

Clinical Application of Percutaneous Transluminal Angioplasty in the Treatment of Autologous Arteriovenous Fistula Stenosis

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ABSTRACT

Objective: A retrospective study was conducted on the patients with stenosis of autologous Arteriovenous Fistula (AVF) confirmed by color Doppler Ultrasound (CDU) or Digital Subtraction Angiography (DSA). The clinical features were analyzed and the effectiveness of PTA was confirmed by percutaneous transluminal angioplasty.

Methods: This study reviewed the relevant data of patients who received PTA treatment for AVF stenosis in the Department of Nephrology of 404 Hospital of Mianyang, Sichuan Province from January 1, 2017 to December 31, 2020. The vascular access of all patients was arteriovenous end-to-side anastomosis, the medical history and related data were complete, and the patency rate of internal fistula in 3, 6 and 12 months was statistically analyzed. **Results:** A total of 124 patients successfully completed PTA treatment (120 cases guided by color ultrasound, 4 cases guided by DSA), with a success rate of 100%. There were no complications such as vascular rupture and pulmonary embolism in all cases. There were 72 males (58.06%) and 52 females (41.94%). The average age of the patients was 57.7 ± 13.15 (24-84) years, and the average dialysis age was 44.63 ± 40.31 months. The internal diameter of stenotic vessels before and after PTA treatment was 1.45 ± 0.6 mm and 3.73 ± 0.64 mm respectively. The average interval of re-intervention was 185.98 ± 108.47 days, and the 3-month patency rate was 93.55%. The 6-month patency rate was 80.65%, and the 1-year patency rate was 67.74%. In addition, routine antiplatelet aggregation therapy is given to patients with cardiovascular risk factors (such as hypertension, diabetes, etc.) and excluding a history of hemorrhage (such as gastrointestinal hemorrhage, cerebral hemorrhage, etc.). A total of 90 patients were treated with clopidogrel (80 cases) and aspirin (10 cases). The postoperative patency rate in clopidogrel group was significantly higher than that in aspirin group ($P < 0.05$). No obvious bleeding complications were found during the follow-up period. **Conclusion:** The patency of vascular pathway is of great significance for maintenance hemodialysis patients. PTA is effective, minimally invasive and repeatable in the treatment of autologous arteriovenous fistula stenosis, which can be used as the first choice for the treatment of AVF stenosis. It is preliminarily observed that clopidogrel is superior to aspirin in maintaining vascular patency, but a large sample of further case-control studies are still needed.

INTRODUCTION

Vascular pathway is the lifeline of Maintenance Hemodialysis (MHD) patients. According to the recommendations of the guidelines, autologous Arteriovenous Fistula (AVF) is the best choice [1-4]. However, due to repeated vascular puncture, hemodynamic changes, hypotension and other factors in the process of dialysis, internal fistula stenosis is easy to be secondary to thrombosis. Among them, the stenosis near the anastomosis / anastomosis is the most common (accounting for about 51% of all strictures) [5]. The pathological basis of arteriovenous fistula stenosis is intimal hyperplasia [6]. Intimal hyperplasia is gradually aggravated and vascular lumen becomes smaller. If not treated in time, further stenosis of vascular lumen, thrombosis and even vascular occlusion may occur, resulting in the loss of AVF function. At present, there is no specific and effective method for intimal hyperplasia, and the treatment is mainly focused on the treatment after stenosis. Now, the treatment of arteriovenous stenosis mainly includes surgery and intracavitary treatment. Compared with surgery, intracavitary therapy has the advantages of less trauma, full utilization and saving of vascular resources. Therefore, for the treatment of internal fistula stenosis, we often choose Percutaneous Transluminal Angioplasty (PTA) guided by COLOR DOPPLER ULTRASOUND (CDU) or Digital Subtraction Angiography (DSA). Bojakowski, K et al reported that the effective rate of PTA treatment under the guidance of CDU was between 92% and 97% [7]. For patients with central vein stenosis, PTA can be performed under DSA, and the technical success rate can reach 88.52% [8]. In addition, there is no final conclusion on whether oral drug intervention is needed to maintain vascular patency after PTA treatment of AVF stenosis, and more studies are needed to guide it. 124 cases of PTA treated in our hospital in recent 4 years are reported as follows.

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OBJECTS AND METHODS

Research object

This study reviewed the relevant data of patients who received PTA treatment for AVF stenosis in the Department of Nephrology of 404 Hospital of Mianyang, Sichuan Province from January 1, 2017 to December 31, 2020. The vascular

access of all patients was arteriovenous end-to-side anastomosis, and the medical history and related data were complete. Inclusion criteria: 1) use time of internal fistula > 3 months; 2) internal fistula dysfunction, pump-controlled flow < 200ml during hemodialysis; 3) intact ultrasound and DSA data. Exclusion criteria: 1) patients with AVF infection; 2) patients who were treated with PTA because of immature internal fistula; 3) patients with non-AVF vascular pathway; 4) patients with cardiac dysfunction and left ventricular ejection fraction < 30%. This study was approved by the Ethics Committee of Sichuan Mianyang 404 Hospital, and all patients or their families signed informed consent forms.

Research methods

The general data and imaging data of the above patients were reviewed retrospectively, including sex, age, age of hemodialysis, primary disease, internal diameter of vascular stenosis before and after operation, time of re-intervention, use of antiplatelet drugs (drug type and medication time) and so on.

Operation method

All patients were evaluated by color Doppler ultrasonography (Resona7T) or DSA (Artiszeefloor) before operation and the operation plan was made. The patient was in supine position, limb abduction, color Doppler ultrasound or DSA to understand the stenosis and location of internal arteriovenous fistula. Routine disinfection towels, 2% lidocaine (Taiji Southwest Pharmaceutical Co., Ltd.) local anesthesia, puncture using Seldinger method, placement of 5F or 6F vascular sheath (TERUMO). The super-slippery guide wire (TERUMO) was inserted into the sheath to reach the stenosis. Under the guidance of ultrasound or DSA, the balloon catheter (Boston Science Company) was pushed along the catheter sheath to dilate the vascular stenosis (balloon selected high pressure balloon) after intravenous heparinization (0.13-0.2mg/kg). For the diseased vessels near the anastomosis and in the vein puncture section, the diameter of 5-12mm balloon is generally selected, the central venous segment is generally selected, and the diameter of 8-12mm balloon is generally selected (the balloon diameter is selected according to the diameter of blood vessels displayed by intraoperative color Doppler ultrasound or DSA). The pressure pump (Shenzhen Yixinda

Medical New Technology Co., Ltd.) is pressurized repeatedly and slowly (between pressure 4-30atm), lasting for 1 minute each time, repeating 2-3 times until the balloon notch disappears. After dilatation, the stenosis is confirmed by color ultrasound or DSA to be less than 30%. After the operation, the catheter sheath was pulled out and the puncture point 20min (palpable vascular tremor) was bandaged under pressure. Hemodialysis could be performed at least once through this internal fistula.

Statistical analysis

SPSS 25.0 software was used for data statistics. The measurement data are expressed by $\bar{X} \pm s$, the t-test is used, and the counting data are expressed by n (%). $P < 0.05$, it was considered that the difference was statistically significant.

RESULT

General information of patients

A total of 124 patients successfully completed PTA treatment (120 cases guided by color ultrasound, 4 cases guided by DSA), with a success rate of 100%. There were no complications such as vascular rupture and pulmonary embolism in all cases. There were 72 males (58.06%), 52 females (41.94%), 19 hypertensive nephropathy, 35 diabetic nephropathy, 7 polycystic kidney disease, 54 chronic nephritis, 3 systemic lupus erythematosus nephritis, 1 nephrotic syndrome, 2 IgA nephropathy, 1 Henoch-Schönlein purpura nephropathy, 1 ANCA-associated vasculitis nephropathy and 1 uric acid nephropathy. The average age of the patients was 57.7 ± 13.15 (24-84) years, and the average dialysis age was 44.63 ± 40.31 months. The diameter of stenotic vessels before and after PTA was 1.45 ± 0.6 and 3.73 ± 0.64 mm, respectively (Table 1). Routine antiplatelet aggregation therapy was performed in patients with cardiovascular risk factors (such as hypertension, diabetes, etc.) and excluding a history of hemorrhage (such as gastrointestinal hemorrhage, cerebral hemorrhage, etc.). A total of 90 patients (80 patients treated with clopidogrel and 10 patients treated with aspirin) had no obvious bleeding complications during the follow-up period and the treatment period was 3 months (Table 2).

Related contents of follow-up after PTA

Combined with physical examination and color ultrasound examination: the murmur and tremor of internal fistula, infection and limb edema were observed during each dialysis. Vascular

color Doppler ultrasound was performed every 3 months after operation to evaluate the vascular condition (internal diameter of blood vessels, thrombosis, etc.). If it is found that internal fistula tremor, murmur weakening or disappearance, and / or stenosis more than 50% confirmed by ultrasound can be defined as restenosis during follow-up, it needs to be intervened again. In this study, the average interval of re-intervention was 185.98 ± 108.47 days, the 3-month patency rate was 93.55%, the 6-month patency rate was 80.65%, and the 1-year patency rate was 67.74%.

Table 1: comparison of the diameter of stenotic vessels before and after percutaneous transluminal balloon angioplasty.

Group	Number of cases	Internal diameter of stenotic vessels (mm)
Before treatment	124	$1.45 \pm 0.60^*$
After treatment	124	$3.73 \pm 0.64^*$

Note: *there is a significant difference in the diameter of blood vessels before and after operation ($P < 0.05$).

Table 2 : Comparison of patency rate of different antiplatelet aggregation drugs after PTA.

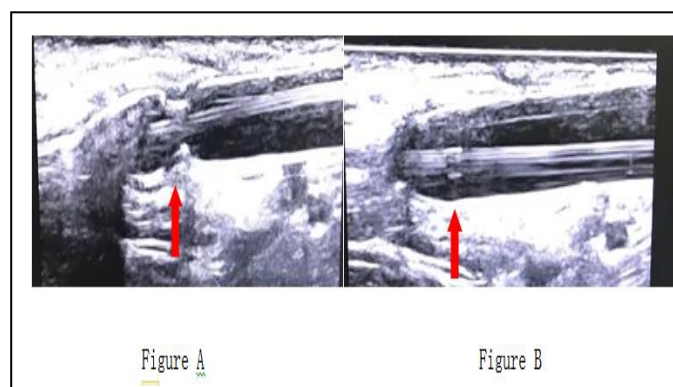
Primary disease	Types of drugs	Number of cases (case)	Patency rate		
			3 months	6 months	9 months
Overall	Clopidogrel	80	95.00%	81.25%	66.25%
	aspirin	10	70.00%	50.00%	50.00%*
Diabetic nephropathy	Clopidogrel	24	95.83%	87.50%	79.17%
	aspirin	3	66.67%	33.33%	33.33%*
Chronic nephritis	Clopidogrel	38	100.00%	81.58%	63.16%
	aspirin	4	50.00%	50.00%	50.00%*

Note: *A comparison between aspirin group and clopidogrel group ($P < 0.05$).

DISCUSSION

Autologous Arteriovenous Fistula (AVF) is considered to be the main and best vascular pathway for maintenance hemodialysis (MHD) in patients with End-Stage Renal Disease (ESRD). It is also closely related to prolonging the survival time of patients [9,10]. However, it can be found that infection, stenosis, thrombosis, aneurysm and limb ischemia can cause internal fistula failure in patients with AVF during hemodialysis. Among these factors, stenosis and thrombosis are the main causes. For patients with uremia, it is not easy to form intravascular thrombosis because of its coagulation dysfunction. The intravascular thrombosis of arteriovenous fistula is mostly due to the anatomical abnormality of the blood vessel itself, and the

main reason is vascular stenosis [11]. The highest incidence rate was found in the 3cm before and after the anastomosis [12]. In recent years, with the development of technology, Percutaneous Transluminal Angioplasty (PTA) has become the main treatment for vascular recanalization [3]. Argyriou, C. reported that surgical treatment of peristomal stenosis of AVF anastomosis is recommended [13]. However, it is mentioned in JSDT [4] that if the guide wire can narrow through the anastomosis, PTA can be used as the first choice for treatment, and endovascular treatment is recommended for other types of stenosis.



PTA: percutaneous transluminal angioplasty; Figure A: before ultrasound-guided PTA: the arrow shows obvious stenosis; Figure B: after ultrasound-guided PTA: the arrow shows the disappearance of vascular stenosis after dilation.

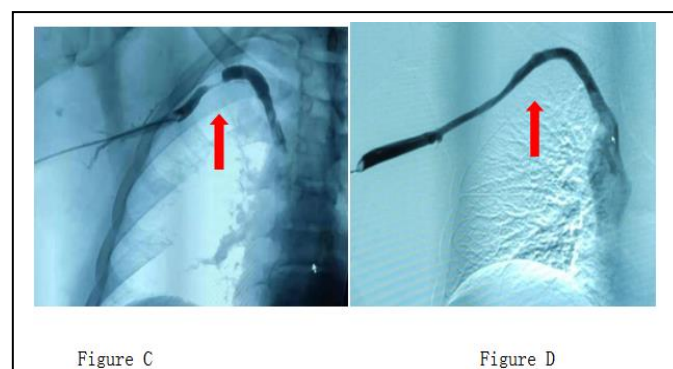
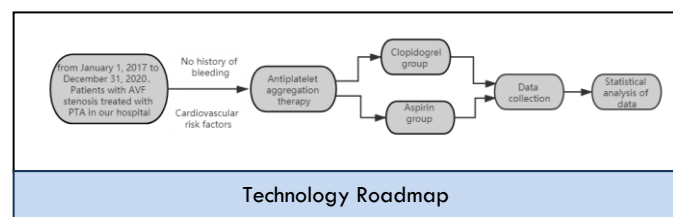


Figure C: DSA-guided PTA: the arrows showed obvious stenosis; Figure D: DSA-guided PTA, the arrows showed that the vascular stenosis has been resolved.



Some domestic studies have pointed out that the success rate of ultrasound-guided PTA in the treatment of internal fistula stenosis is 87% -93% [14]. In this study, the success rate of operation was 100%. The reason for the difference was related to the technical proficiency of surgeons, the degree of vascular stenosis of patients and so on. If the stenosis time is too long, tissue calcification and scarring will affect the effect of balloon dilatation. It is concluded that the indication of PTA treatment for AVF stenosis [4,15]: 1) The pump blood flow from arteriovenous fistula during dialysis is lower than 180-200ml stroke min, or lower than the bottom limit blood flow of maintenance dialysis adequacy of the patient. 2) The internal diameter of the internal fistula stenosis is less than 50% of the surrounding normal vein internal diameter, and the general internal diameter of the internal fistula is less than 2.5mm; the internal diameter of the internal fistula artery is 50% smaller than that of the surrounding normal artery; and the internal diameter of the internal fistula anastomosis is generally less than 2.5mm. 3) The natural blood flow of internal fistula is lower than that of 500ml/min.

In addition, in order to better maintain vascular patency after PTA, oral drug intervention can be chosen. For routine oral anticoagulant or antiplatelet aggregation drugs after PTA, warfarin increases the risk of bleeding [16,17]. Therefore, there are no relevant recommendations in the guidelines. The results of a randomized controlled trial show that clopidogrel can reduce early postoperative thrombotic events [18]. In addition, Nikam MD. et al. pointed out that aspirin can better maintain vascular patency [5]. Tozzi M, et al. indicated that for patients with chronic kidney disease, the risk of massive bleeding increased by 33% and the risk of mild bleeding increased by 48% after the use of antiplatelet drugs [19]. Therefore, the effects of antiplatelet aggregation drugs such as aspirin, clopidogrel and dipyridamol after PTA need to be further discussed. In this study, 90 patients were treated with anti-platelet aggregation therapy (clopidogrel group 80 cases, aspirin group 10 cases) according to the patient's condition after operation. The 3-month patency rate was 93.55%, the 6-month patency rate was 80.65%, and the 1-year patency rate was 67.74%. The results of grouping comparison showed that the postoperative patency rate of clopidogrel group was significantly higher than that of aspirin

group ($P < 0.05$). There were no bleeding complications during the follow-up period. We also compared the patency rates of clopidogrel and aspirin after different primary diseases PTA, and confirmed that clopidogrel was better than aspirin (as shown in Table 2). Clopidogrel is effective in maintaining vascular patency after PTA and can be used in clinical practice. However, this study is a retrospective study, the number of cases is relatively small, there may be selection bias, it is necessary to further expand the sample size for case-control study.

Although PTA has many advantages in the treatment of AVF stenosis, there are still some limitations, such as vascular rupture is a serious complication of PTA, which is mainly related to the choice of dilated balloon diameter and the speed of opening. When choosing the dilated balloon size, the balloon catheter with a ratio of the internal diameter of the normal blood vessel to the diameter of the balloon connected to the narrow blood vessel at 1:1 should not open too fast and maintain an increase in atmospheric pressure every 2 seconds [20]. And balloon pressure should not exceed the marked explosion pressure, in order to reduce the occurrence of such complications. After PTA treatment, the recurrence rate of vascular stenosis is high, but in order to maintain long-term vascular patency, we can choose repeated endovascular treatments [21].

To sum up, the advantage of PTA in the treatment of AVF stenosis is that it can be operated repeatedly, which can save the limited vascular resources of hemodialysis patients and reduce the pain of internal fistula reconstruction. This is a feasible and safe method, and it is worth popularizing and applying. Further exploration is needed for postoperative anti-platelet aggregation therapy to maintain vascular patency.

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