Cardiovascular Bypass Surgery: Contemporary Strategies for Postoperative Cardiac Follow-Up

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SOUHRN

Aortokoronární bypass (coronary artery bypass grafting, CABG) představuje i nadále základ chirurgického řešení komplexního srdečního onemocnění nebo pokročilé ischemické choroby srdeční. Přesto dlouhodobá úspěšnost CABG do velké míry závisí na systematickém sledování pacienta po výkonu na srdci. V časné pooperační době se sledování zaměřuje na prevenci arytmií, stabilitu hemodynamických poměrů a zjišťování případného perioperačního poškození myokardu, přičemž dlouhodobá péče zahrnuje pozorování funkce štěpu, úpravu rizikových faktorů a rehabilitaci. Novější údaje upozorňují na význam biomarkerů, jako jsou NT-proBNP, galektin-3 a adropin, spolu s používáním zobrazovacích metod, jako jsou „speckle tracking“ echokardiografie a CT angiografie srdce. Multidisciplinární model s celostním přístupem k pacientovi je spojen s příznivějšími výsledky a vyšší kvalitou života po CABG.

ABSTRACT

Coronary artery bypass grafting (CABG) remains the cornerstone surgical therapy for complex or advanced coronary artery disease. Yet, the long-term success of CABG depends heavily on systematic postoperative cardiac follow-up. Early evaluation focuses on arrhythmia prevention, hemodynamic stability, and detection of perioperative myocardial injury, whereas long-term care integrates graft surveillance, risk-factor modification, and rehabilitation. New data highlight biomarkers such as NT-proBNP, galectin-3, and adropin, together with imaging modalities like strain echocardiography and cardiac CT angiography. A multidisciplinary, patient-centered model ensures better outcomes and quality of life after CABG.

Introduction

Coronary artery bypass grafting (CABG) remains the cornerstone surgical approach for patients with advanced multivessel coronary artery disease (CAD), significant left main stenosis, or anatomically complex lesions not suitable for percutaneous coronary intervention (PCI).[1] Although percutaneous techniques and stent technology have improved markedly, CABG continues to provide superior long-term outcomes, particularly in diabetic populations and those with diffuse atherosclerosis. Several major randomized trials and meta-analyses confirm the survival advantage and reduced need for repeat revascularization with CABG compared to PCI.[2]

Beyond restoring coronary perfusion, CABG enhances ventricular function, alleviates angina, and improves overall quality of life. However, the long-term success of CABG is influenced by multiple factors, including graft selection, surgical technique, and patient adherence. In particular, the increasing use of arterial conduits such as the left and right internal mammary arteries and the radial artery has substantially improved long-term patency compared with saphenous vein grafts. Recent evidence supports total arterial revascularization (TAR) as an emerging strategy that enhances survival and reduces late graft failure.

Within this surgical framework, systematic postoperative cardiovascular follow-up remains essential for optimizing secondary prevention, monitoring ventricular function, and ensuring long-term graft performance. The postoperative period should therefore be regarded as a clinical continuum, beginning with hemodynamic stabilization in the early phase and extending to lifelong surveillance. Throughout this trajectory, cardiologists play a pivotal role in ensuring graft patency, preventing recurrent ischemia, and managing secondary prevention.

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Postoperative management targets three main objectives: (a) the early identification and prevention of complications such as atrial fibrillation, tamponade, and low-output syndrome; (b) optimization of medical therapy and risk-factor control to prevent disease progression in grafted and native vessels; and (c) promotion of functional recovery through structured cardiac rehabilitation programs.

In recent years, advances in cardiovascular imaging and circulating biomarkers have significantly refined risk assessment following CABG. Biomarkers such as high-sensitivity troponin, NT-proBNP, galectin-3, and adropin offer insights into myocardial injury, ventricular stress, fibrosis, and endothelial function, respectively.[3–5] In parallel, imaging modalities including strain echocardiography, three-dimensional echocardiography, and coronary computed tomography (CT) angiography enable the noninvasive evaluation of ventricular mechanics and graft patency. The integration of these diagnostic parameters supports early detection of subclinical dysfunction and timely intervention, leading to improved patient outcomes.

Equally important is the implementation of multidisciplinary, patient-centered care models. Collaboration between cardiologists, cardiac surgeons, physiotherapists, dietitians, and psychologists provides a holistic framework that addresses physical recovery, psychological well-being, and lifestyle adherence. This comprehensive approach reduces hospital readmissions and enhances long-term prognosis.

This review aims to consolidate the current evidence regarding postoperative cardiac follow-up after CABG, emphasizing structured surveillance, risk modification, biomarker-based assessment, and rehabilitative strategies. By aligning clinical practice with the latest ESC/EACTS recommendations, clinicians can optimize graft longevity, preserve ventricular function, and improve survival in patients undergoing surgical revascularization.

Early postoperative follow-up

The first 48–72 hours after surgery are crucial for identifying complications that influence long-term prognosis. Continuous ECG monitoring detects arrhythmias especially atrial fibrillation (AF) which affects 25–40% of CABG patients. Early administration of beta-blockers and correction of electrolyte imbalances reduce AF incidence.

Myocardial injury and biomarker monitoring

Biomarker assessment in the early postoperative period should be guided by clinical findings rather than performed routinely. High-sensitivity troponin should be measured only when perioperative myocardial infarction is suspected, as postoperative elevations are common after cardiac surgery and may not indicate true ischemic injury. CK-MB testing has been removed from the recommendations due to its limited added value in this setting.

In contrast, electrolyte monitoring especially serum potassium and magnesium is essential during the first 48–72 hours, as disturbances significantly increase the risk of postoperative atrial fibrillation. Persistent postoperative troponin elevation is linked to higher mortality and prolonged hospitalization.[3]

Hemodynamic and echocardiographic assessment

Echocardiography remains a cornerstone in the early phase, allowing assessment of ventricular function, wall-motion abnormalities, pericardial effusion, and hemodynamic stability.[6] Parameters such as ejection fraction and global longitudinal strain (GLS) provide valuable prognostic information. In hemodynamically unstable patients, transesophageal echocardiography assists in detecting tamponade or graft failure. Recommended evaluations for the early and intermediate phases are summarized in **Table 1**.

Pharmacologic optimization

Prompt initiation of secondary prevention drugs aspirin, statins, beta-blockers, and ACE inhibitors is essential for improving outcomes.[7] Dual antiplatelet therapy (DAPT) with aspirin and clopidogrel can enhance saphenous vein graft patency in selected cases.[8]

Intermediate and long-term follow-up

The first year after CABG represents a decisive period for consolidating recovery and optimizing long-term outcomes. Structured follow-up visits every 3–6 months are

Table 1 – Recommended follow-up assessments after CABG surgery

Time period	Recommended assessment	Clinical objective
0–48 hours	• Continuous ECG monitoring • Serum electrolytes (K^+, Mg^{2+}) • High-sensitivity troponin only if perioperative MI is suspected • Echocardiography when clinically indicated	• Early detection of arrhythmias • AF prevention via electrolyte optimization • Identification of suspected myocardial injury • Assessment of LV function and pericardial effusion
1–6 months	• Clinical follow-up visit • Stress testing only for symptoms or high ischemic risk • Lipid and glucose monitoring	• Management of secondary prevention • Symptom evaluation • Optimization of therapy
6–12 months	• Coronary CT angiography only when clinically indicated	• Non-invasive evaluation of graft patency when justified clinically
>1 year	• Annual clinical visit • Echocardiography in symptomatic or high-risk patients • Biomarkers (e.g., NT-proBNP) selectively	• Long-term LV function monitoring • Heart failure risk assessment • Individualized surveillance

recommended to evaluate symptoms, adjust therapy, and monitor comorbidities.[9]

Clinical and functional surveillance

Non-invasive ischemia testing treadmill ECG, stress echocardiography, or myocardial perfusion imaging should be performed selectively in symptomatic or high-risk patients.[10] Intermediate follow-up should be individualized and guided by symptoms, functional status, and overall clinical risk. Non-invasive ischemia testing such as treadmill ECG, stress echocardiography, or myocardial perfusion imaging should be performed only in patients with recurrent symptoms or those considered at higher risk of ischemia (**Table 1**).

Coronary CT angiography may be useful for evaluating graft patency; however, it should not be performed routinely. Instead, CT imaging should be reserved for cases in which graft dysfunction is clinically suspected, stress testing is abnormal, or new ischemic symptoms develop. Avoiding unnecessary radiation exposure in asymptomatic patients is an important consideration.

Risk factor modification and secondary prevention

Effective secondary prevention is vital for maintaining graft patency. Blood pressure should be maintained below 130/80 mmHg, LDL cholesterol below 55 mg/dL, and HbA_{1c} below 7% in diabetic patients.[7] High-intensity statins remain the foundation of lipid-lowering therapy and may be combined with ezetimibe or PCSK9 inhibitors to achieve optimal targets.[11]

Antithrombotic therapy

Aspirin (75–100 mg daily) is the standard therapy following CABG. Dual antiplatelet therapy for 6–12 months may be beneficial for patients with SVGs or recent acute coronary syndromes.[12] For patients with concurrent atrial fibrillation requiring oral anticoagulation, short-term triple therapy (≤1 month) followed by oral anticoagulant plus single antiplatelet is recommended to minimize bleeding risk.[10]

Cardiac rehabilitation

Comprehensive cardiac rehabilitation (CR) is a multidisciplinary intervention that promotes physical, psychological, and social recovery. Participation in CR reduces mortality by approximately 25% and significantly improves functional capacity and adherence to therapy.[13] The rehabilitation process is illustrated in **Figure 1** and summarized below.

Physical rehabilitation

CR consists of three sequential but overlapping phases:

- **Phase I (In-hospital):** Begins within 24–48 hours after extubation once the patient is hemodynamically stable. The aim is early mobilization, prevention of pulmonary complications, and patient education about sternal precautions and wound care.
- **Phase II (Supervised outpatient, 6–12 weeks):** Involves ECG-monitored aerobic exercise 3–5 times per week, with each session lasting 30–45 minutes. The target intensity is 60–80 % of the maximal heart rate, with gradual progression. Resistance training may begin 8–12 weeks postoperatively once the sternum has healed.
- **Phase III (Maintenance and lifestyle):** Focuses on lifelong adherence to exercise, dietary measures, and pharmacological therapy. Remote telemonitoring programs are particularly useful for elderly or geographically distant patients.[14]

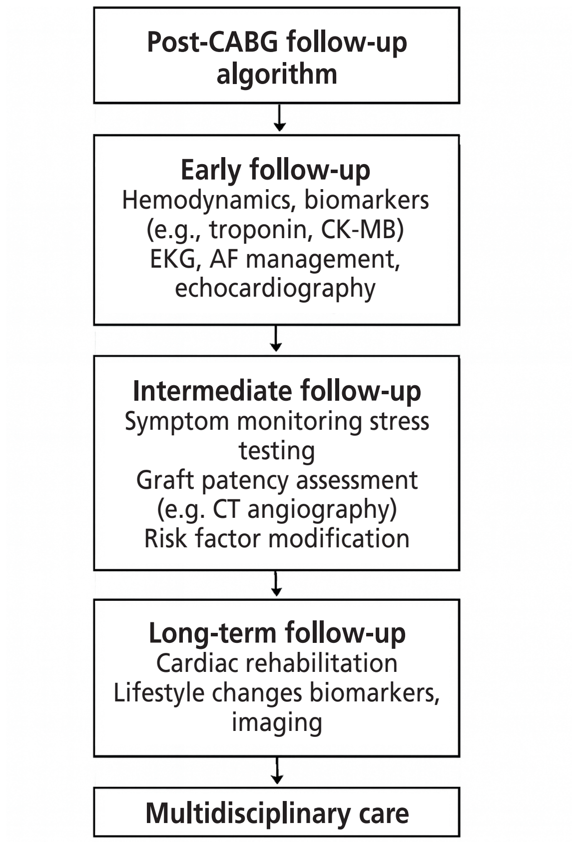

Fig. 1 – Multidisciplinary care.

Psychological and behavioral rehabilitation

Psychological recovery is a crucial but often neglected aspect of postoperative care. Depression and anxiety are reported in up to 40% of CABG survivors, and both conditions adversely affect prognosis.[15] Structured interventions such as cognitive-behavioral therapy (CBT), mindfulness, and stress management programs have proven to improve mood and compliance. The use of validated screening tools like the Hospital Anxiety and Depression Scale (HADS) or the Patient Health Questionnaire-9 (PHQ-9) is recommended during follow-up. When needed, selective serotonin reuptake inhibitors (SSRIs) such as sertraline are preferred because of their cardiac safety profile.

Education and lifestyle modification

Education is the foundation of successful rehabilitation. Patients and families should receive counseling regarding diet (e.g., Mediterranean diet), medication adherence, and early recognition of ischemic or heart failure symptoms. Lifestyle changes: smoking cessation, weight control, and moderation of alcohol are reinforced during follow-up visits. Motivational interviewing enhances long-term commitment to behavioral change.

Biomarkers and imaging modalities

In long-term follow-up after CABG, biomarker and imaging assessments should be guided by clinical context rather than performed routinely. Among circulating biomarkers, NT-proBNP remains the most clinically relevant parameter, providing information on ventricular wall stress and the risk of heart failure related events.[4] High--sensitivity troponin may be useful when there is a clinical suspicion of myocardial injury but has no role in routine surveillance.[3]

Other biomarkers such as galectin-3 and adropin are currently considered investigational.[5] Although galectin-3 may offer prognostic insight into myocardial fibrosis, it does not influence treatment decisions, and routine measurement is not recommended. Similarly, adropin has been associated with endothelial dysfunction and graft atherosclerosis in research settings, but its clinical applicability remains limited.[16]

Regarding imaging modalities, standard transthoracic echocardiography continues to be the primary tool for evaluating ventricular function and structural abnormalities during follow-up. Strain echocardiography can detect subtle myocardial dysfunction; however, its use is largely confined to research environments and selected specialized centers. Coronary CT angiography may aid in assessing graft patency but should be reserved for patients with symptoms, abnormal stress testing, or clinical suspicion of graft failure rather than applied routinely.

These parameters are summarized in **Table 2**.

Multidisciplinary care and future perspectives

The success of CABG depends not only on surgical skill but also on comprehensive, coordinated postoperative management. Effective long-term outcomes are achieved through close collaboration among cardiac surgeons, cardiologists, nurses, physiotherapists, nutritionists, and psychologists.[7]

Multidisciplinary cardiac care models improve medication adherence, lifestyle modification, and patient satisfaction while reducing rehospitalization rates. The cardiologist plays a central role in coordinating this care continuum—integrating pharmacological management, imaging surveillance, and rehabilitation progress.

Telemedicine and digital health technologies now enable remote ECG and hemodynamic monitoring, facilitating early detection of arrhythmias and heart failure decompensation.[14] Mobile applications that track vital signs, exercise data, and medication adherence have proven effective in improving compliance and reducing adverse events. In addition, artificial intelligence algorithms applied to cardiac imaging and clinical data are emerging as powerful tools for predicting graft patency, ventricular recovery, and long-term prognosis.[17]

The future of CABG follow-up lies in personalized medicine a combination of clinical data, imaging parameters, biomarker profiles, and patient-reported outcomes. This integrative approach supports risk prediction and proactive management, improving both survival and quality of life in surgical revascularization patients.

Conclusion

Coronary artery bypass grafting remains a fundamental treatment for advanced coronary artery disease, and long-term outcomes are shaped by several key factors, including graft selection, surgical technique, and patient adherence to secondary prevention. Contemporary strategies increasingly emphasize the use of arterial conduits and total arterial revascularization, which have been shown to enhance long-term graft patency and survival.

Within this surgical foundation, structured postoperative follow-up continues to play an essential supporting role. Early identification of complications, optimization of medical therapy, careful management of cardiovascular risk factors, and participation in cardiac rehabilitation all contribute meaningfully to recovery and long-term stability. Follow-up imaging and biomarker assessments should be individualized and performed only when clinically indicated.

A multidisciplinary and patient-centered approach integrating cardiac surgery, cardiology, rehabilitation, and

Table 2 – Biomarkers and imaging modalities in long-term follow-up

Parameter	Clinical utility	Status
hs-troponin	Detection of myocardial injury when clinically suspected	Routine clinical use (selective)
NT-proBNP	Assessment of ventricular wall stress and HF risk	Routine clinical use (selective)
Echocardiography (standard)	Evaluation of LV function, chamber size, effusion	Routine clinical use
Coronary CT angiography	Assessment of graft patency when symptoms or suspicion are present	Selective clinical use
Strain echocardiography	Detection of subtle LV dysfunction	Research/investigational (not routine)
Galectin-3	Marker of myocardial fibrosis; prognostic only	Research/investigational
Adropin	Endothelial function; associated with graft atherosclerosis	Research/investigational

preventive care remains central to achieving the best possible outcomes. As techniques and evidence evolve, individualized and judicious follow-up strategies will help ensure durable graft performance and improved quality of life after CABG.

Conflict of interest

The authors declare that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Ethical statement

The authors emphasize that this article is a review of contemporary strategies and does not involve original clinical trials or experimental studies on human or animal subjects conducted by the authors. All referenced data and procedures were handled in accordance with the ethical standards of the 1964 Helsinki Declaration and its later amendments.

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