The Feasibility of Thrombolysis Followed with Ultrasound-Guided Percutaneous Transluminal Balloon Angioplasty in Acutely and Sub-Acutely Thrombosed Arteriovenous Fistulas

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Keywords. Arteriovenous fistulas; Sub-acute; AVF thrombosis; Percutaneous transluminal balloon angioplasty; Thrombolysis; Ultrasound.

Introduction. Prompt resolution of arteriovenous fistula (AVF) thrombosis is essential to minimize the need for temporary dialysis catheters. Identifying the ideal timing for the management of thrombosed arteriovenous fistula (AVF) is an area that has not been thoroughly explored. Herein, we examined a local infusion of urokinase for thrombolysis followed by ultrasound-guided percutaneous transluminal balloon angioplasty (PTA) in acute and subacute AVF thromboses.
Methods. This retrospective cohort research assessed thrombosed AVF in patients referred to the Second Xiangya Hospital. We included patients who underwent local thrombolysis followed by ultrasound-guided PTA treatment between January 1, 2018, and January 1, 2020.
Results. We enrolled the records of 86 patients into the present study, including 44 patients with acute AVF thrombosis (group 1: thrombus age, < 72 hours) and 42 patients with subacute AVF thrombosis (group2: thrombus age, 72 hours to seven days). The thrombolytic success rate was 79.5% in group 1 and 42.9% in group 2 ($P < .001$). All patients underwent ultrasound-guided PTA to dissolve any residual thrombi regardless of thrombolytic success. Technical success after PTA procedures was achieved in 93.2% of patients in group 1 and 88.1% in group 2 ($P = .417$). Primary patency at six months was comparable between the two groups (67.5% vs. 64.8%, $P = .564$). We observed that thrombolytic effect does not affect PTA success rate, and six-month patency rate.
Conclusion. Direct local infusion of urokinase to the affected area followed by ultrasound-guided PTA constitutes a minimally invasive and effective method for salvaging thrombosed AVF in contrast to abandoning the occluded fistula.

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INTRODUCTION

An arteriovenous fistula (AVF) comprises the most promising access in dialysis patients due to its cost-effectiveness, and appears to be closely associated with prolonged patient survival.[1,2] AVF thrombosis in dialysis patients occurs 0.1 to 0.5 times per year[3] and is responsible for 80 to 85 percent of access failures.[4] Previous studies revealed that endovascular interventions such as local thrombolysis, percutaneous balloon dilatation, thrombectomy, and stent placement were successful in treating acute access thrombosis.[5] For subacute and chronic AVF thromboses, however, open procedures (non-minimal and non- endovascular techniques) or the insertion of a new, more proximal AVF are believed to provide better short- and long-term outcomes.[6-8] However, approximately 2.3–2.5 interventions are needed per dialysis year to maintain the functional patency of AVF.[9] Therefore, it is our responsibility to identify a less invasive and more efficient technique to save the occluded fistula, especially for those with compromised vascular conditions.

Percutaneous transluminal balloon angioplasty (PTA) aims to eliminate residual thrombi and treat any underlying stenoses. Ultrasound-guided PTA allows for locating the puncture site and stenoses as well as visualizing the guidewire and balloon catheter during the procedure. In previous trials, PTA was successfully conducted following thrombolysis in patients with acutely thrombosed AVFs.[10-15] In this investigation, we evaluated the effectiveness of local thrombolysis followed by ultrasound-guided PTA in treating acutely and subacute AVF thromboses. Outcomes included technical success rate and patency rate at six months after PTA. The main objective of this research was to explore the maximal treatment window for thrombosed AVFs.

MATERIALS AND METHODS

Definitions

The age of an AVF was described as the time from AVF creation to the time of the index PTA, and the thrombus age was defined as the interval between the disappearance of the AVF thrill and the onset of thrombolytic therapy.[16] AVF thrombosis was diagnosed when no thrill, bruit, or pulse was present upon physical examination.[17] Ultrasonography was used to detect an interruption of flow and thrombosis in the lumen. We diagnosed AVF stenosis when the peak systolic velocity (PSV) exceeds 375 cm/s or 50% of the lumen narrowed in the ultrasonogram.[17] Acutely thrombosed AVF was defined as a thrombus with an age of less than 72 hours, while a subacute AVF thrombosis was described as possessing a thrombus age of more than 72 hours but less than seven days.[18,19] Technical success was then depicted as less than 30% residual stenotic diameter as measured immediately after successfully completing the PTA procedure.[20] We defined primary patency as the time from PTA to the next vascular thrombosis or reintervention. Thrombolytic complications included dermal ecchymosis, epistaxis, gum bleeding, puncture site bleeding, and systemic bleeding. PTA-related complications included puncture-site hematoma, arterial embolism or bleeding, venous rupture or laceration, and severe pulmonary embolism. Major adverse events were characterized as distal limb ischemia, severe bleeding leading to surgery, or peripheral embolism as well as those requiring critical care or hospitalization, or cases of irreversible adverse sequela, or death.

Study design and participants

This study was a retrospective cohort analysis of the medical records of all patients who were referred to the Nephrology Department of the Second Xiangya Hospital due to the presence of an occluded AVF. Cases which experienced local thrombolysis followed by ultrasound-guided PTA treatment for thrombosed and stenotic AVF between January 1, 2018, and January 1, 2020 were included in this study. The inclusion criteria were: 1) mature AVF > two months; 2) AVF occlusion due to thrombosis; 3) platelet count > 50×10^9/L. The exclusion criteria were: 1) active bleeding, severe bleeding tendency, or any coagulopathy; 2) surgery within the last three months, pregnancy, or serious cardiovascular disorders; 3) poor pulmonary or cardiac reserve; 4) clotted mega-fistula; 5) AVF infection; 6) thrombus age greater than one month.

A total of 86 cases were enrolled and allocated to two groups based on the thrombus age: group 1 were the patients with thrombus age < 72 hours (n = 44), and group 2, who had a thrombus age between 72 hours and seven days (n = 42). The clinical information of all patients was obtained from their medical records. Thrombolytic information (thrombosis to intervention time, patency after thrombolysis, thrombolytic complications), PTA information (balloon-catheter size, balloon pressure, procedural time, technical success rate), ultrasonographic examinations (site-stenotic lesion, diameter and length of target stenosis, blood flow) were recorded by a nephrologist who preceded all surgical procedures. All patients returned for an ultrasonographic evaluation to assess AVF patency at six months (the enrollment process is shown in Figure 1). Informed consents were obtained from all patients (prior to the procedure, as required

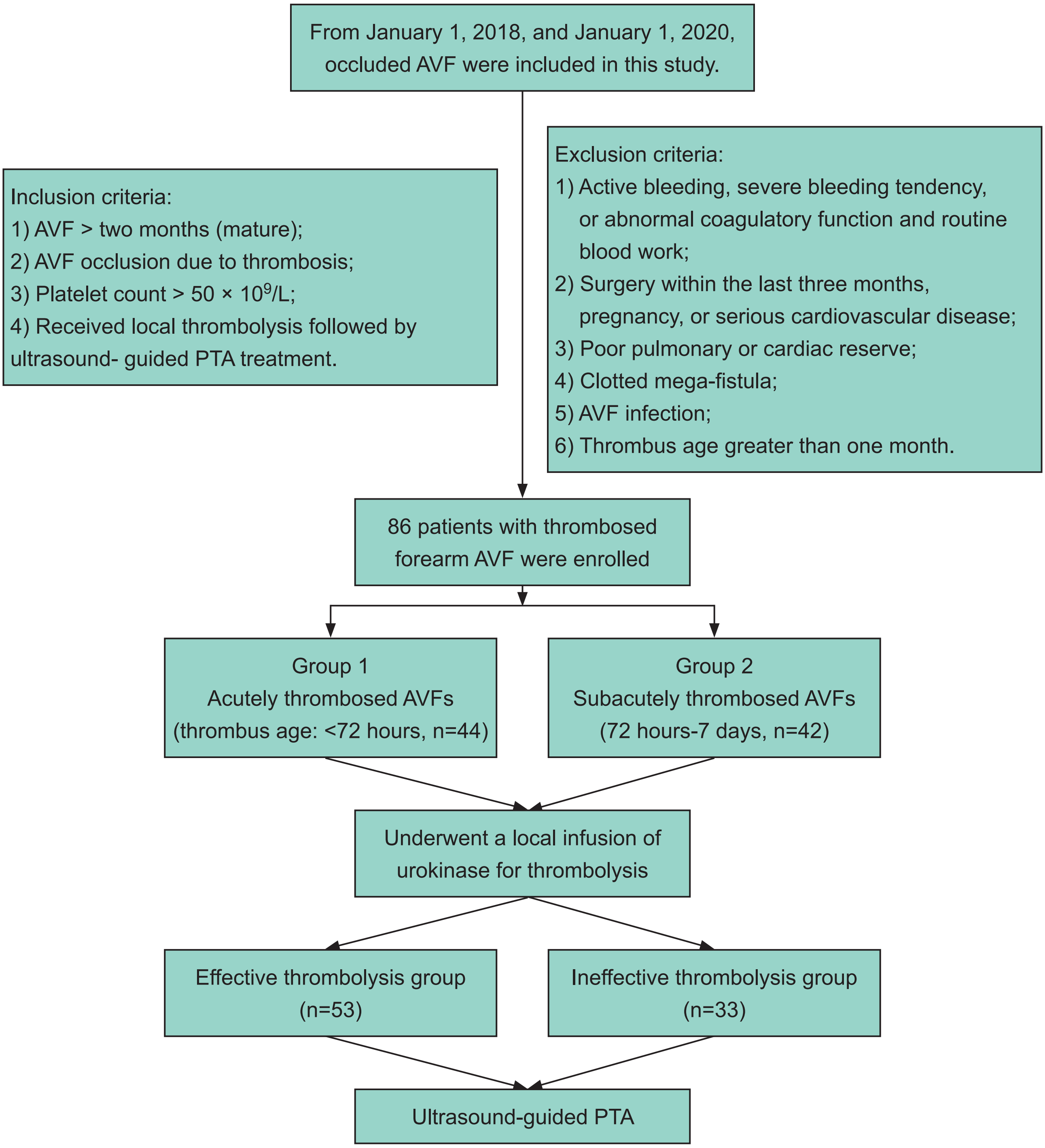

Figure 1. Summary of case enrollment in the study. AVF, Arteriovenous fistula; PTA, percutaneous transluminal balloon angioplasty

for clinical management). The Institutional Review Board of the Second Xiangya Hospital of Central South University reviewed and approved the study (IRB2018148).

Thrombolytic procedure

All patients underwent a local infusion of urokinase for thrombolysis prior to the PTA procedure. For each thrombolytic therapy, an intravenous needle was inserted in an antegrade direction into the AVF vein with the tip pointed toward the thrombus. A urokinase solution (300,000 IU) in 20 ml of saline was subsequently infused through the fistulous vein within a period of one hour. A total of two urokinase thrombolytic treatments were given within 24 hours prior to PTA. Patients'pulse, temperature, respiratory rate, blood pressure, and access flow. Hemoglobin, hematocrit, PT, aPTT, and fibrinogen level were recorded every 8 hours during thrombolysis. The infusion was halted if the fibrinogen level decreased below 1g/L.[21] Successful thrombolysis is defined as the thrill reappearance, thrombi dissolution and restoration of blood flow in the AVF as assessed by ultrasound.

Ultrasound-guided PTA procedure

Ultrasound-guided PTA was performed by two skilled interventional nephrologists after providing local anesthesia. Information on thrombosis, stenosis, blood flow and velocities in AVF during procedure was measured by the same ultrasound machine (Shantou Institute of Ultrasonic Instruments Co., Ltd, Guangdong, China). Angioplasty of all stenoses was conducted via access in the outflow vein. Percutaneous access to AVF was gained with a needle of 18G size, 64mm (TERUMO corporation, Tokyo, Japan) under 1% lidocaine local anesthesia. The choice of either an antegrade or retrograde technique was determined by the location of the stenosis and thrombosis. Under high frequency (8-15 MHz) linear probe guidance, a sheath of either 5Fr or 6Fr (TERUMO corporation, TOKYO, Japan) was inserted over a short J wire, and another 0.89mm angled guidewire (Radifocus; Terumo Corporation, Tokyo, Japan) was passed through the AVF. In the next step, an angioplasty balloon catheter (Invatea S.p.A, Roncadelle, Italy; Bard Peripheral Vascular Inc, Tempe, Arizona, USA) was placed over the guidewire to dilate the occluded and stenotic vein. The diameter of balloon catheter ranged from 5 to 7 mm, and the lengths were 4 cm. The balloon catheter was attached to the balloon-inflation device (Kangdefu Corporation, Shanghai, China), and the balloon was then inflated to a pressure of 10 to 18 atmospheres (the maximum pressure was 30 atm) for 30 s to 120 s at the target sites. After balloon dilatation for removal of the narrowed waist, the balloon catheter, guidewire, and sheath were extracted.[22] The operation took half an hour to one hour time. After PTA procedure, all patients were given a single dose of clopidogrel 300 mg to prevent operation-related acute thrombosis.

Statistical analysis

The statistical analysis was conducted by using GraphPad Prism 7 software and SPSS 23.0 software (SPSS Inc., Chicago, IL, USA). The Student's t-test was used to compare continuous variables expressed as the mean ± SD. The Chi-square tests or Fisher's exact test was used to analyze categorical data expressed as percentages (%). Kaplan-Meier analysis and the log-rank test were used to analyze primary patency rates at 6 months during the follow-up period. Univariate and multivariate Cox regression models were used to evaluate independent risk factors for primary patency rates at 6 months. Results were expressed as hazard ratios (HR) with 95% confidence intervals (CI).and statistical significance was considered if two-sided $P < .05$.

RESULTS

Patient characteristics

From January 2018 to January 2020, a total of 86 patients with thrombosed forearm AVF (51 males; median age, 58.93 ± 10.09 years) were enrolled at the Second Xiangya Hospital of Central South University. These patients received a local infusion of urokinase for thrombolysis and underwent ultrasound-guided PTA. After performing balloon dilatation to remove the narrowed waist, the balloon catheter, guidewire, and sheath were extracted. Our study cohort comprised 44 patients with acutely thrombosed AVFs (group 1) and 42 patients with subacute AVF thromboses (group 2).

Patient characteristics are listed in Table 1. Diabetes mellitus was observed in 43.5% of the patients, hypertension in 76.8% of the patients, dyslipidemia in 37% of the patients, and coronary artery disease in 23.2% of the patients. The average age of fistula was 24.11 ± 18.21 months (range, 2 to 89 months), and 74.4% of AVFs were of radio-cephalic type. The average age of the thrombus was 70.47 ± 45.62 hours (range, 5 to 168 hours). Before thrombolysis, the two groups of patients showed no differences with respected to age, sex, or presence of comorbidities (coronary artery disease, diabetes mellitus, hypertension, or dyslipidemia), dialysis time, AVF age, or AVF blood flow. The inflammatory marker C-reactive protein in group 2 was slightly higher than in group1, but this was not statistically significant (9.23 ± 7.24 vs 6.43 ± 5.36, $P = .075$). The mean time of referral

Table 1. Patient characteristics, treatments and outcome data of early versus late intervention groups

Variables	All (n = 86)	group 1 thrombus age < 72h (n = 44)	group 2 thrombus age 72h to 7d (n = 42)	*P*
Age (years)	58.93 ± 10.09	57.63 ± 10.91	60.28 ± 9.10	.226
Male (%)	59.3	61.4	57.1	.690
Diabetes history (%)	43.5	52.3	38.1	.187
Hypertension (%)	76.8	76.2	77.5	.888
Current smoker (%)	29.1	29.5	28.6	.921
Dyslipidemia (%)	37.0	42.9	30.8	.260
Coronary artery disease (%)	23.2	16.7	30.0	.153
C-reactive protein (mg/l)	7.73 ± 6.41	6.43 ± 5.36	9.23 ± 7.24	.075
AVF Age (months)	24.11 ± 18.21	21.45 ± 15.38	26.90 ± 20.59	.167
AVF Side (left %)	81.4	81.8	81.0	.918
Radio-cephalic AVF (%)	74.4	72.7	76.2	.713
Blood flow per minute (ml/min)	240.17 ± 74.64	250.90 ± 80.36	228.92 ± 67.27	.174
Thrombolysis information				
Thrombosis to intervention time (h)	70.47 ± 45.62	33.13 ± 18.65	109.59 ± 29.78	< .001*
Patency after thrombolysis (%)	61.6	79.5	42.9	< .001*
Thrombolysis complication rate (%)	7.0	4.5 (2/44)	9.5 (4/42)	.428
PTA information				
Target stenosis length (cm)	2.49 ± 1.42	2.67 ± 1.56	2.31 ± 1.25	.239
Target stenosis diameters (mm)	1.95 ± 0.33	1.98 ± 0.36	1.92 ± 0.31	.409
Postoperative vessel diameter (mm)	4.03 ± 0.72	3.97 ± 0.61	4.08 ± 0.82	.488
Postoperative blood flow per minute (ml/min)	614.92 ± 152.65	590.97 ± 164.39	637.70 ± 138.78	.173
Technical success rate (%)	90.7	93.2	88.1	.417
Primary patency at 6 months (%)	66.2	67.5	64.8	.564
Procedure complication rate (%)	3.5	2.3 (1/44)	4.8 (2/42)	.529

Data are presented as N (%) or mean ± SD
P < .05 was considered significant. **P* < .05 vs Group 1;

to thrombolysis was 33.13 ± 18.65 hours in group 1 and 109.59 ± 29.78 hours in group 2 (*P* < .001). After urokinase thrombolysis, a significant difference was found between the groups in terms of thrombolysis patency, as 79.5% of patients in group 1 recovered partial or whole blood flow, but only 42.9% of patients in group 2 recovered either partial or whole blood flow (*P* < .001). All patients underwent ultrasound-guided PTA to remove residual thrombi and treat all potential stenoses, whether or not blood flow reappeared after thrombolysis. Figure 2 shows example images of post-thrombolysis AVF and post-PTA. The two groups were comparable in terms of target stenosis length and diameter before treatment, with no significant difference noted between the two groups in terms of technical success rate (93.2% vs. 88.1%, respectively). Technical failures were principally caused by the difficulty in crossing the occluded segment. The mean postoperative vessel diameter was 4.03 ± 0.72 mm, and the mean postoperative blood flow was 614.92 ± 152.65 ml/min, with the two groups comparable in these indices.

Complications

The incidence of thrombolytic complications was 7%. Patients in group 2 had an increased risk of minor events during the thrombolysis period compared to those in group 1; however, this difference was not statistically significant. (9.5% vs. 4.5%, *P* = .428). One patient in each group experienced epistaxis; one patient in group 1, and three in group 2 experienced ecchymosis at the puncture site . During PTA procedure, complication rate was 3.5%, with no difference between the two groups. One patient in each group experienced puncture-site hematomas, and there was only one patient in group 2 who experienced minor venous rupture that spontaneously healed without intervention. None of the patients complained of dyspnea, which would have denoted pulmonary embolism. We observed no major complication.

Follow up

Postoperative follow-up was conducted within six months after intervention. Kaplan-Meier survival curves for primary patency rates after the restoration

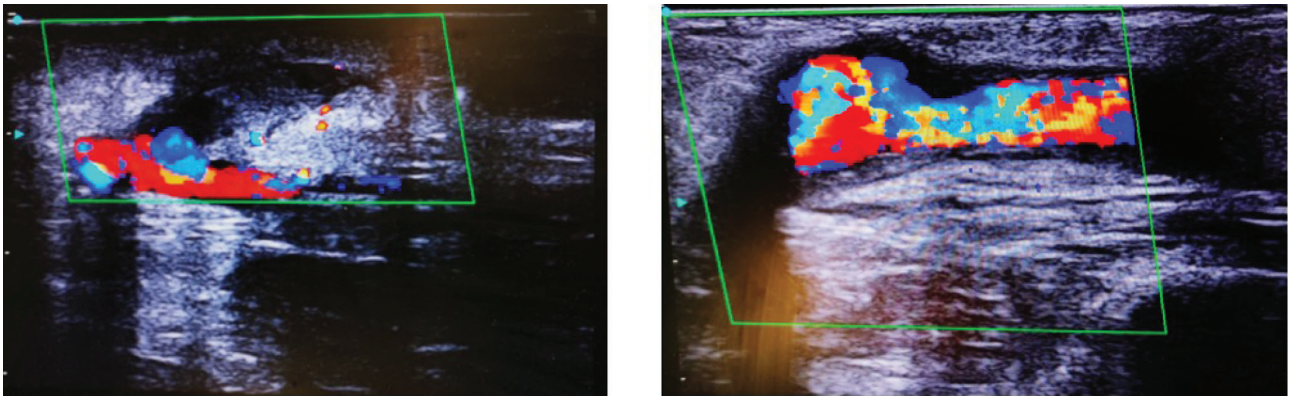

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Figure 2. Ultrasound images of post-thrombolysis (A) and post-PTA after thrombolysis (B).

of the dialysis fistula are provided in Figure 3. The primary patency rates for all patients were 94.8%, 79.1%, and 66.2% at 1, 3, and 6 months, respectively. In group1, the primary patency rates were 92.5%, 82.5%, and 67.5% at 1, 3, and 6 months, respectively; while in group 2, they were 97.2%, 75.6%, and 64.8% at 1, 3, and 6 months, respectively. Though the primary patency rate for group 1 was slightly higher than that of group 2, this difference was not statistically significant. Univariate and multivariate Cox regression analyses for predictors of post-intervention six-month primary patency are provided in Table 2. In univariate analysis, only female sex was associated with post-intervention six-month primary patency among the baseline variables. In multivariate analysis, after adjusting for the possible confounders (including age, sex, presence of comorbidities, AVF information, patency after thrombolysis, and thrombus age), we found that only female sex (HR 0.436; 95% CI, 0.202–0.942; *P* = .035) and right-side AVF (mostly radio-cephalic) (HR 0.450; 95% CI, 0.206–0.984; *P* = .046) were independent predictors for failure in six-month primary patency. Thrombus age was not associated with post-intervention six-month primary patency.

Relationship between thrombolysis and procedure success rate

Patients were further divided into seven groups according to thrombus age (Figure 4). The longer the duration of thrombosis, the worse the effect of thrombolysis. However, the PTA success rate and the six-months AVF patency did not diminish with increasing thrombus age. As shown in Table 3, patients with partial or whole blood flow recovered after thrombolysis were designated the effective thrombolysis group (n = 53). The remaining patients were classified as ineffective thrombolysis group (n = 33). There

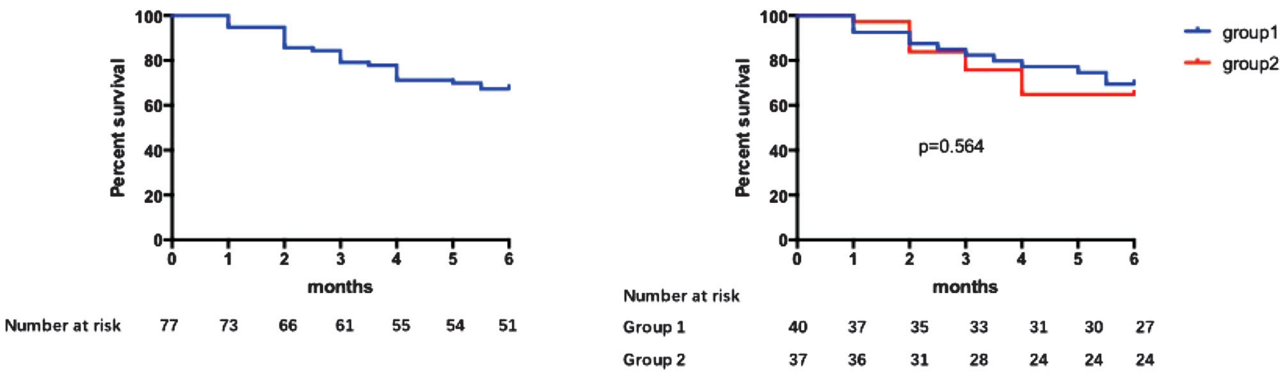

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Figure 3. Kaplan–Meier analysis for primary patency rates after restoration of dialysis fistula. (A) Kidney survival rates in all patients; (B) kidney survival rates in acutely thrombosed AVF (group 1) and subacute AVF thrombosis (group 2). The data were analyzed using the log-rank test. P < .05 was considered significant.

Table 2. Univariate and multivariate Cox regression analysis for predictors of post-intervention 6-month primary patency

Variables	Univariate Cox		Multivariate Cox	
	HR (95%CI)	*P*	HR (95%CI)	*P*
Age (years)	0.982 (0.938-1.028)	.444	–	.584
Male (%)	0.277 (0.097-0.792)	.017*	0.436 (0.202-0.942)	.035*
Diabetes history (%)	1.845 (0.736-4.622)	.191	–	
Hypertension (%)	1.128 (0.423-3.011)	.810	–	.858
Current smoker (%)	1.488 (0.407-5.441)	.548	–	
Dyslipidemia (%)	0.994 (0.371-2.659)	.990	–	.418
Coronary artery disease (%)	0.476 (0.132-1.649)	.237	–	
C-reactive protein (mg/l)	1.056 (0.974-1.143)	.185	–	.138
AVF Age (mons)	1.026 (1.000-1.054)	.051	–	.166
AVF Side (left %)	0.403 (0.156-1.042)	.061	0.450 (0.206-0.984)	.046*
Blood flow per minute (ml/min)	0.993 (0.985-1.001)	.097	–	.177
Thrombus age	1.310 (0.534-3.218)	.555	–	.226
Patency after thrombolysis	1.039 (0.390-2.767)	.938	–	.615
Target stenosis length (cm)	1.190 (0.846-1.676)	.318	–	.634
Target stenosis diameters (mm)	0.764 (0.212-2.753)	.681	–	.888

Data are presented as hazard ratios (HRs) and 95% confidence intervals (CIs). *$P < .05$ was considered significant.

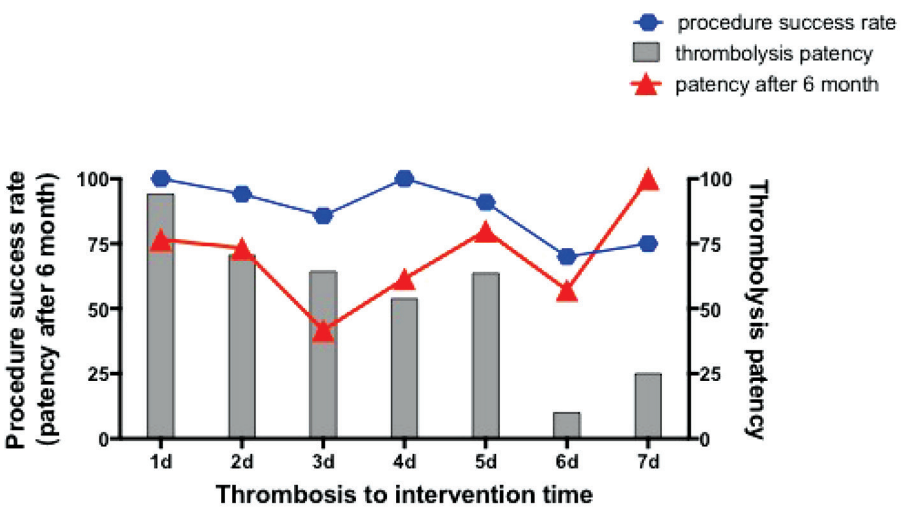

Figure 4. The relationship curve between thrombolysis patency and procedure success rate (patency at 6 month)

Table 3. Procedure outcome of patients with successful or failed thrombolytic therapy

Variables	effective thrombolysis			Ineffective thrombolysis		
	group 1 (n = 35)	group 2 (n = 18)	*P*	group 1 (n = 9)	group 2 (n = 24)	*P*
PTA success rate	91.4	94.4	.694	100	83.3	.191
Primary patency at 6 months	71.0	58.8	.393	66.7	70.0	.858

Data are presented as N (%) or mean ± SD
$P < .05$ was considered significant.

was no significant difference between the two groups in the operative PTA technical success rate or six-months AVF primary patency rate. The thrombotic duration and thrombolytic effect also did not affect the PTA success rate or six-month primary patency rate in our study.

DISCUSSION

There is no consensus as to the optimal duration from thrombosis to salvage in thrombosed AVF. The findings of the studies have supported the assumption that restoration of a thrombosed AVF should be performed as soon as possible (within

48 hours).[23] As numerous dialysis centers in less-developed area of China lack adequate management in treating thrombosed AVF, when AVF thrombosis and stenosis are diagnosed, patients need to go to higher-level hospitals for intervention. The time from thrombosis diagnosis to salvage is thus often much longer than 48 hours. Our modified protocol therefore prolonged the effective salvage time to seven days, which is necessary in developing area.

Success rate for thrombolytic therapy was initially less than 50%.[24] Local infusion allows thrombolytic agents to be concentrated around the thrombus, decreasing thrombolysis complications and increasing success rates.[16] Local infusion of urokinase and secondary manual aspiration or angioplasty of residual clots and stenoses have recently improved the success rate to 89.5% in acutely thrombosed AVF.[13,25] In our study, we selected urokinase as the thrombolytic agent, due to its cost-effectiveness and efficacy. We demonstrated that a two-hour local infusion of urokinase achieved an almost 80% success rate in acutely thrombosed AVF. Our results were therefore comparable to the reported success rates of surgical and percutaneous approaches.[13] However, thrombolytic monotherapy is unsuccessful in almost half of the patients with a thrombus lasting longer than 72 hours. This result was nevertheless acceptable because the thrombus age was related to thrombolysis failure. The primary purpose of thrombolysis in our trial was not to dissolve the thrombus, but rather to soften it.

All patients in our study accepted PTA after thrombolysis to treat the residual thrombus and all underlying stenosis. We recommend that re-establishing and maintaining patency of thrombosed AVF include thrombus clearance and treatment of the underlying stenosis.[26] Optimal approaches to treat thrombosed AVF are inconclusive. Some researchers have concluded that surgical intervention offers favorable short- and long-term outcomes only when performed in a timely manner by a skilled interventional nephrologist.[6,8] Clinical practice guidelines for vascular access (i.e., the U.S. National Kidney Foundation-Kidney Disease Outcomes Quality Initiative, NKF-KDOQI) have indicated that surgical interventions for thrombosed AVF is not recommended unless the stenosis is located in the juxta-anastomotic area or if it happens recurrently.[27] Endovascular techniques have now been developed and supersede surgery in managing thrombosed AVFs.[12,28] Endovascular thrombectomy has the advantage of a shorter operative time and a lower thrombolytic agent dosage required. However, this approach requires a large-diameter target vessel to accommodate the high-cost device and may result in potential damage to the vein.[29,30] Stent placement is more costly and less effective compared to PTA. In addition, vessel diameter is positively correlated with stent patency.[31,32] Many centers have reported an increased use of PTA over surgery for thrombosed AVF.[12] PTA is a quick and repeatable intervention with less trauma, fewer complications, and lower costs. Under ultrasonographic guidance, the entire vascular circuit can be visualized. More importantly, the AVF can be implemented immediately for the next dialysis session after PTA.[1,11,12] Thus, at our center, PTA is the standard intervention applied to remove all thrombi and to dilate potential stenoses.

Pharmacologic thrombolysis can remove or soften the thrombus in occluded AVF,[33,34] while angioplasty addresses the residual thrombus and restores the blood flow of a stenosed AVF.[35] Previous studies have revealed the effectiveness of thrombolysis combined with PTA in reestablishing blood flow in acutely thrombosed AVF (2-72 h). The reported initial success rates range from 86% to 94%, with a six-month patency rate ranging from 60% to 76% for AVFs.[11,14,16,36] However, recombinant tissue plasminogen activator (rTPA) infusion, ICU monitoring, and angioplasty in the endovascular suite are costly in this procedure.[36] Although transcatheter thrombolysis during PTA procedure has been proved to be effective in thrombosed AVF, catheter-directed thrombolysis with PTA, prolonged procedure time, and increased the risk of infection. Most importantly, the study participants are still limited to acutely thrombosed AVF.[11] The major breakthrough of our study was to verify that local thrombolysis followed by ultrasound-guided PTA was effective in treating subacute AVF thrombosis. It was reported that the endovascular approach performed for thrombosed AVFs had achieved a success rate of 73% to 96%,[37-39] and that the success rate of open surgery ranges from 66% to 100%.[40,41] We achieved an immediate success rate of 88.1%, and a six-month patency rate of 64.8% in subacute AVF thrombosis, which are very close to published reports.[42]

The use of ultrasound-guided PTA is another advantage of our study. Ultrasonography can avoid contrast agents and X-rays, reducing the risk of harm to blood vessels.[42,43] In China, ultrasonography is relatively more affordable and available than radiography, especially in medium and small hospitals. Accordingly, the practical ultrasound-guided PTA is more suitable for thrombosed AVF. Portable ultrasonographic scanning facilitates the expansion of the application field. Our own practice has shown that real-time ultrasonographic images can allow visualization of the vascular structures, the location of the stenosis and thrombus, and the instruments used during PTA.

CONCLUSIONS

Our study shows local thrombolysis followed by ultrasound-guided PTA can be effective in treating acutely and subacute AVF thromboses. We were able to extend the treatment window for thrombosed AVF to seven days, which can assist in delaying the timing of fistula reconstruction or dialysis-catheter insertion.

STATEMENTS

Statement of ethics

The Study has been approved by the Institutional Review Board of the Second Xiangya Hospital of Central South University (IRB2018148) and have been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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