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Original Article

Comparison of Outcomes of Hybrid and Surgical Correction for *De Novo* Arteriovenous Graft Occlusion

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Purpose: This study aimed to compare surgical revisions and balloon angioplasty after surgical thrombectomy on thrombosed dialysis access as a first event.

Materials and Methods: Records of patients undergoing creation of arteriovenous grafts (AVGs) at the Gachon University Gil Medical Center between March 2008 and February 2016 were reviewed. Among them, patients who underwent treatment on first-time thrombotic occlusion after AVG creation were identified. Outcomes were primary, primary-assisted, and secondary patency. The patency was generated using the Kaplan-Meier method, and patency rates were compared by log-rank test.

Results: A total of 59 *de novo* interventions (n=26, hybrid interventions; n=33, surgical revisions) for occlusive AVGs were identified. The estimated 1-year primary patency rates were 47% and 30% in the surgery and hybrid groups, respectively. The estimated primary patency rates were not different between the two groups (log-rank test, P=0.73). The Kaplan-Meier estimates of 6 and 12 months for primary-assisted patency rates were 68% and 57% in the surgery group and 56% and 56% in the hybrid group. The Kaplan-Meier estimates of 12 and 24 months secondary patency rates were 90% and 71% in the surgery group and 79% and 62% in the hybrid group. There were no differences in the estimated primary-assisted and secondary patency rates between the two groups.

Conclusion: Our results showed no significant difference between the two groups in terms of primary patency (P=0.73), primary-assisted patency (P=0.85), and secondary patency (P=0.78). However, percutaneous transluminal angioplasty can give more therapeutic options for both surgeons and patients.

Key Words: Arteriovenous graft occlusion, Surgical salvage, Endovascular salvage

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INTRODUCTION

Approximately 42,500 patients in Korea are dependent on hemodialysis (HD), and this number is increasing by 5%-8% annually [1]. The National Kidney Foundation Kidney Disease Outcomes Quality Initiative recommends to increase the use of autogenous fistula; however, many patients in Korea continue to rely on artificial prosthesis graft for access in renal replacement therapy [2]. The reasons for this disparity between the recommendation and clinical practice are multifactorial and still to be debated [3-7].

HD access is the lifeline of patients with end-stage renal disease, and its patency is of paramount importance for patients' survival. Among 649 patients with new arteriovenous grafts (AVG) enrolled in the Dialysis Access Consortium Study, 77% developed stenosis or thrombosis within

the first year [8]. Similarly, among 201 patients with a new AVG enrolled in the Fish Oil Inhibition of Stenosis in HD Grafts Study, 62% developed stenosis or thrombosis within 1 year [9]. Once thrombosis of the graft occurred, thrombectomy should be performed immediately and the underlying stenotic lesions corrected.

In Gachon University Gil Medical Center, we performed two techniques to correct underlying vascular stenotic lesions of thrombosed dialysis access: surgical revision and balloon angioplasty. Surgical revision is the traditional method and may offer definite anatomical correction [10]. However, surgical revision extended the access further up to some extent, so more outflow vein ended up wasted. In addition, balloon angioplasty is available of repetitive procedure without using further outflow vein. Hence, this study aimed to compare surgical revisions and balloon angioplasty (hybrid) after surgical thrombectomy on thrombosed dialysis access as a first event.

MATERIALS AND METHODS

1) Study design

In this retrospective, single-center study, outcomes between hybrid and surgery procedures on first time thrombosis of AVGs were compared. All patients undergoing creation of AVGs at the Gachon University Gil Medical Center between March 2008 and February 2016 were enrolled in the database. Among them, patients who underwent treatment on first-time thrombotic occlusion after AVG creation were identified. Stenotic lesions without thrombosis were excluded, and infection-related thrombosis was also excluded. The study protocol was approved by the Institutional Review Board of Gachon University Gil Medical Center (IRB No. GBIRB2018-218). This study was a retrospective study that did not cause any harm to the study subjects; therefore, the requirement of informed consent was waived by the board.

2) Data collection

Electronic medical records were retrospectively reviewed. The patients' demographics including the type of graft, graft configuration, length of time between thrombosis and salvage procedure, technical success rates, and procedure-related complications were collected. Technical success was defined as restoration of flow through the occluded AVG and resolution of stenosis (<30% residual stenosis) by percutaneous transluminal angioplasty (PTA).

3) Outcomes

For the purpose of this study, the first intervention was identified as the index procedure. The primary outcome was the post-interventional primary patency of thrombosed AVGs. The secondary outcomes were post-interventional primary-assisted patency, secondary patency, and procedure-related complications. Patency was defined as per the recommended reporting standards of the Society for Vascular Surgery.

4) Hybrid procedure

After local anesthesia was administered on the apex of the loop graft, a small longitudinal incision was made. Through transverse anterior graftomy, mechanical thrombectomy was performed using a 5-French Fogarty balloon catheter (Edwards Lifesciences, Irvine, CA, USA) on the venous limb first and then arterial limb sequentially until the bullet was retrieved. Then, the graft was closed, but not tied, so that an interventional sheath (usually 7F) can be introduced. After fistulography, culprit lesions were identified and corrected by plain balloon angioplasty.

5) Surgical procedure

Mechanical thrombectomy was performed using in the same manner as mentioned above. Culprit lesions were identified by exploring venous anastomosis site without

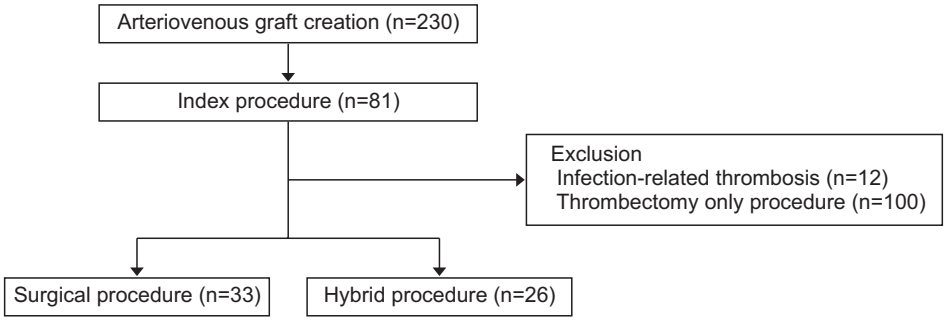

Fig. 1. Schematic diagram of inclusion and exclusion criteria.

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Table 1. Characteristics of patients and grafts

Characteristic	Overall (n=59)	Surgery (n=33)	Hybrid (n=26)	P-value
Age (y)	72 (60-78)	66 (57-76)	76 (67-79)	0.02
Male	24 (40.7)	14 (42.4)	10 (38.5)	0.76
Hypertension	49 (83.1)	26 (78.8)	23 (88.5)	0.33
Diabetes	41 (69.5)	22 (66.7)	19 (73.1)	0.60
Body mass index	22.0 (19.2-24.6)	21.3 (18.2-24.2)	23.3 (20.8-25.2)	0.06
Graft type				0.36
6 mm, ePTFE	40 (67.8)	24 (72.7)	16 (61.5)	
4-6 mm, ePTFE	19 (32.2)	9 (27.3)	10 (38.5)	
Configuration				0.31
Forearm loop	54 (91.5)	31 (93.9)	23 (88.5)	
Upper arm straight	4 (6.8)	1 (3.0)	3 (11.5)	
L. ext. loop	1 (1.7)	1 (3.0)	0 (0.0)	
Inflow artery				0.48
Brachial artery	54 (91.5)	29 (87.9)	25 (96.2)	
Radial artery or ulnar artery	4 (6.8)	3 (9.1)	1 (3.8)	
Femoral artery	1 (1.7)	1 (3.0)	0 (0.0)	
Outflow vein				0.61
Basilic vein	24 (40.7)	13 (39.4)	11 (42.3)	
Cephalic vein	5 (8.5)	2 (6.1)	3 (11.5)	
Brachial vein	23 (39.0)	15 (45.5)	8 (30.8)	
Others	7 (11.9)	3 (9.1)	4 (15.4)	

Values are presented as median (interquartile range) or number (%).
ePTFE, expanded polytetrafluoroethylene.

Table 2. Characteristics of the index procedure

Characteristic	Value
Surgery group	
Time from creation to first occlusion (mo)	9.9 (3.4-20.0)
Procedural type	
Bypass	21 (63.6)
Patch angioplasty	12 (36.4)
Procedural time (min)	75 (60-113)
Hybrid group	
Time from creation to first occlusion (mo)	8.1 (5.3-13.3)
Procedural type	
Balloon angioplasty	23 (88.5)
Bypass+balloon angioplasty	1 (3.8)
Patch angioplasty+balloon angioplasty	2 (7.7)
Procedural site	
Single site	14 (53.8)
Multiple sites	12 (46.2)
Procedural time (min)	103 (80-138)

Values are presented as median (interquartile range) or number (%).

fistulography. Then theywere corrected surgically by patch angioplasty and jump graft.

6) Statistical analysis

We compared patient's demographics, characteristics of graft and index procedure, and outcome between hybrid and surgery interventions. Comparisons were made using Student t-test for continuous variables and chi-square test for categorical variables. The patency was generated using the Kaplan-Meier method, and patency rates were compared using the log-rank test. All analyses were conducted using IBM SPSS Statistics ver. 22.0 software (IBM Co., Armonk, NY, USA). A P-value of <0.05 was considered statistically significant.

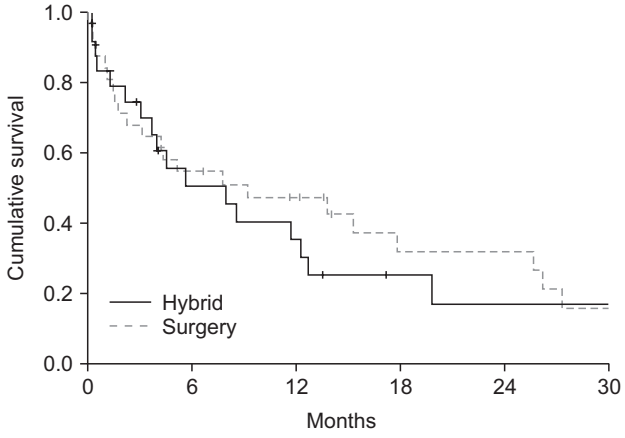
RESULTS

1) Patients

During the study period, 59 *de novo* interventions were performed for occlusive AVGs. Hybrid interventions were indicated for 26 patients and surgical revisions for 33 patients. Inclusion and exclusion criteria are shown in Fig. 1. The clinical characteristics of patients treated with the hybrid and surgical procedures are shown in Table 1. No significant differences were found between the two groups, except for age.

2) Lesions and procedures

Most of the graft types were 6 mm polytetrafluoroethylene with forearm loop configurations (Table 1). The inflow arteries were mostly brachial artery, but outflow veins were mostly the basilic vein or brachial vein. There were no statistical differences between the two groups in terms of graft characteristics. The characteristics of index procedures between two groups were compared, and the median time from AVG creation to the first occlusion event was 9.9 months (interquartile range [IQR], 3.4-20.0 months) in the surgery group and 8.1 months (IQR, 5.3-13.3 months) in the hybrid group (Table 2). In the surgery group, all procedures were performed to correct intimal hyperplasia at the venous anastomosis site by patch angioplasty and bypass. In the hybrid group, most procedures were balloon angioplasty (88.5%), but in three cases (12.0%), surgical correction was also performed (3.8% for bypass, 7.7% for patch angioplasty). Statistically significant difference was found in the procedural time between the two groups. Longer procedural time was needed in the hybrid group than in the surgery group (P=0.005); the median time was 75 minutes (IQR, 60-113 minutes) for the surgery group and 103 minutes (IQR, 80-138 minutes) for the hybrid group.

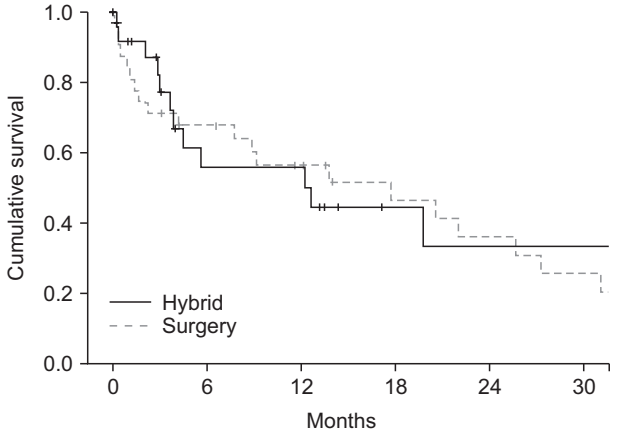


Primary patency	0	3 mo	6 mo	12 mo
Surgery group				
Rate	1.00	0.68	0.55	0.47
No. at risk	33	21	15	13
Hybrid group				
Rate	1.00	0.70	0.50	0.30
No. at risk	26	15	10	6

Fig. 2. Post-intervention primary patency of arteriovenous grafts.

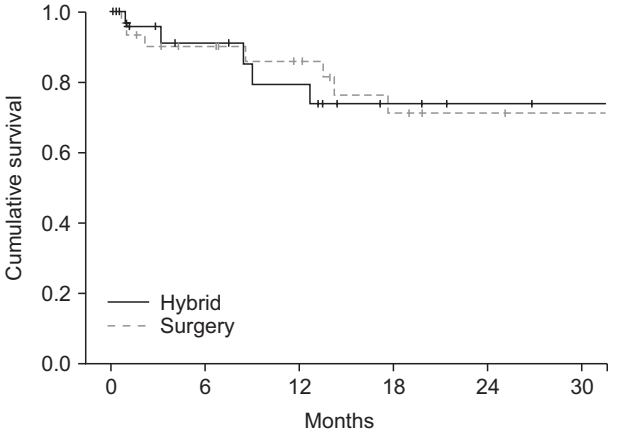
3) Primary outcomes

The median follow-up was 13.6±20.9 months (IQR, 3.1-34.2 months). The Kaplan-Meier estimates of 6-month primary patency rates were 55% in the surgery group and 50% in the hybrid group. The estimated one-year primary



Primary-assisted patency	0	3 mo	6 mo	12 mo
Surgery group				
Rate	1.00	0.71	0.68	0.57
No. at risk	33	22	19	14
Hybrid group				
Rate	1.00	0.77	0.56	0.56
No. at risk	26	16	10	10

Fig. 3. Post-intervention primary assisted patency of arteriovenous grafts.



Secondary patency	0	3 mo	6 mo	12 mo	18 mo	24 mo
Surgery group						
Rate	1.00	0.90	0.90	0.86	0.71	0.71
No. at risk	33	26	24	20	14	12
Hybrid group						
Rate	1.00	0.96	0.90	0.79	0.74	0.62
No. at risk	26	19	18	14	9	5

Fig. 4. Post-intervention secondary patency of arteriovenous grafts.

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patency rates were 47% and 30%, respectively. The estimated primary patency rates were not different between the hybrid and surgery groups (log-rank test, P=0.73) (Fig. 2). The Kaplan-Meier estimates of 6- and 12-month primary-assisted patency rates were 68% and 57% in the surgery group and 56% and 56% in the hybrid group, respectively (Fig. 3). The Kaplan-Meier estimates of 12- and 24-month secondary patency rates were 90% and 71% in the surgery group and 79% and 62% in the hybrid group, respectively (Fig. 4). There were no differences in the estimated primary-assisted and secondary patency rates between the two groups. Technical success was 97% in the surgery group and 92% in the hybrid group. One procedural complication was found, such as vein rupture during angioplasty in the hybrid group.

DISCUSSION

In this study, we compared the outcomes between the hybrid technique and surgery on *de novo* AVG thrombosis. The result showed no significant difference between the two groups in terms of primary patency (P=0.73), primary-assisted patency (P=0.85), and secondary patency (P=0.78).

Prior to the introduction of PTA, most procedures on thrombosed AV access were surgeries, such as patch angioplasty and jump graft. Thereafter, some centers reported that outcomes of PTA were similar or superior to conventional surgery [11-13]. Nowadays, many centers perform mechanical thrombectomy and PTA on culprit lesions [14-16].

PTA has many advantages over surgical methods as follows. First, hospitalization is not required, as it can be performed as an outpatient procedure. Second, dialysis is immediately possible after the procedure. Third, PTA can be done repeatedly without use of outflow vein. Surgical revision usually extends the access further up to some upstream veins. PTA can correct the stenotic lesions through balloon dilation and stent insertion without wasting extra veins. In this study, results revealed no difference in the patency between the hybrid technique and surgery on thrombosed AVGs. Even if the outcomes of PTA are not superior to surgery, PTA can give more therapeutic options for both surgeons and patients. Hence, PTA has become the gold standard and most preferred treatment of AV access occlusion [17].

In conclusion, our study has some limitations that should be considered. This is a retrospective study with a small sample size. Further large prospective study is required on this topic. This study may help the vascular surgeons chose options to treat thrombosed AVGs.

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