Grafts patency and failure following coronary artery bypass grafting: A single-center experience

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Abstract. The present study aimed to evaluate the patency of different types of grafts in coronary artery bypass grafting (CABG) and identify factors influencing graft failure, such as cross-clamp time, number of grafts, comorbidities and surgical techniques. A prospective cohort study was conducted from December, 2018 to December, 2022 in a single cardiac surgery center. All patients with coronary artery disease who underwent CABG, regardless of sex or comorbidities, were enrolled. Patients were excluded if they met the following criteria: An age <30 years, single or two-vessel grafts, surgery performed <1 year or >5 years prior, or total arterial revascularization. A total of 50 patients were included in the study; among these, 38 (76%) patients were male. Additionally, 45 (90%) individuals were >50 years of age. As regards the number of grafts, there were three, four and five grafts in 15 (30%), 17 (34%) and 18 (36%) patients, respectively. The left internal mammary artery (LIMA) to left anterior descending artery was patent in 45 (90%) individuals at 3 years with saphenous vein graft (SVG), with a patency rate ranging from 84-92%. On the whole, the present study demonstrates that LIMA grafts have superior patency at 1- and 3-year follow-ups compared to SVGs using the no-touch technique. Additionally, diabetes mellitus was significantly associated with the number of grafts. Distal lesions were the most common site of graft failure.

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Introduction

Coronary artery bypass grafting (CABG) is a surgical intervention aimed at improving myocardial blood flow in patients with coronary artery disease. This procedure involves the use of the arteries or veins of the patient as grafts to reroute blood around coronary arteries that are either partially or completely obstructed due to the buildup of atherosclerotic plaques. The grafts are surgically connected to bypass the areas of blockage, thereby restoring adequate perfusion to the affected myocardial tissue and alleviating symptoms (1). This procedure remains one of the most frequently performed major surgical procedures, which is typically carried out at a rate of 44 procedures per 100,000 individuals (2). However, over the past 10 years, there has been a notable reduction in the number of CABG procedures, with a decrease of ~30%. This may be attributed to advancements in alternative treatments, such as percutaneous coronary interventions, as well as improvements in medical management and preventive care for coronary artery disease. Despite this trend, CABG continues to be a critical option for patients with severe coronary artery obstruction where other treatment methods may be less effective (1).

In CABG surgery, the heart is deliberately halted to allow for accurate grafting. This is achieved by blocking the ascending aorta and introducing a cold, potassium-rich solution to stop the activity of the heart. To compensate for the lack of natural circulation, a cardiopulmonary bypass machine is utilized, ensuring oxygenation and blood flow during the period of cardiac arrest, typically lasting 1 to 2 h (1).

In CABG, grafts are primarily sourced from either arteries or veins. Arterial grafts are commonly harvested from the internal mammary artery, radial artery, or right gastroepiploic artery, while vein grafts are typically taken from the lower extremities, such as the great saphenous veins. The internal mammary artery provides excellent long-term patency rates of >90% and resistance to atherosclerosis. The radial artery is a strong alternative, with improved patency than venous grafts, particularly for high-grade stenosis. Saphenous vein grafts (SVGs), although less durable, remain common due to ease of harvest and versatility, despite a progressive failure rate. Conduit selection should be personalized, considering patient factors, vessel quality and stenosis severity, with modern approaches using tools such as fractional flow reserve for optimal graft performance (3-5).

The present study aimed to evaluate the patency of different types of grafts in CABG and identify factors influencing graft failure, such as cross-clamp time (CXT), number of grafts, comorbidities and surgical techniques.

Patients and methods

Study design. A prospective cohort study was conducted from December, 2018 to December, 2022 in a single Ibn Al-Bitar Specialized Center for Cardiac Surgery in Baghdad, Iraq.

Eligibility criteria. All patients with coronary artery disease who underwent CABG, regardless of sex or comorbidities, were enrolled. Patients were excluded if they met the following criteria: An age <30 years, single or two-vessel grafts, surgery performed <1 year or >5 years prior, or total arterial revascularization.

Ethical approval. The present study was approved by the Medical Ethics Committee of Kscien Organization for Scientific Research, Sulaymaniyah, Iraq (approval no. 53/2018). The study was conducted in accordance ethical principles and was designed to ensure the safety, rights and confidentiality of all participants. Informed consent was obtained from all enrolled participants prior to inclusion in the study, with the understanding that participation was voluntary, and that they could withdraw at any time without consequence. The ethical approval and consent to participate were obtained under the supervision of the Medical Ethics Commission at Ibn Al-Bitar Specialized Center for Cardiac Surgery.

Patient preparation. All patients were initially examined by a general practitioner and then referred to a cardiologist who examined them for vital signs. In addition, echocardiography and laboratory analyses were performed, and a coronary computed tomography (CT) angiogram was conducted using a multi-slice [electrocardiogram (ECG)-gated] protocol CT scanner (Ingenuity CT 64/128 MDCT). Patients were assessed for risk factors, and graft patency was evaluated at the 1- and 3-year follow-up periods.

The ECG gated coronary CT angiography is a reliable non-invasive imaging modality for evaluating CABG patency during follow-up. It provides the high-resolution visualization of bypass grafts including the internal mammary and saphenous vein graft, it has a high diagnostic accuracy (sensitivity and specify; often >95%) for detecting graft occlusion or significant stenosis, and is also beneficial in assessing the entire graft course along with the evaluation of native coronary artery. It increasingly used as a safe alternative to invasive coronary angiography (6).

Post-operative graft evaluation was performed using CT coronary angiography at 1 and 3 years following surgery. A total of 50 eligible patients were enrolled in the study and a total of 145 grafts were analyzed, including left internal mammary artery-left anterior descending artery (LIMA-LAD) (n=50), SVG-posterior descending artery (PDA) (n=36), SVG-obtuse marginal (OM; OM1, OM2) (n=44) and SVG-diagonal (D1, D2) (n=15). All patients completed both imaging follow-up assessment and there were no missing imaging or follow-up data. Due to the relatively small sample size and the limited number of graft failure events. Multivariable analysis was not performed in order to avoid model instability; therefore, statistical analysis was limited to univariable comparisons. The study flow chart, including patient enrollment, graft distribution and follow-up, is illustrated in Fig. 1.

The graft status was categorized into three groups (patent, critical lesion and total occlusion). Patent grafts were defined as uninterrupted contrast opacifications without significant stenosis (<50% luminal narrowing) critical lesion defined as sever graft stenosis (>50-70% luminal narrowing). Total occlusion was defined as the complete absence of contrast opacifications along the graft lumen distal to anastomosis, no patient was excluded due to poor visualization or motion artifact. The estimation of the percentage of stenosis was performed by comparing the minimal luminal diameter at the site of narrowing with the reference diameter of the adjacent normal graft. Quantitative analysis was conducted utilizing the Comprehensive Cardiac Analysis software on a Brilliance Workstation (Philips Healthcare).

Surgical approach and cardiopulmonary bypass. The surgical procedures were performed via standard median sternotomy. Cardiopulmonary bypass was conducted by cannulating the ascending aorta and by performing venous cannulation through the right atrium using a double-stage venous cannula. Myocardial protection was provided by simultaneous antegrade and retrograde perfusion using del Nido cardioplegia solution, prepared according to institutional protocol locally using a crystalloid base solution mixed with oxygenated blood at a 1:4 ratio. The solution was supplemented with potassium chloride, magnesium sulfate, lidocaine and mannitol and administrated as a single dose strategy via aortic root and retrograde with additional dose given as required.

Anastomosis techniques. For the distal anastomosis of the graft to the target coronary artery, a continuous suture technique was used with one suture material in a parachute manner using 8-0 polypropylene monofilaments needle size (6-8 mm). The length of the coronary arteriotomy was 25% shorter than the beveled length of the venous graft, thus leaving a hood.

For the sequential anastomosis of the graft to the coronary arteries, the arteriotomy length was ~1.5-fold greater than the arterial diameter, and the graft incision was 25% longer than the arteriotomy. Instead of using the continuous parachute technique, a continuous suture was placed counterclockwise at the heel of the graft and then tied into place.

For the proximal anastomosis of the graft to the aortic opening, an incision <1 cm was made at the aortic opening. The proximal aortic incision was then enlarged with a 3.5-mm aortic punch. The long axis of the graft opening was to be 1.2- to 1.3-fold the size of the aortic incision. The suture technique followed the same two-suture material method as described for the distal anastomosis. Continuous clockwise stitches

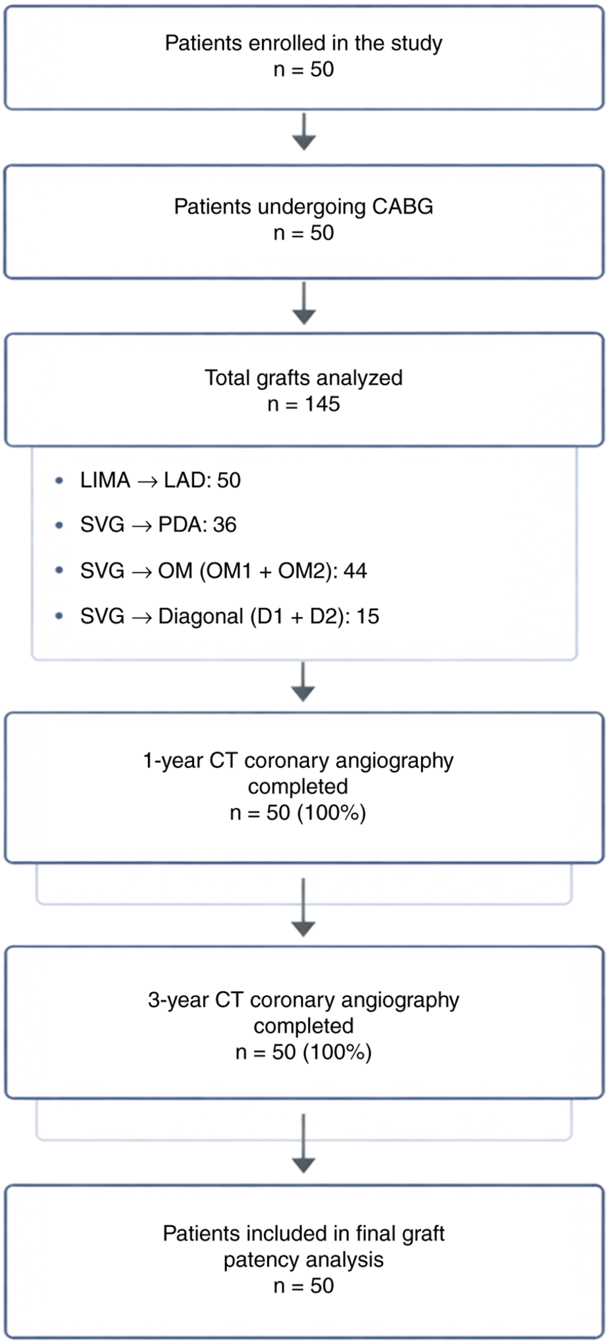

Figure 1. Diagram of the study flow chart, including patient enrollment, graft distribution and follow-up. CABG, coronary artery bypass grafting; LIMA, left internal mammary artery; LAD, left anterior descending artery; SVG, saphenous vein graft; PDA, posterior descending artery; OM, obtuse marginal; CT, computed tomography.

were placed, and when tightened, all graft margins inside the stitches were inverted into the aortic opening to achieve proper hemostasis and a smooth internal lumen. The proximal anastomosis was completed with a small blade (11 mm), in the appropriate direction.

Saphenous graft harvesting and preparation. In the present study, all SVGs where harvested using the open no-touch technique, which represents the standard practice at Ibn Al-Bitar Specialized Center for Cardiac Surgery consequently, no patients underwent endoscopic vein harvesting and thus, the direct comparison between harvesting techniques was not possible. This was typically performed through an open method or by employing a skipped incision technique to preserve ~1 cm of tissue at both ends of the saphenous graft, ensuring the adventitia remained intact. All side branches of the vein were ligated either with 2/0 silk ligature or by using Vascular side branches which were secured using titanium ligating clips (LIGACLIP™ Extra, Ethicon (Johnson & Johnson MedTech). The use of forceps to directly grasp the vein was minimized to avoid damaging it. Stretching or over-distension of the graft while injecting saline solution was carefully controlled. Harvesting commenced from the ankle, extending below the knee, and in some cases, above the knee.

Once the vein was harvested, it was stored in a mixture of heparinized saline. Distal anastomosis was then performed, side branches were ligated, and the sequential anastomosis was checked by flushing with normal saline and blood cardioplegia solution pushed by a syringe. The graft was double-checked to ensure patency before establishing and completing the proximal anastomosis. Hemostasis was achieved, and a closed suction drain (12 or 14 Fr) was inserted into the limb to prevent the formation of hematomas or seromas post-operatively. After the incision was closed, the leg was circumferentially wrapped with an elastic bandage, beginning from the foot. Excessive pressure from the bandage was avoided, particularly in patients with peripheral occlusive artery disease.

Harvesting and preparation of LIMA. A specialized retractor was used to expose the LIMA bed and improve visibility. In all cases, the pleura was opened to enhance LIMA exposure, which also allowed the LIMA to be positioned away from the posterior sternal table during wound closure. The LIMA was harvested in a pedicled manner using electrocautery with a low-power configuration. All branches of the LIMA were clipped and divided. The thoracic transversus muscle was divided to expose the distal LIMA bifurcation.

Once the dissection was completed, the patient received heparin. At 3 min following administration, the distal end of the LIMA, just before the bifurcation, was clipped, and the conduit was divided. Flow quality was visually inspected by allowing the graft to bleed for a few seconds. The distal end of the LIMA conduit was gently clamped with an atraumatic bulldog clamp, or alternatively, it was clipped with one clip to prevent unnoticed bleeding into the pleural space. The internal mammary artery was treated with topical papaverine hydrochloride solution (papaverine hydrochloride injection, Baxter Healthcare Corporation) was applied topically to the graft, and the LIMA was wrapped in damp gauze soaked with a papaverine solution. The direct injection of papaverine into the LIMA lumen was avoided.

Data collection and analysis. An electronic registry database was used to record the data from the medical records of the patients, including demographics, comorbidities, medical summaries, investigations, operative details and follow-up data information. The variables were categorized into baseline and risk factors. Age was grouped into two categories: 30-50 years and >50 years. Risk factors included diabetes mellitus (DM), hypertension, family history, smoking, stroke, hyperlipidemia, chronic kidney disease and thyroid disease.

Operative and cardiac surgery variables were also assessed, including the duration of surgery, CXT, number of grafts and left ventricular function. The graft type and patency were evaluated using CT. Additionally, the site of stenosis was classified as proximal, mid, or distal stenosis.

Graft patency analysis was performed primarily for LIMA -LAD grafts, at patient level as this conduit was used in all patients (n=50). For SVG to other coronary territories (PDA, OM and D), the outcome was analyzed at the graft level and the denominators correspond to number of grafts or patients who received that specific graft.

Statistical analysis. Statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 27 (IBM Corp, Armonk, NY, USA), which enabled a comprehensive quantitative analysis of the collected information. Key variables were organized and presented in summary tables. For categorical variables, the data are displayed in terms of frequency and percentage.

Associations between categorical variables were evaluating using the Chi-squared test; when the expected cell count were <5, Fisher's exact test was applied. The comparison of interest included the association between CXT and graft patency, the endarterectomy status and SVG patency, DM and the number of grafts, and cross-clamp time and the number of grafts.

The sample size (n) for each analysis corresponding to the number of grafts included in the specific comparison, a two-sided α value level of 0.05 was used to determine statistically significant and an exact P-value was reported where applicable. A P-value <0.05 was considered to indicate a statistically significant difference.

Results

Baseline characteristics. A total of 50 patients were included in the present study; among these, 38 (76%) were male. Additionally, 45 (90%) individuals were >50 years of age, and the remainder were between 30-50 years of age. As regarding body mass index, 24 (48%) and 19 (38%) patients were overweight and obese, respectively. The common comorbidities of the patients included hypertension [n=41 (82%)], hyperlipidemia [n=21 (42%)] and DM [n=21 (42%)]. The smoking status was positive in 28 (56%) patients (Table I).

Table I. Demographic characteristics of the patients.

Variables	No. of patients (%)
Age group	
30-50	5 (10)
>50	45 (90)
Sex	
Male	38 (76)
Female	12 (24)
Body mass index	
Normal	7 (14)
Overweight	24 (48)
Obese	19 (38)
Positive family history	
Yes	13 (26)
No	37 (74)
Hypertension	
Yes	41 (82)
No	9 (18)
Smoking status	
Yes	28 (56)
No	22 (44)
Hyperlipidemia	
Yes	21 (42)
No	29 (58)
Diabetes mellitus	
Yes	21 (42)
No	29 (58)
Chronic kidney disease	
Yes	7 (14)
No	43 (86)
Thyroid disease	
Yes	10 (20)
No	40 (80)
Total	50 (100)

Values are presented as number (percentage). Descriptive statistics were used to summarize the bassline characteristics of the study population (n=50).

Number of grafts, CXT and cardiac assessment. Left ventricular dysfunction was present in 16 (32%) patients, with left main stem disease present in 25 (50%) patients. The CXT was ≥60 min in 40 (80%) of the patients, with the CXT in the remaining patients (20%) being <60 min. As regards the number of grafts, there were three, four and five grafts in 15 (30%), 17 (34%) and 18 (36%) patients, respectively. Endarterectomy was performed in 6 (12%) individuals and 26 (52%) had sequential anastomosis.

Follow-up graft failure at 1 and 3 years. The LIMA to the LAD was patent in 45 (90%) individuals at 3 years, with critical lesions and total occlusion in 3 (6%) and 2 (4%) patients, respectively. At the 1- year follow up , the SVG to PDA remained patent in 32 patients (88.9%) while graft failure was observed in 4 patients (11.1%).

The 3-year patency rate of the SVG to the OM artery was 37 (84.1%), while graft failure occurred , while graft failure occurred in 7 patients (15.9%) including 3 (6.8%) with critical lesions and 4 (9.1%) with total occlusion . The details of graft failure are summarized (Table II).

Site of lesions at the 3-year follow-up. The LIMA to LAD had lesions only in the distal part of the anastomosis in 5 (100%) of the patients, with SVG to OM having 6 (85.7%) lesions distally, and 2 out of 7 (28.6%%) among the failed grafts proximally. A summary of these findings is presented in Table III.

Table II. Follow-up graft failure at 1 and 3 years.

Graft type	Patients receiving graft (n)	Follow-up	Patent graft (%)	Critical lesion, n (%)	Total obstruction, n (%)	Total (n)
LIMA → LAD	50	1 year	46 (92.0%)	2 (4.0%)	2 (4.0%)	50
	50	3 years	45 (90.0%)	3 (6.0%)	2 (4.0%)	50
SVG → PDA	36	1 year	32 (88.9%)	1 (2.8%)	3 (8.3%)	36
	36	3 years	30 (83.3%)	2 (5.6%)	4 (11.1%)	36
SVG → OM (OM1+OM2)	44	1 year	38 (86.4%)	3 (6.8%)	3 (6.8%)	44
	44	3 years	37 (84.1%)	3 (6.8%)	4 (9.1%)	44
SVG → diagonal	15	1 year	14 (93.3%)	1 (6.7%)	0 (0.0%)	15
(D1+ D2)	15	3 years	14 (93.3%)	1 (6.7%)	0 (0.0%)	15

LIMA, left internal mammary artery; LAD, left anterior descending artery; SVG, saphenous vein graft; PDA, posterior descending artery; OM, obtuse marginal.

Table III. Failure site according to graft type patient received at the 3-year follow-up.

Graft type	Total lesion graft (n)	Failure site		
		Proximal lesion, n (%)	Middle lesion, n (%)	Distal lesion, n (%)
LIMA → LAD	5	0	0	5 (100)
SVG → PDA	6	4 (66.7)	1 (16.7)	1 (16.6)
SVG → OM (OM1+OM2)	7	2 (28.6)	0 (0)	5 (71.4)
SVG → diagonal (D1+ D2)	1	1 (100)	0	0

LIMA, left internal mammary artery; LAD, left anterior descending artery; SVG, saphenous vein graft; PDA, posterior descending artery; OM, obtuse marginal.

Table IV. Association between cross-clamp time and the patency of the LIMA to LAD grafts.

LIMA to LAD graft status	<60 min	>60 min	Total, n (%)
Patent	7	38	45 (90%)
Critical stenosis	2	1	3 (6%)
Occluded	1	1	2 (4%)
Total	10	40	50

Data were analyzed using Fisher's exact test (Freeman-Halton extension) (n=50); P=0.050. LIMA, left internal mammary artery; LAD, left anterior descending artery.

Table V. Association between endarterectomy and the patency of SVG to PDA grafts.

SVG-PDA graft status	Endarterectomy, yes	Endarterectomy, no	Total
Patent	2	42	44 (88%)
Critical stenosis	1	1	2 (4%)
Occluded	0	4	4 (8%)
Total	3	47	50 (100%)

Data were analyzed using Fisher's exact test (Freeman-Halton extension) (n=50 patients). A statistically significant association was observed (P=0.026). A two-sided α level of 0.05 was used. SVG, saphenous vein graft; PDA, posterior descending artery.

Association between CXT and the patency of LIMA to LAD graft. The association between CXT and the patency of the LIMA to LAD graft was analyzed using the Fisher's exact test. No statistically significant association was observed (P=0.050), although a trend toward improved graft patency with shorter cross-clamp time (<60 min) was noted (Table IV).

Status of endarterectomy and the patency of SVG to PDA. There association between the endarterectomy status and the patency of SVG to PDA was evaluated using Fisher's exact test; a statistically significant association was detected between enterectomy and graft patency (P=0.026, n=50). Patients who underwent endarterectomy demonstrated a higher proportion of graft dysfunction compared with those who did not undergo the procedure (Table V).

Table VI. Association between DM and the number of grafts.

No. of grafts	DM, yes	DM, no	Total
Three	0	15	15 (30%)
Four	11	6	17 (34%)
Five	10	8	18 (36%)
Total	21	29	50 (100%)

Data were analyzed using Fisher's exact test (Freeman-Halton extension) (n=50 patients). A statistically significant association was observed (P<0.001). A two-sided α level of 0.05 was used. DM, diabetes mellitus.

Table VII. The association between cross-clamp time and the number of grafts.

No. of grafts	Cross-clamp time <60 min	Cross-clamp time >60 min	Total
Three	1	14	15 (30%)
Four	2	15	17 (34%)
Five	7	11	18 (36%)
Total	10	40	50 (100%)

Data were analyzed using Fisher's exact test (n=50); no statistically significant association between cross clamp time and number of grafts (P=0.063).

Association between DM status and the number of grafts. A Chi-squared test was conducted to assess the association between the DM status and the number of grafts. Among patients with DM, none received three grafts, while 11 (52.4%) received four grafts and 10 (47.6%) received five grafts. The significant P-value (P<0.001) suggested that the DM status was strongly associated with the number of grafts received (Table VI).

Association between CXT and the number of grafts. Using Fisher's Exact Test, there was no statistically significant association between the number of grafts and cross-clamp time (P=0.063). (Table VII).

Discussion

The success of CABG in improving patient outcomes is fundamentally linked to the sustained patency of grafts. Despite this critical role, contemporary clinical practice seldom incorporates routine, systematic evaluations of graft integrity. The majority of existing data on the long-term viability of CABG grafts originates from studies conducted several decades ago, which may not accurately reflect advancements in surgical techniques and postoperative care. Moreover, much of the currently available evidence is drawn from patient cohorts undergoing imaging due to symptomatic concerns, introducing a potential selection bias that limits the generalizability of findings (7). In the present study, all patients were assessed for graft patency at the 1 and 3-year follow-up periods.

The underlying mechanisms driving graft failure are influenced by both the type of graft utilized and the temporal phase following CABG. In the early post-operative period, within the first month, graft occlusion is primarily attributed to acute thrombosis, a process that antithrombotic therapy aims to mitigate. While both arterial and venous grafts are susceptible to thrombotic occlusion, the incidence is notably higher in venous grafts. Beyond the initial post-operative month, venous graft failure is predominantly driven by pathological processes such as intimal hyperplasia and the rapid progression of atherosclerosis, which compromise long-term graft patency (4).

Among the various factors contributing to vein graft failure following CABG, smoking and dyslipidemia have been identified as the predominant atherosclerotic risk determinants. Smoking, in particular, serves as an independent predictor of both mortality and the necessity for repeat revascularization in patients who have undergone venous graft procedures. Consequently, post-CABG smoking cessation is of paramount importance, particularly in cases where vein grafts have been employed. Similarly, elevated cholesterol and triglyceride levels are strongly implicated in the pathogenesis of vein graft disease, ultimately leading to graft failure. Furthermore, substantial evidence underscores a robust association between persistently high cholesterol levels and increased long-term mortality following coronary surgery. As a result, the rigorous management of dyslipidemia should be a fundamental component of post-operative care to optimize long-term clinical outcomes (7). In line with this, in the present study, almost half of the patients were smokers and had dyslipidemia, with hypertension being present in up to 80% of the cases highlighting their major role for patients that undergo CABG. In addition, DM was found to significantly affect the number of grafts required, as more than half of the patients who required five grafts were diabetic, while none of the patients who required three grafts had diabetes.

Furthermore, the present study demonstrated that graft patency varied depending on the specific conduit used and its connection to the coronary artery. The LIMA exhibited patency rates of 90% at 3 years . However, In the present study, SVG patency was 88.9% at 1 year for SVG to PDA grafts and 84.1% at 3 years for SVG to OM grafts; notably, SVG anastomosed to PDA and OM arteries demonstrated a higher rate of graft failure with total occlusion reaching 9.1% at the 3 years follow-up; furthermore, graft failure predominantly occurred at the distal anastomosis site in LIMA grafts, all occlusions occurred in the distal segment. In addition, in SVGs, the majority of occlusions were also observed in the distal portion. This finding is likely due to reduced flow velocity and increased turbulence at the distal anastomosis, promoting thrombosis and intimal hyperplasia, particularly in smaller recipient vessels. The relatively small sample size from a single center limits the statistical power of subgroups; thus, larger multicenter studies are required to confirm the observation and provide a more thorough observation and identification of predictors of graft failure following CABG. Another limitation of the present study was the absence of multivariable regression analysis to adjust for potential cofounding factors, such as age, hypertension and other cardiovascular risk variables, although multivariable analysis can help identify independent predictors of graft failure. The relatively small size sample and the limited number of graft failure even observed during follow-up may have resulted in model instability and overfitting. Therefore, the present study was restricted to univariable comparison. Future studies with larger sample sizes and multicenter cohorts are warranted to perform more robust multivariable analysis to better identify independent predictors of graft patency following CABG.

Graft failure represents a critical clinical challenge, often resulting in a cascade of adverse outcomes. These may include the development of myocardial ischemia, persistent angina that resists medical management, life-threatening arrhythmias, compromised cardiac output, and, in severe cases, fatal heart failure. The failure of coronary grafts can, therefore, undermine the therapeutic benefits of CABG, leading to a decline in patient prognosis and an increased risk of morbidity and mortality (8). LIMA to LAD graft patency did not exhibit a statistically significant association (P=0.050), although a trend toward improved patency was observed with shorter cross-clamp durations. Furthermore, the study by Gaudino *et al* (9) demonstrated that graft patency on imaging may not indicate the clinical status of the patient. In the event that the patient is asymptomatic and has an occlusion of a graft, it may not necessarily indicate urgent surgical intervention (9).

In the present study, all SVGs were harvested using the open no-touch technique, which is routine practice at our center Ibn Al-Bitar Specialized Center for Cardiac Surgery, Baghdad, Iraq; therefore, a direct comparison with alternative harvesting techniques, such as endoscopic vein harvesting was not possible. In line with the SVG harvesting technique used herein, the study by Kim *et al* (10) utilized the no-touch technique SVG for aortocoronary grafts, which yielded favorable graft patency rates up to the 3-year follow-up period. The 2018 guidelines from the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) on myocardial revascularization endorsed the ‘no-touch’ technique as a Class IIa recommendation with a level of evidence B, specifically when an open harvesting method is employed (8,11). Souza *et al* (12) demonstrated that ‘no-touch’ SVG exhibited significantly superior conduit patency at 18 months, a finding that was consistently validated over extended follow-up periods of 8 and 16 years. Notably, the patency of ‘no-touch’ SVG was found to rival that of the LIMA (12,13). Another harvesting technique explored in the clinical trial by Zenati *et al* (14) was the endoscopic approach for SVG, compared to the traditional open harvesting method. Their study revealed that the endoscopic technique was associated with lower patency rates after 1 year of follow-up (15).

In the study by Gaudino *et al* (15), seven trials involving 4,413 patients and 13,163 grafts were analyzed, with a median time to imaging of 1.02 years. Their study found that 33.7% of individuals had graft failure, with 16.6% of the total grafts failing, with factors such as an older age, female sex and smoking being independently associated with increased graft failure, while statin use provided a protective effect. Graft failure was linked to higher risks of myocardial infarction, repeat revascularization and increased all-cause mortality. By contrast, in the present study, SVG patency was 88.9% at 1-year follow-up, indicating relatively favorable short-term outcomes and after the imaging assessments, which occurred at an average of 1-year post-surgery (15).

It is also crucial to highlight the significance of dual antiplatelet therapy in preserving graft patency over both the short and long term, as emphasized by Harik *et al* (16) and Kim *et al* (10); these findings align with the approach adopted for the patients in the present study.

In conclusion, the present study demonstrated that LIMA grafts have superior patency at the 1- and 3-year follow-ups compared to SVGs using the no-touch technique. Additionally, DM was significantly associated with the number of grafts reflecting more advance coronary artery disease, whereas cross-clamp time did not exhibit a statistically significant association; furthermore, graft failure most commonly occurred at the distal anastomotic site.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

SSA and FHK conceived and designed the study. SSA performed the surgical procedures, supervised patient management, and was responsible for patient recruitment and prospective data collection, conducted the statistical analysis and contributed to data interpretation, and drafted the manuscript. BAA contributed to statistical analysis, data verification, and critical revision of the manuscript for important intellectual content. DH and SHT contributed to data interpretation and the critical revision of the manuscript. RO, OFA, ZAZ, FJA and DHMS contributed to patient data acquisition and manuscript revision. BAA and FHK independently verified the underlying data. BAA and FHK confirm the authenticity of all the raw data. All authors contributed to the interpretation of the results, critically revised the manuscript, and approved the final version.

Ethics approval and consent to participate

The present study was approved by the Medical Ethics Committee of Kscien Organization for Scientific Research, Sulaymaniyah, Iraq (approval no. 53/2018). The study was conducted in accordance ethical principles and was designed to ensure the safety, rights and confidentiality of all participants. Informed consent was obtained from all enrolled participants prior to inclusion in the study, with the understanding that participation was voluntary, and that they could withdraw at any time without consequence. The ethical approval and consent to participate were obtained under the supervision of the Medical Ethics Commission at Ibn Al-Bitar Specialized Center for Cardiac Surgery.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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