Endovascular Thrombectomy versus Open Surgical Thrombectomy for Thrombosed Arteriovenous Hemodialysis Graft

Nattawut Puangpunngam, M.D.*, Nathakorn Supokaivanich, M.D.*, Chanean Ruangsetakit, M.D.*, Chumpol Wongwanit, M.D.*, Nuttawut Sermsathanasawadi, M.D., Ph.D.*, Khamin Chinsakchai, M.D.*, Suteekhanit Hahtapornsawan, M.D.*, Kiattisak Hongku, M.D.*, Pramook Mutirangura, M.D.*, Somrach Thamtorawat, M.D., Satit Rojwatcharapibarn, M.D.**, Walailak Chaiyasoot, M.D.**, Jirawadee Yodying, M.D.**, Trongtum Tongdee, M.D.****

**Department of Surgery, **Department of Radiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand*

ABSTRACT

Objective: The aim of this study was to investigate the procedure success rate, one-year primary patency rate, one-year secondary patency rate, and complications compared between endovascular therapy and open surgical thrombectomy for treatment of thrombosed arteriovenous hemodialysis graft.

Methods: This retrospective chart review included patients with thrombosed arteriovenous hemodialysis graft who were treated at the Division of Vascular Surgery, Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand during January 2012 to December 2016. Demographic, graft type, time before treatment, thrombus removal technique, additional technique, procedure success rate, operative, primary and secondary patency, follow-up time, and complication data were collected.

Results: Seventy-four thrombosed dialysis grafts were included. Twenty-five and 49 grafts underwent endovascular therapy and open surgical thrombectomy, respectively. There was no significant difference in demographic data, graft type, or adjunct procedure between groups. The procedure success rate was 92% and 98% in the endovascular group and thrombectomy group, respectively (p=0.262). The one-year primary patency rate was 26% in the endovascular group, and 33% in the thrombectomy group (p=0.054). One-year secondary patency rate was 82.6% in the endovascular group, and 56.3% in the thrombectomy group (p=0.122).

Conclusion: No significant differences were observed between groups for procedure success rate or 1-year primary patency rate; however, the one-year secondary patency rate in the endovascular group was significantly better than in the thrombectomy group. No difference in complications was observed between groups.

Keywords: Endovascular thrombectomy; open surgical thrombectomy; thrombosed arteriovenous hemodialysis graft (Siriraj Med J 2019; 71: 491-498)

INTRODUCTION

Arteriovenous hemodialysis access facilitates a connection between the patient and the hemodialysis system in end-stage renal disease patients. Current guideline[1] recommends the use of native arteriovenous fistula (AVF) as the first choice for hemodialysis access. However, arteriovenous hemodialysis graft (AVG) is still preferred in many patients due to vessel-related

Corresponding author: Nattawut Puangpunngam
E-mail: nattawut.pua@mahidol.ac.th
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ORCID ID: http://orcid.org/0000-0002-4874-5285
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limitations, and the fact that some patients in need of urgent hemodialysis cannot wait for AVF maturation after surgery. Although AVG does not require time for maturation, it is easier to puncture than AVF and it has a higher likelihood of complications. One of the most important complications of AVG is acute thrombosis that leads to graft blockage that results in loss of function and access.

Restoration of thrombosed hemodialysis AVG can be managed by either endovascular therapy or open surgical thrombectomy. Several studies have compared outcome of treatment between endovascular therapy and open surgical thrombectomy. A 2002 meta-analysis review by Green, *et al.*[2] found that open surgical thrombectomy had a significantly better outcome relative to both failure rate and 90-day patency rate.

Another meta-analysis review by Tordior, *et al.*[3] in 2009 analyzed 78 studies that included 8 randomized controlled trials and 1 meta-analysis. That group found results similar to those reported by Green, *et al.* except that a comparison between studies conducted before and after 2002 revealed no significant difference in outcome between the two treatment groups in studies conducted after 2002. This difference may be explained by improvements in endovascular techniques over time. The most recent retrospective study in Thailand was published in 2015 by Hongsakul, *et al.*[4] That group also found no significant difference in outcomes between the two treatment options.

Objective

The aim of this study was to investigate the procedure success rate, one-year primary patency rate, one-year secondary patency rate, and complications compared between endovascular therapy and open surgical thrombectomy for treatment of thrombosed arteriovenous hemodialysis graft.

MATERIALS AND METHODS

Population

This retrospective chart review included patients (age >18 years) with acute thrombosed arteriovenous hemodialysis graft (onset 0-14 days) who were treated at the Division of Vascular Surgery, Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand during the January 2012 to December 2016 study period. Demographic, graft type, time before treatment, thrombus removal technique, adjunct procedure, procedure success rate, operative, primary and secondary patency, follow-up time, and complication data were collected, recorded, and analyzed. Included data were retrieved from the databases of the Division of Vascular Surgery of the Department of Surgery and the Division of Interventional Radiology of the Department of Radiology at our center. Only patients who were follow-up for at least one year were included. Patients who had thrombosis of AVG related to infected graft or aneurysm were excluded. The treatment method was determined by the patient's attending vascular surgeon or nephrologist. The protocol for this study was approved by the Siriraj Institutional Review Board (Si 603/2559).

Open surgical thrombectomy

The procedure was performed by vascular surgeons under general or local anesthesia. The only thrombus removal technique used in this group was surgical thrombectomy with Fogarty catheter. In the operating room, the hemodialysis graft was opened directly at the venous limb and thrombectomy was performed by advancing the Fogarty thrombectomy catheter through the graft into the native venous outflow. The same thrombectomy technique was also performed on the arterial limb. Angiography was then performed to evaluate for residual thrombus, and to investigate for underlying stenotic lesions of arteries and veins in every cases. Surgical thrombectomy would be repeated if residual thrombus was observed in the graft. After adequate thrombus removal was confirmed, then any needed adjunct procedure was selected according to angiographic finding. If underlying lesion was revealed, balloon angioplasty was performed to correct luminal stenosis of vessels. Stent was deployed if there was residual stenosis greater than 30% after balloon angioplasty. In case of recurrent stenosis of venous outflow, graft revision using a short bypass graft to more central venous outflow was performed in selected cases. Final angiogram was performed to assess the patency of graft and anastomosis.

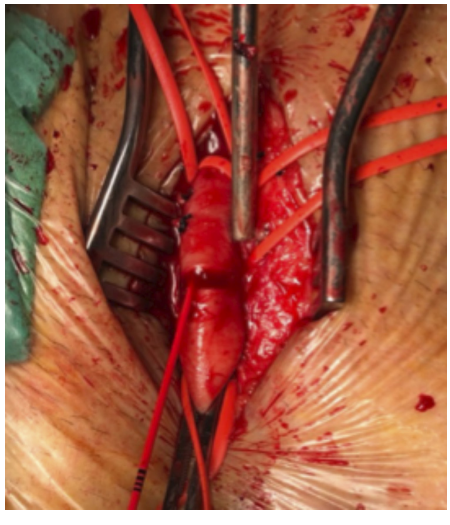


Fig 1. Open surgical thrombectomy

Endovascular therapy

All endovascular procedures were performed by interventional radiologists. The majority of these procedures were performed under local anesthesia. A needle was used to puncture the graft, after which an introducer sheath was inserted into the graft. In this group, three different endovascular thrombus removal techniques were used, as follows. Method 1: Catheter aspiration technique using 5-6 Fr. catheter to aspirate thrombus from the AVG until the thrombus was removed. Method 2: Mechanical thrombectomy technique that uses a thrombectomy device that generates mechanical force to dissolve the thrombus and aspirate clot fragments into a catheter. Method 3: Catheter-directed thrombolysis (CDT) technique that uses a catheter to directly infuse a thrombolytic agent (recombinant tissue plasminogen activator [rt-PA]) into the thrombus. For all methods, angiography was performed after thrombus removal to check for residual thrombus and to reveal underlying stenotic lesions of arteries and veins. Adjunct procedure was selected according to angiographic finding. If residual thrombus was found, the same thrombus removal technique could be repeated, or another of the 3 techniques could be used to ensure adequate thrombus removal. Then underlying lesion was revealed, balloon angioplasty was performed to correct luminal stenosis of vessels. Stent was deployed if there was residual stenosis greater than 30% after balloon angioplasty. After the aforementioned procedures were completed, final angiogram was performed to confirm the patency of graft and anastomosis.

Follow-up

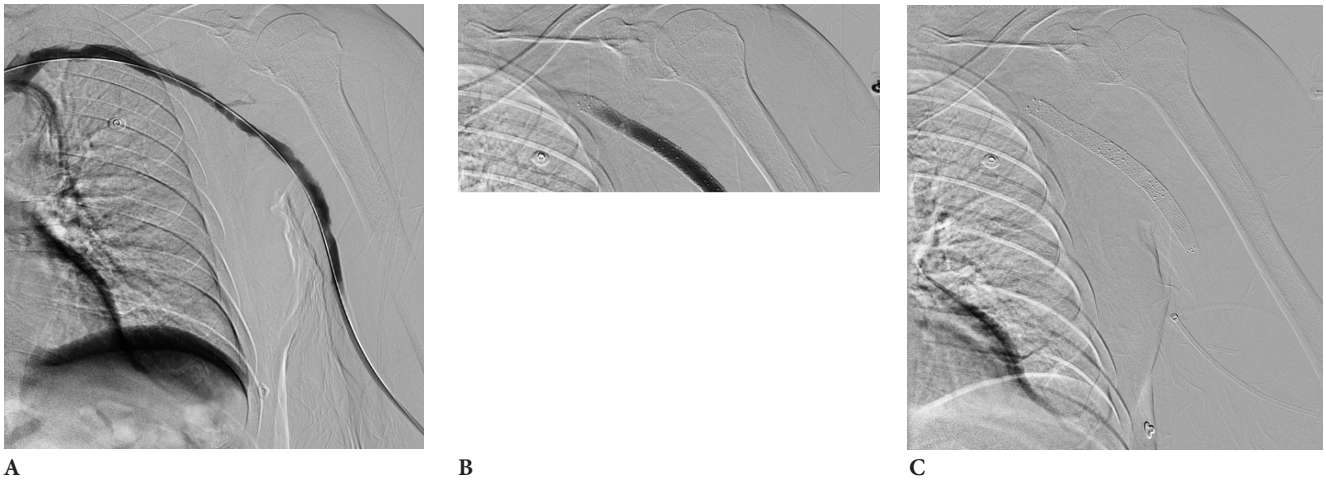
All patients were clinically followed-up at the outpatient vascular surgery clinic or nephrology clinic at 1 month, 3 months, and then every 3 months thereafter. If we found any problem in dialysis or physical examination, duplex ultrasound was used to evaluate graft function. Graft dysfunction was confirmed before further correction by duplex ultrasound in all cases. Decision to abandon graft was maded by vascular surgeon who performed ultrasound and we abandoned it only very poor patency after restoration of flow (less than 1 months).

Definitions

According to standard practice guideline published by the Society of Intervention Radiology[5], procedural success is defined as restoration of flow in the dialysis graft and palpable thrill. Primary patency is defined as the time interval after the procedure until the next access thrombosis or first subsequent intervention. Secondary patency is defined as the time interval after the procedure until the access was surgically revised or abandoned. Major complication is defined as complication that requires additional treatment or that results in permanent sequelae or death.

Statistical analysis

We compared demographic data, clinical data, procedure-related data, complications, and outcomes of procedures between groups. Paired-samples t-test was used to compare continuous variables, and chi-square test was used to compare categorical variables. Normally and non-normally distributed continuous data are reported at mean ± standard deviation and median and range, respectively. Categorical data are shown as frequency and proportion. Survival analysis was performed using Kaplan-Meier method and log rank test was used to compare patency. A *p*-value less than 0.05 indicates statistical significance. SPSS Statistics data analysis program (SPSS, Inc., Chicago, IL, USA) was used to perform all data analyses.



A **B** **C**

Fig 2. (A) Angiogram after thrombus removal showing long stenosis at venous outflow. (B, C) Angioplasty with stent was performed and final angiogram revealed improvement in lumen stenosis.

RESULTS

Of the 74 patients that were included in this study, 25 were in the endovascular group, and 49 were in the open thrombectomy group. The mean age of patients was 60.68±14.37 years in the endovascular therapy group, and 64.33±14.81 years in the open thrombectomy group. All patients had hypertension as a comorbidity, and diabetes was the second most common comorbidity in both groups. Loop forearm and loop upper arm AVG were the most common graft types in the endovascular and open thrombectomy groups, respectively.

There was no significant difference between groups for time of graft function after creation, time since last graft revision, or number of prior graft thrombectomies. Eighty percent of patients in the endovascular group and 55% of patients in the open thrombectomy group that developed failure of hemodialysis access presented with clinical signs and symptoms of thrombosis. Mostly of patients had total graft thrombosis, only 11 of 25 patients in the endovascular group presented with clinical partial graft thrombosis. Median time from graft thrombosis to treatment was 2 days (range: 1-14) in the endovascular group, and 1 day (range: 1-14) in the open thrombectomy group (p=0.078). A summary of patient and graft data is shown in Table 1.

All endovascular procedures were performed under local anesthesia. Eighty percent of the cases used catheter aspiration as the thrombus removal technique. Mechanical thrombectomy and catheter-directed thrombolysis were also used as single or combined thrombus removal technique. The vast majority (96%) of procedures required angioplasty for stenosis lesion correction. Stent was required in 1 case.

In the open thrombectomy group, 73.5% of procedures were performed under local anesthesia, and additional angioplasty was needed in 90% of cases. After angioplasty, stent was required in 2 cases, and jump graft procedure was required in 3 cases due to failure of angioplasty (Table 2). The most common graft stenotic lesions in both groups were venous anastomosis and venous outflow.

There was no significant difference between the endovascular and open thrombectomy groups relative to procedure success rate (92% *vs.* 98%; p=0.262). Median operative time was significantly shorter in the endovascular group than in the open thrombectomy group (17 *vs.* 120 minutes; p=0.001). There was no mortality in this study, and both groups had a median hospital stay of 3 days. There was no significant difference between groups for minor procedure-related complications (Table 3).

TABLE 1. Patient demographic and graft data.

Data	Endovascular (n=25)	Open (n=49)	*P* value
Age (years), mean±SD	60.68±14.37	64.33±14.81	0.315
Gender, n (%)			0.083
Male	8 (32.0%)	26 (53.1%)	
Female	17 (68.0%)	23 (46.9%)	
Graft type, n (%)			0.207
Loop forearm	10 (43.5%)	13 (27.1%)	
Loop upper arm	11 (47.8%)	28 (58.3%)	
Straight upper arm	2 (8.7%)	2 (4.2%)	
Femoral	0 (0.0%)	5 (10.4%)	
Time before treatment (days), median (min-max)	2 (1-14)	1 (1-7)	0.078

A p-value<0.05 indicates statistical significance
Abbreviation: SD = standard deviation

TABLE 2. Procedure-related data.

Data	Endovascular (n=25), n (%)	Open (n=49), n (%)	*P* value
Thrombus removal technique			
Open thrombectomy	0 (0.0%)	49 (100%)	
Mechanical thrombectomy	8 (34.8%)	0 (0.0%)	
CDT	3 (13.0%)	0 (0.0%)	
Catheter aspiration	20 (80.0%)	0 (0.0%)	
Adjunct procedure after thrombus removal			
Angioplasty	25 (100%)	44 (89.8%)	0.098
Stent	1 (4.0%)	2 (4.1%)	0.987
rt-PA	0 (0.0%)	0 (0.0%)	
Jump graft	0 (0.0%)	3 (6.1%)	0.207

A *p*-value <0.05 indicates statistical significance
Abbreviations: CDT = catheter-directed thrombolysis, rt-PA = recombinant tissue plasminogen activator

TABLE 3. Operative, follow-up, patency, and complication data.

Operative data	Endovascular (n=25)	Open (n=49)	*P* value
Procedure success rate, n (%)	23 (92.0%)	48 (98.0%)	0.262
Median operative time (minutes)	17	120	0.001
Follow-up time (months), mean±SD	24.0±3.9	17.6±4.0	0.111
Primary patency time (months), median (min-max)	6.37 (0.79-54.47)	6.37 (0.13-43.04)	0.703
Secondary patency time (months), median (min-max)	25.75 (1.58-54.47)	14.48 (0.13-57.56)	0.037
Minor complication, n (%)	2 (8.6%)	5 (9.5%)	0.546

A *p*-value <0.05 indicates statistical significance
Abbreviation: SD = standard deviation

As shown in Table 3, the median average primary patency times in the endovascular and open thrombectomy groups were the same at 6.37 months (p=0.703). In contrast, the median secondary patency time was significantly longer in the endovascular group (25.75 months) than in the open thrombectomy group (14.48 months) (p=0.037).

The 1-year primary patency rate was 26.1% in the endovascular group, and 33.3% in the open thrombectomy group (p=0.875) (Fig 3). The 1-year secondary patency rate was 82.6% in the endovascular group, and 56.3% in the open thrombectomy group (p=0.028) (Fig 4). The mean follow-up time was 24 months and 17.6 months in the endovascular group and open thrombectomy group, respectively (p=0.111).

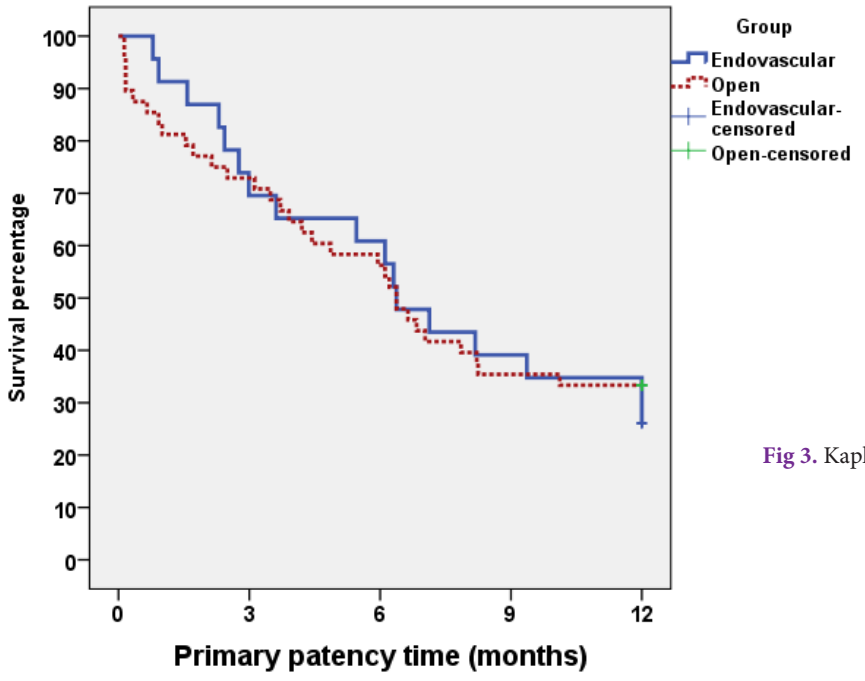


Fig 3. Kaplan-Meier curve for primary patency rate

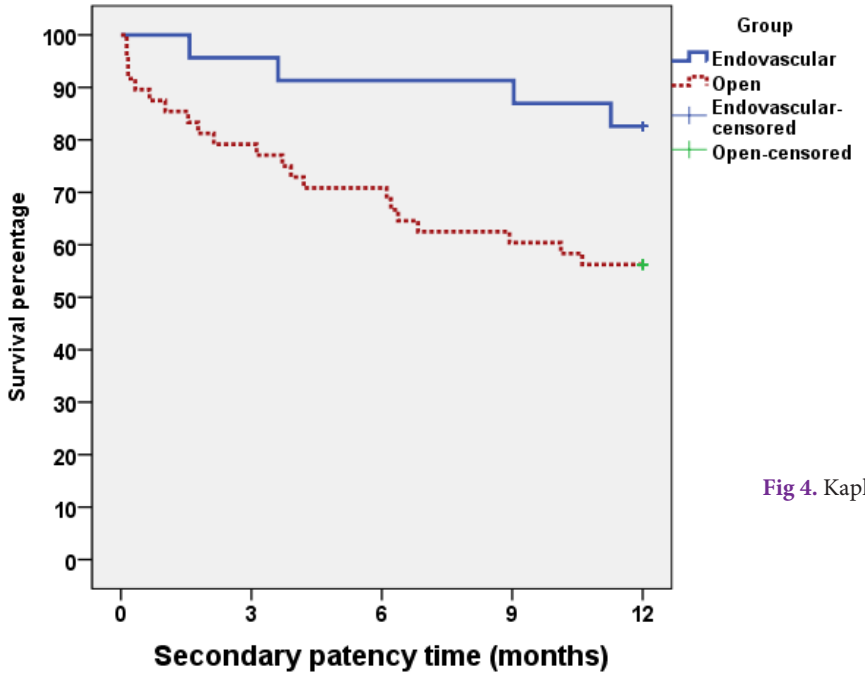


Fig 4. Kaplan-Meier curve for secondary patency rate

DISCUSSION

AVG is preferred as permanent hemodialysis access in end-stage renal disease patients with limited time to first hemodialysis, but access thrombosis is a common complication. Endovascular therapy for thrombosed hemodialysis graft is now used worldwide as an alternative to open surgical thrombectomy. Early studies found open surgical thrombectomy to have better outcome than endovascular therapy. Green, *et al.*[2] reviewed 7 randomized controlled trials and found that open surgical thrombectomy had significantly better outcome for both failure rate (risk ratio [RR]: 1.90, 95% confidence interval [CI]: 1.32-2.73; p=0.0005) and 90-day patency rate (RR: 1.22, 95% CI: 1.05-1.40; p=0.007) than endovascular therapy. However, a 2009 meta-analysis review by Tordior, *et al.*[3] and a 2015 retrospective study by Hongsakul, *et al.*[4] both reported equivalent outcome between groups.

The 92% and 98% procedure success rates in the endovascular and open thrombectomy groups, respectively, in our study were comparable to the rates reported in the

aforementioned meta-analysis (92-95% and 79-100%, respectively) and retrospective study (94% and 93.8%, respectively).

The time interval from graft thrombosis to intervention is one of the factors that significantly influences the procedure success rate. In the present study, the median duration before treatment was longer in the endovascular group than in the open thrombectomy group (2 days *vs.* 1 day), and there was some difference in the procedure success rate (92% *vs.* 98%), but the difference for both comparisons failed to achieve statistical significance.

Our comparative analysis revealed operative time to be one of the variables most different between groups. Open thrombectomy had a significantly longer operative time than endovascular method. This may be explained by additional graft open and closure steps, and the need for general or regional anesthesia in some patients. Although, longer operative time was required, open thrombectomy still had similar procedural success rate and primary graft patency compared to endovascular procedure. Moreover, the rate of complications was non-significantly different between groups.

Mechanical thrombectomy and catheter-directed thrombolysis were reported to be effective and safe techniques for endovascular graft thrombectomy.[4,6-10] Catheter aspiration, which accounted for 80% of the endovascular procedures performed in our study, is a simple and effective technique that requires no expensive surgical devices, but it yields comparable results relative to procedure success rate and graft patency.

We found significant lesions after open thrombectomy that need intervention to correct lesions more than 90% of cases. These data near the result in previous report (78%) from Kuma, *et al.*[11]

Regarding one-year primary patency rate, the 26% and 33% rates of one-year primary patency in the endovascular and open thrombectomy groups in our study were near the upper end of the range reported by Tordoir, *et al.* (8-29% and 10-30%), and similar to the rate reported by Hongsakul, *et al.* (28% and 30%).

Concerning the one-year secondary patency rate, the 82.6% and 56.3% rates of one-year secondary patency in the endovascular and open thrombectomy groups in the present study are in some ways different and in some ways comparable to the results reported by Tordoir, *et al.* (23-62% and 27-65%) and Hongsakul, *et al.* (54.3% and 57%). Recent study from Koraen-Smith, *et al.*[12] show the same results that thrombolysis group had better assist primary patency.

Our study showed markedly better one-year secondary patency compared to previous studies due to selection bias and different severity of thrombosis in the endovascular group. We found that 11 of 25 patients in the endovascular group presented with clinical partial graft thrombosis, so lower severity of graft thrombosis may lead to better secondary patency rate. Furthermore, early follow-up at 1 and 3 months in our study resulted in early additional endovascular therapy for partial graft stenosis before complete graft thrombosis occurred.

To summarize, our study found advantage of endovascular therapy to open thrombectomy in thrombosed AVBG, with significantly better one-year secondary patency, significantly shorter operative time, and all endovascular procedures could be performed under local anesthesia.

Limitations

This study has some limitations. First, the retrospective design of our study suggests the potential for missing or incomplete data. Second, our center is a national tertiary referral hospital that is often referred complex cases. As such, our results may not reflect or be generalizable to other care settings. Third, our overall study population was relatively small, and we had a small number of patients in the endovascular group. These factors suggest the possibility that our study may have lacked the statistical power to identify all significant difference and associations between groups. Fourth, we were not able to include detail relating to improvement in lumen stenosis from post-procedure angiogram, which could influence graft patency. Further randomized controlled study is recommended to determine the advantage of endovascular therapy over open thrombectomy in patients with thrombosed AVBG.

CONCLUSION

No significant differences were observed between groups for procedure success rate or 1-year primary patency rate; however, the one-year secondary patency rate in the endovascular group was significantly better than in the thrombectomy group. No difference in complications was observed between groups. These results suggest endovascular treatment as a safe and efficacious treatment alternative in patients with thrombosed arteriovenous hemodialysis graft.

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Conflict of interest declaration

All authors declare no personal or professional conflicts of interest, and no financial support from the companies that produce and/or distribute the drugs, devices, or materials described in this report.

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This was an unfunded study.

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