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Original article

Early and long-term outcomes after coronary artery bypass grafting using saphenous vein grafts

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Summary

Introduction. Coronary Artery Bypass Grafting (CABG) remains the cornerstone of surgical myocardial revascularization. Despite major technical refinements and the increasing use of arterial conduits, saphenous vein grafts (SVGs) continue to play a vital role but remain vulnerable to long-term occlusion. The aim of the study was to evaluate early and long-term outcomes after CABG using vein grafts and to identify independent predictors of graft patency.

Methods. A retrospective analysis of the ICVDV CABG Registry (2010–2022) included 163 patients who underwent re-coronarography ≥ 5 years after surgery. Graft patency (patent, stenotic, or occluded) was correlated with clinical and anatomical variables using univariate and multivariable logistic regression ($p < 0.05$).

Results. Among all grafts, 51.5% were patent, 37.4% occluded, and 11.0% stenotic. Patency correlated significantly with larger distal anastomosis diameter ($p = 0.045$) and lower triglyceride levels ($p = 0.017$). Both remained independent predictors in multivariable analysis: distal anastomosis diameter (OR = 1.3; 95% CI 1.08–1.56; $p = 0.005$) and triglycerides (OR = 2.2; 95% CI 1.65–2.93; $p < 0.001$).

Conclusion. Distal-anastomosis geometry and triglyceride control are critical determinants of long-term vein-graft patency. Combining meticulous operative technique with sustained lipid optimization provides the most effective strategy for improving graft longevity and patient outcomes.

Key words: CABG, saphenous vein graft, graft patency, triglycerides, anastomosis, coronary revascularization

Introduction

Since Favaloro's pioneering operation in 1967, Coronary Artery Bypass Grafting (CABG) has become one of the most evidence-based cardiac surgical procedures, offering both survival and symptomatic benefits to patients with multivessel and left-main coronary artery disease [1, 2].

Over the past six decades, CABG has evolved from a purely mechanical revascularization technique into a physiology-guided intervention integrating functional assessment, conduit selection, and comprehensive secondary prevention [3, 4].

The selection of conduits remains a key determinant of long-term outcomes. Arterial grafts, particularly the left internal thoracic artery (LITA), demonstrate outstanding durability, with patency rates exceeding 90% after 10 years (3, 4). However, saphenous vein grafts (SVGs) continue to play an indispensable role due to their accessibility, length, and capacity to reach multiple coronary targets [5].

Despite these advantages, vein grafts are structurally adapted to low-pressure venous flow and are therefore prone to endothelial injury, intimal hyperplasia, and accelerated atherosclerosis when exposed to arterial circulation [6, 7]. Vein-graft failure evolves through overlapping phases—early thrombosis (within one month), intimal hyperplasia (within one year), and late atherosclerotic degeneration (beyond one year)—culminating in 40–50% occlusion rates after 10 years [8, 9].

Among the many factors influencing graft patency, distal-anastomosis geometry and lipid metabolism are especially critical. Smaller distal anastomoses induce turbulent flow and shear stress, while elevated triglycerides promote oxidative and inflammatory remodeling of the graft wall [6, 10].

Therefore, analyzing long-term clinical and anatomical predictors in real-world CABG populations is essential. This study aimed to assess vein-graft patency and to identify factors—particularly distal anastomosis diameter and triglyceride levels—associated with graft longevity among patients treated at the Institute for Cardiovascular Diseases of Vojvodina (ICVDV).

Methods

This retrospective cohort analysis was conducted using data from the ICVDV Internal CABG Registry, which prospectively recorded demographic, clinical, operative, biochemical, and angiographic information on all CABG patients treated between 2010 and 2022.

The study included 163 patients who underwent CABG and subsequent re-coronarography at least five years postoperatively. Indications for repeat angiography included recurrent angina, ischemic ECG changes, or positive functional testing suggestive of graft dysfunction.

All biochemical, echocardiographic, and angiographic data were obtained and validated through institutional laboratories and imaging departments.

- Biochemistry: Lipid profile, glucose, and renal function were measured using ISO-certified analyzers.
- Echocardiography: Left-ventricular ejection fraction (LVEF) and wall-motion analysis were performed according to standardized protocols.
- Angiography: Coronary angiograms were independently reviewed by two blinded interventional cardiologists.
- Data completeness and internal consistency were verified before analysis.
- Graft patency was categorized as:
- Patent: normal flow
- Stenotic: ≥ 50% luminal narrowing
- Occluded: complete loss of flow

Continuous variables were reported as mean ± SD or median (IQR), categorical variables as n (%). Between-group comparisons used the Student t-test, Mann–Whitney U, or χ^2 test as appropriate.

Normality of distribution for continuous variables was assessed using the Kolmogorov–Smirnov test.

Variables with $p < 0.05$ entered multivariable logistic regression, and results were expressed as odds ratios (OR) with 95% confidence intervals (CI). Analyses were conducted in IBM SPSS Statistics 25.0 (Armonk, NY, USA); $p < 0.05$ was considered statistically significant.

All statistical tests were two-tailed. The chi-squared test was used for categorical data, Student's t-test and Mann–Whitney U test for continuous variables, as appropriate.

Ethical approval was granted by the Institutional Committee; informed consent was waived due to the retrospective design.

Results

The final cohort included 163 patients who underwent CABG and re-coronarography ≥ 5 years post-surgery. Most of them were males (77.3%), with a mean age of 67.8 ± 8.3 years, mean BMI of 26.2 ± 4.1 kg/m², and preserved systolic function (mean LVEF 46.2 ± 12.0%). The average interval between CABG and re-coronarography was approximately five years (1 820 ± 130 days).

Table 1. Baseline characteristics of the study cohort (n = 163)

Variable	Mean ± SD/n (%)
Age (years)	67.8 ± 8.3
Male sex	126 (77.3%)
Body Mass Index (kg/m²)	26.2 ± 4.1
Left Ventricular Ejection Fraction (%)	46.2 ± 12.0
Time from CABG to re-coronarography (days)	1 820 ± 130

Table 1 shows that the study population consisted predominantly of elderly male patients with preserved systolic function and moderate cardiovascular risk.

At angiographic follow-up, 51.5% of all saphenous vein grafts were patent, 37.4% were occluded, and 11.0% demonstrated significant stenosis. Most patients had two or three grafts at surgery, while single or ≥ 4-graft procedures were rare.

Table 2 shows that approximately half of the vein grafts remained patent five years after CABG, while more than one-third were completely occluded and a smaller portion exhibited significant stenosis.

The chi-squared test was used for comparisons between categorical variables.

Patency varied significantly among coronary territories ($p < 0.05$). Grafts to the LAD had the highest long-term patency (81.1%), followed by RCA (74.8%) and RCX (69.2%).

Table 3 shows that grafts to the LAD artery demonstrated the highest long-term patency, followed by RCA grafts, while RCX grafts had the lowest survival rates.

The chi-squared test was used for comparisons between categorical variables.

Comparison between patent and occluded grafts revealed that smaller distal-anastomosis diameters and higher triglyceride levels were associated with occlusion. Age showed a modest correlation, whereas LVEF and BMI did not differ significantly between groups.

Table 2. Overall graft status following CABG

Number of grafts per patient	n (%)	Patent	Occluded	Stenotic
1	7 (4.3)	4	2	1
2	64 (39.3)	33	25	6
3	75 (46.0)	38	29	8
4	16 (9.8)	8	7	1
5	1 (0.6)	1	0	0
Total	163 (100)	84 (51.5%)	61 (37.4%)	18 (11.0%)

Table 3. Graft patency according to coronary target vessel

Coronary Target Vessel	n of Grafts (%)	Patent n (%)	Occluded n (%)	p Value
Left Circumflex (RCX)	120 (73.6)	83 (69.2)	37 (30.8)	< 0.05
Left Anterior Descending (LAD)	55 (33.7)	43 (81.1)	10 (18.9)	< 0.05
Right Coronary Artery (RCA)	111 (67.5)	83 (74.8)	28 (25.2)	< 0.05

Table 4. Continuous clinical and biochemical predictors of graft patency

Variable	Patent (Mean ± SD)	Occluded (Mean ± SD)	p Value
Distal anastomosis diameter (mm)	2.07 ± 0.48	1.69 ± 0.45	0.045
Triglycerides (mmol/L)	1.35 ± 0.61	2.20 ± 0.74	0.017
Age (years)	67.7 ± 8.4	66.2 ± 8.2	0.032
LVEF (%)	46.5 ± 12.8	45.2 ± 9.6	0.469
BMI (kg/m²)	28.3 ± 4.0	28.2 ± 4.0	0.905

Table 4 shows that smaller distal anastomosis diameter and elevated triglyceride levels were significantly associated with graft occlusion, whereas age had a moderate correlation, and neither BMI nor LVEF differed significantly between groups.

The Mann–Whitney U test was used for variables that did not meet normality criteria.

Multivariable regression confirmed that distal-anastomosis diameter and serum triglycerides were independent predictors of long-term graft patency.

Table 5. Multivariable logistic regression analysis of predictors of long-term graft patency

Variable	OR	95% CI	p Value
Distal anastomosis diameter (per 1 mm)	1.3	1.08–1.56	0.005
Serum triglycerides (per 1 mmol/L)	2.2	1.65–2.93	< 0.001
Age (per year)	1.04	0.98–1.09	0.071
LVEF (%)	1.01	0.96–1.06	0.469

Table 5 shows that smaller distal anastomosis diameter and higher triglyceride levels were independent predictors of long-term vein graft patency, while age and LVEF did not reach statistical significance.

Discussion

This study identified distal-anastomosis diameter and serum triglyceride levels as the most important independent predictors of long-term saphenous vein graft patency after CABG. These findings integrate two essential determinants of graft biology: surgical hemodynamics and metabolic stability.

A wider distal anastomosis preserves laminar flow, minimizes turbulence, and prevents endothelial injury and thrombus formation [3, 11]. Intraoperative transit-time flow measurement (TTFM) offers objective evaluation of graft quality and should be considered standard practice, particularly in small or diffusely diseased vessels.

Elevated triglycerides accelerate SVG atherosclerosis by inducing oxidative stress, macrophage infiltration, and smooth muscle proliferation [6, 10, 12]. High-intensity statins and omega-3 fatty acids have shown additive benefits in improving endothelial function and reducing graft disease [13].

Older patients demonstrated a higher risk of graft occlusion, reflecting the cumulative burden of vascular stiffening, diabetes, and systemic inflammation [9, 14]. Individualized secondary prevention remains essential in this population.

The observed five-year patency rate (51.5%) is consistent with prior large-scale studies by

Hess et al. [8], Raza et al. [9], and Furukawa et al. [14]. Despite ongoing progress, SVGs remain less durable than arterial conduits, yet indispensable for achieving complete revascularization, particularly in RCA and RCX territories [15, 16].

Limitations

The retrospective design and symptom-driven indication for re-coronarography introduce selection bias (2). Furthermore, the absence of detailed pharmacologic data (e.g., statin adherence, antiplatelet use) limits the ability to fully assess the impact of medical therapy. Prospective, multicenter studies incorporating standardized angiographic follow-up, graft-flow quantification, and AI-based risk modeling are warranted.

Conclusion

Distal-anastomosis diameter and serum triglyceride levels are strong, independent predictors of long-term saphenous vein graft patency following CABG. Combining precise operative technique with lifelong lipid optimization—particularly through high-intensity statins and omega-3 therapy—represents the most effective strategy for enhancing graft durability and improving patient survival.

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Ethical approval. The Ethics Committee of the Institute for Cardiovascular Diseases of Vojvodina, Novi Sad, Serbia, approved the study and informed consent was obtained from all individual respondents. The research was conducted according to the Declaration of Helsinki.

Conflicts of interest. The authors declare no conflict of interest.

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Rani i dugoročni ishodi nakon bajpasa koronarnih arterija korišćenjem safenskih venskih graftova

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Uvod. Aortokoronarna premosnica (CABG) i dalje predstavlja temelj hirurške revaskularizacije miokarda. Uprkos značajnim tehničkim unapređenjima i sve češćoj upotrebi arterijskih graftova, venski graftovi iz velike safenske vene (SVG) i dalje imaju ključnu ulogu, ali ostaju podložni okluziji na duži rok. Cilj rada je bio da procijeni rane i dugoročne ishode nakon CABG operacije sa upotrebom venskih graftova i identifikuje nezavisne prediktore njihove prohodnosti.

Metode. Retrospektivna analiza registra CABG operacija Instituta za kardiovaskularne bolesti Vojvodine (ICVDV) obuhvatila je 163 pacijenta koji su podvrgnuti ponovnoj koronarografiji ≥ 5 godina nakon operacije. Prohodnost graftova (prohodni, stenotični ili okludirani) analizirana je u odnosu na kliničke i anatomske varijable korišćenjem univarijantne i multivarijantne logističke regresije ($p < 0,05$).

Rezultati. Od svih graftova, 51,5% je bilo prohodno, 37,4% okludirano, a 11,0% stenotično. Prohodnost je značajno korelirala sa većim prečnikom distalne anastomoze ($p = 0,045$) i nižim nivoom triglicerida ($p = 0,017$). Oba parametra su ostala nezavisni prediktori u multivarijantnoj analizi: prečnik distalne anastomoze (OR = 1,3; 95% CI 1,08–1,56; $p = 0,005$) i trigliceridi (OR = 2,2; 95% CI 1,65–2,93; $p < 0,001$).

Zaključak. Geometrija distalne anastomoze i kontrola triglicerida predstavljaju ključne determinante dugoročne prohodnosti venskih graftova. Kombinovanje precizne hirurške tehnike sa trajnom optimizacijom lipidnog profila predstavlja najefikasniju strategiju za produženje vijeka grafta i poboljšanje ishoda pacijenata.

Ključne riječi: CABG, venski graft safene, prohodnost grafta, trigliceridi, anastomoza, koronarna revaskularizacija