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Clinical Research

Graft Patency of No-Touch Saphenous Veins Used as Aortocoronary Bypass Grafts

Jeongwon Kim, M.D.[1], Suk Ho Sohn, M.D.[1], Jae-Sung Choi, M.D., Ph.D.[2], Se Jin Oh, M.D., Ph.D.[2,*], Ho Young Hwang, M.D., Ph.D.[1,*]

[1]*Department of Thoracic and Cardiovascular Surgery, Seoul National University Hospital, Seoul National University College of Medicine;* [2]*Department of Thoracic and Cardiovascular Surgery, SMG-SNU Boramae Medical Center, Seoul National University College of Medicine, Seoul, Korea*

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Corresponding author
Ho Young Hwang
Tel 82-2-2072-3020
Fax 82-2-764-3664
E-mail scalpel@snu.ac.kr
ORCID
https://orcid.org/0000-0002-8935-8118

*These two authors contributed equally to this work.

Background: This study evaluated the early, 1-year, and 3-year graft patency rates and mid-term clinical outcomes after no-touch saphenous veins (NT-SVs) were used as aortocoronary grafts in coronary artery bypass grafting (CABG).
Methods: In total, 101 patients who underwent CABG using NT-SVs as aortocoronary grafts were included. The 2 most common indications for performing aortocoronary grafting with NT-SVs were unavailability of the left internal thoracic artery (n=36) and moderate lesions where flow competition was expected (n=27). Early (median, 1 day; interquartile range [IQR], 1–2 days), 1-year (median, 13 months; IQR, 11–16 months), and 3-year (median, 34 months; IQR, 27–41 months) graft angiography was performed in 98 (97.0%), 84 (83.2%), and 40 patients (39.6%), respectively. The median follow-up duration was 43 months (IQR, 13–76 months). Overall survival rates and the cumulative incidence of major adverse cardiac events were evaluated.
Results: The operative mortality rate was 2% (2 of 101 patients). Early postoperative patency rates for overall and aortocoronary NT-SV grafts were 98.2% (223 of 227 distal anastomoses) and 98.2% (164 of 167), respectively. The 1- and 3-year patency rates for aortocoronary SV grafts were 94.9% (131 of 138) and 90.6% (58 of 64), respectively. The overall survival rates at 5 and 10 years were 81.7% and 59%, respectively. The cumulative incidence of major adverse cardiac events at 5 and 10 postoperative years was 20.7% and 39%, respectively.
Conclusion: The feasibility of using NT-SVs as aortocoronary grafts in CABG was shown in this study, based on the graft patency rates up to 3 years and the mid-term clinical outcomes.

Keywords: Saphenous vein, Coronary artery bypass grafting

Introduction

Clinical evidence from the 1980s showed the internal thoracic artery (ITA) to be the graft of choice in surgical myocardial revascularization [1]. In addition, the superiority of the left ITA (LITA) was affirmed because of its long-term patency and favorable clinical outcomes [2,3]. After the LITA, the saphenous vein (SV) is the second-most widely utilized graft [4]. However, the SV has limitations including decreasing patency due to anatomical and functional characteristics. Various pharmaceutical and surgical techniques have been attempted to improve the outcomes after coronary artery bypass grafting (CABG) with SV grafts, including antiplatelet therapy, lipid-lowering agents, and the adoption of no-touch (NT) techniques [5,6].

Arterial composite grafting based on the *in-situ* LITA is an established strategy in CABG [7]. Recent studies have also shown that CABG using SV grafts harvested with the NT technique and used as composite grafts based on the LITA might result in similar graft patency and clinical outcomes up to 10 years after surgery [8,9]. Although the NT-SV technique was first introduced for aortocoronary grafting in CABG, there is limited data regarding the patency of NT-SV aortocoronary grafts [10,11]. Therefore,

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this study evaluated the early postoperative, 1-year, and 3-year graft patency rates after CABG using NT-SV aortocoronary grafts.

Methods

The study was approved by the review boards of 2 institutions, and the requirement for written informed consent was waived because this was a retrospective study with minimal risk and utilized anonymized data (approval numbers: H-2212-164-1391 and 10-2023-29).

Patient characteristics

We evaluated subjects treated from January 2006 to December 2021 at 2 institutions. All patients in whom the CABG was done using the NT-SV as the aortocoronary graft were included. There were no exclusion criteria, and a total of 101 patients were retrospectively enrolled (Fig. 1).

Operative techniques and revascularization strategy

The basic surgical procedures and strategies for CABG have been previously described [8,12]. During the study period, an aortic off-pump CABG using composite grafting based on the *in-situ* LITA or right ITA (RITA) was the preferred revascularization strategy. In the study patients, aortocoronary grafting using the SV was applied for several reasons: (1) damage to the LITA during harvesting (n=9); (2) neither ITA was available (n=8); (3) the small caliber of the LITA precluded its use as a main graft (n=7); (4) moderate lesions (50%–70% of diameter stenosis) in the left anterior descending artery (LAD) or other target vessels where flow competition of the LITA-to-LAD anastomosis or composite graft-to-other target vessels was expected (n=21 and 16, respectively); (5) redo CABG (n=15); (6) non-LAD territory revascularization only (n=20); (7) emergency operation (n=4); and (8) need for a third graft in addition to the composite SV grafts (n=2).

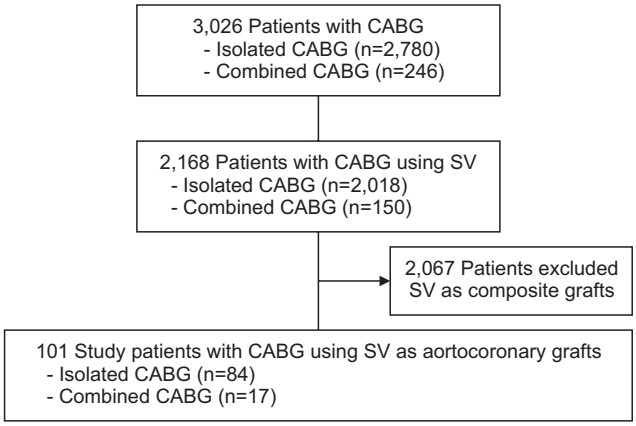

Fig. 1. Summary flow diagram of patient enrollment in a study of coronary artery bypass grafting (CABG) using aortocoronary saphenous vein (SV) grafts.

In the early study period, the SV was harvested using the NT technique, but without the surrounding perivascular tissue (no PVT group, n=26). After October 2013, it was harvested with surrounding perivascular tissue (PVT group, n=75) [12]. The SV from a lower leg site was preferred over the SV from an upper leg site to decrease the possibility of size mismatch with the native coronary arteries. The SV remained in its original position until use. Just before starting anastomosis, the SV was resected and proximal anastomosis to the ascending aorta was performed. After proximal anastomosis, the SV conduit was spontaneously dilated by native flow and the pressure of the aorta. The valves of the spontaneously dilated SV were then destroyed using a 2 mm vessel dilator with an atraumatic round head, which was inserted into the lumen through the distal end of the aortocoronary graft (the anatomically proximal site of the SV) and passed through the entire length of the SV, tearing out valves that resisted the passage of the dilator. This was performed to increase the SV flow rate [13,14] and prevent blood stagnation between sequential distal anastomoses in the event of flow competition. Surgical strategies during the study period were not changed except for the preservation of perivascular soft tissue during NT-SV graft harvesting after October 2013.

Postoperative pharmacologic management

Changes in medical management during the study periods included the regimen for dual antiplatelet treatment (DAPT) and the target level of low-density lipoprotein cholesterol (LDL-C). In patients who underwent isolated CABG, DAPT was started as soon as possible, usually on the first postoperative day. In the early study period, ticlopidine hydrochloride (200 mg/day) in addition to acetylsalicylic acid was used as a DAPT regimen and continued for 2 months, and statin therapy was used with a target LDL-C level of <100 mg/dL. In the late period, the DAPT regimen was changed to clopidogrel and acetylsalicylic acid and maintained until 1 year after surgery. In addition, the target LDL-C level was lowered to <70 mg/dL. If there were no other indications for maintaining DAPT, the regi-

men was then changed to a single antiplatelet treatment.

Evaluation of graft patency

The early, 1-year, and 3-year graft patency values were studied through a postoperative evaluation protocol at both institutions, with patient consent. Early (median, 1 day; interquartile range [IQR], 1–2 days) postoperative angiograms were performed in 97.0% (98/101) of patients. At 1 year (13.1±2.5 months), graft angiography was performed in 83.2% (84/101) of patients, and conventional angiography or multidetector computed tomographic angiography (MDCT) was performed in 26 and 58 patients, respectively. At 3 years (33.9±6.7 months), graft angiography was performed in 39.6% (40/101) of patients, and conventional angiography or MDCT was performed in 12 and 28 patients, respectively.

Coronary angiograms and MDCT results were reviewed by 2 specialists in each study. Each set of specialists reached a consensus in their interpretations of graft patency. Grafts that were occluded or showed diffuse string signs were considered occluded [15].

Evaluation of clinical outcomes

Death within 30 days of operation was considered operative mortality. An episode of atrial fibrillation lasting more than 30 seconds on 24-hour electrocardiogram monitoring was defined as new onset postoperative atrial fibrillation. A rise in serum creatinine of 0.3 mg/dL or 50% of the baseline level was considered to indicate acute kidney injury.

Patients received routine postoperative follow-up care through an outpatient clinic at an interval of 3 to 6 months. If the most recent clinic appointment could not be completed on time, patients were contacted by phone to verify their status. In addition, data regarding survival and death from cardiovascular diseases up to December 2021 were obtained from death certificates available at Statistics Korea. The clinical and angiographic follow-up examinations through October 31, 2022, were included in this study. Complete follow-up data were available for 92.1% (93/101) of patients, with a median follow-up duration of 42.5 months (IQR, 13.1–75.7 months).

Cardiac death was defined as any death related to cardiac events including operative mortality and sudden death during the follow-up period. Major adverse cardiac events (MACEs) included cardiac death, acute myocardial infarction, and coronary reintervention such as percutaneous intervention and redo CABG.

Statistical analysis

Statistical analyses were performed using R ver. 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria). Categorical data were expressed as numbers and percentages. Continuous data were expressed as means with standard deviation for data with a normal distribution or as medians with IQR for non-normally distributed data.

Survival rates were also estimated using the Kaplan-Meier method. The cumulative incidences of MACEs were estimated with all-cause death and noncardiac death as competing risks. Comparisons of categorical variables were performed using the chi-square test or Fisher exact test. The cumulative incidence of each event in the 2 groups was compared using the Fine-Gray test, and the hazard ratio (HR) was determined with a 95% confidence interval (CI). Variables with a p-value <0.100 in the univariate analysis were entered into the multivariate models. A p-value <0.05 indicated statistical significance.

Results

Operative data

Patients' mean age at the time of the operation was 65.6±

Table 1. Preoperative characteristics and risk factors of patients who underwent CABG with NT-SVs as aortocoronary grafts

Characteristic	Value
No. of patients	101
Age (yr)	65.6±10.3
Female sex	25 (24.8)
Smoking	
Never	55 (54.5)
Former	22 (21.8)
Current (within 1 month)	24 (23.8)
Hypertension	67 (66.3)
Diabetes mellitus	48 (47.5)
Dyslipidemia	39 (38.6)
Overweight or obesity (BMI ≥25 kg/m^2)	40 (39.6)
History of stroke	14 (13.9)
Chronic kidney disease	29 (28.7)
Previous percutaneous coronary intervention	38 (37.6)
Left ventricular dysfunction (EF <0.35)	38 (37.6)
Acute coronary syndrome	67 (66.3)
Left main disease	32 (31.7)
3-Vessel disease	35 (34.7)

Values are presented as mean±standard deviation or number (%).
CABG, coronary artery bypass grafting; NT-SV, no-touch saphenous vein; BMI, body mass index; EF, ejection fraction.

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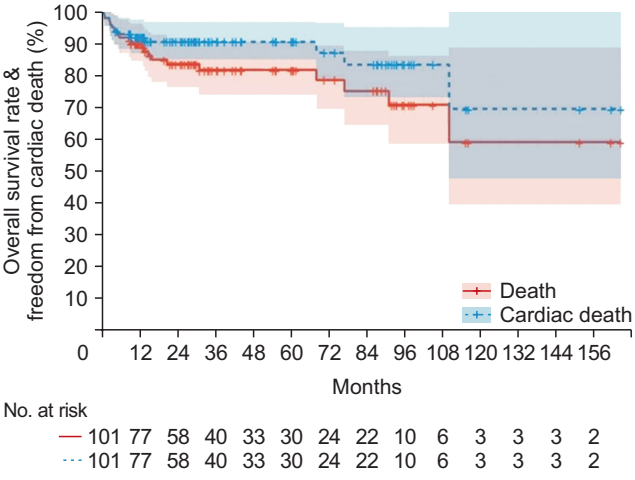
10.3 years, and 75.2% (n=76) were male. Hypertension (n=67, 66.3%) and diabetes (n=48, 47.5%) were the most common risk factors. Twelve patients (11.9%) had a history of previous CABG (Table 1). Off-pump, on-pump beating, and conventional CABG procedures were performed in 67 (66.3%), 30 (29.7%), and 4 (4.0%) cases, respectively. Concomitant cardiac surgery was performed in 17 patients including aortic valve replacement (n=9), total arch replacement (n=4), mitral valve surgery (n=4), and arrhythmia surgery (n=2). The average number of distal anastomoses per patient was 2.3±1.1 (3.1±1.0 in 35 patients with 3-vessel disease and 1.9±0.9 in the other 66 patients). The number of distal anastomoses using aortocoronary SV grafts was 1.8±1.0. In 9 patients, the SV was used for both composite and aortocoronary grafts (Fig. 2). Other conduits used were the LITA (n=46, 45.5%), RITA (n=2, 2.0%), and right gastroepiploic artery (n=1, 1.0%). Revascularization of the LAD was needed in 78 patients. The LITA was used for LAD anastomosis in 34 patients. In 3 patients, the LITA was too short to reach the LAD, and extension with another conduit was performed to revascularize the LAD. Other reasons to use grafts other than the LITA included: (1)



	5-Year survival (95% CI)	10-Year survival (95% CI)
Overall survival rate (%)	81.7 (73.8–90.5)	59.0 (39.2–88.6)
Freedom form cardiac death (%)	90.7 (85.0–96.7)	69.5 (47.4–100.0)

Fig. 3. Overall survival rate and freedom from cardiac death in a study of aortocoronary bypass grafting using the saphenous vein. Estimates were calculated using the Kaplan-Meier method. CI, confidence interval.

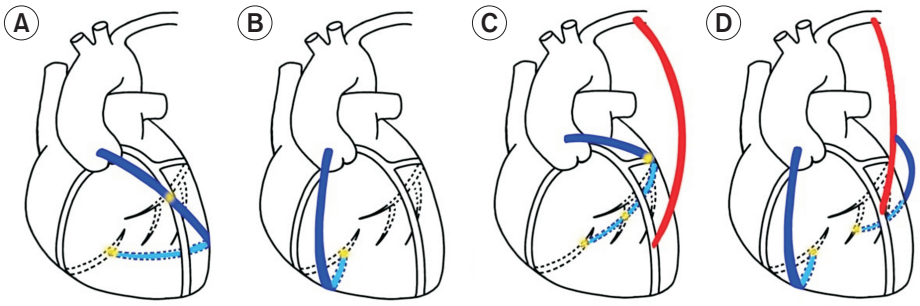


Fig. 2. Diagram of graft configurations used in the study patients. The aortocoronary saphenous vein grafts were used as a single conduit (A, B), a second conduit in addition to the left or right internal thoracic artery (ITA) (C), or a third conduit in addition to composite grafts based on the left ITA (D). A sequential anastomosis technique was used if needed.

Table 2. Early clinical results of coronary artery bypass grafting with SVs as aortocoronary grafts in all patients, patients with the SV harvested with PVT, and those without PVT (no PVT)

Early clinical outcomes	Total (n=101)	No PVT (n=26)	PVT (n=75)
Early mortality	2 (2)	1 (3.8)	1 (1.3)
Postoperative complications			
Atrial fibrillation	29 (28.7)	9 (34.6)	20 (26.6)
Acute kidney injury	14 (13.9)	6 (23.1)	8 (10.7)
Respiratory complications	11 (10.9)	6 (23.1)	5 (6.7)
Perioperative myocardial infarction	4 (4.0)	3 (11.5)	1 (1.3)
Low cardiac output syndrome	4 (4.0)	0	4 (5.3)
Bleeding reoperation	2 (2.0)	1 (3.8)	1 (1.3)
Stroke	0	0	0
Mediastinitis	0	0	0

Values are presented as number (%).
SV, saphenous vein; PVT, perivascular tissue.

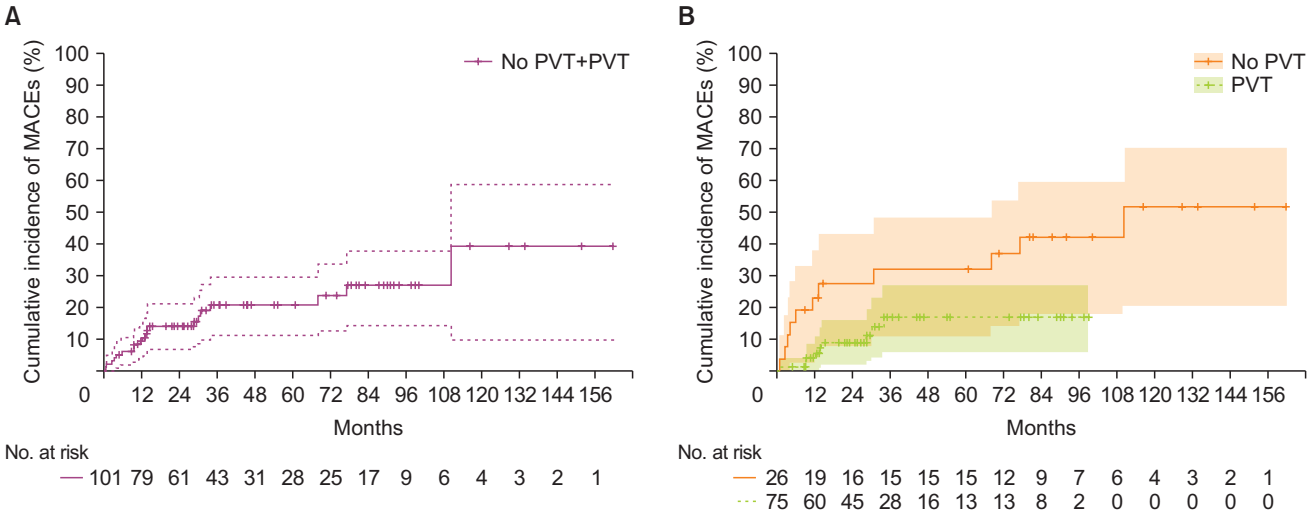
damage to the LITA during harvesting (n=6), (2) both ITAs were unavailable (n=7), (3) the small caliber of the LITA precluded its use as a main graft (n=5), (4) redo CABG (n=15), and (5) emergency operations (n=3). In 5 patients, the SV was used instead of the LITA at the discretion of the operating surgeons because of moderate LAD stenosis.

Early and follow-up clinical outcomes

The operative mortality rate was 2.0% (2 of 101 patients). One patient died of acute respiratory distress syndrome and the other died from low cardiac output syndrome. Common postoperative morbidities included atrial fibrillation (n=29, 28.7%), acute kidney injury (n=14, 13.9%), and respiratory complications (n=11, 10.9%) (Table 2).

Late death occurred in 18 patients, including 12 cardiac deaths. The overall survival rate at 5 years and 10 years was 81.7% and 59%, respectively. The rate of freedom from cardiac death at 5 years and 10 years was 90.7% and 69.5%, respectively (Fig. 3). Percutaneous coronary intervention and redo CABG were needed in 9 and 1 patients, respectively. Other MACEs occurred in 13 patients, including cardiac death in 12 and acute myocardial infarction in 3. The cumulative incidence of MACEs at 5 and 10 postoperative years was 20.7% and 39%, respectively (Fig. 4A).

There were no significant differences in early clinical



	5-Year incidence (95% CI)	10-Year incidence (95% CI)
Overall probability (%)	20.7 (11.0–29.2)	39.0 (9.7–58.8)

	5-Year incidence (95% CI)	10-Year incidence (95% CI)
No PVT (%)	32.1 (10.8–48.2)	51.8 (20.4–70.8)
PVT (%)	16.9 (5.6–26.8)	

Fig. 4. A cumulative incidence curve for major adverse cardiac events (MACEs) in a study of aortocoronary bypass grafting using the saphenous vein: all study patients (A) and patients separated into 2 groups based on the harvesting techniques used (perivascular tissue [PVT] vs. no PVT) (B). CI, confidence interval.

Table 3. Comparison of early, 1-year, and 3-year angiographic patency rates in SV grafts versus arterial grafts commonly used in coronary artery bypass grafting

Grafts	Early (n=98)	1-Year (n=84)	3-Year (n=40)
Left ITA	44/44 (100.0)	41/41 (100.0)	19/19 (100.0)
Right ITA	2/2 (100.0)	2/2 (100.0)	2/2 (100.0)
Right gastroepiploic artery	1/1 (100.0)	0/1 (0)	0/1 (0)
SV	176/180 (97.8)	143/151 (94.7)	64/71 (90.1)
Composite graft	12/13 (92.3)	12/13 (92.3)	6/7 (85.7)
Aortocoronary graft	164/167 (98.2)	131/138 (94.9)	58/64 (90.6)
Total	223/227 (98.2)	186/195 (95.4)	85/93 (91.4)

Values are presented as number of patent anastomoses/number of total anastomoses (%).
SV, saphenous vein; ITA, internal thoracic artery.

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outcomes between the 2 groups (Table 2). Although there was a difference in the cumulative incidence of MACEs on univariate analysis, it was not statistically significant on multivariate analysis (PVT versus no PVT group; HR, 0.540; 95% CI, 0.187–1.558) (Fig. 4B).

Early, 1-year, and 3-year postoperative graft patency rates

Early postoperative angiography demonstrated that the patency rate of all grafts, including arterial and SV grafts, and the patency rate for distal anastomoses using aortocoronary SV grafts were 98.2% (223 of 227 distal anastomoses) and 98.2% (164 of 167), respectively. One year after surgery, the patency rates of all grafts and aortocoronary SV grafts were 95.4% (186/195) and 94.9% (131/138), respectively. On 3-year graft angiography, the patency rates of all grafts and aortocoronary SV grafts were 91.4% (85/93) and 90.6% (58/64), respectively (Table 3). The patency rates of SV grafts in the LAD, left circumflex, and right coronary artery territories are described in Table 4. There were no significant differences in the graft patency rates between the 2 groups (Table 5).

Discussion

This study demonstrated favorable outcomes for CABG using NT-SV aortocoronary grafts in terms of 1- and 3-year graft patency rates. Various factors have been shown to affect the results of CABG [16-18], with graft patency being one of the most important factors. Although the LITA is considered the best graft to use [2,3], research into the next best graft has continued because multiple grafting is needed in most CABG patients. The SV has remained one of the most frequently used graft for CABG since its introduction in the 1960s [4] due to its ease of use, sufficient length, and short harvesting time. Despite these advantages, low graft patency and the resulting poor clinical outcomes have been highlighted as important caveats when using SV grafts in CABG [19,20].

Previous studies have compared the occlusion rates of radial artery and SV grafts [21,22]. One randomized controlled trial demonstrated late (7±1.5 years after surgery) radial artery and SV graft occlusion rates of 12% (28/234) and 20% (46/234), respectively [21]. Another retrospective study showed occlusion rates of 16% (65/420) and 39% (141/364) at an average of 5.0 years after surgery. This inferior patency of SV grafts compared with arterial grafts can be explained by vascular injury during SV graft harvest-

Table 4. Early, 1-year, and 3-year angiographic patency rates of the SV graft in coronary artery bypass grafting according to the coronary artery territories

Grafts	Early (n=98)			1-Year (n=84)			3-Year (n=40)		
	LAD	LCX	RCA	LAD	LCX	RCA	LAD	LCX	RCA
SV total	65/67 (97.0)	45/45 (100.0)	66/68 (97.1)	56/59 (94.9)	35/36 (97.2)	52/56 (92.9)	26/27 (96.3)	15/16 (93.6)	23/28 (82.1)
Composite	5/5 (100.0)	5/5 (100.0)	2/3 (66.7)	5/5 (100.0)	5/5 (100.0)	2/3 (66.7)	2/2 (100.0)	3/3 (100.0)	1/2 (50.0)
Aortocoronary	60/62 (96.8)	40/40 (100.0)	64/65 (98.5)	51/54 (94.4)	30/31 (96.8)	50/53 (94.3)	24/25 (96.0)	12/13 (92.3)	22/26 (84.6)

Values are presented as the number of patent anastomoses/number of total anastomoses (%).
SV, saphenous vein; LAD, left anterior descending coronary artery; LCX, left circumflex coronary artery; RCA, right coronary artery.

Table 5. Early, 1-year, and 3-year angiographic patency rates of the SV harvested with PVT and without PVT (no PVT) for use in coronary artery bypass grafting

Grafts	Early (n=98)		1-Year (n=84)		3-Year (n=40)	
	No PVT (n=26)	PVT (n=72)	No PVT (n=20)	PVT (n=64)	No PVT (n=16)	PVT (n=24)
SV total	39/41 (95.1)	137/139 (98.9)	30/32 (93.8)	113/119 (95.0)	23/26 (88.5)	41/45 (91.1)
Composite	1/2 (50.0)[a]	11/11 (100.0)[a]	1/2 (50.0)	11/11 (100.0)	1/2 (50.0)	5/5 (100.0)
Aortocoronary	38/39 (97.4)	126/127 (99.2)	29/30 (96.7)	102/108 (94.4)	22/24 (91.7)	36/40 (90.0)

Values are presented as the number of patent anastomoses/number of total anastomoses (%).
SV, saphenous vein; PVT, perivascular tissue.
[a]Lowest p-value among comparisons: p=0.154.

ing, which causes platelet activation and thrombus propagation as well as a decrease in transmural blood flow [23]. To overcome this issue, the "no-touch" technique, which preserves perivascular structures with minimal manipulation during graft harvesting was introduced in the late 1990s [6]. This technique was introduced as an aortocoronary grafting strategy, but only single-center experiences have been published [10,11]. Other studies have shown that NT-SV grafts can be used as composite grafts with the *in-situ* LITA. This strategy can be a safe and effective alternative to the use of aortocoronary SV grafts in CABG in terms of the graft patency rate and long-term clinical outcomes [13].

As described above, NT-SV grafts were first introduced as aortocoronary grafts, and a favorable graft patency rate was reported [24]. While the theoretical drawbacks of using the SV as an aortocoronary graft include the high diastolic pressure and shear force of the ascending aorta [25], the advantages of the SV composite graft include the supply of vasoprotective substances from the in-situ LITA and the need for less SV length [9,26,27]. However, these have not been proven in previous studies. Despite the above concerns, this study demonstrated favorable outcomes after CABG using NT-SV grafts as aortocoronary bypass grafts, with a 1-year graft patency rate of 94.9%. A previous study from our institution raised the concern that the patency of aortocoronary SV grafts might be unsatisfactory, particularly when used in off-pump CABG, with a 1-year patency rate of 67.9% (106 of 156 distal anastomoses) [19]. Therefore, subsequent SV grafts were harvested using the NT technique, and a composite grafting strategy was applied. Although there might be differences in perioperative management and surgeons' techniques between the previous study and the current study, the aortocoronary SV grafts using the NT technique in the present study showed a satisfactory patency rate compared with that in the previous study. In addition, although the number of grafts used as composite SV grafts was small in the present study, the patency rate of the aortocoronary SV grafts was higher than that of the composite SV grafts at the 3 time points. Although further long-term clinical and angiographic outcomes need to be evaluated to form a more solid conclusion, the NT-SV appears to be a valid option in the current era of CABG that emphasizes the use of arterial grafts [28,29].

In the present study, the SV was frequently used when the LITA was unavailable, even to revascularize the LAD. The RITA, which has the same characteristics as the LITA, might be a good alternative when the LITA is unavailable. However, when the LITA is found to be unavailable during surgery, due to mechanical trauma during harvesting or an unexpectedly small caliber, harvesting the RITA to replace the LITA could be time-consuming, since surgical procedures periodically come to a halt as every surgeon except the one harvesting the RITA leaves the operating theater in such cases. In addition, the RITA is often too short to replace the LITA or SV [30]. Therefore, the SV was used at the discretion of the operating surgeons.

The present study had limitations that should be noted. First, the present study was retrospective in nature, and the number of study patients was relatively small because the studied strategy was not a preferred grafting strategy during the study period. Second, the study period was relatively long, and changes in procedures, perioperative management, and pharmaceutical drugs could affect the study results. Finally, an unusual grafting strategy performed at the discretion of the operating surgeon might also affect the study results.

In conclusion, harvesting SVs using the NT technique and using them as aortocoronary grafts during CABG resulted in favorable 1-year and 3-year graft patency rates.

Article information

ORCID

Jeongwon Kim: https://orcid.org/0000-0001-9684-2277
Suk Ho Sohn: https://orcid.org/0000-0001-7391-3415
Jae-Sung Choi: https://orcid.org/0000-0001-5408-9029
Se Jin Oh: https://orcid.org/0000-0002-1516-5313
Ho Young Hwang: https://orcid.org/0000-0002-8935-8118

Author contributions

Conceptualization: HYH. Data curation: HYH, SJO. Formal analysis: HYH, JK. Methodology: HYH. Project administration: HYH, SJO. Visualization: HYH, JK. Writing–original draft: JK. Writing–review & editing: HYH, JK. Final approval of the manuscript: all authors.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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