

Factors Affecting Graft Patency and Long-Term Survival Outcomes after Off-pump Coronary Artery Bypass Grafting

Permyos Ruengsakulrach¹, Vitoon Pitiguagool¹, Piyapan Pamornsing¹, Jamorn Udomkusonsri¹, Pairote Satiracoo^{2,3}

¹Division of Cardiovascular Surgery, Bangkok Heart Hospital, Bangkok Hospital Group, Bangkok, Thailand

²Department of Mathematics, Faculty of Science, Mahidol University, Rama 6 Rd., Bangkok, Thailand

³Centre of Excellence in Mathematics, CHE, Bangkok, Thailand

Objectives: The aims of this study are to evaluate the graft patency and long-term survival outcomes after Off-pump Coronary Artery Bypass Grafting (OPCAB) and determine factors influencing outcomes.

Methods: All 1849 consecutive patients who underwent isolated OPCAB (Figure 1) between January 2002 and October 2020 were studied. Demographics, clinical baseline, surgical details and postoperative investigations/ treatments were collected. This report focused on 610 (33%) patients who had a coronary computed tomography angiography (CCTA) or a coronary angiogram (CAG) after OPCAB (Table 1). There were 164 (26.9%) patients with symptom directed CCTA or CAG. Mean age was 60.7±9.7 years and 80.3% was male. The mean time interval of CCTA or CAG after the operation was 954.6±1288.6 days. Left internal thoracic artery (LITA), right internal thoracic artery (RITA), radial artery (RA), gastroepiploic artery (GEA) and saphenous vein graft (SVG) were used as a graft in 97, 25.7, 61.5, 13.8 and 47.4% of patients, respectively. Sequential technique was used in 254 patients (41.6%). The T-graft technique was used in 140 patients (23.0%): 128 (21.0%) was RA T-graft from the LITA and 12 (2.0%) was SVG T-graft from the LITA. Fitzgibbon classification was used to classify graft patency (grade A: excellent graft with unimpaired runoff, grade B: stenosis reducing caliber of proximal or distal anastomoses or trunk to < 50%, and grade O: occlusion). Stepwise variable selection was utilized in logistic regression and Cox regression analyses to determine factors influencing outcomes.




Figure 1. The LITA graft was anastomosed to the LAD.

Patient Characteristics	Number (%) or Mean ± SD
Preoperative data	
Age	60.7±39.7
Gender	490 (80.3)
Current Smoke	100 (16.4)
Diabetes	285 (46.7)
Hypertension	453 (74.3)
Dyslipidemia	489 (80.2)
Chronic Obstructive Pulmonary Disease	34 (5.6)
Cerebrovascular Accident	30 (4.9)
Prior Myocardial Infarction	76 (12.5)
Heart Failure	79 (13.0)
Cardiogenic Shock	16 (2.6)
Redo Coronary Artery Bypass Grafting	12 (2.0)
Left Main Disease (≥50% Stenosis)	224 (36.7)
Left Ventricular Ejection Fraction	59.5±13.2
Intra-Aortic Balloon Pump	60 (9.8)
Preoperative Serum Creatinine	1.0±0.5
Surgical details	
Number of grafts	2.8±0.8
Number of anastomoses	4.3±1.3
LITA	592 (97.0)
RITA	157 (25.7)
RA	375 (61.5)
GEA	84 (13.8)
SVG	289 (47.4)
Postoperative Investigations/ Treatments	
Graft Occlusion Rate	16.2%
Symptoms	
• Recurrent chest pain	57 (9.3)
• Dyspnea	65 (10.7)
• Atypical chest pain	20 (3.3)
• Unstable angina	3 (0.5)
• Non ST elevation Myocardial Infarction	9 (1.5)
• ST Elevation Myocardial Infarction	2 (0.3)
• Congestive Heart Failure	8 (1.3)
Duration From Operation To CCTA/CAG	954.6±1288.6
Stress Test Results	
• Positive	61 (24.3)
• Negative	176 (70.1)
• Equivocal	1 (0.4)
• Inadequate	13 (5.2)
Pre CCTA/CAG Blood Sugar	116.8±36.5
Pre CCTA/CAG LDL Cholesterol	85.9±31.7
Pre CCTA/CAG ASA	531 (88.2)
Pre CCTA/CAG Plavix	429(71.3)
Pre CCTA/CAG Statin	537 (89.2)
Re-percutaneous coronary intervention	49 (8.0)

Graft Occlusion Rate = Number of A/ Number of A + O

Results: The total number of evaluated anastomoses was 2340. Grades A and B were considered patent, while Grade O was considered occluded. Overall graft patency was 90% (647/719) for the LITA, 81.3% (139/171) for the RITA, 84% (568/676) for the RA, 81.1% (60/74) or the GEA and 78% (546/700) for the SVG (Table 2 and Figure 2). Overall graft patency rates by type of grafts and target coronary artery territories are shown in table 3 and figure 3.

Table 2. Results of graft patency.

GRAFTS	GRADES				TOTAL
	Grade A (%)	Grade B (%)	Grade O (%)	Indetermine (%)	
LITA	633 (84.6)	14 (1.9)	72 (9.6)	29 (3.9)	748
RITA	134 (77.0)	5 (2.9)	32 (18.4)	3 (1.7)	174
RA	546 (77.2)	22 (3.1)	108 (15.3)	31 (4.4)	707
GEA	59 (74.7)	1 (1.3)	14 (17.7)	5 (6.3)	79
SVG	512 (70.9)	34 (4.7)	154 (21.3)	22 (3.0)	722

Figure 2. Overall graft patency rates.

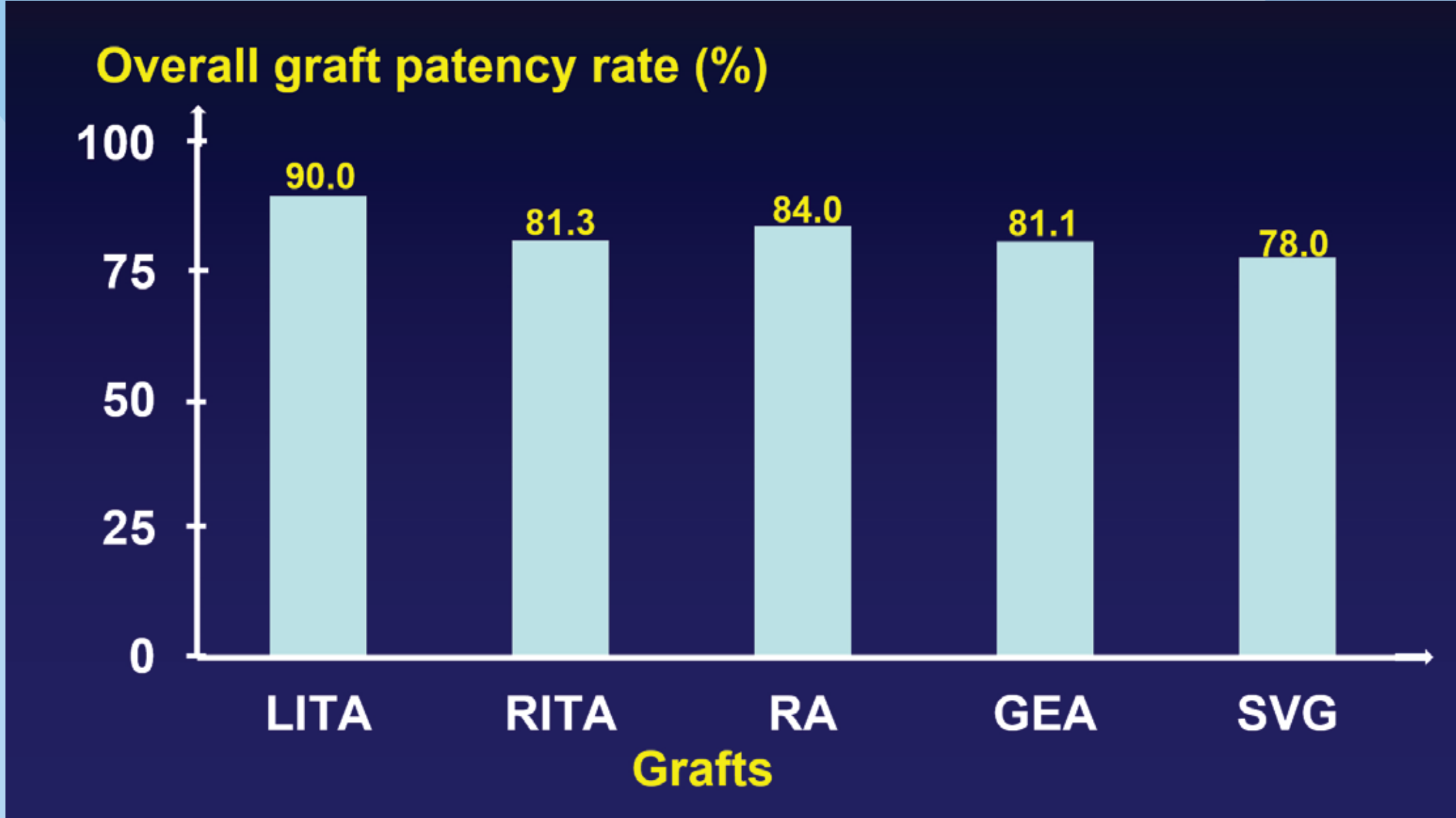


Figure 3. Patent LITA graft to the LAD coronary artery

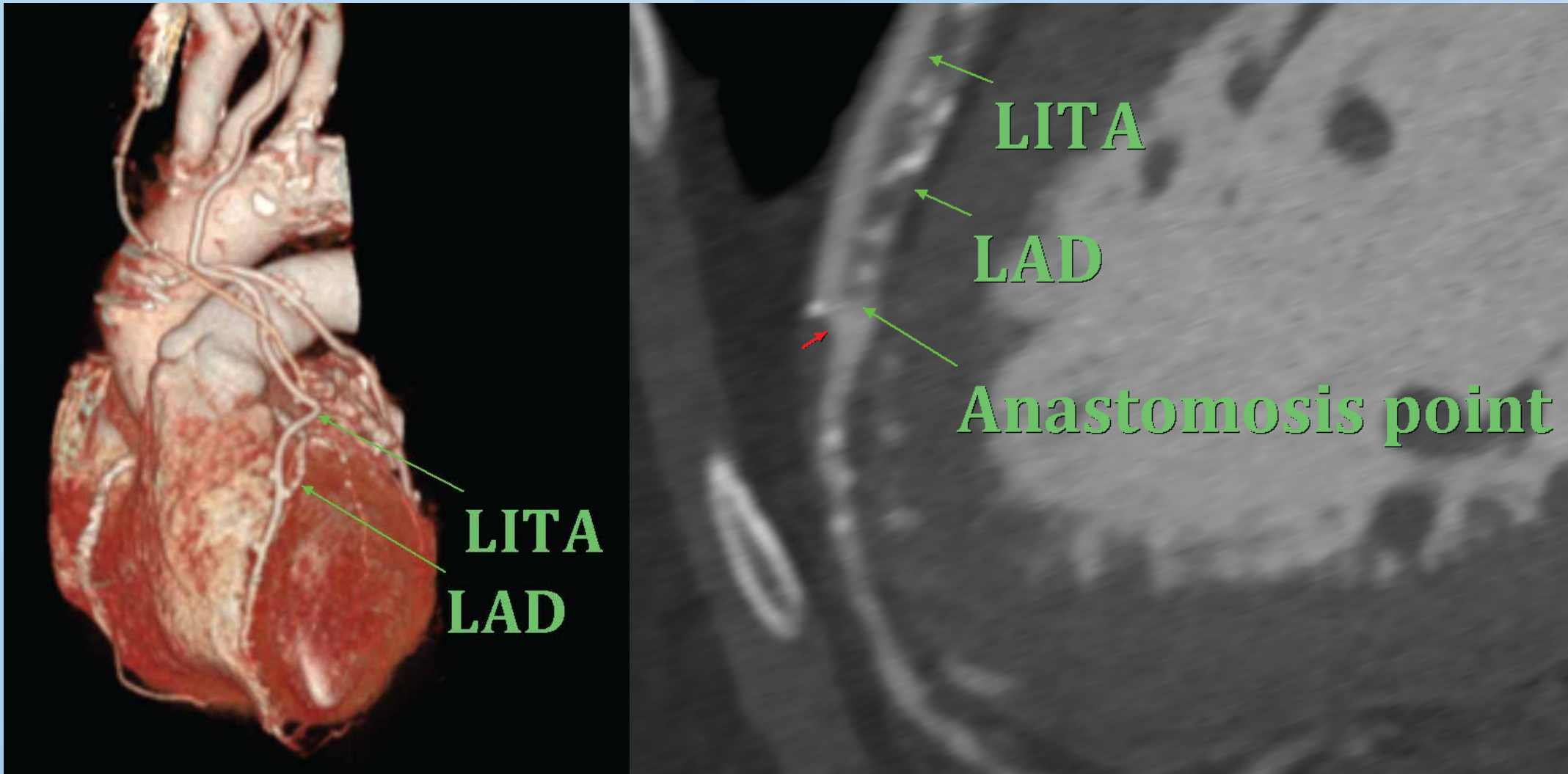


Table 3: Overall graft patency rates by type of grafts and territories

GRAFTS	Territories	Number of patent anastomoses	Total number of anastomoses	Patency rate (%)
LITA	1	643	713	90.2
	2	4	5	80.0
RITA	1	76	85	89.4
	2	11	19	57.9
	3	4	4	100.0
RA	4	48	63	76.2
	1	78	86	90.7
	2	292	349	83.7
	3	23	27	85.2
GEA	4	175	214	81.8
	4	60	74	81.1
SVG	1	108	135	80.0
	2	209	266	78.6
	3	20	24	83.3
	4	209	275	76.0

Territory 1 = Left anterior descending artery (LAD) and Diagonal artery (DG)
Territory 2 = Obtuse marginal artery (OM) and Distal part of circumflex artery
Territory 3 = Intermediate artery (IM)
Territory 4 = Main right coronary artery (RCA), posterior descending artery (PDA) and Posterolateral artery (PLA)

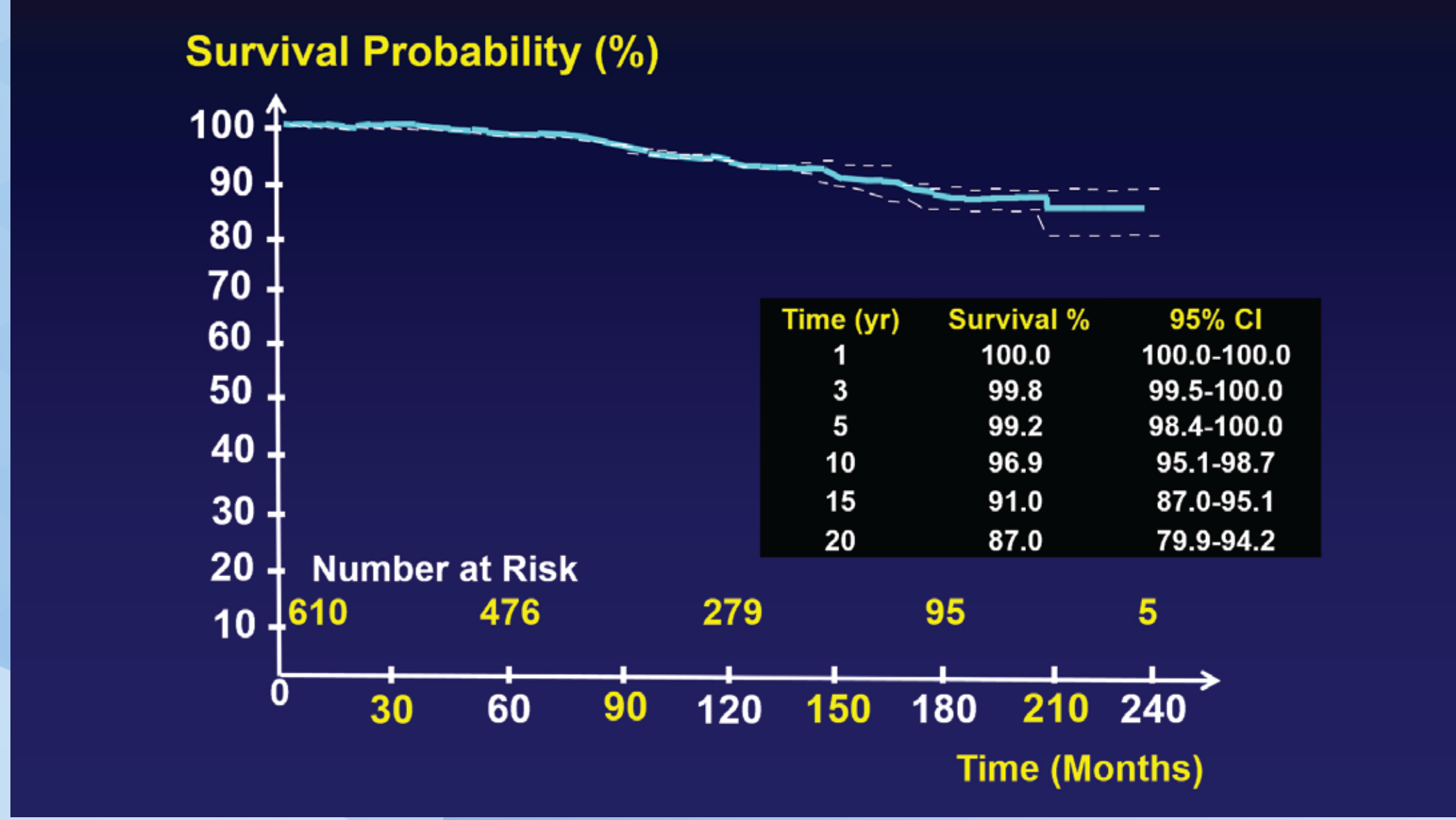
Type of grafts, target coronary arteries, sequential technique and T-graft from the LITA were considered factors for graft occlusion. In stepwise regression analysis, RA [*P*=0.001, Odds ratio (OR)=1.70], GEA (*P*=0.014, OR=2.24), RITA (*P*=0.001, OR=2.29), Vein T-graft (*P*=0.004, OR=2.52) and SVG (*P*<0.001, OR=2.64) were significantly associated with higher occlusion rates compared to the LITA graft, while no association was found with RA T-graft, sequential technique and target coronary arteries (Table 4).

Forty-nine patients (8%) had postoperative percutaneous coronary intervention. Twenty-four patients (3.9%) died during follow-up. The 1-yr, 3-yr, 5-yr, 10-yr and 15-yr survival rates were 100, 99.8, 99.2, 96.9 and 91%, respectively with the mean follow-time of 9.4 years (Figure 4).

Table 4. Factors Influencing Graft Patency.

Variables	Coefficient	P value	Odds ratio	95%CI
Intercept	-2.31	<0.001	0.1	0.07-0.13
RA	0.53	0.001	1.7	1.24-2.36
GEA	0.81	0.014	2.24	1.14-4.17
RITA	0.83	<0.001	2.29	1.42-3.63
VeinTgraft	0.92	0.004	2.52	1.32-4.65
SVG	0.97	<0.001	2.64	1.93-3.65
Sequential Technique	0.20	0.144	1.22	0.93-1.6

Figure 4. Survival of Patients after Off-Pump Coronary Artery Bypass Grafting.



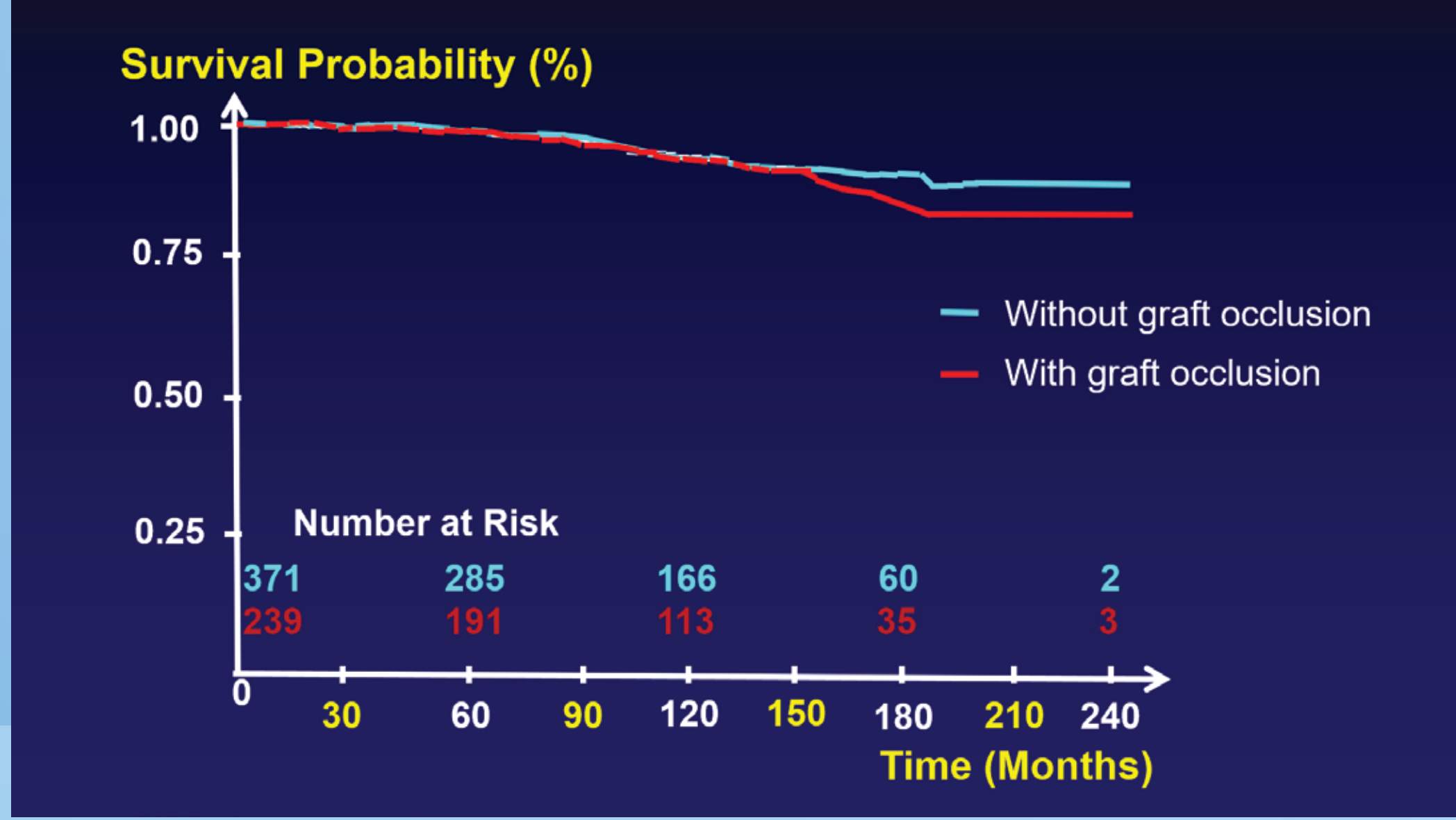
Thirty three variables (preoperative characteristics: age, gender, current smoke, diabetes, dyslipidemia, hypertension, chronic obstructive pulmonary disease, cerebrovascular accident, prior myocardial infarction, heart failure, cardiogenic shock, redo coronary artery bypass grafting, intra-aortic balloon pump, serum creatinine, left main disease (≥50% stenosis), left ventricular ejection fraction, surgical details: the number of grafts, the number of anastomoses, LITA, RITA, RA, GEA, SVG and postoperative investigations/ treatments: graft occlusion rate, symptoms, duration from operation to CCTA/CAG, Stress test results, pre CCTA/CAG blood sugar, pre CCTA/CAG low density-lipoprotein (LDL) cholesterol, pre CCTA/CAG ASA, pre CCTA/CAG Plavix, pre CCTA/CAG Statin, re-percutaneous coronary intervention) were considered in Cox regression analysis. The stepwise selection procedure identified 4 out of 33 variables significantly associated with survival outcome, namely age [*P*<0.001, Hazard ratio (HR)=1.13], preoperative serum creatinine (*P*<0.001, HR=2.50), preoperative shock (*P*=0.009, HR=6.82) and postoperative acute coronary syndrome (ACS) or congestive heart failure (CHF) (*P*=0.01, HR=19.84).

Additionally, high LDL cholesterol (*P*=0.07) and utilization of clopidogrel after operation (*P*=0.09) showed a trend towards lower survival rates (Table 5). For every 5-year increase in age, the hazard (or risk) of death is approximately 1.85 times higher (CI: 1.36-2.52). The hazard ratio for a 1 mg/dl increase in creatinine increases the risk of death of 2.50 (CI: 1.49-4.21). Graft patency did not affect long term survival Figure 5, *P* = 0.17).

Table 5. Factors influencing survivals

Variables	Coefficient	P value	HR	95%CI
Age	0.12	<0.001	1.13	1.06-1.2
Preoperative serum creatinine	0.92	<0.001	2.50	1.49-4.21
Preoperative shock	1.92	0.009	6.82	1.6-29.03
Postoperative acute coronary syndrome or congestive heart failure	2.99	0.010	19.84	2.04-192.99
Low density-lipoprotein cholesterol	0.01	0.067	1.01	1-1.03
Utilization of clopidogrel after operation	1.12	0.095	3.06	0.82-11.34

Figure 5. Survival curves by graft occlusion



Conclusions: In OPCAB, the grafts were ranked based on their patency rates, with LITA showing the most favorable patency, followed by RA, GEA, RITA and SVG. Vein T-graft from LITA had higher occlusion rate than RA T-graft from LITA. The 5-yr and 10-yr survival rates in this group were 99.2% and 96.9%. Age, preoperative shock, high preoperative serum creatinine and postoperative ACS or CHF were associated with poor survival.

Dr. Permyos Ruengsakulrach,
MD, PhD, FRCST, FCCP, AFEEAT
Cardiovascular and Thoracic Surgeon
Bangkok Heart Hospital
Bangkok, 10320, Thailand
E-mail: Permyos.Ru@bangkokhospital.com
Mobile: 66-81-8660286

