Direct Angiography Demonstrates Equal 8-12 years Patency Rates of Radial Artery and Saphenous Vein Grafts

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Abstract

Objectives: The benefits of coronary artery bypass surgery depend on lasting graft patency. To aid rational graft selection, the relative long-term merits of radial artery and saphenous vein grafts need to be determined by a gold standard method and with minimal clinically driven selection bias.

Methods: The patency rates of various conduits were determined by direct angiography in 76 patients from a cohort of 119 undergoing coronary artery bypass grafting 7.6 – 12.1 (mean 8.9) years before.

Results: 14 out of 76 radial artery and 10 out of 61 saphenous vein grafts were occluded (rates 0.18 and 0.16, respectively).

Conclusion: The high long-term patency rate of saphenous vein grafts does not support a preferential use of the radial artery as a coronary artery bypass conduit.

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Keywords

bypass – graft disease - radial artery – saphenous vein – ischemic heart disease

Introduction

The saphenous vein and the radial artery are alternative conduits to complement internal mammary artery (IMA) grafting in coronary bypass surgery. Their relative merits would best be determined by prospective monitoring of long-term patency by direct angiography, the gold standard method for graft evaluation, in a patient cohort with high a follow-up rate and minimal clinically driven selection bias. Accordingly, in order to facilitate rational conduit selection, we designed the Radial Artery BypAss GrAft Study of Tromsø (RABAGAST) [1] and here report angiographic patency rates 8-12 years post-operatively.

Materials and methods

When the University Hospital North Norway took up radial artery grafting, all patients revascularized this way from April 4 2001 to October 7 2003 (119 out of 811 isolated CABG operations), were included in the study protocol. Our CABG program had been running for 23 years, and the annual volume of open-heart surgeries was 600 cases. The patient characteristics, ethics approval, angiographic evaluation, and computerized data analysis have been described together with clinical outcomes and graft patency rates after 1.3 – 3.9 years [1]. The staff was advised to graft the LAD with the left IMA (LIMA) in the presence of significant left main or left anterior descending branch pathology and to consider the use of at least one additional arterial graft in dual or triple vessel disease patients < 65 years of age and in those without a suitable saphenous vein [1]. All grafts were harvested by open (not endoscopic) technique. Whether to use the radial artery and choice of coronary target territory was at the discretion of the surgeon. 111 patients (93 %) received at least one IMA graft and 84 (71 %) at least one saphenous vein graft in addition to the radial artery conduit. 108 radial arteries were proximally anastomosed to the ascending aorta, 7 to a LIMA and 4 to a saphenous vein graft. They were mostly used for the left coronary artery territory whereas the predominant targets of saphenous vein grafts were right coronary artery branches.

Specifically, the radial artery targets were 97 circumflex/intermediate, 28 right coronary artery (including 17 descending posterior and 7 main stem), 22 diagonal, and three left anterior descending branches. The targets of the saphenous vein grafts were 69 right coronary artery (including 51 descending posterior and 3 main stem), 23 circumflex/intermediate, one left anterior descending and 20 diagonal branches. Amlodipine was routinely prescribed postoperatively as it was assumed to mitigate graft spasm.

Long-term follow-up included direct angiography when not contraindicated. Angiograms were thus obtained solely for the study purpose 7.6 – 12.1 (mean 8.9) years postoperatively in 76 patients (64 % of the original cohort, 74 % of those alive). Each segment of a sequence graft was counted as an individual bypass. Grafts and bypasses were classified as open (lumen diameter > 50 % of normal along entire length), stenotic (opacification with contrast along entire length, but lumen diameter < 50 %), or occluded (none or discontinuous opacification).

Vital status and cause of death, verified by autopsy in 7 cases, were collected form the patient records or The Norwegian Institute of Public Health.

Statistical analyses were performed with the SPSS® software (SPSS Inc., Chicago, IL).

Results

78 patients (66 %) were alive 16.3 years after the index operation (Fig. 1). Ischemic heart disease was the most common cause of death (16 out of 41).

7.6 – 12.1 years post-operatively, 14 out of 76 radial artery and 10 out of 61 saphenous vein grafts were occluded (rates 0.18 and 0.16, respectively) (Fig. 2, upper panel). 75 out of 83 IMA grafts remained open without stenosis (occlusion rate 0.08). Occlusion rates were 0.16 for radial artery and 0.14 for saphenous vein bypasses (Fig. 2, lower panel). Equal long-term

performance of radial artery and saphenous vein was evident also when restricting the analysis to those patients who had both types of conduits (Fig. 3).

Although the patency of radial artery and saphenous vein grafts were equal at follow-up, the possibility remained that the time to occlusion differed among them so as to render the arterial graft to be preferred. However, in a time-to-event analysis, the durability of the saphenous veins were not inferior to that of radial arteries (Fig. 4).

In contrast to saphenous vein grafts, all arterial grafts that were anastomosed to a proximally occluded target vessel, maintained long-term patency (Table 1).

Discussion

Their susceptibility to atherosclerotic degeneration limits the durability of aortocoronary vein grafts [2]. Being resistant to atherosclerosis, the radial artery is an attractive alternative [3, 4] and its use for high-grade stenotic target vessel grafting has a class I ESC/EACTS guideline recommendation [5]. But clinical outcomes studies are inconsistent and graft failure rates vary widely in the range of 17-37 % beyond 10 years [2, 4]. It is unclear whether any perceived benefit of radial artery over saphenous vein grafting reflects inherent conduit characteristics or rather results from confounders like treatment allocation bias [4]. To unequivocally clarify whether distinct biological properties translate into different long-term patency of various graft types, their merits should be compared in the same patient with the same method during the same interval of time. This would eliminate confounding effects of patient, treatment, and evaluation variables. Any selection bias should be mitigated by high follow-up rates and an evaluation protocol minimally affected by clinical events. In the present long-term comparison of radial and saphenous vein grafts, target vessel properties remained the only potential confounder in those 53 out of 76 patients subjected to protocol-directed angiography who had both graft types. As we were inclined to prioritize arterial over saphenous vein

grafting of the obstructed coronary arteries with large diameters and territories, it is unlikely that saphenous vein patency was maintained by better distal run-off. Thus, our finding that radial artery and saphenous vein grafts have equal long-term patency is robust. The data corroborate the only randomized radial artery graft trial reporting long-term data with high follow up-rates and exclusively protocol-driven angiographic evaluation [4 (review), 6]. The favorable results with saphenous vein grafts may reflect our procurement protocol, which includes irrigation and storage in autologous blood (30 %) and papaverine (0.6 mg/mL) [1].

A meta-analysis [7] of earlier randomized controlled trials [8-13] concluded that radial artery grafts were superior to vein grafts at 50±30 months. In particular, excellent radial artery graft patency considerably better than that of saphenous vein (occlusion rates 9 and 19 %, respectively) was achieved in a randomized trial with a follow up-rate of 75 % and 91 % protocol-directed angiographies 7.7 ± 1.5 years postoperatively [11]. The study populations differed somewhat from the RABAGAST cohort with respect to risk factors for intermediate-term radial artery graft occlusion [1, 14]. Risk factors for late graft failure will be reported (Bahar et al., in preparation), and may explain patency discrepancies.

Radial artery grafts appear vulnerable to occlusion when the target vessel stenosis is only moderate [15]. Strikingly, we found that all radial arteries grafted to proximally occluded targets remained patent after 7.6 – 12.1 years. Although not statistically significant, this observation supports the contention that the degree of native flow obstruction impacts long-term graft patency. Accordingly, dissimilar target vessel properties and revascularization strategies may contribute to differences in graft patency across various trials.

The vein graft patency rates of the RABAGAST study compares favorably with those of the EPICS [16] and PREVENT-IV [17] randomized trials. We assume that this was mainly due to

a lower proportion of diabetics among RABAGAST participants (10 % [1] vs. 37 % and 36 % in EPICS [16] and PREVENT-IV [17], respectively), since diabetes mellitus impairs run-off by inducing microangiopathy and potentiating target vessel atherosclerosis and also accelerates saphenous vein graft degeneration [18, 19]. In addition, an open graft harvesting technique most likely contributed to the higher patency rate in the RABAGAST trial, as the endoscopic procedures used in the majority of EPICS and PREVENT-IV participants (62 % and 55 %, respectively) were associated with vein graft failure [16, 17, reviewed in 20].

The saphenous vein is the most widely used coronary artery bypass graft and the only conduit in addition to the IMA in more than 90 % of cases [21]. The RABAGAST study provides evidence to support this practice.

Conclusion

In our study the long term patency rates of saphenous vein grafts and radial artery grafts were similar. The high long term patency rate of saphenous vein grafts in our study does not support preferential use of the radial artery. Both conduits are equally effective when appropriately harvested and used.

Acknowledgement

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Declaration of interest statement

The authors report no conflict of interest.

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Table 1. Preoperative target vessel occlusion and conduit patency 7.6 – 12.1 years after radial artery grafting of the coronary circulation

		Graft status at per protocol angiography					
		IMA		Radial artery		Saphenous vein	
		Open	Occluded	Open	Occluded	Open	Occluded
Preoperative proximal target vessel pathology	Stenotic	60	7	51	14	37	6
	Occluded	16	0	11	0	14	4
	Sum	76	7	62	14	51	10

Preoperative target vessel obstruction (stenotic or occluded) and long-term graft patency (open with or without stenosis, or occluded) is shown for the 76 patients subjected to direct angiography per protocol out of the 119 included in the RABAGAST trial. IMA: internal mammary artery. For IMA grafts, P = 0.34; radial artery grafts, P = 0.20; arterial grafts combined, P = 0.027; saphenous vein grafts P = 0.46 (Fisher`s exact test).

Legends

Figure 1. Mortality after radial artery grafting of the coronary circulation

The number of patients alive is depicted as a function of time after coronary bypass surgery with a radial artery graft. Each patient who died during follow-up (•) and the cause of death is indicated.

Figure 2. Patency after radial artery grafting of the coronary circulation

Out of 119 patients included in the study, 76 underwent direct angiography per protocol 7.6 – 12.1 (mean 8.9) years after the index operation. 177 single and 43 sequence grafts were examined. Each segment of a sequence graft was counted as an individual bypass. On each column is depicted the number of grafts (upper panel) and bypasses (lower panel) open without stenosis, stenotic, and occluded, respectively. Their relative proportions (%) are given on the ordinate. n.d: distal segments of sequence grafts that were indeterminate due to occlusion of the proximal segment; L(R)IMA: left (right) internal mammary artery. For occluded vs. non-occluded radial artery and saphenous vein grafts, P = 0.76, for bypasses, P = 0.73 (chi square test[a]).

Figure 3. Direct comparison of conduit patencies in patients receiving an internal mammary artery or a saphenous vein in addition to a radial artery graft to the coronary circulation

[a] The statistical analyses were not adjusted for potential within-subject dependence.

Conduit patencies are shown for those patients out of a study cohort of 119 who per protocol underwent direct angiography 7.6 – 12.1 (mean 8.9) years after radial artery grafting and also had an internal mammary artery (IMA) or a saphenous vein graft (73 and 53 patients, respectively). Each segment of a sequence graft was counted as an individual bypass. On each column is depicted the number of grafts and bypasses open without stenosis, stenotic, and occluded, respectively. Their relative proportions (%) are given on the ordinate. n.d: distal segments of sequence grafts that were indeterminate due to occlusion of the proximal segment. Comparing occlusion rates of radial artery vs. IMA grafts, P = 0.05, for corresponding bypasses, P = 0.10, for radial artery vs. saphenous vein grafts, P = 0.45, for corresponding bypasses, P = 0.73 (chi square test[a]).

Figure 4. Durability of bypasses

Among 119 patients operated with a radial artery graft to the coronary circulation, 104 (87 %) were subjected to direct angiography per study protocol after 1.3 – 3.9 [1] (102 patients) and/or after 7.6 – 12.1 years (Fig. 2) (76 patients). Depicted is a Kaplan-Meier time-to-event analysis which includes all and exclusively those 300 conduits (97 left internal mammary artery (LIMA), 104 radial artery, 86 saphenous vein, and 13 right internal mammary artery (RIMA) grafts) which were angiographed per protocol, indicating the interval between the index operation and the first per protocol angiography documenting graft occlusion (for sequence grafts, occlusion of ≥ 1 bypass). The time points of the last per protocol demonstration of non-occlusion were censored. The estimated mean patency (i.e., graft not occluded) with 95 % confidence interval of the various graft types were: LIMA: 3670 (3570-3770) days; radial artery: 3053 (2805-3300) days; saphenous vein: 3324 (3100-3547) days; RIMA: 3133 (2555-3712) days.

Fig. 1

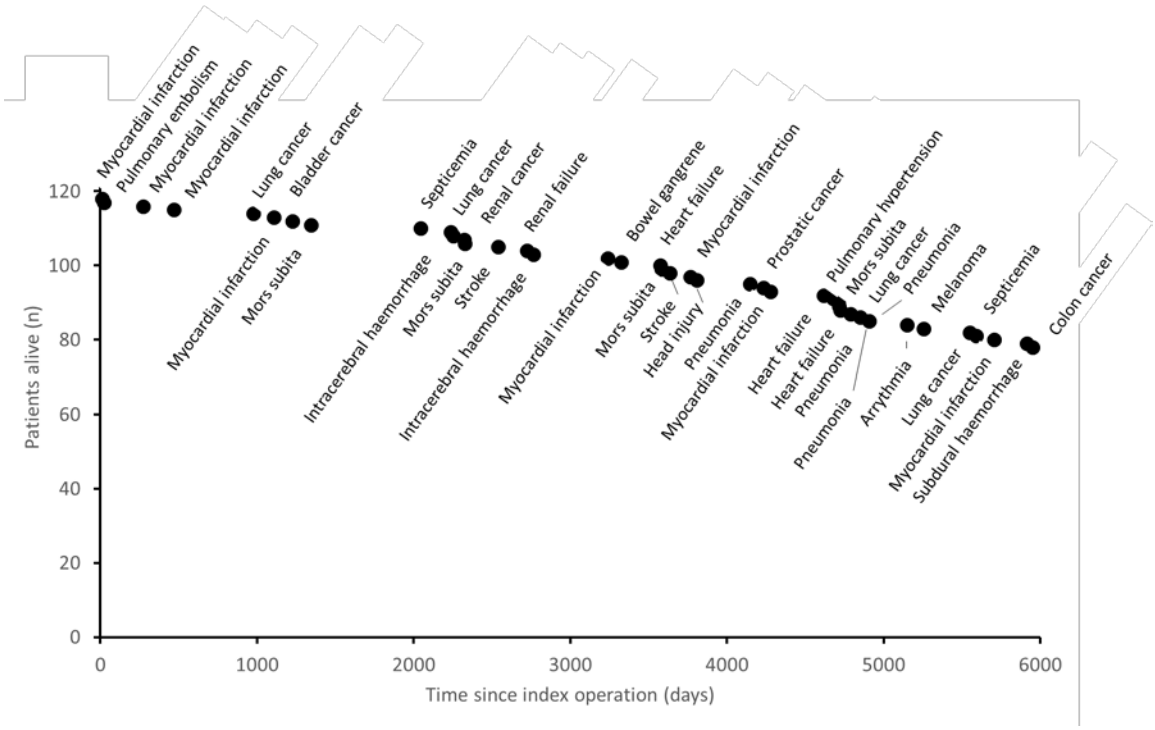

Patients alive (n)
0
20
40
60
80
100
120
0
1000
2000
3000
4000
5000
6000
Time since index operation (days)
Myocardial infarction
Pulmonary embolism
Myocardial infarction
Myocardial infarction
Lung cancer
Bladder cancer
Myocardial infarction
Mors subita
Septicemia
Lung cancer
Renal cancer
Renal failure
Intracerebral haemorrhage
Mors subita
Stroke
Intracerebral haemorrhage
Bowel gangrene
Heart failure
Myocardial infarction
Myocardial infarction
Mors subita
Stroke
Head injury
Pneumonia
Myocardial infarction
Prostatic cancer
Pulmonary hypertension
Mors subita
Lung cancer
Pneumonia
Melanoma
Heart failure
Heart failure
Pneumonia
Pneumonia
Arrythmia
Septicemia
Lung cancer
Myocardial infarction
Subdural haemorrhage
Colon cancer

Fig. 2

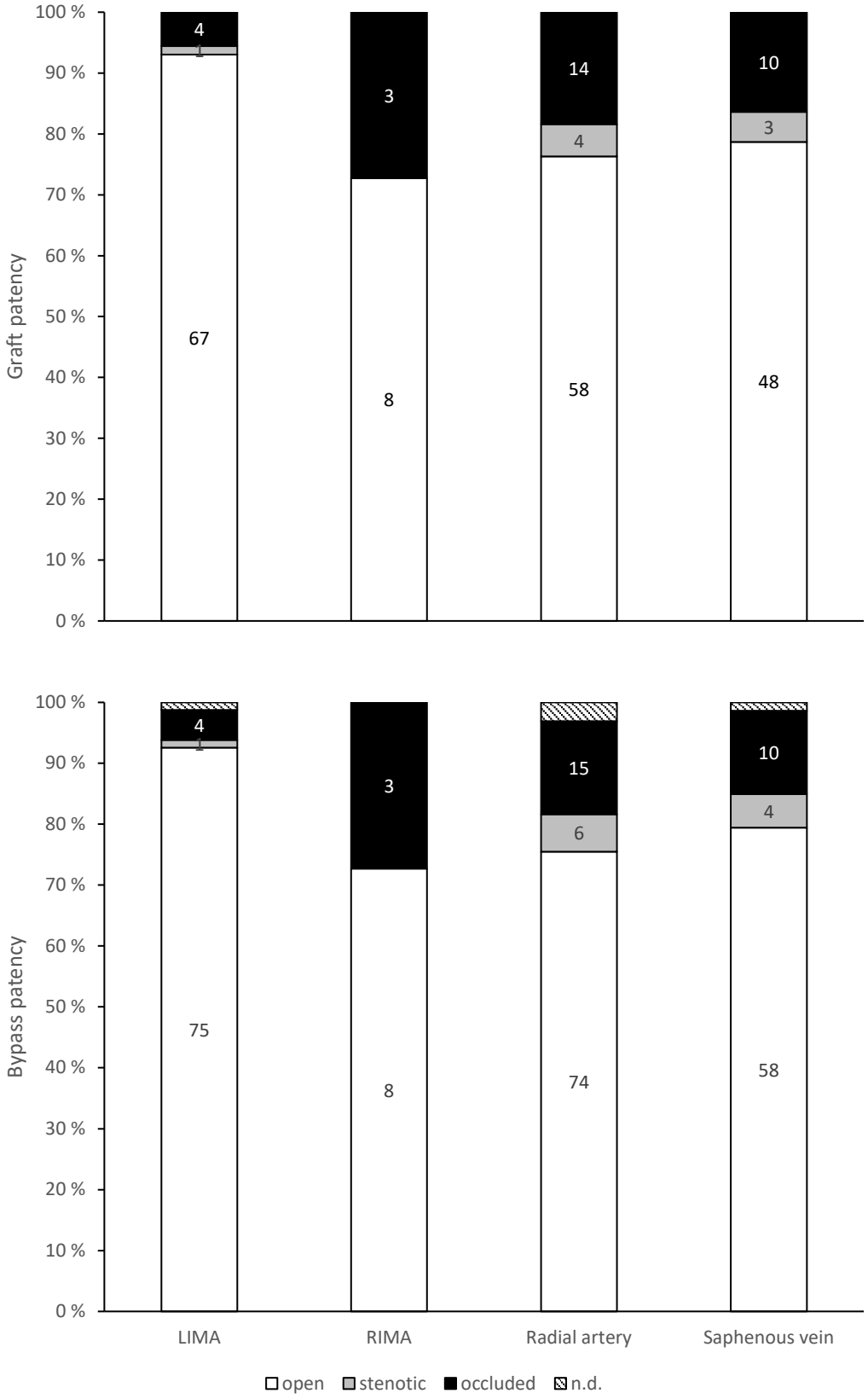

Graft patency
100 %
90 %
80 %
70 %
60 %
50 %
40 %
30 %
20 %
10 %
0 %
4
1
67
3
8
14
4
58
10
3
48
Bypass patency
4
1
75
3
8
15
6
74
10
4
58
LIMA
RIMA
Radial artery
Saphenous vein
open
stenotic
occluded
n.d.

Fig. 3

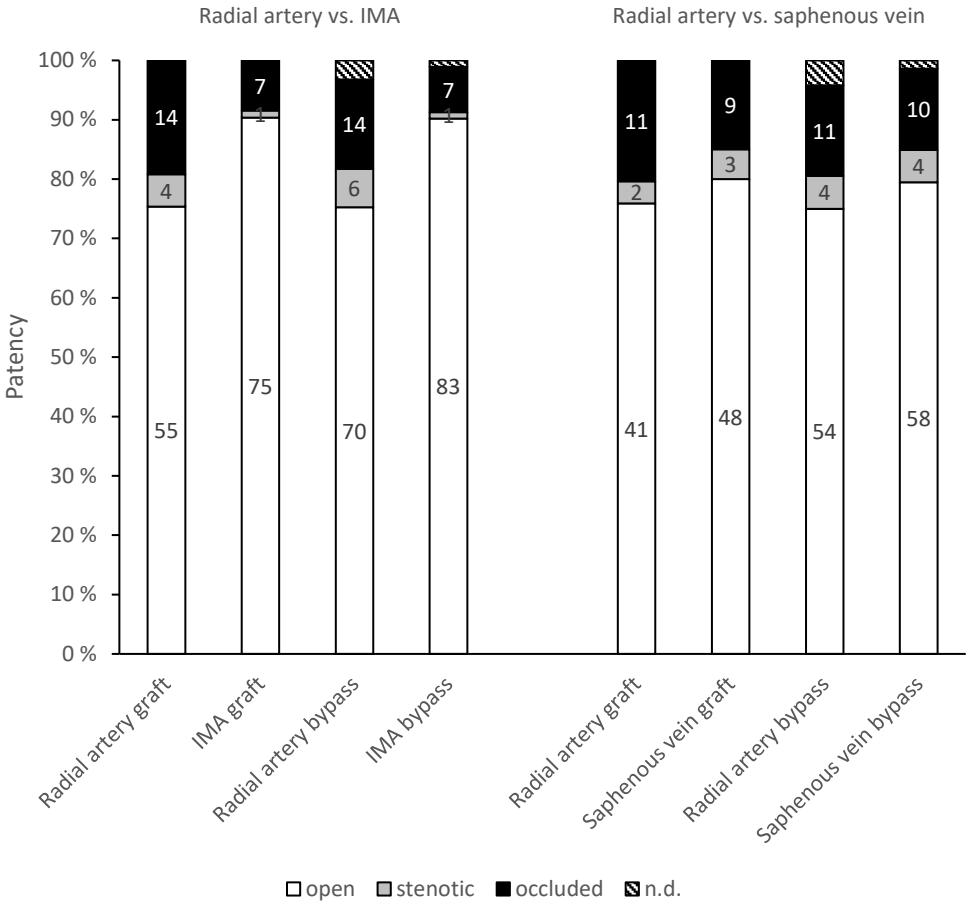
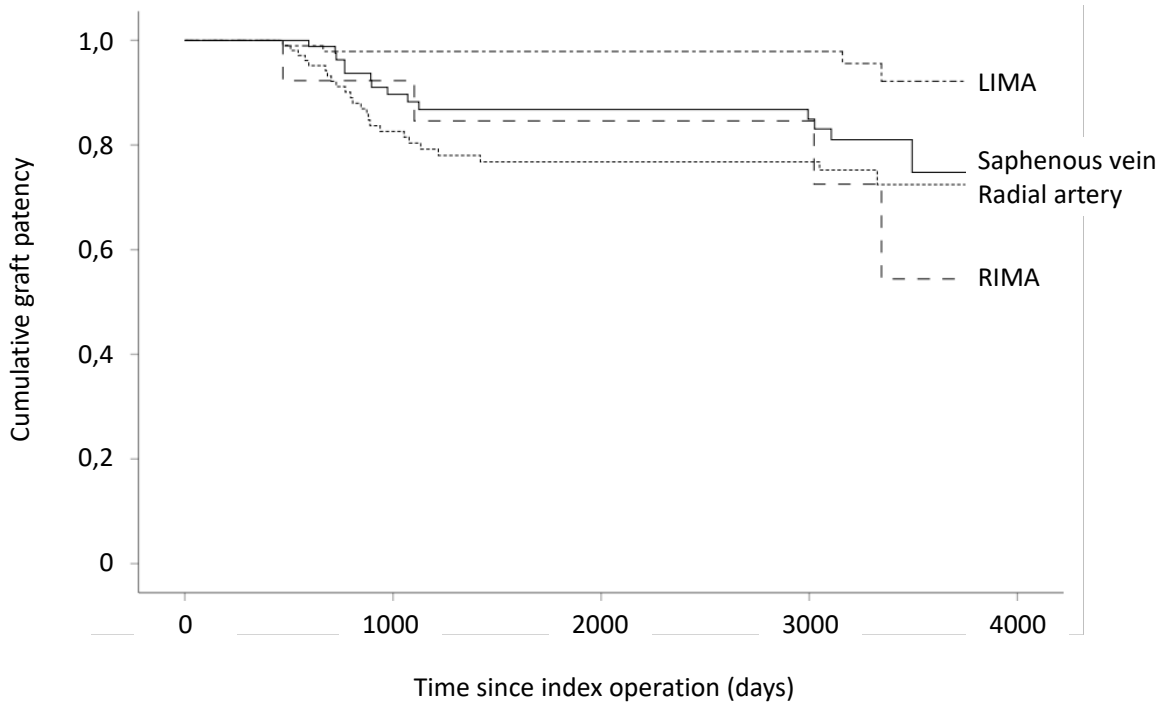

Radial artery vs. IMA
Radial artery vs. saphenous vein
Patency
100 %
90 %
80 %
70 %
60 %
50 %
40 %
30 %
20 %
10 %
0 %
14
4
55
7
1
75
14
6
70
7
1
83
11
2
41
9
3
48
11
4
54
10
4
58
Radial artery graft
IMA graft
Radial artery bypass
IMA bypass
Radial artery graft
Saphenous vein graft
Radial artery bypass
Saphenous vein bypass
open
stenotic
occluded
n.d.

Fig. 4


1,0
0,8
0,6
0,4
0,2
0
Cumulative graft patency
0
1000
2000
3000
4000
Time since index operation (days)
LIMA
Saphenous vein
Radial artery
RIMA