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Review article

Percutaneous coronary intervention after CABG: An evolving paradigm

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Abstract This review evaluates revascularization strategies following coronary artery bypass grafting (CABG), focusing on the management of graft failure after initial surgery. While redo CABG has been the traditional approach, its significant procedural risks, elevated perioperative mortality, and extended recovery have prompted a shift toward minimally invasive alternatives such as percutaneous coronary intervention (PCI). Nevertheless, redo CABG operations have seen a staggering decline over the last 20 years. To date, randomized clinical trials comparing a strategy of native vessel PCI with SVG PCI have not been conducted. This paper examines the evolving role of PCI in post-CABG patients, with a particular emphasis on the benefits of native vessel PCI over graft interventions. Advances in drug-eluting stents (DES) and intravascular imaging modalities have significantly improved PCI's safety and efficacy, broadening its applicability to diverse patient populations. Native vessel PCI demonstrates superior long-term outcomes by mitigating risks of restenosis and adverse cardiac events, outperforming saphenous vein graft PCI, which is frequently complicated by embolization and graft degeneration. Although redo CABG remains indispensable for select cases involving complex coronary anatomy or multivessel disease, PCI offers comparable survival outcomes with lower procedural morbidity, making it a preferred option for high-risk cohorts. This review highlights the clinical impact of these advancements, supports personalized decision-making in post-CABG revascularization, and underscores the importance of further research to refine guidelines and optimize therapeutic outcomes.

Key words coronary artery bypass grafting, redo CABG, percutaneous coronary intervention, revascularization

Percutaneous coronary intervention (PCI) after CABG

Ischaemia after CABG may be due to the progression of disease in native vessels or de novo disease of bypass grafts. Once coronary angiography following CABG in cases of suspected graft failure, the treatment strategy (conservative vs. revascularisation) depends on many factors, and the decision needs to be made in close consultation with the Heart Team. The debate regarding graft intervention versus native coronary artery interventions is still ongoing. To date, randomized clinical trials comparing a strategy of native vessel PCI with SVG PCI have not been conducted. Redo coronary artery bypass grafting (CABG) has traditionally been considered the gold standard for managing graft failure following a primary CABG. However, the significant procedural risks, increased perioperative mortality, and prolonged recovery associated with redo CABG have underscored the need for alternative revascularization strategies. In this context, percutaneous coronary intervention (PCI) has emerged as a less invasive and increasingly effective option, particularly in patients with advanced age, high comorbidity burden, or unfavorable surgical profiles. However, native lesions are often complex with a high degree of calcification and chronic total occlusions (CTOs) requiring advanced PCI technology and expertise, and higher acuity presentations may additionally impede necessary pre-procedural planning and affect target vessel choice[1,2].

Technological advances and PCI's role in post-CABG management

Over the past two decades, PCI has witnessed transformative advancements, primarily driven by the development of drug-eluting stents (DES), intravascular imaging modalities, and enhanced pharmacologic therapies. The advent of second-generation DES has substantially reduced rates of in-stent restenosis and target lesion revascularization, making PCI a viable option even in complex coronary anatomy[3,4].

Moreover, the integration of advanced imaging techniques, such as intravascular ultrasound (IVUS) and optical coherence tomography (OCT), has facilitated precise lesion assessment, optimal stent deployment, and improved patient outcomes[5]. These innovations have broadened the applicability of PCI, allowing interventional cardiologists to address challenging scenarios, including graft occlusions and chronic total occlusions (CTOs), with greater confidence[6].

Native vessel PCI: A paradigm shift

The preference for native vessel PCI over graft interventions has been solidified by its superior safety profile and

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procedural efficacy. Graft interventions, particularly those involving saphenous vein grafts (SVGs), are fraught with complications such as distal embolization, no-reflow phenomena, and high rates of restenosis, which can adversely impact patient outcomes[7,8].
Native vessel PCI, on the other hand, bypasses these challenges by targeting the primary ischemic substrates, thereby ensuring a more physiological restoration of coronary perfusion. Studies comparing native vessel PCI with graft PCI have consistently demonstrated better patency rates, lower rates of restenosis, and improved long-term clinical outcomes for native vessel interventions[9,10]. Additionally, the use of drug-eluting stents in native vessels has further augmented procedural success by minimizing rates of neointimal hyperplasia and subsequent target lesion failure[11].
A meta-analysis evaluating outcomes in post-CABG patients highlighted that native vessel PCI is associated with lower rates of adverse cardiac events and a reduced need for repeat revascularization compared to graft PCI. This reinforces the strategic importance of prioritizing native vessel interventions whenever anatomically feasible[12].

Challenges in SVG PCI and the role of embolic protection devices

Intervening on SVGs poses unique challenges due to their propensity for occlusion, degeneration, and friability over time. These factors increase the risk of embolization and subsequent microvascular obstruction, leading to adverse procedural outcomes. Although embolic protection devices (EPDs) have been introduced to mitigate these risks, their routine application remains controversial. EPDs are often constrained by lesion characteristics and operator expertise, and their effectiveness is not absolute. Consequently, native vessel PCI, when feasible, remains the preferred approach[13,14].

Comparative analysis: PCI versus redo CABG

Redo CABG is inherently more complex than a primary CABG due to factors such as adhesions, graft injury risks, and limited conduit availability. These challenges contribute to a higher perioperative mortality rate, reported to range from 4.6% to 6.0%, compared to 1% to 2% in primary CABG[15,16]. Additionally, redo CABG is associated with increased rates of perioperative bleeding, renal dysfunction, and prolonged ventilation[17].
While redo CABG offers durable long-term outcomes and reduces the likelihood of subsequent revascularization, its benefits are often offset by its procedural risks and extended recovery times. Nevertheless, redo CABG operations have seen a staggering decline over the last 20 years. In contrast, PCI provides a less invasive alternative with a significantly lower perioperative risk profile. A multicenter study comparing PCI and redo CABG for graft failure found no significant differences in long-term survival but demonstrated superior procedural safety and recovery with PCI[18,19].

PCI in Specific post-CABG scenarios

1. Chronic Total Occlusions (CTOs)

PCI for CTOs in native vessels has become increasingly feasible due to advancements in techniques such as retrograde wiring and controlled dissection re-entry. These approaches allow for successful revascularization in scenarios previously deemed unsuitable for intervention[20,21].

2. Multivessel Disease

In patients with multivessel disease post-CABG, PCI allows for selective revascularization of the most critical ischemic territories, thus avoiding the systemic risks associated with redo CABG[22].

3. Emergency Revascularization

PCI has proven invaluable in emergency settings, such as acute graft failure or myocardial infarction, where it provides rapid symptom relief and stabilization[23].

Clinical implications and future directions

The evolution of PCI, particularly native vessel interventions, has redefined the management of patients with graft failure post-CABG. The strategic use of PCI, supported by advanced imaging, drug-eluting stents, and tailored pharmacological regimens, ensures safer and more effective revascularization[24,25]. However, the decision-making process must remain individualized, incorporating patient-specific factors such as anatomical feasibility, comorbid conditions, and prior procedural history.
Future research should focus on refining patient selection criteria, optimizing procedural strategies, and further exploring the role of PCI in high-risk subgroups. The development of novel stent designs, improved imaging modalities, and next-generation pharmacologic agents will undoubtedly expand the scope of PCI, solidifying its role as a cornerstone of post-CABG revascularization.

Conclusion

The shift toward PCI as a preferred strategy for managing graft failure post-CABG reflects a broader trend in interventional cardiology toward minimally invasive, patient-centered care. Native vessel PCI, in particular, offers a safer and more effective alternative to graft interventions, circumventing the challenges associated with SVG PCI and the inherent risks of redo CABG. As technological advancements continue to enhance the safety and efficacy of PCI, its integration into clinical practice will likely increase, providing better outcomes for patients with complex coronary disease.

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Sažetak

Perkutana koronarna intervencija posle CABG: paradigma koja se razvija

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Ovaj pregled procenjuje strategije revaskularizacije nakon hirurške koronarne revaskualrizacije (CABG), fokusirajući se na lečenje neuspeha grafta nakon inicijalne operacije. Dok je ponovna hirurška operacija bio tradicionalni pristup, njegovi značajni proceduralni rizici, povišen perioperativni mortalitet i produženi oporavak su podstakli prelazak na minimalno invazivne alternative kao što je perkutana koronarna intervencija (PCI). Ipak, ponovne CABG operacije su zabeležile zapanjujući pad u poslednjih 20 godina. Do danas, randomizovana klinička ispitivanja koja upoređuju strategiju PCI nativnih krvnih sudova sa SVG PCI nisu sprovedena. Ovaj rad ispituje razvoj PCI kod pacijenata nakon CABG, sa posebnim naglaskom na prednostima PCI nativnih krvnih sudova u odnosu na intervencije na graftu. Napredak u stentovima koji oslobađaju lekove (DES) i intravaskularnim modalitetima snimanja značajno su poboljšali bezbednost i efikasnost PCI, proširujući njegovu primenljivost na različite populacije pacijenata. PCI nativnih krvnih sudova pokazuje superiorne dugoročne rezultate ublažavanjem rizika od restenoze i neželjenih srčanih događaja, nadmašujući PCI grafta vene safene, koji je često komplikovan embolizacijom i degeneracijom grafta. Iako ponovni CABG ostaje neophodan za odabrane slučajeve koji uključuju složenu koronarnu anatomiju ili višesudovnu bolest, PCI nudi uporedive ishode preživljavanja sa nižim proceduralnim morbiditetom, što ga čini poželjnom opcijom za kohorte visokog rizika. Ovaj pregled naglašava klinički uticaj ovih napretka, podržava personalizovano donošenje odluka u revaskularizaciji nakon CABG-a i naglašava važnost daljih istraživanja kako bi se poboljšale smernice i optimizovali terapijski rezultati.

Ključne reči: *CABG, ponovna CABG, perkutana koronarna intervencija, revaskularizacija*