Safety and Efficacy of Sequential Left Internal Thoracic Artery Grafting to Left Circumflex Area

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Background. **This study investigated short-term and long-term results of coronary artery bypass grafting (CABG) with in situ sequential left internal thoracic artery (LITA) grafting to the left circumflex area.**

Methods. **The study divided 452 patients who underwent CABG with bilateral ITA grafting to the left coronary artery into two groups: 191 in the sequential group and 261 in the individual group. The 147 pairs were matched by the propensity score.**

Results. **In the matched pairs, the rates of off-pump, complete revascularization, and hospital death were comparable between the two groups. Early graft evaluation was performed in 78.6%. There was no occlusion of the sequential LITA graft itself, but 5 complications occurred involving the distal segment of the LITA graft (occlusion, 2; string, 2; and competition, 1), and 3 complications (occlusion, 2; and string, 1) developed in the individual group. Event-free anastomosis rates were 97.8% in the sequential group and 97.4% in the individual group ($p = 0.847$). Diamond anastomosis of proximal sequential grafting showed a better patency of the distal part of sequential anastomosis compared with a parallel anastomosis of proximal sequential grafting (98.4% vs 90.7%, respectively). The freedom from target lesion revascularization and overall survival at 8 years was 94.6% and 96.3% in the sequential and individual groups, respectively (log-rank $p = 0.645$) and 80.7% and 77.4% ($p = 0.300$), respectively.**

Conclusions. **In situ sequential LITA grafting provides acceptable early graft patency and freedom from repeat revascularization, resulting in excellent survival. This technique is a useful strategy for multivessel revascularization including the left circumflex area.**

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Bilateral internal thoracic artery (BITA) grafting has been demonstrated to improve survival after coronary artery bypass grafting (CABG) [1–6]. BITA grafting is more beneficial for patients with diabetes or chronic kidney disease [3, 5]. At present, we often need to revascularize multiple targets in patients with an increasing severity of disease [3–5]. Sequential arterial grafting in a skeletonized fashion is a useful procedure to achieve effective revascularization in these patients with a limited number of grafts [7–18]. In the presence of more than 2 targets in the left coronary arteries (LCAs) besides the left anterior descending artery (LAD), we have used sequential left ITA (LITA) grafting to the left circumflex artery (LCx) area to apply in situ BITA grafting. Although the benefits of BITA grafting have been recognized, there have been few reports of the results of in situ sequential ITA grafting in the context of BITA grafting [9, 11, 19]. The aim of this study was to examine the short-term and long-term clinical results of in situ sequential LITA grafting for multivessel revascularization including the LCx area.

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Material and Methods

The Kyoto Prefectural University of Medicine Institutional Review Board approved this study. Individual consent was obtained from each patient. Between 2001 and 2012, 943 consecutive patients underwent isolated CABG performed by two surgeons (H.Y. and K.D.). BITA grafting was performed in 676 patients. Of these, data of 452 patients undergoing BITA grafting to the LCA were retrospectively analyzed: 191 patients underwent sequential LITA grafting (sequential group), and 261 patients underwent individual LITA grafting to the LCx area (individual group). Excluded were the remaining 224 BITA grafting cases: LITA to LAD and right ITA (RITA) to LCx (n = 93), RITA to LAD and composite LITA grafting to LCx (n = 52), RITA or LITA to right coronary artery (n = 50), sequential RITA grafting (n = 24, eg, RITA to LAD to diagonal), and free ITA grafting (n = 5).

Revascularization Strategy

We adopted an off-pump technique whenever possible for isolated CABG. At least one branch of the LCx was

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Abbreviations and Acronyms

ASD	= absolute standardized difference
BITA	= bilateral internal thoracic artery
CABG	= coronary artery bypass grafting
COPD	= chronic obstructive pulmonary disease
CT	= computed tomography
GEA	= gastroepiploic artery
LAD	= left anterior descending artery
LCA	= left coronary artery
LCx	= left circumflex artery
LITA	= left internal thoracic artery
NYHA	= New York Heart Association
PAD	= peripheral artery disease
RCA	= right coronary artery
RITA	= right internal thoracic artery
SVG	= saphenous vein graft
TLR	= target lesion repeat revascularization

grafted by in situ LITA according to the number of distal targets with more than 50% stenosis. The sequential pattern was basically determined to form a natural configuration and shortest way of the LITA graft. In this study, the LAD was revascularized by in situ RITA as an individual fashion. In patients with both diagonal and LCx lesions, the revascularization strategy was:

1. If there were 2 targets, such as diagonal and obtuse marginal branches, sequential LITA grafting was adopted.
2. If there were 2 targets and the LITA was not long enough or relatively narrow to perform sequential grafting, the LITA was anastomosed to the LCx in an individual fashion and the other target was revascularized by a vein graft or the gastroepiploic artery in either a sequential or an individual fashion.
3. If there were 3 targets including the diagonal branch, sequential LITA grafting was performed to revascularize the 2 vessels according to the LITA length, and the other was anastomosed by another graft.

If sequential grafting was not available due to the reasons described in the second strategy, 1 or 2 other grafts were used.

Surgical Techniques

Our surgical techniques were described previously [17]. Briefly, skeletonized BITA grafts were harvested using a harmonic scalpel [7]. ITA grafts were anastomosed with 8-0 polypropylene. A proximal anastomosis of sequential LITA grafting was performed in a diamond (cross direction) or parallel fashion to form a natural configuration of the graft (Fig 1). In a diamond fashion, incision of the ITA was placed longitudinally, being careful not to exceed the diameter of the ITA.

Graft Evaluation

Postoperative graft evaluation was performed by coronary angiography or computed tomography (CT) angiography before discharge. The details are described in the Appendix.

End Points and Definition

The presence of stenosis causing more than a 50% diameter reduction was defined as a diseased vessel and considered as a target of bypass grafting. The end points were target lesion repeat revascularization (TLR), cardiac events, and overall death. TLR was defined as reintervention for vessels revascularized by CABG. Postoperative cardiac events were defined as cardiac death, coronary reintervention, recurrent ischemia, and congestive heart failure requiring admission. Cardiac death included deaths caused by arrhythmia, myocardial infarction, heart failure, or sudden death. More details are described in the Appendix.

Statistical Analysis

We estimated propensity scores using nonparsimonious multiple logistic regression analysis, with sequential LITA grafting as the dependent variable. The following 26 characteristics were entered into the multivariate models: age, male sex, body mass index, creatinine, ejection fraction, number of diseased vessels, New York Heart Association Functional Classification, left main disease, diagonal lesion, priority of operation, off-pump, intra-aortic balloon pump, redo operation, history of hypertension, hyperlipidemia, diabetes, insulin user, acute myocardial infarction, old myocardial infarction, percutaneous coronary intervention, smoking, chronic obstructive pulmonary disease, peripheral artery disease, stroke, atrial fibrillation, and mitral regurgitation of 2 or higher.

The C statistic for this model was 0.754, which indicates acceptable discrimination. The Hosmer-Lemeshow goodness-of-fit test result was 8.08 ($p = 0.426$). One-to-one matching without replacement was performed using a greedy nearest matching within a caliper width equal to 0.2 of the standard deviation of the logit of the propensity scores, and 147 pairs were successfully matched. Absolute standard differences were calculated to compare the balance in baseline characteristics between both groups. A threshold of 0.10 was used to indicate a significant imbalance. All analyses were performed using SPSS 22.0 software (IBM Corp, Armonk, NY). More details are described in the Appendix.

Results

In-Hospital Outcomes

Patients in the nonmatched groups who received sequential LITA grafting were significantly younger, with lower ejection fraction, kidney function, and a higher prevalence of diabetes and the number of diseased vessels (Appendix Table E1). After the propensity-score matching, these basic characteristics were adjusted (Table 1). The rates of off-pump, complete revascularization, deep sternal wound infection, and hospital death were comparable in the nonmatched (Appendix Table E2)

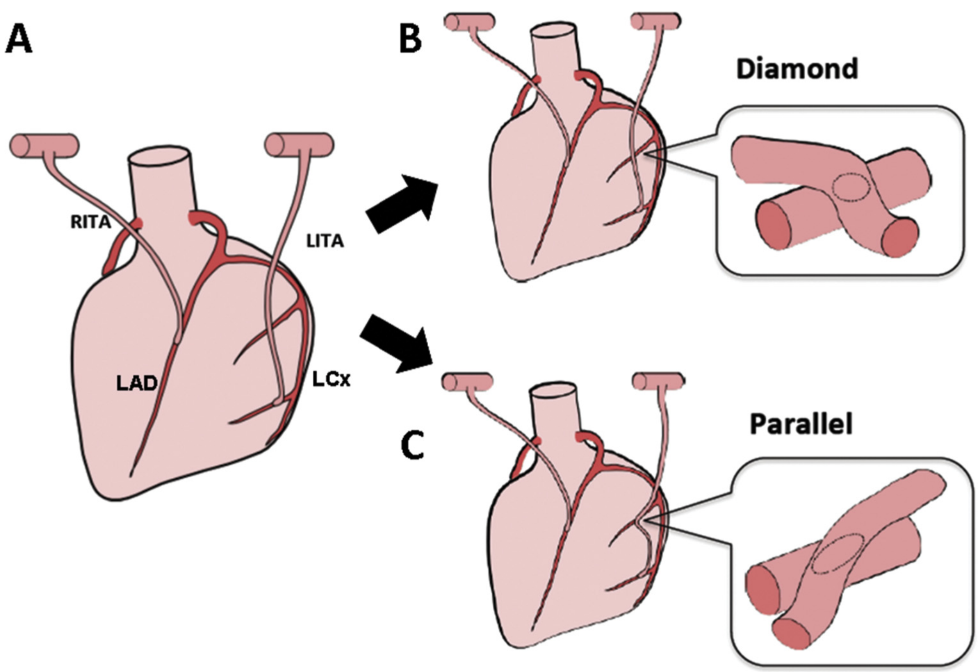

Fig 1. (A) Schema of sequential left internal thoracic artery (LITA) grafting. Two different ways of sequential grafting for proximal sequential anastomosis: (B) diamond and (C) parallel fashion. (LAD = left anterior descending artery; LCx = left circumflex artery; RITA = right internal thoracic artery.)

and matched group (Table 2). All incomplete revascularizations were located in the right coronary artery in both nonmatched and matched group. The graft design in the LCA area was similar in the nonmatched (Appendix Table E3) and matched (Table 3) groups: In sequential grafting, the LCA was completely revascularized by BITA grafts without additional grafting in 79.1% of the nonmatched group and in 80.3% of the matched group.

Graft Evaluation

Early graft evaluation was performed in 80.3% in the nonmatched group (Appendix Table E4) and in 78.6% in matched group (Table 4). In the nonmatched group, 5 patients received CT, followed by angiography (sequential, 2; individual, 3). In the matched group, 2 patients received CT, followed by angiography (sequential, 2; individual, 0). The rates of event-free distal anastomoses of LITAs in sequential vs individual groups were 97.0% vs 97.6% ($p = 0.884$), respectively, in the nonmatched group and 97.8% vs 97.4% ($p = 0.847$), respectively, in the matched group. In the sequential group of matched pairs, there were complications in 5 patients: occlusion, 2; narrowed between the proximal and distal anastomoses, 2; and flow competition, 1. However, there was no occlusion of the LITA trunk.

The patency rates of the sequential group according to the method of proximal sequential anastomosis are reported in Appendix Table E5 (nonmatched group) and in Table 5 (matched group), respectively. Graft complications between the proximal and distal sequential anastomoses (graft end) were higher in patients with a parallel anastomosis: significantly in the nonmatched group ($p = 0.049$) with a borderline significance in the matched group ($p = 0.097$). A parallel anastomosis of the diagonal branch as a proximal anastomosis showed poorest patency rates of the graft end in both the nonmatched and matched groups.

Long-Term Results

The follow-up rate and mean follow-up duration were 95.3% and 5.2 ± 3.2 years (range, 0 to 13.7 years) in the nonmatched group and 94.2% and 5.8 ± 3.2 years (range, 0 to 13.7 years) in the matched group, respectively. Survival curves of the nonmatched patients are shown in Appendix Figures E1 and E2, and the results were comparable to those in the matched patients. TLR was observed in 14 patients (sequential, 7; individual, 7) in the matched group. The freedom from TLR at 8 years was 94.6% ± 2.0% and 96.3% ± 1.6% in the sequential and individual groups, respectively (log-rank $p = 0.645$; Fig 2A). The cardiac event-free (Fig 2B), cardiac death-free, and survival rates were not significantly different (Fig 3). There were 50 deaths during the follow-up period: 19 and 31 in the sequential and individual groups, respectively; of these, 7 (2 and 5, respectively) were cardiac deaths. Cancer and infection were the leading causes of death (8 and 7, respectively) in the individual group. Overall survival at 8 years was 80.7% ± 4.8% and 77.4% ± 4.1% in the sequential and individual groups, respectively (log-rank $p = 0.300$).

In the matched group, a multivariate Cox proportional hazard model showed that a history of myocardial infraction and mitral regurgitation of 2 or higher were predictors of cardiac events. Complete revascularization was associated with a lower risk of cardiac events (hazard

Table 1. Preoperative Characteristics in Matched Groups

Characteristics[a]	Sequential (n = 147)	Individual (n = 147)	*p* Value	ASD
Age, y	65.7 ± 9.3	65.8 ± 8.4	0.995	0.013
Male	131 (83.4)	131 (83.4)	1.000	0.000
Body mass index, kg/m^2	24.1 ± 2.9	24.1 ± 3.9	0.944	0.008
Ejection fraction	0.593 ± 0.129	0.603 ± 0.150	0.467	0.072
Diseased vessels, No.	2.6 ± 0.7	2.5 ± 0.8	0.334	0.008
Left main disease	67 (46)	69 (47)	0.907	0.027
LAD >50%	128 (87)	123 (84)	0.509	0.096
Diagonal >50%	66 (44)	66 (45)	1.000	0.014
LCx >50%	117 (80)	115 (78)	0.886	0.033
RCA >50%	106 (72)	107 (73)	0.896	0.015
Diabetes	75 (51)	75 (51)	1.000	0.000
Insulin user	25 (17)	28 (19)	0.762	0.053
Hypertension	108 (74)	105 (71)	0.794	0.046
Hyperlipidemia	84 (57)	85 (58)	0.906	0.014
COPD	6 (4)	6 (4)	1.000	0.000
Smoking	81 (55)	89 (61)	0.408	0.110
Creatinine, mg/dL	1.2 ± 1.1	1.3 ± 1.6	0.412	0.084
Hemodialysis	9 (6)	9 (6)	1.000	0.000
Stroke	11 (7)	13 (8.3)	0.828	0.025
PAD	11 (8)	15 (10)	0.538	0.096
NYHA ≥III	28 (19)	34 (23)	0.475	0.100
Myocardial infarction				
Previous	53 (36)	60 (41)	0.472	0.098
Acute	4 (3)	4 (3)	1.000	0.000
Coronary intervention	46 (31)	46 (31)	1.000	0.000
Mitral regurgitation ≥2	7 (5)	7 (5)	0.617	0.086
Atrial fibrillation	5 (3)	6 (4)	0.759	0.036
Redo operation	1 (0.7)	2 (1.4)	0.562	0.068
Emergency operation	8 (5)	12 (8)	0.487	0.108

[a] Values are n (%) or mean ± standard deviation.

ASD = absolute standardized difference; COPD = chronic obstructive pulmonary disease; LAD = left anterior descending artery; LCx = left circumflex artery; NYHA = New York Heart Association; PAD = peripheral artery disease; RCA = right coronary artery.

ratio [HR], 0.40). Male sex (HR, 2.82), New York Heart Association classification III or higher (HR 1.85), and history of stroke (HR, 3.59) were independent predictors of overall survival (Table 6).

Comment

There were three main findings in this study. Firstly, sequential LITA grafting could be performed safely without increasing morbidity or death. Secondly, early patency of sequential LITA grafting was comparable with that of individual grafting, and a diamond anastomosis showed a more favorable patency of a distal part of sequential graft. Thirdly, as for remote outcomes, sequential grafting provides excellent results of freedom from TLR and survival.

Although the selection of the second arterial graft is still controversial, BITA grafting exhibits clear superiority over single ITA with a vein graft [1–6]. An in situ approach is more logical, if available. The skeletonization technique enables harvesting of the maximal length of the ITA [7, 8]. This technique minimizes tissue damage and contributes to a lower incidence of deep sternal wound infection, which comprises the major concerns associated with the use of BITA grafts. In this study, the rate of deep sternal wound infection was acceptable (1.4% in matched group and 2.2% in nonmatched group) and comparable with previous studies (1% to 3.9%) [5, 7, 17].

Sequential ITA grafting is a useful but technically demanding procedure. There have been few reports on the long-term results of sequential ITA grafting including the LCx, and no studies have used propensity matching. Bakay and colleagues [9] reported an excellent midterm patency of sequential LITA grafting to the LCx and right coronary artery. With the increasing severity of patients' conditions, we often need to revascularize more than 3 vessels in the LCA area, including the LAD. Although sequential vein grafting is frequently used, the long-term patency is inferior to that of ITAs, resulting in repeat revascularization, cardiac events, or death [5]. Gagne and colleagues [11] demonstrated that the long-term results of sequential ITA grafting with BITA grafts were superior to those of single ITA with sequential vein grafting.

When using BITA grafts, the in situ RITA is not long enough to reach the distal LCx. In addition, recent studies demonstrated an excellent patency of the in situ RITA to the LAD, even based on long-term results [19, 20]. Therefore, we adopt the in situ LITA to the LCx and the RITA to the LAD. Repeat sternotomy after in situ RITA grafting is another concern. However, it is rare (0.25%) after isolated CABG in our 15-year experience, and exposure of the patent RITA can be performed safely using an ultrasonic scalpel [21].

There is another benefit of sequential grafting concerning patency. Nordgaard and colleagues [22] showed that the blood flow in a sequential graft is significantly increased compared with a single graft. Nakano and colleagues [23] demonstrated that sequential grafting is one of the factors promoting ITA patency. These results suggest that sequential grafting reduces the total resistance of graft flow, resulting in a more favorable hemodynamic performance and patency. O'Neill and colleagues [24] demonstrated that the proximal part of a sequential bypass graft has more favorable hemodynamics. They suggested that the smaller coronary artery should be chosen as a proximal target to maximize the hemodynamic advantage. In the present study, no occlusion of the LITA trunk occurred in the sequential group, whereas the distal part of the sequential grafting was compromised in 5 patients (2.6%).

The obtuse marginal branches, which are a key target of the lateral wall, sometimes run inside the myocardium. In this study, we did not intraoperatively convert from sequential to individual LITA grafting due to deeply

Table 2. *Operative Results in Matched Groups*

Results[a]	Sequential (n = 147)	Individual (n = 147)	*p* Value	ASD
No. of RITA distal anastomosis				
One	147	147		
No. of LITA distal anastomoses				
One		147		
Two	146			
Three	1			
Distal anastomosis, No.	4.0 ± 0.8	3.1 ± 1.0	<0.001	0.880
Grafts, No.	2.8 ± 0.5	2.8 ± 0.5	0.816	0.076
Saphenous vein graft	76 (52)	83 (57)	0.483	0.096
Gastroepiploic artery	35 (24)	30 (20)	0.574	0.082
Additional graft to circumflex	16 (11)	13 (9)	0.696	0.068
Additional graft to diagonal	13 (9)	26 (18)	0.038	0.263
Complete revascularization	136 (92.5)	135 (91.8)	0.828	0.025
Off-pump	141 (96)	139 (95)	0.784	0.064
Intraaortic balloon pump	23 (16)	27 (18)	0.507	0.054
Perioperative myocardial infarction	7 (5)	7 (5)	1.000	0.000
Renal failure	7 (5)	6 (4)	0.388	0.067
Stroke	2 (1.4)	1 (0.7)	0.562	0.068
Deep sternal wound infection	3 (2)	1 (0.7)	0.622	0.118
Hospital death	2 (1.4)	1 (0.7)	0.562	0.068

[a] Values are n (%) or mean ± standard deviation.

ASD = absolute standardized difference; LITA = left internal thoracic artery; RITA = right internal thoracic artery.

Table 3. *Graft Design to the Left Coronary Area in Matched Groups*

Group	n (%) (n = 147)[a]
Sequential LITA	
RITA-LAD + LITA-LCx	118 (80.3)
LITA-LCx-LCx	64
LITA-diagonal-LCx	34
LITA-LCx-diagonal	20
RITA-LAD + LITA-LCx + other grafts	29 (19.7)
LITA-LCx-LCx + SVG-diagonal	13
LITA-diagonal-LCx + SVG-LCx	6
LITA-LCx-diagonal + SVG-LCx	4
LITA-LCx-LCx + SVG-LCx	4
LITA-LCx-diagonal + GEA-LCx	2
Individual LITA	
RITA-LAD + LITA-LCx	109 (74.1)
RITA-LAD + LITA-LCx + other grafts	38 (25.9)
LITA-LCx + SVG-diagonal	24
LITA-LCx + SVG-LCx	12
LITA-LCx + SVG-diagonal + SVG-LCx	1
LITA-LCx + SVG-diagonal + GEA-LCx	1

[a] Diamond in 83 patients and parallel in 64 patients.

GEA = gastroepiploic artery; LAD = left anterior descending artery; LCx = left circumflex artery; LITA = left internal thoracic artery; RITA = right internal thoracic artery; SVG = saphenous vein graft.

located obtuse marginal branches; therefore, the effect of the anatomic location of the obtuse marginal branch on matching seemed to be minimal. In sequential grafting, the intramyocardial branches could be treated in a diamond fashion by shaving the surrounding myocardium to

Table 4. *Graft Evaluation in Matched Groups*

Evaluation	Sequential n (%)	Individual n (%)
LITA grafts assessed	115/147	116/147
Angiography	60 (52.2)	66 (56.9)
Computed tomography	55 (47.8)	50 (43.1)
LITA distal anastomosis	231	116
One		116
Two	114	
Three	1	
Event-free anastomosis	226/231 (97.8)	113/116 (97.4)
Sequential proximal	115/115 (100)	
Sequential graft end	111/116 (95.7)	
Occlusion	2	2
String	2	1
Competition	1	
LITA trunk occlusion	0/115 (0)	2/212 (1.7)
RITA	115/115 (100)	114/116 (98.3)

LITA = left internal thoracic artery; RITA = right internal thoracic artery.

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Table 5. Patency of Sequential Left Internal Thoracic Artery Grafting in Matched Cohort (n = 115/147) According to a Proximal Anastomosis Fashion

Variable	Diamond n (%)	Parallel n (%)	*p* Value
LITA graft, No.	61	54	
Sequential proximal	61/61 (100)	54/54 (100)	1.00
Sequential graft end	60/61 (98.4)	49/54 (90.7)	0.097
Graft end patency			
LITA-LCx-LCx	37/38 (97.4)	21/23 (91.3)	0.551
LITA-diagonal-LCx	20/20 (100)	9/12 (75)	0.044
LITA-LCx-diagonal	3/3 (100)	19//19 (100)	1.00

LCx = left circumflex artery; LITA = left internal thoracic artery.

create a route for the LITA. However, a parallel fashion might be chosen in some patients with a deeply located intramyocardial branch or a diseased coronary artery. Although these factors may influence the patency rate of a parallel anastomosis, these cases were very few. A parallel anastomosis of the diagonal branch as a proximal anastomosis showed the poorest patency rates of the sequential graft end, possibly because the diagonal that needs to be grafted is usually a large vessel with more extensive blood flow, resulting in a string or competition of the graft end.

The size of the target vessels was not available in our database, and this is a limitation. These results may support a potential importance of the size of proximal anastomosis in sequential grafting [24]. Nakajima and colleagues [14] showed that the mild stenosis of a target vessel at the graft end is a predictor of the graft string and competition in sequential grafting. We consider that the degree of stenosis at the native coronary artery plays an important role in graft patency; however, the severity of stenosis was not a risk factor for graft complications in logistic regression analysis (data not shown). A graft angulation or the length of the graft in this configuration might affect the poorer patency rates of the graft end in sequential grafting.

The event-free rates of TLR and cardiac death were excellent in both groups. This result regarding TLR is one of the benefits of BITA grafting [3, 5]. No significant difference was found in freedom from cardiac events and overall survival between the groups. The rate of complete revascularization was comparable, and there was no incomplete revascularization of the LCA in either group. Additional long-term benefits of sequential grafting are difficult to demonstrate, as noted in a previous study [11]. After propensity-score matching, the difference of patients' backgrounds between the groups was simply the presence of 1 or more target vessels in the LCx or diagonal branch.

To truly demonstrate the superiority of sequential LITA to the circumflex strategy, both groups must have an equivalent number of targets in the circumflex territory, and comparison of sequential LITA grafts needs to be made with LITA to a single circumflex target with additional circumflex targets revascularized by non-LITA conduits. However, we have preferentially adopted sequential grafting for those who have more than 2 targets in the circumflex area including the diagonal branch. That is why the number of distal anastomosis was larger in the sequential group even after propensity-score matching. Although there might be concern that the long-term prognosis and survival may be compromised

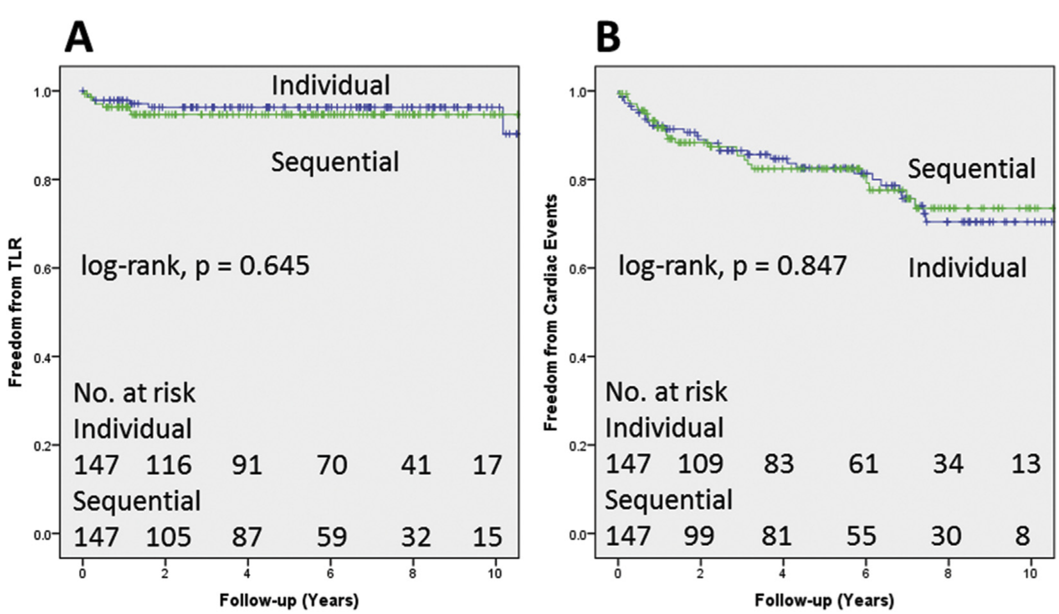

Fig 2. The freedom from (A) target lesion repeat revascularization (TLR), and (B) cardiac events in matched groups undergoing individual (blue line) and sequential (green line) revascularization.

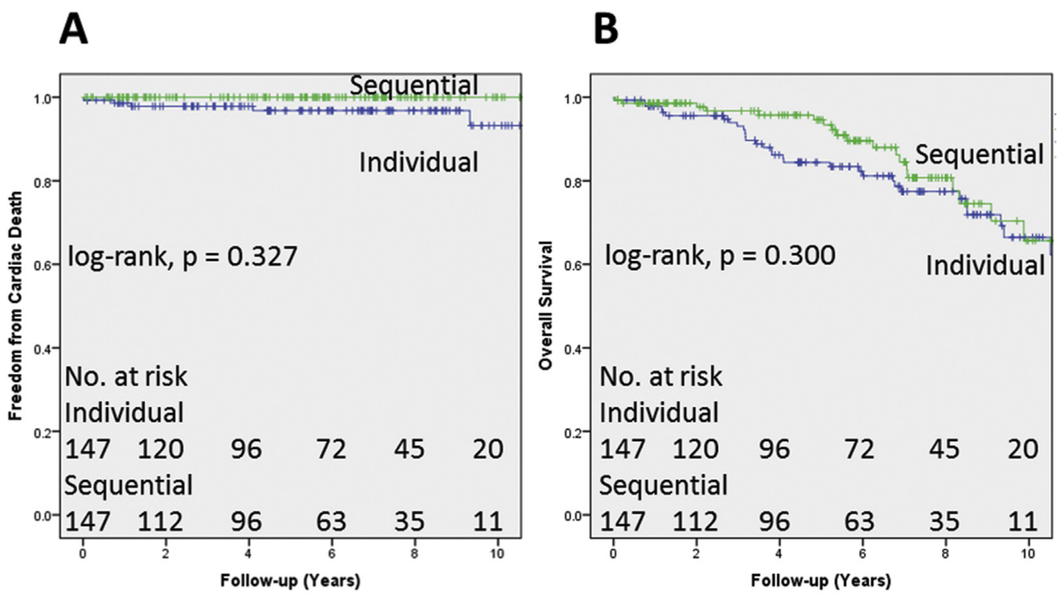

Fig 3. (A) The freedom from cardiac death and (B) overall survival in matched groups undergoing individual (blue line) and sequential (green line) revascularization.

in patients with fewer distal anastomoses, we considered that the effects of the different number of distal anastomoses in the sequential and individual grafting on long-term outcomes were small because the rates of complete revascularization (any vessel ≥1.5 mm) were similar between the two groups.

The advantage of sequential grafting is being able to revascularize most of the LCA area with BITA grafts. Indeed, the LCA area was completely revascularized using only BITA grafts in 80.3% of patients in the sequential group. In addition, in the case of an off-pump operation, a porcelain aorta with more than 3 target lesions in the LCA, or a limited number of grafts, sequential LITA grafting is definitely an important strategy to effectively perform revascularization.

Table 6. Cox Proportional Hazard Model of Matched Groups

Variable	Adjusted Hazard Ratio	95% Confidence Interval	*p* Value
Cardiac events			
Complete revascularization	0.40	0.196–0.830	0.014
Mitral regurgitation ≥2	2.46	1.099–5.483	0.028
Previous myocardial infarction	1.57	0.936–2.629	0.088
Overall survival			
Sequential LITA	0.68	0.382–1.210	0.190
Previous stroke	3.59	1.656–7.762	<0.001
Male sex	2.82	1.004–7.942	0.049
NYHA ≥III	1.85	1.031–3.322	0.039

LITA = left internal thoracic artery; NYHA = New York Heart Association.

This study has several limitations. Although propensity-score matching adjusts for confounding, we cannot eliminate residual confounding due to unobserved factors. Secondly, this was a single-center, nonrandomized, retrospective study, and the population was small, resulting in insufficient statistical power. Thirdly, CT and angiography were both performed to evaluate the grafts. CT could easily confirm patency of a trunk of the LITA, but a precise flow pattern could not be assessed. Fourthly, although the rate of a narrow LITA not being used as a conduit or for sequential grafting was very low, this potential selection bias may influence the patency rates. Finally, information about follow-up medication and coronary angiography was not available in all patients.

In conclusion, in situ sequential LITA grafting provides acceptable early graft patency without increasing postoperative complications. The TLR-free and long-term survival rates were excellent with both grafting patterns using BITA grafts. Sequential LITA grafting is a useful option for multivessel revascularization.

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