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Clinical Research

Clinical Outcomes of Arteriovenous Grafts Using the Superficial Vein versus Venae Comitantes as Venous Outflow

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Background: The superficial veins are commonly used in conventional autogenous arteriovenous fistulas and the placement of prosthetic grafts. When they are unsuitable, however, the use of the deep veins (venae comitantes) is generally considered to be a reasonable alternative. This study conducted a comparative analysis of clinical outcomes for arteriovenous grafts between 2 groups based on the type of venous outflow: superficial veins or venae comitantes.
Methods: In total, 151 patients who underwent arteriovenous grafts from November 2005 to March 2022 were retrospectively analyzed. The patients were divided into 2 groups: group A (superficial veins, n=89) and group B (venae comitantes, n=62). The primary, secondary patency, and complication rates were analyzed in each group. A propensity score-matched analysis was performed.
Results: In total, 55 well-balanced pairs were matched. Kaplan-Meier analysis revealed no significant differences in the primary patency rate between the 2 groups at 1-year, 3-year and 5-year intervals (group A, 54.7%, 35.9%, 25.4% vs. group B, 47.9%, 16.8%, 12.6%; p=0.14), but there was a difference in the secondary patency rate (group A, 98.2%, 95.3%, 86.5% vs. group B, 87.3%, 76.8%, 67.6%; p=0.0095). The rates of complications, simple percutaneous transluminal angioplasty, and stent insertion were comparable between the groups.
Conclusion: Although this study demonstrated not particularly favorable secondary patency rates in the venae comitantes group, the venae comitantes may still be a viable option for patients with unsuitable superficial veins because there were no significant differences in the primary patency and complication rates between the 2 groups.

Keywords: Arteriovenous fistula, Graft, Vein, Hemodialysis, Chronic kidney failure

Introduction

Hemodialysis, a commonly used method of dialysis for patients with end-stage renal disease, depends heavily on the stability and durability of the access site. Successful hemodialysis requires a reliable and long-lasting access pathway. The creation of an arteriovenous fistula (AVF) using the patient's own blood vessels is the most common method for establishing a suitable access pathway, and it is favored for its low complication rates and stability [1-3]. However, the formation of an autogenous AVF may not always be feasible in hemodialysis patients due to the poor condition of veins from repeated venipuncture and cannulation.

In cases where a prosthetic graft is used to create an arteriovenous anastomosis, alternative approaches may be considered [4-6]. The aging population is on the rise, and with it, the prevalence of renal disease has also increased. This has led to a corresponding surge in surgical procedures to establish hemodialysis access. Consequently, the use of arteriovenous grafts (AVGs) has become more common. In AVG procedures, the outflow vein is typically a superficial vein (SV), such as the cephalic, antecubital, or basilic vein. However, in certain cases, the deeper-seated venae comitantes (VCs) may be utilized, depending on the patient's vascular condition. The VCs are usually in better condition than the SVs, as they are located deeper within the body [5-9]. Despite the increasing frequency of these surgeries, there is a paucity of research comparing long-term outcomes based on different venous outflows or offering guidance on vessel selection. To address this gap, we conducted a study at our university hospital. The aim was to compare and analyze the long-term patency rates and the incidence of complications in AVG procedures, with a focus on the variations in venous outflow chosen.

Methods

Patients

We conducted a retrospective analysis of the clinical outcomes for 151 patients who underwent AVG surgery for chronic renal failure and hemodialysis at Konkuk University Hospital from November 2005 to March 2022. From the initial cohort of 162 patients, we excluded 9 due to loss of follow-up and 2 who passed away within 1-month post-surgery for reasons not related to the procedure. Our study drew upon medical records to assess various clinical parameters, including sex, age, medical history (comprising hypertension, diabetes, cardiovascular disease, cerebrovascular disease, and peripheral vascular disease), current dialysis status, and any previous AVF surgery.

Grouping was performed based on the type of venous outflow: patients who underwent surgery with an SV were placed in group A, while those who had surgery involving the VCs were placed in group B. Primary and secondary patency rates were evaluated for each group at 1-year, 3-year, and 5-year intervals post-surgery, and complication rates were also analyzed. The primary patency rate was defined as the duration from surgery to the first intervention required due to graft malfunction, such as infection, hematoma, or thrombosis. The secondary patency rate was defined as the duration from surgery to the point of complete graft failure, rendering it unusable for hemodialysis, regardless of the number of interventions. Complications were defined as events necessitating surgical intervention within 6 months postoperatively, including aneurysms, infections, and occlusions. The follow-up observation period extended from the date of surgery to the last outpatient visit. In cases where patients died from causes unrelated to the AVG, the follow-up continued until the date of death.

Surgical procedures

Before surgery, venography was conducted on both arms to assess the venous system from the wrist to the axilla. The results of this evaluation guided the selection of the arm and the surgical approach to be used. If the venography showed autogenous vessels to be notably thin or tortuous, an AVG procedure was chosen. Cases with severe stenosis or complete occlusion in more than 90% of the vessels, as indicated by venography, were excluded from the study.

The final decision regarding venous outflow was made intraoperatively through direct evaluation of the veins. If the SV was deemed suitable, the procedure was carried out immediately; if not, the VCs were selected as an alternative. Typically, surgery was performed on the nondominant arm. Local anesthesia with lidocaine was used when patients could effectively cooperate. For those unable to cooperate due to conditions such as dementia or mental impairment, general anesthesia was administered. Polytetrafluoroethylene grafts, ranging from 4 to 6 mm in diameter, were utilized as artificial conduits. Vascular anastomosis was performed using either 7-0 Pronova (Ethicon, Raritan, NJ, USA) or 7-0 Gore-Tex (Gore Medical, Flagstaff, AZ, USA) sutures. During the procedure, a heparin solution (10 units/mL, 50 mL) was applied locally to the target vessel.

A 4 cm horizontal skin incision was made approximately 2 cm from the antecubital fold. The brachial artery and SV were exposed, and a vascular evaluation was performed. If the condition of the SV was suboptimal, characterized by small size or weak vessel walls, the exposure was extended to include the cephalic vein. To create a tunnel for the graft, a rough outline was drawn on the skin with a pen, about 10 cm from the incision site, and a 2 cm horizontal incision was made. A tunneling device was then used to create the pathway for the graft. The graft was subsequently trimmed to the appropriate size. Using bulldog clamps, the brachial artery was clamped both proximally and distally, and an arteriotomy of 0.8 cm was performed. Heparin was administered, and an end-to-side anastomosis was initiated. Just before completing the anastomosis, the clamps were released to evacuate any air. Hemostasis was achieved using a hemostatic agent (Fibrillar; Ethicon). The venous anastomosis was performed using a similar technique, followed by the attainment of hemostasis. A thorough check for a palpable thrill was conducted, and if the thrill was weak, the subcutaneous tissues around the venous outflow were dissected to ensure adequate blood flow. A Penrose drain was inserted, and the skin was closed with interrupted sutures using 4-0 nylon. The presence of thrill and bruit was confirmed again postoperatively. Systemic heparin was not administered.

Statistical analysis

Statistical analyses were conducted using R software ver.

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4.2.1 (R Foundation for Statistical Computing, Vienna, Austria). To compare the clinical characteristics between the 2 groups, we used the Wilcoxon signed-rank test, chi-square test, Fisher exact test, and McNemar test. Propensity score matching was utilized to adjust for differences in baseline characteristics between the groups. We conducted a survival analysis of primary and secondary patency rates by dividing the groups into intervals of 1 year, 3 years, and 5 years post-surgery, employing Kaplan-Meier curves and the log-rank test for this purpose. The chi-square and Fisher exact tests were applied to analyze the complication rates between the groups. Additionally, the McNemar test was used to compare the rates of simple percutaneous transluminal angioplasty (PTA) and stent insertion. A significance level of 5% was adopted for all statistical tests.

This study was reviewed and approved by the Institutional Review Board of Konkuk University Hospital, which waived the requirement for informed consent (IRB approval no., 2023-05-065).

Results

Patients' clinical characteristics

The study included 63 men and 47 women, with an average patient age of 70.0 years (range, 27–96 years). Hypertension was present in 90 patients (81.8%), while diabetes was noted in 67 patients (60.9%). Additionally, 21 patients (19.1%) had a history of cerebrovascular disease, 33 (30.0%) had cardiovascular disease, and 4 (3.6%) had peripheral vascular disease. At the time of surgery, 70 patients (63.6%) were receiving hemodialysis, and 18 patients (16.4%) had previously undergone AVF surgery. Following propensity score matching, no significant differences were observed across any of the variables (Table 1).

Table 1. Demographic characteristics of patients

Characteristic	Unmatched patients				Propensity score-matched patients			
	Total (N=151)	Superficial vein (N=89)	Venae comitantes (N=62)	p-value	Total (N=110)	Superficial vein (N=55)	Venae comitantes (N=55)	p-value
Sex								
Male	86 (57.0)	49 (55.1)	37 (59.7)	0.573	63 (57.3)	33 (60.0)	30 (54.5)	0.728
Female	65 (43.0)	40 (44.9)	25 (40.3)		47 (42.7)	22 (40.0)	25 (45.5)	
Age (yr)	69 (57.5–77)	69 (56–75)	69 (60–81)	0.274	70 (60–78)	73 (66.5–78)	68 (60–80.5)	0.362
History								
Hypertension								
No	34 (22.5)	23 (25.8)	11 (17.7)	0.241	20 (18.2)	9 (16.4)	11 (20.0)	0.823
Yes	117 (77.5)	66 (74.2)	51 (82.3)		90 (81.8)	46 (83.6)	44 (80.0)	
Diabetes mellitus								
No	58 (38.4)	33 (37.1)	25 (40.3)	0.687	43 (39.1)	23 (41.8)	20 (36.4)	0.663
Yes	93 (61.6)	56 (62.9)	37 (59.7)		67 (60.9)	32 (58.2)	35 (63.6)	
Cerebrovascular disease								
No	127 (84.1)	77 (86.5)	50 (80.6)	0.332	89 (80.9)	44 (80.0)	45 (81.8)	1.000
Yes	24 (15.9)	12 (13.5)	12 (19.4)		21 (19.1)	11 (20.0)	10 (18.2)	
Cardiovascular disease								
No	106 (70.2)	66 (74.2)	40 (64.5)	0.203	77 (70.0)	39 (70.9)	38 (69.1)	1.000
Yes	45 (29.8)	23 (25.8)	22 (35.5)		33 (30.0)	16 (29.1)	17 (30.9)	
Peripheral vascular disease								
No	145 (96.0)	87 (97.8)	58 (93.5)	0.229	106 (96.4)	53 (96.4)	53 (96.4)	1.000
Yes	6 (4.0)	2 (2.2)	4 (6.5)		4 (3.6)	2 (3.6)	2 (3.6)	
Hemodialysis								
No	48 (31.8)	26 (29.2)	22 (35.5)	0.416	40 (36.4)	20 (36.4)	20 (36.4)	1.000
Yes	103 (68.2)	63 (70.8)	40 (64.5)		70 (63.6)	35 (63.6)	35 (63.6)	
History of AVF								
No	125 (82.8)	69 (77.5)	56 (90.3)	0.04	92 (83.6)	43 (78.2)	49 (89.1)	0.077
Yes	26 (17.2)	20 (22.5)	6 (9.7)		18 (16.4)	12 (21.8)	6 (10.9)	

Values are presented as number (%) for categorical variables [tested by the McNemar test] or median (Q1–Q3) for continuous variables [tested by the Wilcoxon signed-rank test].
AVF, arteriovenous fistula.

Primary patency rate

The primary patency rates were analyzed using Kaplan-Meier survival analysis. The 1-year, 3-year, and 5-year patency rates for group A were 54.7%, 35.9%, and 25.4%, respectively, while for group B, they were 47.9%, 16.8%, and 12.6%. Although group A demonstrated better outcomes, the difference was not statistically significant (p=0.14). The median intervention times were 500 days for group A and 329 days for group B (Fig. 1).

Secondary patency rate

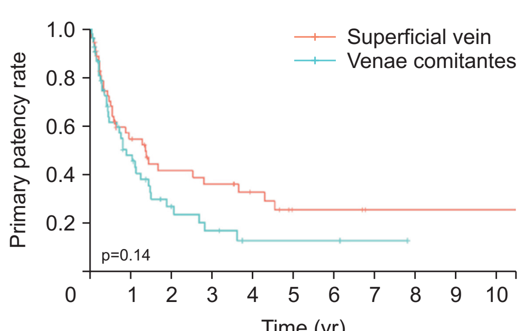
The secondary patency rates were analyzed using Kaplan-Meier survival analysis. The 1-year, 3-year, and 5-year patency rates for group A were 98.2%, 95.3%, and 86.5%, respectively, while for group B, they were 87.3%, 76.8%, and 67.6%, respectively. In contrast to the primary patency rate results, the secondary patency rates were significantly better in group A (p=0.0095). The median intervention time was not applicable for group A, whereas it was 2,422 days for group B (Fig. 2).

Complication, simple percutaneous transluminal angioplasty, and stent insertion rates

A total of 65 patients (59.1%) experienced complications, with occlusion being the most common, affecting 59 patients (group A: n=27, 49.1%; group B: n=32, 58.2%). Infections were noted in 9 patients (group A: n=5, 9.1%; group B: n=4, 7.3%), aneurysms in 2 (group A: n=2, 3.6%), and other complications, such as hematoma and malfunction, occurred in 2 patients, both in group A. However, there were no statistically significant differences in complication rates between the 2 groups (Table 2). Additionally, 67 patients (61.0%) underwent further interventions, with 49 (44.5%) receiving PTA alone and 18 (16.4%) undergoing additional stenting. There was no significant difference in the rate of additional interventions between the groups (Table 3).

Discussion

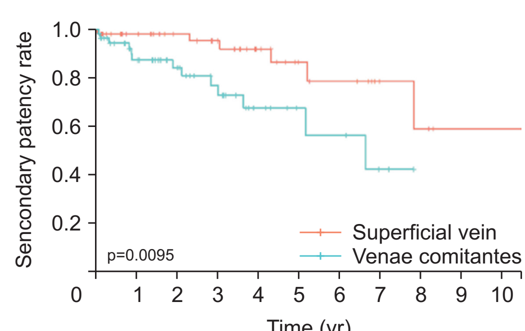
With the ongoing trend of population aging, the number of patients with end-stage renal disease is steadily increasing. Moreover, the age at which dialysis is initiated has been progressively decreasing. For patients with poor or no renal function, hemodialysis is essential for sustaining life, making the establishment of stable vascular access imperative. Currently, the autogenous AVF is considered the first-choice option for vascular access, as numerous studies have demonstrated its superiority over AVGs in terms of long-term patency and lower complication rates [1-6,10,11].Although an AVF at the snuffbox or wrist is considered the optimal choice, many patients with chronic kidney disease face challenges. Repeated blood sampling can often damage or narrow the veins, making them unsuitable for use or leading to their immaturity after surgery [4,6,9]. Consequently, anastomosis of the brachial artery near the elbow is commonly performed. However, this method can cause discomfort during hemodialysis due to the mature brachial vessels and increase the risk of complications such as congestive heart failure [5]. In situations where AVF creation is



No. at risk	0	1	2	3	4	5	6	7	8	9	10
Superficial vein	55	23	15	13	9	3	3	1	1	1	1
Venae comitantes	55	20	9	5	2	2	2	1	0	0	0

	N	Event	Secondary patency rate (%)			Median patency time (day)	Log-rank test p
			1-yr	3-yr	5-yr		
Superficial vein	55	32	54.7	35.9	25.4	500	0.14
Venae comitantes	55	37	47.9	16.8	12.6	329	

Fig. 1. Kaplan-Meier plot of primary patency rates after 1:1 propensity score matching (n=110).



No. at risk	0	1	2	3	4	5	6	7	8	9	10
Superficial vein	55	41	34	29	19	11	9	4	3	1	1
Venae comitantes	55	37	27	19	10	6	5	2	0	0	0

	N	Event	Secondary patency rate (%)			Median patency time (day)	Log-rank test p
			1-yr	3-yr	5-yr		
Superficial vein	55	6	98.2	95.3	86.5	-	0.0095
Venae comitantes	55	13	87.3	76.8	67.6	2,422	

Fig. 2. Kaplan-Meier plot of secondary patency rates after 1:1 propensity score matching (n=110).

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Table 2. Comparison of complications between the 2 groups

Variable	Total (N=110)	Superficial vein (N=55)	Venae comitantes (N=55)	p-value
Complications				
No	45 (40.9)	24 (43.6)	21 (38.2)	0.700
Yes	65 (59.1)	31 (56.4)	34 (61.8)	
Occlusion				
No	51 (46.4)	28 (50.9)	23 (41.8)	0.458
Yes	59 (53.6)	27 (49.1)	32 (58.2)	
Infection				
No	101 (91.8)	50 (90.9)	51 (92.7)	1.000
Yes	9 (8.2)	5 (9.1)	4 (7.3)	
Aneurysm				
No	108 (98.2)	53 (96.4)	55 (100.0)	0.480
Yes	2 (1.8)	2 (3.6)	0	
Others				
No	108 (98.2)	53 (96.4)	55 (100.0)	0.480
Yes	2 (1.8)	2 (3.6)	0	

Values are presented as number (%) and tested by the McNemar test.

Table 3. Comparison of PTA between 2 groups after 1:1 propensity score matching (N=110)

Variable	Total(N=110)	Superficial vein (N=55)	Venae comitantes (N=55)	p-value
PTA				
Non-PTA	43 (39.1)	21 (38.2)	22 (40.0)	0.688
Simple PTA	49 (44.5)	27 (49.1)	22 (40.0)	
PTA with stent	18 (16.4)	7 (12.7)	11 (20.0)	

Values are presented as number (%) and tested by the McNemar test.
PTA, percutaneous transluminal angioplasty.

not feasible, the formation of an AVG serves as a viable alternative. Although AVGs have a low rate of early closure, their susceptibility to infection as a foreign material and the relatively complex surgical technique contribute to a higher incidence of late complications, such as thrombosis or stenosis, resulting in lower long-term patency rates.

The trend toward using an SV for venous outflow in AVGs has gained prominence. However, there are numerous instances where repeated blood sampling or compromised vein conditions present challenges. In such cases, the VCs could serve as an alternative. These veins are relatively well-preserved, more branched, and larger in diameter. Additionally, their thin vessel walls facilitate effective postoperative vein expansion, which is responsive to interventions such as balloon angioplasty [5,6,9]. While not addressed in this study, the axillary vein in the upper arm could also be considered as an alternative when the vascular condition of the lower arm is unfavorable [6,12]. However, the thin wall and complex vascular course of the axillary vein increase the surgical complexity, often leading to a higher risk of anastomotic site stenosis. This increased complexity may contribute to the significantly lower secondary patency rate observed in VCs than in SVs in this study.

Srinivasaiah et al. [13] reported a 30% rate of both early and late failure in 20 cases of AVF where VCs were used for venous outflow. They observed that 30% of these cases were suitable for use without surgical intervention, whereas an additional 30% necessitated further surgical procedures. In a similar study, SHA HL and colleagues presented 12 cases of AVF, with approximately 58% maintaining successful patency for up to one month [8].

This study has several limitations. First, as this was a single-center study, the sample size was relatively small. Additionally, the study design is retrospective. Second, the last outpatient visit was used as the endpoint of primary and secondary patency. This approach may have led to inaccuracies in patients who did not attend outpatient appointments regularly.

In conclusion, there was no significant difference in primary patency outcomes between the 2 groups. However, the SV group exhibited improved secondary patency rates. This study also showed that postoperative complications, including arm swelling, congestive heart failure, or steal syndrome, were not associated with the use of the VC for venous outflow. Additionally, there was no difference in the rates of simple PTA and stent insertion between the groups. These results indicate that the VCs represent a feasible alternative for venous outflow in AVG formation when the use of SVs is challenging or inappropriate.

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Conceptualization: SAL. Data curation: YSL. Formal analysis: YSL, SAL. Methodology: YSL, SAL. Visualization: YSL. Writing–original draft: YSL. Writing–review & editing: all authors. 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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