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Efficacy and Safety of Ureteral Catheter Use During Arteriovenous Fistula in End-Stage Renal Disease Patients with Poor Vascular Status

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Background: The aim of this study was to evaluate the efficacy and safety of use of a ureteral catheter during arteriovenous fistula in end-stage renal disease patients with poor vascular status.

Material/Methods: Fifty patients with standard arteriovenous fistulas at Sir Run Run Hospital of Nanjing Medical University from April 2018 to April 2019 were included. Based on the use of ureteral catheter exploration and tourniquet hydraulic dilatation, patients were divided into study and control groups. The operative success rate, inner diameter of cephalic vein 1 day post-operatively, blood flow in the internal fistula, patency rate and blood flow in the internal fistula 3 months post-operatively, and complications 6 months post-operatively were compared between the 2 groups.

Results: There were 25 cases in each group, with no significant differences in sex or age between the 2 groups. The operative success rate in the study group was higher than in the control group (96% *vs.* 88%) (F=1.087, P=0.297). The patency rates at 3 and 6 months post-operatively in the study group were higher than in the control group. The inner diameter of the cephalic vein 1 day post-operatively, the blood flow in the internal fistula, and the complications 6 months post-operatively in the study group were significantly superior to those of the control group (P=0.002).

Conclusions: In standard arteriovenous fistula, especially vascular catheter exploration of unhealthy vessels, the application of a ureteral catheter can improve the operative success rate and promote internal fistula maturity, with low cost and ease of use.

MeSH Keywords: Arteriovenous Fistula • Kidney Failure, Chronic • Urinary Catheters

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Background

Hemodialysis is one of the most important life-sustaining treatment options for patients with end-stage renal disease, accounting for 85% of the treatment choices for patients with end-stage renal disease worldwide [1]. Hemodialysis requires the establishment of long-term vascular access. Ideal long-term vascular access requires adequate blood flow, which is associated with few complications and is suitable for long-term use [2].

The arteriovenous fistula (AVF) was first reported in 1966, and it has become the preferred and most widely used method for hemodialysis access [3]. The KNF-KDOQI research guide recommends that an AVF should be the first choice for hemodialysis patients [3]. Saving limited vascular resources was considered to be a useful way to improve the success rate of a forearm AVF and to prolong the life of patients with end-stage renal disease. Ureteral catheters were widely used in surgical endoscopy and had the characteristics of low cost, intraoperative exploration, injection, and guiding support [4,5].

However, in patients undergoing AVF, the application of ureteral catheters has not been evaluated. Therefore, the aim of this study was to evaluate the efficacy and safety of ureteral catheters in AVF in end-stage renal disease patients with poor vascular status.

Material and Methods

General information

We retrospectively analyzed the clinical data of 50 patients undergoing a standard AVF at the Sir Run Run Hospital of Nanjing Medical University from April 2018 to April 2019. The patients were divided into study and control groups according to whether the physician decided to use a ureteral catheter during the procedure.

The inclusion criteria were: (1) pre-operative color Doppler ultrasound exploration showed a vein diameter >1.5 mm and a segmental stenosis vein diameter>1 mm; (2) pre-operative color Doppler ultrasound record showed an artery diameter >1.5 mm; (3) platelet count and coagulation function was normal and the hemoglobin was >90 g/L; and (4) cardiac function was corrected to at least level 2, and the blood pressure was controlled at 160/100–120/60 mmHg. The exclusion criteria were: (1) the vein diameter was>2.00 mm and the artery diameter was >2.00 mm; (2) thrombosis was identified on pre-operative color Doppler ultrasound; (3) severe heart failure and severe coagulopathy; and (4) swelling and infection at the operative site.

Operation methods

All the operations were performed by the same surgeon. The patient was routinely placed in the supine position, with abduction of the upper limb on the operative side. Local routine disinfection and brachial plexus anesthesia were performed. A longitudinal incision was made according to the operative site marked pre-operatively, a side-to-side anastomosis was performed, and ligation of the distal end of the vein lateral limb circulation was performed according to the intra-operative condition. The cephalic vein was dissociated and matched the radial artery. A longitudinal, 6–8 mm vein incision was made. Endangium injury was avoided as much as possible during the operation. In the study group, a 5 or 6 F (diameters were approximately 1.5 mm and 1.9 mm, respectively) ureteral catheter was selected for exploration according to the inner diameter of the vein (Figure 1A). Instead of removing the internal guide wire, the ureteral catheter was inserted antegrade in the brachiocephalic vein for at least 30 cm (the anatomic length of the axillary vein). If the ureteral catheter did not pass smoothly in the venous cavity, indicating that the vein diameter was <1.5 mm or there were branches, then the direction of the ureteral catheter was changed and another attempt would be made. If the ureteral catheter encountered great resistance when passing through the blood vessel, a 0.4% heparin sodium chloride solution was quickly injected to determine whether the injection was smooth and whether there was blood reflux. In the case of a stenosis, a sterile tourniquet at the proximal end was applied and heparin sodium saline was quickly injected for dilation for a period of time to prevent venous thrombosis. A side-to-side anastomosis was performed in conjunction with the above procedure. The ureteral catheter exploration and tourniquet test was not performed in the control group.

After side-to-side anastomosis in the study group, if the internal hemorrhage was insufficient and the vein was not filled, the ureteral catheter was used again to explore the vein (Figure 1B). The proximal end of the cephalic vein and the upper and lower ends of artery were clamped with vascular clips. The distal end of vein was ligated and divided, and the catheter was transported from the distal end of vein to the anastomotic stoma and venous end to explore whether there was a thrombus when the ureteral catheter was pulled out or whether there was a suture error when the catheter could not pass the anastomotic stoma smoothly. If the test failed and the anastomosis needed to be repeated, heparin sodium saline was quickly injected until blood flowed out and the distal end of vein was ligated. After the operation was completed, blood leakage at the anastomotic stoma, the shape of the anastomotic stoma, pulsations of the artery or tremors of vein were evaluated. Color

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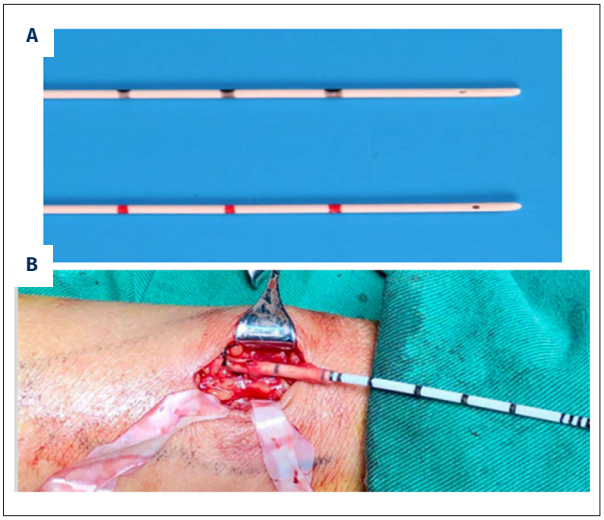

Figure 1. Application of a ureteral catheter during arteriovenous fistula. (**A**) Ureteral catheter; (**B**) Ureteral catheter exploration.

Doppler ultrasound was performed in both groups to detect blood flow in the internal fistula and the inner diameter of the cephalic vein, and the proximal end of the internal fistula was measured at 3 cm.

Observation indicators

The operative success rate, inner diameter of the cephalic vein within the first week post-operatively, blood flow in the internal fistula, patency rate, and complications at 3 and 6 months post-operatively were evaluated and compared between the 2 groups.

Statistical analysis

All data in this study were analyzed using SPSS 22.0. (SPSS Inc., Chicago, IL, USA). The normality of distribution of continuous variables was tested. Continuous variables with normal distribution are presented as mean±standard deviation (SD); Means of continuous normally distributed variables were compared by independent-samples *t* test and chi-square test. Non-normal variables were reported as median and interquartile range (IQR); non-parametric test was used to compare the medians of non-normal variables. A alue of P<0.05 was considered significant.

Results

Basic characteristics

Our study included 29 males and 21 females with average age of 47.9±14.8 years. There were 15 patients with glomerulonephritis, 20 with diabetic nephropathy, 5 with lupus nephritis, 3 with polycystic kidney disease, and 7 in whom the etiology was undetermined. The study group consisted of 25 patients undergoing intra-operative ureteral exploration and tourniquet pressure measurement, including 14 males and 11 females with average age of 46.6±15 years. The control group consisted of 25 patients not undergoing intra-operative ureteral exploration, including 15 males and 10 females with average age of 48.9±14.6 years (Table 1).

Table 1. Basic characteristics.

	Study group	Control group
Male	14	15
Female	11	10
Age (mean±SD)	46.6±15 years	48.9±14.6 years (22–76 years)
Age (median, interquartile range)	47 years (19–74 years)	50 years (22–76 years)
Pre-operative inner diameter of vessels	0.17±0.01 mm	0.18±0.01 mm
Duration of dialysis	4h	4h
Frequency of dialysis	3 times per week	3 times per week

Table 2. Comparison of the operative success rate, the inner diameter of the cephalic vein on day 1 post-operatively, and the fistula maturation time between the two groups.

	n	Success rate (100%)	Inner diameter (mm)	Blood flow in the internal fistula (ml/min)
Experimental group	25	96%	0.29±0.03	536.06±39.92
Control group	25	88%	0.23±0.02	525.38±37.67
t			2.516	3.966
p			0.019	0.001

Operative success rate

The operative success rate of the 25 patients in the study group was 96%. In 1 case, the ureteral catheter only entered for approximately 15 cm in the vessel and the vessel texture was brittle. The operative success rate of the 25 patients in the control group was 88%. There were no tremors and blood flow after anastomosis in 2 patients. Thrombus in the anastomotic stoma within 24 h was observed in 1 patient. The operative success rate in the study group was higher than in the control group (96% *vs.* 88%) (F=1.087, P=0.297).

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Table 3. Comparison of patency rate and blood flow in the internal fistula 3 months post-operatively between two groups.

	n	Patency	Patency rate (%)	Blood flow in the internal fistula (ml/min)
Study group	25	23	92%	559.98±24.39
Control group	25	19	76%	542.39±23.38
t				3.512
p				0.002

Table 4. Comparison of patency and complication rates 6 months post-operatively between the two groups.

	n	Patency rate (%)	Heart failure	Steal syndrome	Venous tumor-like dilation	Thrombosis/ stenosis
Study group	25	88%	0	0	0	2%
Control group	25	72%	0	0	0	16%
p		0.014				

Inner diameter of the cephalic vein

One day after the operation, ultrasound was used to assess the inner diameter of the cephalic vein and the blood flow in the internal fistula. The inner diameter of the cephalic vein was 0.29±0.03 mm in the study group, which was significantly wider than in the control group (0.23±0.02). (t=2.516, P=0.019).

Blood flow in the internal fistula

The blood flow in the internal fistula in the study group was 536.06±39.92 ml/min, which was significantly stronger than in the control group (525.38±37.67 ml/min) (t=3.966, P=0.001; Table 2). The blood flow in the internal fistula 3 months post-operatively was 559.98±24.39 ml/min in the study group and 542.39±23.38 ml/min in the control group (t=3.512, P=0.002).

Patency rates

The patency rates at 3 and 6 months post-operatively in the study group were 92% and 88%, respectively. The patency rates at 3 and 6 months post-operatively in the control group were 76% and 72%, respectively. The patency rates at 3 and 6 months post-operatively in the study group were higher than in the control group (F=2.381, P=0.123 at 3 month post-operatively and F=2.000, P=0.157 at 6 months post-operatively).

Complications

After 6-month follow-up, 1 patient had anastomotic stenosis in the study group, and the complication rate was 2%. In the control group, 2 patients had anastomotic thrombi and 2 patients had anastomotic stenosis. Therefore, the complication rate in control group was 16%, which was significantly higher than in the study group (P=0.002). There were no cases with heart failure, steal syndrome, or venous tumor-like dilation in either group (Tables 3, 4).

Discussion

Chronic kidney disease is one of the major diseases threatening human health [6]. The number of elderly patients with end-stage renal disease is gradually increasing. However, poor vascular status is one of the difficulties in the use of internal fistula in dialysis. A forearm AVF has become a favored approach due to its advantages of less trauma, simplicity, and low mortality rate [7,8].

Suboptimal hemodynamic patterns that develop in response to the abnormal artery-vein connection have been described as key factors associated with undesirable inward vein remodeling through the development of neointimal hyperplasia resulting in stenosis and, eventually, occlusion of the AVF. This rapid formation of a neointimal layer occurs in response to the hemodynamic changes that promote EC activation, increased expression of growth factors, and secretion of prothrombotic and vasoconstrictive substances [9].

Protecting distal vessels and saving the limited blood vessels were considered to be important to improve the operative success rate. However, Silva et al. believed that the standard for satisfactory venous outflow tract was that the arteriovenous fistula lumen diameter should be at least 2.5 mm [10]. If the vein diameter was less than 2 mm, the success rate of the internal fistula procedure would decrease; moreover, the internal fistula maturation would be difficult and the effective patency rate would also decrease [10]. Therefore, it was difficult to achieve effective patency rates of AVF in patients with veins <2 mm and >1.4 mm. It was considered that the conditions of the internal fistula in hemodialysis could still be satisfactory when the vein diameter was less than 2 mm [11]. It was reported that the veins during an AVF were smooth and elastic, and the artery and vein with a diameter >1.5 mm were suitable for AVF, which caused fewer complications and longer service life than with artificial vessels and central venous catheters [12–14]. The association between geometric characteristics of the arteriovenous anastomosis and AVF outcomes has been investigated in several

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retrospective clinical studies and computational fluid dynamics models, but the findings have not been translated into a technology that improves clinical outcomes [15].

In the present study, we evaluated the use of a ureteral catheter during arteriovenous fistula in end-stage renal disease patients with poor vascular status. The ureteral catheter exploration and tourniquet pressure measurement could help to improve the operative success rate of patients with poor vascular status. The advantages of a ureteral catheter procedure are as follows. Using a ureteral catheter for vascular tourniquet dilatation and expansion of the vessel diameter can help the suture to achieve the desired effect [16], and injecting heparin saline into the blood vessel can effectively prevent the formation of anastomotic thrombus. The ureteral catheter tip is round and smooth and thus does not damage the intima when passing through the blood vessel. The blood flow in the internal fistula can be increased by exploring the venous valve on the venous circuit in an injured vein [17]. It is important that the operation is atraumatic and avoids forcible passage when entering the catheter so as not to damage the vascular endothelium. The surface scale provides convenience and verification for conditional sterile color Doppler detection during the operation. To achieve a high operative success rate, pre-operative physical examination and color Doppler ultrasonography of the vein are very important, as the human forearm superficial vein variation is very complicated [18]. Finally, the cost of using ureteral catheters is low. Fogarty catheters are currently used for dilation exploration of stenotic vessels [19], but they are expensive, which increases the economic burden of patients [20]. The use of ureteral catheters to explore and dilate blood vessels in AVF can effectively conserve limited vascular resources.

The operation is affected by the subjectivity of the ultrasonographer and resolution of the equipment. The measurement of the vein may have deviation, so comprehensive analysis is particularly important. End-stage renal disease patients have poor vascular status, even though some blood vessels have met the requirements. Post- or intra-operative failure may occur; thus, an operative plan should be developed and pre-operative preparation should be implemented. Pre-operative physical examination and color Doppler, operative experiences, and the application of ureteral catheter all contribute to the success rate of complex AVFs, which could reduce the risk of internal fistula complications and decrease the internal fistula maturation time.

Conclusions

Ureteral catheters are widely used in minimally invasive surgery, with little effect on blood vessels. Their use is safe and inexpensive, with wide clinical application, and is especially suitable for extensive application in local hospitals. Our conclusions need to be confirmed by research with larger sample sizes, longer follow-up times, post-operative ultrasound Doppler monitoring of vascular flow changes, and comparison of the first dialysis patency rate.

Conflict of Interest

None.

References:

1. Vora AN, Stanislawski M, Grunwald GK et al: Association between chronic kidney disease and rates of transfusion and progression to end-stage renal disease in patients undergoing transradial versus transfemoral cardiac catheterization-an analysis from the veterans affairs Clinical Assessment Reporting and Tracking (CART) Program. J Am Heart Assoc, 2017; 6(4): e004819
2. Golper TA, Fissell R, Fissell WH et al: Hemodialysis: Core curriculum, 2014. Am J Kidney Dis, 2014; 63(1): 153–63
3. Brescia MJ, Cimino JE, Appel K et al: Chronic hemodialysis using venipuncture and a surgically created arteriovenous fistula. N Engl J Med, 1966; 275(20): 1089–92
4. Kim KH, Cho KS, Ham WS et al: Early Application of permanent metallic mesh stent in substitution for temporary polymeric ureteral stent reduces unnecessary ureteral procedures in patients with malignant ureteral obstruction. Urology, 2015; 86(3): 459–64
5. Stravodimos K, Katafigiotis I, Fragkiadis E et al: Correcting and sharing our complications. Misplacement of pigtail catheter, during a Robot Assisted Pyeloplasty. Clinical findings, diagnosis, possible causes and endoscopic treatment. Arch Ital Urol Androl, 2015; 87(2): 165–66
6. Ping HX, Zhang N: Xing. Prevalence of chronic kidney disease in China. Lancet, 2012; 380(9838): 216
7. Zhang JC, Al-Jaishi AA, Na Y et al: Association between vascular access type and patient mortality among elderly patients on hemodialysis in Canada. Hemodial Int, 2014; 18(3): 616–24
8. Amedia CA Jr., Bolton WK, Cordray T et al: Vascular access for HD: Aligning payment with quality. Semin Dial, 2011; 24(1): 37–40
9. Remuzzi A, Bozzetto M, Brambilla P et al: Is shear stress the key factor for AVF maturation? J Vasc Access, 2017; 18: 10–14
10. Silva MB Jr., Hobson RW 2nd, Pappas PJ et al: A strategy for increasing use of autogenous hemodialysis access procedures: impact of preoperative noninvasive evaluation. J Vasc Surg, 1998; 27(2): 302–7;discussion 307–8
11. Parmar J, Aslam M, Standfield N et al: Pre-operative radial arterial diameter predicts early failure of arteriovenous fistula (AVF) for haemodialysis. Eur J Vasc Endovasc Surg, 2007; 33(1): 113–15
12. Goel N, Kwon C, Zachariah TP et al: Vascular access placement in patients with chronic kidney disease Stages 4 and 5 attending an inner-city nephrology clinic: A cohort study and survey of providers. BMC Nephrol, 2017; 18(1): 28
13. Rodriguez JA, López J, Clèries M et al: Vascular access for haemodialysis--an epidemiological study of the Catalan Renal Registry. Nephrol Dial Transplant, 1999; 14(7): 1651–67
14. Wish JB: Vascular access for dialysis in the United States: Progress, hurdles, controversies, and the future. Semin Dial, 2010; 23(6): 614–18

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15. Sadaghianloo N, Jean-Baptiste E, Rajhi K et al: Increased reintervention in radial-cephalic arteriovenous fistulas with anastomotic angles of less than 30 degrees. J Vasc Surg, 2015; 62(6): 1583–89
16. Ramos JR, Berger K, Mansfield PB et al: Histologic fate and endothelial changes of distended and nondistended vein grafts. Ann Surg, 1976; 183(3): 205–28
17. Leskovar B, Furlan T, Poznic S et al: Using CorMatrix for partial and complete (re)construction of arteriovenous fistulas in haemodialysis patients: (Re)construction of arteriovenous fistulas with CorMatrix. J Vasc Access, 2019; 20(6): 597–603
18. Mat Said N, Musa KI, Mohamed Daud MA et al: The combination of sonography and physical examination improves the patency and suitability of hemodialysis arteriovenous fistula in vascular access. Malays J Med Sci, 2016; 23(4): 26–32
19. Kim MH, Kim YK, Jun KW et al: Clinical importance of intraoperative cephalic vein distensibility as a predictor of radiocephalic arteriovenous fistula maturation. Semin Dial, 2015; 28(6): E64–70
20. Demir D, Ceviker K, Aydin MS et al: Complications of arteriovenous fistula with polytetraflouroethylen grafts in hemodialysis patients. Niger J Clin Pract, 2015; 18(1): 120–23

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