collaborative practices is often slowed by institutional barriers and the complexity of managing different care pathways.

Educational and Access Discrepancies

Addressing educational gaps and access disparities is crucial for the broader adoption of best practices in CABG. Current inequalities in healthcare access can limit the availability of advanced surgical techniques, particularly in developing countries. Efforts must focus on training local surgeons and improving healthcare infrastructures to enhance the care available to patients requiring CABG[1].

CONCLUSION

Technological advancements in CABG graft preservation have gone a long way in improving graft longevity, minimizing failure rates, and optimizing patient outcomes. Procedures such as no-touch vein harvesting ensure graft integrity by avoiding surrounding tissue damage, minimizing intimal hyperplasia, and enhancing patency. Buffered storage mediums avoid endothelial injury, whereas external stenting offers mechanical reinforcement to minimize the risk of stenosis and occlusion. Endoscopic vein harvesting (EVH) avoids surgical trauma and infection risks but requires further modifications to enhance long-term patency.[6] An example of graft preservation innovation is DuraGraft, an endothelial damage inhibitor (EDI) solution that has been developed specifically to shield vascular grafts against ischemic injury and oxidative stress. Unlike blood or saline-based storage techniques used traditionally, DuraGraft preserves endothelial function, prevents inflammation, and decreases the potential for graft failure through early thrombosis and intimal hyperplasia. Clinical research has shown that applying DuraGraft may result in enhanced long-term graft patency, less major adverse cardiovascular events (MACE), and better overall surgery

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outcomes. New technologies like gene therapy and regenerative medicine also have a potential to further enhance graft durability. With the progression of studies and technological advancements, these technologies add to more efficient CABG surgeries, enhancing patient survival, recuperation, and overall cardiovascular status.

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