Original article

The effect of ultrasound-guided percutaneous balloon dilatation on arteriovenous fistula stenosis in hemodialysis patients

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ABSTRACT

Objective: To explore the influence of ultrasound-guided percutaneous balloon dilation on arteriovenous fistula stenosis in hemodialysis patients. **Methods:** A total of 62 hemodialysis patients with arteriovenous fistula stenosis admitted to our hospital from February 2019 to February 2021 were selected as research objects and divided into control group and research group according to random number table method, with 31 cases in each group. The control group was treated with catheterization and thrombolytic therapy, while the research group was treated with ultrasound-guided percutaneous balloon dilation. The clinical efficacy, perioperative parameters and postoperative complication rate were observed and compared. **Results:** The success rate of operation and clinical success rate of research group were 96.77% and 93.55%, respectively, which were significantly higher than that of control group 83.87% and 70.97% (P<0.05). After operation, the internal diameter of fistula stenosis, brachial artery blood flow and hemodialysis blood flow in both groups were increased compared with that before operation, and the internal diameter of fistula stenosis, brachial artery blood flow and hemodialysis blood flow in the research group were significantly higher than those in the control group (P <0.05). During the follow-up period, the incidence of postoperative complications in the research group was 22.58%, which was significantly lower than that in the control group (9.68%) (P<0.05). **Conclusion:** After ultrasound-guided percutaneous balloon dilation intervention for arteriovenous fistula stenosis in hemodialysis patients, the stenosis part of arteriovenous fistula was reduced, the internal diameter of the stenosis was increased, and arterial blood flow was increased, achieving good therapeutic effect and prognostic effect.

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Keywords: Ultrasonic guidance; Percutaneous balloon dilatation; Hemodialysis; Arteriovenous fistula stenosis

Introduction

As an important organ tissue, kidney has the function of regulating metabolism, water and electrolyte balance, and endocrine system balance. In recent years, under the influence of diet, drugs, and lifestyle, the incidence of kidney diseases increases year by year, including diabetic nephropathy, chronic glomerulonephritis, and polycystic kidney disease. It is often accompanied by malignant vomiting, arrhythmia and other systemic reactions, which has seriously affected the quality of life and life safety of patients [1].

Hemodialysis is the main treatment plan to replace kidney. Through the semi-permeable membrane dialysis function, metabolic substances and excess electrolytes in the body are excluded, thus playing the role of kidney replacement and controlling the disease process, which helps to prolong the survival time of patients [2, 3]. However, some studies [4] have pointed out that with the prolongation of dialysis time, repeated and long-term puncture of dialysis channels will cause vascular scars and proliferation, leading to local vascular occlusion and stenosis, making it difficult to smoothly carry out hemodialysis, and affecting the hemodialysis effect and the use duration of arteriovenous internal fistula. Thrombolysis or surgical fistula reconstruction is usually selected for the treatment of arteriovenous fistula stenosis in hemodialysis patients in the past. Among them, urokinase is mainly administered for thrombolysis treatment to degrade coagulation factors and fibrin garden so as to exert the effect of dissolving thrombus. However, complications such as gingival bleeding and blood in urine may accompany the treatment period, thus affecting the clinical success rate. In surgical fistula reconstruction, healthy blood vessels in other parts are often selected to reconstruct the internal fistula, which will increase the pain in patients during the perioperative period and is difficult to be promoted [5, 6]. Therefore, the selection of efficient and safe treatment is of great value to improve the success rate of treatment and blood circulation. As a common surgical operation in recent years, ultrasound-guided percutaneous balloon dilatation has the advantages of small trauma, repeated operations and rapid postoperative recovery, but its overall therapeutic effect is still controversial [7, 8]. In view of this, in this study, 62 hemodialysis patients with arteriovenous fistula stenosis who were admitted to our hospital from February 2019 to February 2021 were selected

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as the research subjects. They were treated with catheterization thrombolysis and ultrasound-guided percutaneous balloon dilatation respectively, and the effects on clinical efficacy, perioperative parameters and incidence of postoperative complications were analyzed. We now report as follows.

Material and methods

General material

62 hemodialysis patients with arteriovenous fistula stenosis who were admitted to our hospital from February 2019 to February 2021 were selected as the research subjects, and they were divided into the control group and the research group according to the random number table method, with 31 cases in each group. There was no statistically significant difference in the basic data of patients between the two groups, and they were comparable. All patients were treated with autologous arteriovenous internal fistula. The control group was treated with catheterization thrombolysis, and the research group was given ultrasound-guided percutaneous balloon dilatation. The study was approved by the Hospital Medical Ethics Committee.

Criteria of inclusion and exclusion

Inclusion criteria: ① Patients who met the corresponding diagnostic criteria for kidney disease stated in the European Renal Best Practice (ERBP)[9]. ② patients who were aged from 18 to 80 years old and maintained on hemodialysis for more than three months; ③ The condition was stable, and autologous arteriovenous fistula was used as the dialysis pathway; ④ Difficulty in puncture and blood flow < 500 ml/min during dialysis; ⑤ The stenosis degree of fistulization arteriovenous internal fistula exceeds 50%; ⑥ Patients with no cognitive or mental disorders and normal communication; ⑦ The subjects and relatives were informed of the research content and signed informed consent form voluntarily.

Exclusion criteria: ① Patients with cardiovascular, brain, liver and other organ and tissue dysfunction; ② Patients with past medical history and operation history with renal diseases; ③ Patients with hemodialysis intolerance, malnutrition or blood system diseases; ④ patients with upper limb swelling and central vein stenosis; ⑤ Patients who recently accept antibiotics, infusion and other treatment; ⑥ Patients failed to fully cooperate with the researchers.

Research methods

After admission, the patients in both groups underwent palpation of internal fistula and hematological examinations to assess their primary diseases and stenosis of arteriovenous internal fistula. Catheterization thrombolysis was performed in the control group: 100,000 U urokinase (Guangdong Tianpu Biochemical Co., Ltd., GuoYaoZhunZi H20113006) was diluted in 5ml normal saline, and an indwelling needle was inserted into the catheter at the position 20–30 mm at the end of the cephalic vein stenosis for needle insertion. After the slow injection, the thrombus was gently massaged, and the thrombus was sucked out using the puncture needle.

The tourniquet was loosened and the internal fistula murmur was examined every 10 minutes. If the venous stenosis was not improved or dredged, the thrombolytic therapy was performed in the control group. Can be injected again 100000 u urokinase +10ml normal saline, pay attention to the overall injection of urokinase content shall not be more than 1 million u, during the injection closely observe the gingival bleeding, blood in urine, blood in the stool, if there is one, immediately stop the treatment. In the research group, ultrasound-guided percutaneous balloon dilatation was performed: The location, degree and vascular deviation of arteriovenous fistula stenosis were examined under the Philips color Doppler ultrasonography, the inner diameter and blood flow volume of the distal and proximal vessels of arteriovenous fistula were measured, and the appropriate balloon was selected and marked. Guiding a patient to take a supine position, after brachial plexus anesthesia is adopted, placing a sterile ultrasonic probe coated with a coupling agent in a sterile sleeve, performing vascular puncture on a venous blood vessel at about 5 to 10 cm at the stenosis part of the venous internal fistula under ultrasonic guidance and placing into a skin expander, pulling out the puncture needle and dilating the blood vessel for 1 to 2 times, wherein the duration is 1 to 2 min, and then placing into a 5F arterial sheath; and placing a balloon catheter into a mark part along a loach guide wire under ultrasonic guidance, connecting a pressure pump and dilating the blood vessel at the stenosis part, wherein the pressure is controlled at 12 to 14 atm, continuously dilating until the balloon pressure trace disappears, and slowly releasing the pressure after 1～2min of stability; For patients with multiple internal fistula strictures, dilation should be performed in batches along the anastomosis to the proximal end, and the balloon dilation should be stopped when all the vascular strictures are relieved or the dilation range exceeds 70% of the blood vessel diameter, and the balloon, the loach guide wire, the blood vessel sheath, and the like should be gradually withdrawn. The puncture point and the bleeding site should be sutured with blood vessel thread, which can be used for compression hemostasis when necessary. The skin should be sutured with sterile dressing, and care should be taken to avoid local hematoma. Postoperative contrast-enhanced ultrasound ensures complete or most dilation of the vessels with good visualization. After the operation, 0.5mg/kg heparin injection was given to ensure systemic heparinization. In addition, aspirin enteric-coated tablet (100mg) could be taken orally once a day for three months.

Observational index

(1) Evaluation criteria of clinical efficacy: ① Criteria for successful operation: Postoperative angiography was used to assess the residual vascular stenosis rate < 30% and insufficient blood flow (QB > 200 mL/min); ② Criteria for clinical success[9]: No vascular stenosis of internal fistula was found through color Doppler ultrasonography after operation. The site of internal fistula was palpated with good pulsation and loud auscultation murmur. The hemodialysis could be performed smoothly for two to three times per week, with the duration > one month.

(2) Perioperative parameters: Color Doppler ultrasonography was used to detect the inner diameter of the stenosis site of vascular fistula, brachial artery blood flow and hemodialysis blood flow before and after the operation. (3) The incidence of postoperative complications: The incidence of complications during the follow-up period was counted and recorded, including vascular rupture, thrombosis, retraction of vascular collapse, infection, etc.

Statistical methods

SPSS 24.0 statistical software was used. The data conforming to the normal distribution were measured and expressed as ($\bar{x} \pm s$). The data between groups were compared with t test. Enumeration data were expressed as case number (N) and percentage (%). Intergroup comparison was performed using $\chi 2$ test, and $P < 0.05$ indicated that the difference had statistical significance.

Results

Comparison of general data

The results showed that there was no significant difference in basic data such as gender, age, BMI, type of primary disease, dialysis time, anastomosis method of internal fistula, use time of internal fistula, and location of internal fistula stenosis between the two groups (P>0.05), as shown in Table 1.

Table 1 **Comparison of general data**

Group		Control group (n=31)	Research group (n=31)	t value	P value
Gender (cases)	Male	18 (58.06)	20 (64.52)	5.390	0.194
	Female	13 (41.93)	11 (35.48)		
Age (years)		50.29±4.29	50.07±5.13	4.834	0.331
BMI (kg/m^2)		23.85±1.63	23.89±1.64	3.019	0.425
Primary diseases (cases)	Diabetic nephropathy	8 (25.81)	9 (29.03)	4.395	0.469
	Chronic glomerulonephritis	11 (35.48)	10 (32.26)		
	Polycystic kidney	5 (16.13)	5 (16.13)		
	Hypertensive renal sclerosis	7 (22.58)	7 (22.58)		
Dialysis time (years)		4.89±1.12	4.92±1.22	4.825	0.193
Anastomosis method of internal fistula (cases)	Radial artery-cephalic vein end side	27 (87.10)	29 (93.55)	5.391	0.263
	Brachial artery-distal end venous side	4 (12.90)	2 (6.45)		
Adaption time of internal fistula (cases)		3.48±1.02	3.51±0.98	5.416	0.519
Stenosis of internal fistula (cases)	Left upper limb	26 (83.87)	25 (80.65)	5.395	0.232
	Right upper limb	5 (16.13)	6 (19.35)		

Comparison of clinical efficacy between the two groups

The results showed that the surgical success rate and clinical success rate in the research group were 96.77% and 93.55%, respectively, significantly higher than 83.87% and 70.97% in the control group. The difference was statistically significant (P<0.05), as shown in Table 2.

Table 2 **Comparison of clinical efficacy between the two groups (cases, %)**

Group	Control group (n=31)	Research (n=31)
Successful operations(cases)	26 (83.87)	30 (96.77) #
Clinical success(cases)	22 (70.97)	29 (93.55) #

Note: Compared with the control group, #*P*<0.05

Comparison of perioperative parameters between the two groups

The results showed that there was no significant difference in perioperative parameters between the two groups before operation (P > 0.05). After surgery, the inner diameter of the fistula stenosis, brachial artery blood flow volume and hemodialysis blood flow volume were higher in the two groups than those before surgery. The inner diameter of the fistula stenosis, brachial artery blood flow volume and hemodialysis blood flow volume in the research group were significantly higher than those in the control group with statistically significant differences (P <0.05), as shown in Table 3.

Table 3 **Comparison of perioperative parameters between the two groups ($\bar{x}$±s)**

Group	Time	Control group (n=31)	Research group (n=31)
Internal diameter of stenosis of internal fistula (mm)	Before operation	1.74±0.38	1.75±0.37
	After operation	3.09±0.44*	3.90±0.49*#
Brachial artery blood flow (ml/min)	Before operation	256.38±30.26	257.39±29.57
	After operation	461.26±34.38*	538.54±39.14*#
Hemodialysis blood flow (ml/min)	Before operation	132.50±18.30	132.47±18.32
	After operation	228.29±23.04*	284.38±30.29*#

Note: Compared with before operation, **P*<0.05 ; compared with the control group, #*P*<0.05

Comparison of postoperative complication rate between the two groups

The results showed that during the follow-up period, the incidence of postoperative complications in the research group was 22.58%, which was significantly lower than 9.68% in the control group.

The difference was statistically significant (P<0.05), as shown in Table 4.

Table 4 **Comparison of postoperative complication rate between the two groups (cases, %)**

Group	Control group (n=31)	Research group (n=31)	χ2 value	P value
Rupture of blood vessel	1 (3.23)	0 (0.00)	-	-
Thrombus	3 (9.68)	1 (3.23)	-	-
Vascular collapse retraction	0 (0.00)	0 (0.00)	-	-
Infection	3 (9.68)	2 (6.45)	-	-
Total efficiency	22.58%	9.68%	4.391	0.008

Discussion

Hemodialysis can achieve the effects of maintaining the balance of acid and alkali, water and electrolyte, and purifying the blood by draining the blood from the body to the outside, passing through the semi-permeable membrane, electrolyte solution, and other devices, and removing the metabolic wastes and redundant electrolytes in the blood according to the principles of substance exchange such as dispersion and convection [10]. With the increase in the incidence of renal diseases, the demand for hemodialysis increases year by year. During dialysis, autologous arteriovenous internal fistula serves as an important channel for this process, determining the dialysis adequacy and molecular toxin clearance, which is of great significance for the efficacy of hemodialysis and prolonging the service life [11]. Studies [12] have shown that repeated puncture, infection, atherosclerosis and other factors in the dialysis channel of some hemodialysis patients lead to stenosis of arteriovenous internal fistula, causing damage to the internal fistula and incomplete hemodialysis, which affects the safety and effectiveness of the treatment. Percutaneous balloon dilatation is one of the options for the treatment of arteriovenous fistula stenosis in hemodialysis patients. The balloon dilatation is used to dilate the arteriovenous fistula of the stenosis, which has the advantages of small trauma, safety, and small postoperative adverse reactions. In addition, under the guidance of imaging technology, it can improve the visual field and definition during the operation, and has a wide application prospect [13].

In this study, ultrasound-guided percutaneous balloon dilatation was used to treat hemodialysis patients with arteriovenous fistula stenosis, and achieved good therapeutic effects. It can improve perioperative parameters and reduce the incidence of postoperative complications, which has clinical significance [14]. Arteriovenous internal fistula is a key pathway in the hemodialysis process, and good vascular access can improve the effectiveness of hemodialysis. However, as blood circulates through the heart, high flow of blood will cause damage to the fistula opening and stimulate the venous epithelial cells, which in turn leads to the proliferation of internal fistula and vascular stenosis. In addition, puncture at arteriovenous internal fistula may cause fibrous tissue to enter the vessel, resulting in vascular stenosis, and repeated repair and injury of the puncture point, stimulating hemodynamic changes, and proliferation of fibrous tissue on the inner wall of the vessel, resulting in stenosis and occlusion of the internal fistula. At the same time, excessive incision traction at the anastomosis of internal fistula will stimulate vascular wall damage and increase the risk of aseptic inflammation and intimal hyperplasia, which may also lead to stenosis of internal fistula. Long-term stenosis of internal fistula will reduce the effect of hemodialysis and affect the treatment of the disease [15, 16].

The percutaneous balloon dilatation can place that balloon accord to the position, the range, the degree and the like of the vascular channel stenosis, ensure the balloon to enter the vascular stenosis position, urge the balloon to dilate under the action of pressure, improve the degree of the vascular stenosis and the like, and can accurately position the balloon position under the guidance of ultrasound, reduce the operation time, reduce the trauma of instruments or tools dure the operation and ensure the smooth operation; In addition, percutaneous balloon dilatation under the guidance of ultrasound could perform multiple dilatation of multi-segment stenosis, reduce the possibility of multiple operations, and improve the success rate of operations and clinical success rate [17, 18]. Lučev J et al. [19] performed percutaneous balloon dilatation on patients with vascular stenosis due to hemodialysis arteriovenous fistula, which could effectively improve hemodynamics, reduce the degree of vascular stenosis, and increase arterial blood flow, and achieved high clinical success rate.

AbiMansour JP et al. [20] adopted ultrasound-guided percutaneous transluminal angioplasty to expand the gallbladder and pancreatic duct channel, which can alleviate the stenosis of gallbladder and pancreatic duct channel anastomosis and improve the success rate of surgery. The results of this study showed that the success rate of surgery and clinical success rate in the research group were significantly higher than those in the control group. After surgery, the inner diameter of fistula stenosis, brachial artery blood flow volume and hemodialysis blood flow volume were higher in the two groups than those before surgery. The inner diameter of fistula stenosis, brachial artery blood flow volume and hemodialysis blood flow volume in the research group were significantly higher than those in the control group. The results were basically consistent with those of Lučev J and AbiMansour JP, indicating that ultrasound-guided percutaneous balloon dilatation of arteriovenous fistula stenosis in hemodialysis patients had significant effects and could effectively improve the degree of arteriovenous stenosis. According to research data, the incidence of postoperative complications in the research group during the follow-up period was significantly lower than that in the control group. The results were similar to those in the above literature, indicating that ultrasound-guided percutaneous balloon dilatation for the treatment of hemodialysis arteriovenous fistula stenosis could significantly reduce the postoperative complications and had a good prognosis. With that development of ultrasonic technology and clinical application, the percutaneous balloon dilatation is carry out under the guidance of ultrasonic, the angle, the depth and the direction of the puncture needle can be clearly observe, the loach guide wire is guided to select the nearest stenotic blood vessel, the balloon can be accurately positioned to the stenotic blood vessel, the dynamic blood flow, the flow rate and the like can be monitor during the balloon dilatation, the operation is promoted to be carried out smoothly, the postoperative complications caused by instrument operation during the operation are reduced, and the percutaneous

balloon dilatation device has higher safety; In addition, it has the advantages of small trauma, rapid recovery, and repeated operation. In addition, it can retain the body's vascular resources as much as possible, well reducing the risk of postoperative complications, and has high safety [21].

There are still some shortcomings in this study, including the relatively small number of cases, the possible deviation between the research results and clinical data, which would affect the reliability of the research results; The follow-up time was limited, and the long-term efficacy and recurrence of arteriovenous fistula stenosis after ultrasound-guided percutaneous balloon dilatation were not involved. The research projects only focused on perioperative parameters and complications, and did not pay attention to its biochemical indicators and laboratory indicators. Therefore, the reliability of research results needs to be further verified by expanding the scope of cases and extending the follow-up time.

In summary, ultrasound-guided percutaneous balloon dilatation of arteriovenous fistula stenosis in hemodialysis patients has achieved significant results, which can significantly improve the perioperative parameters and control the complications., which is of guiding value for clinical treatment.

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