Analysis of Intermediate Term Results of Short Vein Bypass Graft in the Patient with Critical Limb Ischemia

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Purpose: Since the introduction of short vein bypass (SVB), many have reported its feasibility when long vein bypass (LVB) cannot be performed due to limited vein conduit. However, the presence of inflow-vessel disease may affect graft patency and thus require endovascular treatment prior to surgery. Our study aims to analyze the results between SVB and LVB.

Materials and Methods: From 2009 to 2013, 27 bypass procedures were reviewed retrospectively. Outcomes such as patency rate, postoperative ankle brachial index (ABI) and limb salvage rate between SVB and LVB were compared. Wound healing time and primary patency rate were analyzed and the former was also analyzed according to the respective angiosome and revascularization type.

Results: There were 11 males and 16 females and the mean age was 66.6±12.3 years. Twenty four patients had TransAtlantic Inter-Society Consensus (TASC) D and 3 patients had TASC C lesions below knee. The 1-year cumulative patency rate between SVB and LVB were 63% and 66%, P=0.627. The limb salvage rate (100% vs. 73%; P=0.280) and postoperative ABI (0.592 vs. 0.508; P=0.620) were higher in the SVB group than in the LVB group, although the differences were not significant. There was no difference in wound healing time by angiosomal revascularization type. In situ vein graft showed higher patency rate than reversed greater saphenous vein (75% vs. 61%; P=0.00)

Conclusion: The results of SVB were similar to those of LVB. SVB is feasible in the setting of limited conduit availability, in combination with endovascular treatment in the presence of proximal lesions.

Key Words: Distal, Bypass, Angiosome

INTRODUCTION

Short vein bypass (SVB) also known as distal origin bypass graft, was proposed by Veith et al. [1] in 1985; in this procedure, the lower end of the superficial femoral artery or popliteal artery is grafted to the distal artery during infrainguinal arterial bypass surgery. SVB can be applied for patients in various clinical conditions, e.g., patients at high risk of lower extremity edema or in obese patients for avoiding excessive groin excision. It is especially useful when the use of autogenous vein is limited during arterial bypass surgery. A previous study by Veith et al. [1] suggested that such patients can benefit from SVB.

Reed et al. [2], in a large-scale research, analyzed the long-term (22 years) outcomes of SVB and found high 5-year cumulative patency (62%) and limb salvage (79%)

rates. Peripheral vascular lesions incurred by patients with diabetes are usually limited to the below-knee blood vessels, and the long-term outcomes with SVB for peripheral vascular lesions in diabetic patients are superior to those of non-diabetic patients [3]. The majority of non-diabetic and a small proportion of diabetic patients with critical limb ischemia can incur lesions in the above-knee inflow artery; it is difficult to surgically treat this part, and such a treatment can adversely affect long-term surgical outcomes. Alternatively, preoperative endovascular treatment can be performed on the inflow artery, thus facilitating surgical interventions in such cases to improve long-term outcomes [4].

However, most SVB-related data have been published in countries other than Korea, and relevant studies in Korea are lacking. Against this background, we aimed to determine the efficacy of distal origin bypass graft by investigating the clinical manifestations of patients with critical limb ischemia who had undergone distal origin bypass, and by performing comparative analyses of proximal and distal origin bypass grafts.

MATERIALS AND METHODS

We performed retrospective analyses by reviewing the medical records and obtaining data using wired network for 27 patients diagnosed with critical limb ischemia who were subjected to lower extremity arterial bypass from April 2009 to May 2013 in Chosun University Hospital. They were divided into SVB (19 patients) and long vein bypass (LVB, 8 patients) groups [5]. SVB was defined as distal (below-ankle) arterial bypass originating from the lower end of the superficial femoral artery or popliteal artery, while LVB was defined as a distal arterial bypass originating from the common femoral artery. Intergroup comparisons were made with respect to clinical features, patency rate, limb salvage rate, and postoperative ankle brachial index (ABI). Cumulative patency rates were evaluated using ABI or ultrasonography by measuring patency rates during each postoperative follow-up. A patency evaluation was performed on 17 patients after the exclusion of 10 patients whose ABI could not be determined. Conduits used in the bypass procedures were also comparatively analyzed. Finally, a comparative analysis was performed on the wound healing time according to direct or indirect angiosomal revascularization. Because of small sample size, we checked the distribution of continuous variables such as age, wound healing time and ABI by Kolmogorov-Smirnov test. In addition to this, ordinal variables such as the TransAtlantic Inter-Society Consensus (TASC) classification and Rutherford classification were analyzed

by Mann-Whitney U test. The remaining variables were nominal variables, so the chi-squared test was used. The Kaplan-Meier method was used for calculation of patency rate and limb salvage rate. IBM SPSS Statistics 20.0 (IBM Co., Armonk, NY, USA) program was used for analysis. The institutional review board approval was obtained (Chosun University Hospital, 2013-12-009).

Table 1. Demographic and clinical characteristics (n=27)

Characteristic	Value
Age (y)	66.68±12.35
Sex	
Male	11 (40.7)
Female	16 (59.3)
Risk factor for vascular disease	
Diabetes mellitus	12 (42.9)
Hypertension	16 (57.1)
Cerebrovascular disease	7 (25.0)
Coronary artery disease	2 (7.1)
Smoking	14 (50.0)
TASC (below the knee)	
A	-
B	-
C	3 (11.1)
D	24 (88.9)
TASC (infrainguinal)	
A	7 (25.9)
B	7 (25.9)
C	6 (22.2)
D	7 (25.9)
Rutherford	
1	-
2	-
3	-
4	10 (37.0)
5	12 (44.4)
6	5 (18.5)
Location of lesion	
Right	16 (59.3)
Left	10 (37)
Both	1 (3.7)
Procedure	
Hybrid surgery	6 (22.2)
Bailout surgery	3 (11.1)
Surgery	18 (66.6)

Values are presented as mean±standard deviation or number (%).
TASC, TransAtlantic Inter-Society Consensus.

RESULTS

1) Comparison of clinical features

The clinical features of the 27 subjects (11 males, 16 females) are as follows: The average age was 66.6±12.3 years. Among the risk factors for vascular disorders, diabetes accounted for 42.9% (n=12), followed by hypertension (n=16; 57.1%), coronary artery diseases (n=7; 25.0%), and cerebrovascular diseases (n=2; 7.1%). In all, 50.0% (n=14) of the patients were smokers (Table 1).

2) Comparison of SVB and LVB

SVB and LVB were performed on 19 and 8 patients, respectively. With respect to location-dependent lesions, no statistically significant intergroup difference was noted. The SVB group included 12 (63.2%) patients with peripheral artery occlusive diseases (PAOD), 4 (21.1%) with aortoiliac occlusive disease, and 3 with Buerger's disease (15.8%), while all 8 patients in the LVB group had PAOD (Table 2).

In terms of TASC classification of below-knee vascular diseases, TASC C was applied to 2 (10.5%) and 1 (12.5%) patients in the SVB and LVB groups, respectively, while TASC D was applied to 17 (89.5%) and 7 (87.5%) patients in the SVB and LVB groups, respectively, indicating severe vascular occlusion in most patients. In TASC classification of infra-inguinal vascular disease, TASC A was applied to 7 (36.8%) patients, TASC B to 7 (36.8%) patients and TASC C to 5 (26.3%) patients in the SVB group, while TASC C was applied to 1 (12.5%) patient and TASC D to 7 (36.8%) patients. According to the Rutherford classification, which is used for clinical purposes, most patients fell under the grades corresponding to critical limb ischemia: Grade 4 was applied to 5 (26.5%) and 5 (62.5%) patients in the SVB and LVB groups, Grade 5 was applied to 10 (52.6%) and 2 (25.0%) patients and Grade 6 was applied to 4 (21.1%) and 1 (12.5%) patients, respectively (Table 2).

Most of the wounds were located in the toe except for 3 cases (malleolar, foot dorsum, heel). Wound type was classified into two groups: ulcerative wound and gangrenous wound. There were 10 cases of ulcerative wound and 4 gangrenous wounds in the SBV group, and 2 ulcerative wounds and 1 gangrenous wound in the LBV group, respectively (Table 2).

Comparison by vascular condition revealed 2 (10.5%) stenotic and 17 (89.5%) occlusive lesions in the SVB group and 8 (100%) occlusive lesions in the LVB group, thus demonstrating no statistically significant intergroup difference and high percentages of occlusive lesions in both groups (Table 2).

When comparing hybrid and surgical treatments, the hybrid treatment was defined as preoperative endovascular treatment of the inflow artery, i.e., balloon angioplasty or stenting therapy. Hybrid-procedure and single-procedure surgery was performed in 5 (26.3%) and 11 (57.9%) patients respectively, in the SVB group and 1 (12.5%) and 7 (87.5%)

Table 2. Comparison of clinical characteristics between short vein bypass (SVB) and long vein bypass (LVB)

Characteristic	SVB (n=19)	LVB (n=8)	P-value
Location of lesion			0.355
PAOD	12 (63.2)	8 (100)	
PAOD, AIOD	4 (21.1)	0	
Others	3 (15.8)	0	
Rutherford			0.163*
1	–	–	
2	–	–	
3	–	–	
4	5 (26.3)	5 (62.5)	
5	10 (52.6)	2 (25.0)	
6	4 (21.1)	1 (12.5)	
TASC (infrainguinal)			<0.05*
A	7 (36.8)	–	
B	7 (36.8)	–	
C	5 (26.3)	1 (12.5)	
D	–	7 (36.8)	
TASC (below the knee)			0.938*
A	–	–	
B	–	–	
C	2 (10.5)	1 (12.5)	
D	17 (89.5)	7 (87.5)	
Wound type (%)			0.128*
None	5 (26.3)	5 (62.5)	
Ulceration	10 (52.6)	2 (25.0)	
Gangrene	4 (21.1)	1 (12.5)	
Vessel condition			0.487
Stenosis	2 (10.5)	–	
Occlusion	17 (89.5)	8 (100)	
Amputation			0.487
+	5 (26.3)	0 (0)	
–	14 (73.7)	8 (100)	
Procedure			0.280
Hybrid surgery	5 (26.3)	1 (12.5)	
Surgery	11 (57.9)	7 (87.5)	
Bailout procedure	3 (15.8)	–	

Values are presented as number (%).
PAOD, peripheral artery occlusive diseases; AIOD, aortoiliac occlusive disease; TASC, TransAtlantic Inter-Society Consensus.
*P-value was calculated by Mann-Whitney U test.

patients in the LVB group. In the SVB group, 3 patients who had endovascular treatment were excluded, which were bailout procedures. There was no statistically significant intergroup difference. By concrete hybrid procedure, 3 patients received balloon angioplasty or stenting on the ipsilateral iliac artery and 2 patients received balloon angioplasty on the superficial femoral artery in the SVB group. In the LVB group, iliac artery balloon angioplasty was performed in 1 patient (Table 2).

No statistical intergroup difference was observed in the time to recovery from injury with an average of 51.92 and 90.00 days for the SVB and LVB groups, respectively. There were no statistically significant intergroup differences in the ABI change from baseline to postoperative values with an average of 0.508 and 0.592 observed in the SVB and LVB groups, respectively (Table 3). The limb salvage rate was 73% in the SVB and 100% in the LVB groups, with no

statistically significant intergroup difference (Table 3). The 1-year cumulative patency rate was 66% for the SVB group and 63% for the LVB group, and the difference was not statistically significant (Fig. 1).
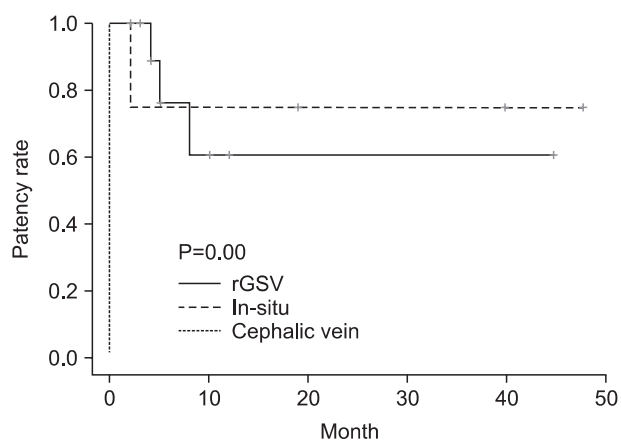
3) Comparison of conduit

The reversed greater saphenous vein (GSV) was used on 20 of the 27 patients (74.1%); specifically, 6 patients (22.2%) received in-situ GSV, and 1 patient (3.7%) received brachial vein graft (Table 4). The comparison of conduit-related limb salvage rate revealed that reversed and in-situ GSV yielded 85.0% and 83.3% salvage rate, respectively, and the brachial vein case was excluded because below-knee limb amputation was performed immediately after surgery (Table 4).

The comparison of 1 year cumulative patency rate showed statistically significant intergroup difference, with reversed and in-situ GSV resulting in 61% and 75% patency, respectively (Fig. 2).

4) Angiosome

Comparison of the wound healing time depending on direct or indirect angiosomal revascularization revealed that the wound healing times for indirect and direct revascularization were 49 and 58 days, respectively, without statistical significance (Table 5).

Table 3. Comparison of outcome between short vein bypass (SVB) and long vein bypass (LVB)

	SVB (n=19)	LVB (n=8)	P-value
Wound healing time (d)	51.92	90.00	0.261
ABI difference after treatment	0.508	0.592	0.620
Limb salvage rate (%)	73	100	0.280

ABI, ankle brachial index.
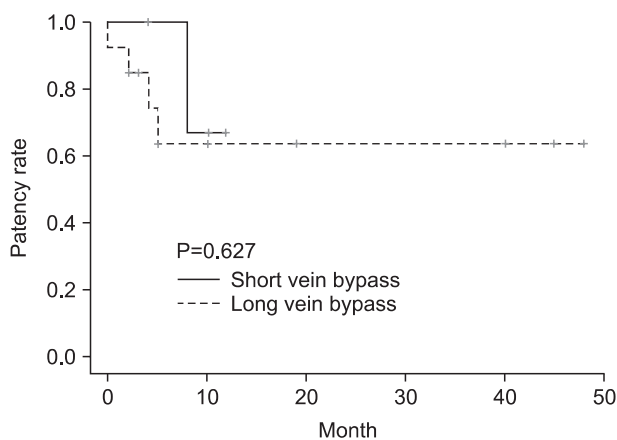
Fig. 1. Cumulative patency rate between short vein bypass and long vein bypass.

Fig. 2. Cumulative patency rate by conduit.

Table 4. Comparison of clinical outcomes of conduit

	Number (%)	Limb salvage rate (P=0.101)
Reversed GSV	20 (74.1)	85.0%
In-situ	6 (22.2)	83.3%
Arm vein	1 (3.7)	0

GSV, greater saphenous vein.

Table 5. Comparison of wound healing time by angiosomal revascularization

	DR (n=5)	IR (n=12)	P-value
Wound healing time (d)	49.00	58.33	0.637

DR, direct revascularization; IR, indirect revascularization.

DISCUSSION

Since the advent of endovascular treatment for peripheral arterial vascular disease, the rapid development of instruments and techniques has enabled endovascular treatment of minor vascular lesions in the superficial femoral artery, as well as treatment of 15-cm-long, moderate-to-severe stenotic or occlusive lesions [6]. However, in cases of patients with critical limbs and multiple vascular lesions or long occlusive lesions, it is difficult to address such issues with this treatment alone, and surgical treatment is desirable for long-term improvement in patency rate [7].

It was found in a comparative meta-analysis of the 1-year cumulative patency rates between endovascular treatment and surgery on below-knee vascular lesions in patients with critical limb ischemia that surgical intervention resulted in 81% and endovascular treatment had a 58.1% rate (P<0.05), thus demonstrating the superiority of surgical intervention [8]. In the event that an autogenous conduit cannot be sufficiently obtained, a synthetic polytetrafluoroethylene vessel and brachial vein can be used, although these may have inferior outcomes compared to conduits [9]. SVB was attempted in such limited circumstances as an alternative to surgical intervention. According to previous related studies, the distal lower limb artery (distal superficial femoral artery or popliteal artery) can be used as inflow vessels so that a short GSV can be used, which can avoid unnecessary surgical excision and lead to reduced surgery time as well as reduce the risk of conduit compression [1, 10]. More recently, a study with 249 patients analyzed the long-term outcomes of SVB; the results revealed a satisfactory 5-year cumulative patency rate (62%) and limb salvage rate (79%) [2,3]. In particular, it was reported that the superior cumulative patency and limb salvage rates of diabetic patients who have vascular lesions that are characteristically limited to below the knee are greater than that of non-diabetic patients (73% vs. 45% [P<0.01] and 84% vs. 69% [P<0.04], respectively) [3]. In our study, however, a hybrid method using preoperative endovascular treatment (balloon angioplasty and stent placement) was concurrently performed to address the problem of concomitant inflow lesions and enable the application of SVB. One study investigating the efficacy of preoperative endovascular treatment in cases of inflow lesions did not find any statistically significant differences in cumulative patency rate between groups without and with inflow lesions, in which the latter received preoperative endovascular treatment. The hybrid procedure is generally effective in patients with TASC A and B lesions as per infrainguinal classification secondary to below-knee arterial lesions. It was also suggested that in cases in which patients cannot be treated with a single-surgery procedure, preoperative endovascular treatment as a preliminary procedure can augment the chances of such patients to undergo surgery [4].

It was found in the present study that 5 of 19 patients (26.3%) in the SVB group could undergo surgery after receiving endovascular treatment to address the inflow lesions. In the LVB group, however, endovascular treatment was performed in only 1 patient (12.5%) because surgery was the first choice for patients with critical limb ischemia due to its proven superiority, provided that sufficient autogenous veins are available [11].

Our comparative analyses of the SVB and LVB groups did not yield any statistically significant intergroup differences in postoperative changes in ABI, wound healing time, limb salvage rate, and 1-year cumulative patency rate. Brochado Neto et al. [5] also reported that the 5-year cumulative patency rates of the SVB and LVB groups were 51% and 55.5% (P=0.87), respectively, the difference of which was not statistically significant. From these results, it may be inferred that SVB is an effective method for treating patients with critical limb ischemia in need of surgical treatment but with insufficient conduits. Moreover, as demonstrated in many studies, it has advantages over LVB in that it can avoid excessive skin excision and reduce surgery time [6,12].

Another study investigating the cumulative patency rate of SVB reported that the 1-year cumulative patency rate of TASC A and B according to the below-knee arterial lesion classification was 74% [4], which is higher than that of the present study; however, considering that the patients in our study had moderate-to-severe vascular lesions corresponding to TASC C and D of generally comparable classifications, this difference cannot be considered significant.

Comparative analysis of conduit-related cumulative patency rates revealed the superiority of in-situ GSV (75%) over reversed GSV (61%; P<0.05). Reversed GSV generally has a better cumulative patency rate [13]; however, skillful surgeons can contribute to the improvement of in-situ GSV through special care and refined vascular manipulation, thus approximating the patency rate of in-situ GSV but resulting in no statistically significant difference from that of reversed GSV [14,15].

After Taylor and Palmer's landmark report in 1987 [16] on the efficacy of angiosome, the angiosome concept was introduced to the treatment of patients with critical limb ischemia. Later comparative studies investigated the direct and indirect angiosomal revascularizations, and some reported on the superiority of direct revascularization over indirect revascularization [17]. In the present study, however, no statistically significant intergroup difference was found in wound healing times. Neville et al. [18] also

reported a lack of intergroup differences in would healing time. The reason for the absence of definitely concordant results on revascularization indicates the limitation inherent to the angiosome concept. First, the angiosome differs in each patient. Second, it cannot be clearly distinguished due to the multifarious arterial interconnections. Finally, there is still lack of data, and no large-scale prospective research with an adequate control group [19]. Therefore, while direct revascularization is favored from the standpoint of vascular surgeons, given the high frequency of cases requiring indirect revascularization, it seems desirable to perform grafting on vessels with good vascular status.

CONCLUSION

The limitations of this study are its small sample size and intermediate-term comparative analysis. As mentioned above, however, the results obtained seem clear enough to infer that SVB is an effective method for surgically treating patients who have critical limb ischemia with limited conduit availability and patients with obesity at high risk of lower extremity edema for avoiding excessive groin excision. In particular, in cases of patients with critical limb ischemia and concomitant multiple vascular lesions who encounter surgical difficulties, preoperative endovascular treatment is expected to be an effective surgical preparation method.

We hope that continuous interest and optimally designed prospective research will contribute to raising general awareness about this effective method that is currently being neglected in Korea.

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