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Analysis of arteriovenous fistula failure in hemodialysis patients.

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Abstract

Objective: To investigate the reason of autogenous arteriovenous fistula failure by analyzing the clinical data of 32 hemodialysis patients in the Department of Nephrology in recent years.

Methods: A total of 32 end-stage renal disease patients who had forearm arteriovenous fistula failure in our hospital from February 2010 to February 2012 were selected, and another 66 patients who had the successful forearm arteriovenous fistula surgery in the same hospital during the same period were selected. The preoperative morning fasting blood hemoglobin (HB), cholestrol (CHOL), fibrinogen (Fib), parathyroid hormone (PTH), blood glucose and preoperative blood pressure were collected for statistical analysis.

Results:

The cephalic vein and radial artery diameter of the experimental group were significantly less than those of the control group ($p<0.05$). The cephalic vein and the radial artery diameters were the main risk factors of fistula failure, the smaller the diameter, the greater the risk of failure ($p<0.05$).

The PTH level in the experimental group were significantly higher than that in the control group ($p<0.05$). Logistic regression analysis considered that PTH was the risk factor of arteriovenous fistula failure ($p<0.05$).

Logistic regression analysis showed that the preoperative systolic blood pressure and diastolic blood pressure of two groups were related with the success of arteriovenous fistula surgery, the lower the blood pressure, the easily the arteriovenous fistula failure ($p<0.05$).

Conclusions: The main reason of autogenous arteriovenous fistula failure is the cephalic vein and the radial artery diameters, the smaller the diameter, the greater the risk of occlusion. Blood pressure and PTH also affect the success rate of fistula.

Keywords: Arteriovenous fistula, Hemodialysis, Cephalic vein, Radial artery, Blood pressure, PTH, Uremia.

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Abbreviations

Hb: Hemoglobin; CHOL: Cholesterol; Fib: Fibrinogen; PTH: Parathyroid hormone; HD: Hemodialysis; AVF: Arteriovenous fistula; AVG: Arteriovenous graft; CVC: Central venous catheter; AD: Artery diameter; VD: Vein diameter; ESRD: End-stage renal disease; GFR: Glomerular filtration rate; TG: Triglycerides.

Introduction

Vascular access is "the life line" for patients on chronic hemodialysis (HD) [1]. Numerous studies have showed the superiority of well-matured upper extremity Autogenous arteriovenous fistula (AVF) compared to the Arteriovenous graft (AVG) or Central venous catheter (CVC). Those results have been incorporated into the well-known guideline [2-4]. Many preoperative, intraoperative, and postoperative parameters may influence the success of AVFs. Some of them are well-known, but there are also unknown factors that could influence the AVFs outcomes.

The main preconditions to perform patent AVF are good inflow and outflow. The impact of the vessel diameter was researched in numerous studies. Artery and vein diameters below 2 mm were the predictors of high incidence of early thrombosis or failure to mature in some studies, and some authors recommended cut-off size of the artery and the vein [5,6]. The most widely mentioned recommendation is: artery diameter (AD) 2 mm and vein diameter (VD) 2.5 mm [7,8] or VD 3 mm [9].Increasing the artery and the vein diameter is necessary for maturation [10,11].

Hemodialysis is one of the main alternative treatments in patients with End-stage renal disease (ESRD). Hemodialysis is completely depends on the good quality of vascular access, autologous AVF is the most safe and effective vascular access. Despite the undeniable benefits of AVF as a form of vascular access, considerable amount of time is required for the fistula to mature and suitably develop into a functional format [12, 13]. Failure or success in maturation of AVFs depends on various factors, such as blood glucose and blood pressure. We choose 32 ESRD patients with forearm arteriovenous fistula surgery failure in our hospital to collect the preoperative cephalic vein and radial artery diameters, and to explore the impact of vessel diameter on AVF, assessing the impact of blood lipids, hemoglobin (Hb), fibrinogen (Fib), parathyroid hormone (PTH), blood glucose and blood pressure on AVF as these clinical index are the common clinical monitoring indicators.

Materials and Methods

Subjects

A total of 32 end-stage renal disease patients who had forearm arteriovenous fistula failure in our hospital form February 2010 to February 2012 were selected as the experimental group (n=32), including 20 males and 12 females, aged 23-79 years; in which the primary disease included: 11 cases of diabetic nephropathy, hypertensive nephropathy in 8 cases, 6 cases of chronic glomerulonephritis, polycystic kidney disease in 4 cases, 2 cases of lupus kidney disease, interstitial nephropathy in 1 case. Another 66 patients who had the successful first-time forearm arteriovenous fistula surgery in the same hospital during the same period were selected as the control group (n=66), and there were no statistical differences in age, gender and primary disease, and can be comparable.

The written informed consent was obtained from the participants. This article has been approved by the ethics committee of the Fourth Affiliated Hospital, China Medical University with the reference number of 2014014.

Diagnostic criteria for ESRD

According to the staging of chronic kidney disease of American Kidney Disease Foundation K/DOQI Group of Experts, glomerular filtration rate (GFR) <15 ml/min is the ESRD.

Exclusion criteria

The following conditions could not participate in this study: patients who had bilateral upper limbs forearm autogenous AVF angioplasty, and received AVF again were not included.

Methods

Morning fasting blood was collected from the patients in two groups,

- Hb, cholesterol (CHOL), Fib, PTH, and fasting blood glucose in the patients of two groups were compared.
- The preoperative blood pressure in the patients of two groups were compared.
- The differences of cephalic vein and radial artery diameter were compared between two groups through ultrasonic testing.

Surgical site: The upper limbs of non-dominant side was the main site, forearm wrist 3-6 cm was the surgical incision.

Surgical methods: Cephalic vein and radial artery end to side anastomosis.

Fistula success criteria

Fistula success: postoperative inner tremor was found in fistula, hair-like bruit auscultation, and after 4-6 weeks, the fistula matured and can be used for hemodialysis, blood volume was 200 ml/min or more.

Fistula failure: postoperative fistula tremor cannot be found, failed to smell and vascular murmur.

Intravascular ultrasound testing equipment and methods

The American GE-LOGIO7 Ultrasound was used with probe frequency of 7.5-15 MHz. Fully exposed test site, the inspection scope included forearm radial artery and cephalic vein, observed and recorded the cephalic vein and the radial artery diameters of the surgical site, the average of the measured values of three target points was taken as the measurement results.

Statistical methods

SPSS 17.0 statistical software was used for analysis. The comparison of cephalic vein, radial artery diameter, Hb, CHOL, triglycerides (TG), Fib, PTH, blood glucose, blood pressure and other indicators between two groups was measure with t test, the analysis on the risk factors of AVF occlusion using binary Logistic regression analysis.

Results

Comparison of preoperative basic information between two groups

The age and gender of the patients in two groups were matched, and there were no statistically significant differences in Hb, CHOL and blood glucose ($P>0.05$); The PTH levels in the experimental group was increased and significantly higher than that in the control group ($P<0.05$); the Fib level of the patients in two groups were increased, and increasing degree of the experimental group was higher than that of the control group ($p<0.05$) (Table 1).

Comparison of preoperative blood pressure between two groups

The systolic and diastolic blood pressure of the control group was significantly increased and higher than that of the experimental group (P <0.05, Table 2). Comparison of vessel diameter between two groups.

Table 1: Comparison of preoperative basic information between two group.

Groups	n	Age (year)	Cholesterol (mmol/L)	Hemoglobin (g/L)	PTH (pg/ml)	Fibrinogen (g/L)	Bloodsugar (mmol/L)
Experimental	32	58.97 ± 15.27	4.88 ± 1.37	99.20 ± 19.75	749.82 ± 412.90	4.57 ± 0.71	7.15 ± 1.69
Control	66	58.88 ± 15.55	4.57 ± 1.28	90.69 ± 24.88	545.35 ± 253.47	4.07 ± 1.56	7.23 ± 4.53
t		-0.309	-1.063	-1.692	-3.024	-2.187	0.123
p		0.758	0.292	0.094	0.003*	0.031*	0.902

Table 2: Comparison of systolic and diastolic pressures between two groups.

Groups	n	Systoli pressure (mmHg)	Diastolic pressure (mmHg)
Experimental	32	134.91 ± 18.24	81.53 ± 18.13
Control	66	156.82 ± 17.34	98.64 ± 16.37
t		5.769	4.682
p		0.013*	0.008*

The cephalic vein and radial artery diameters of the control group were significantly higher than those of the experimental group (p<0.05) (Table3).

Table 3: Cephalic vein and radial artery diameter comparation between two groups.

Groups	n	Cephalic vein diameter (mm)	Radial artery diameter (mm)
Experimental	32	1.33 ± 0.41	2.04 ± 0.69
Control	66	1.68 ± 0.56	2.47 ± 0.74
t		3.136	2.791
p		0.002*	0.006*

Logistic Regression Analysis on arteriovenous fistula failure and related factors

PTH is the risk factors of arteriovenous fistula failure, the higher the PTH, the greater the risk of failure, OR value was 1. 228. Cephalic vein and radial artery diameters were also the important factors of arteriovenous fistula failure, the smaller the diameters, the greater the risk of failure, OR values were 0.029 and 0.115. Systolic and diastolic blood pressure were also the important factors of arteriovenous fistula failure, the smaller the systolic and diastolic diameters, the higher the risk of arteriovenous fistula failure. Age, Hb, CHOL, blood glucose and Fib were not the risk factors for fistula occlusion.

Discussion

Relationship between autogenous arteriovenous fistula failure and vascular diameter

Normal adult radial artery diameter is about 3-4 mm, cephalic vein diameter is about 5-6 mm in the case of full filling, and normal cephalic vein and radial artery diameter size are fully compliant with the actions of arteriovenous fistula angioplasty [14]. Due to the impact of the primary disease in uremic patients and abnormal vascular structure and function caused by uremia, thus affecting the size of their vessel diameter. Wong et al considered that when the vein or artery diameter less than or equal to 1.6mm, the fistula failure rate is the highest [15]. Thomsen et al found that when the cephalic vein diameter less than or equal to 1.0 mm, the fistula is difficult to mature [16]. There are also reports suggested that the arteriovenous fistula surgery need the caliber arteries with the diameter of 2-5 mm and corresponded veins with the match diameter, in order to achieve the blood flow that dialysis required. If the blood vessels diameter is too small, it will increase the difficulty of arteriovenous fistula angioplasty surgery. Vascular caliber is a very important factor that impact fistula blood flow, the thinner the diameter, the higher the rate of fistula failure. In this study, the cephalic vein and radial artery diameters in the experimental group was significantly less than those in the control group. Logistic regression analysis showed that the OR value of cephalic vein diameter was 0.029, the OR value of radial artery diameter was 0.115, both of them are the risk factors for fistula occlusion, the smaller the diameter, the greater the risk of fistula occlusion, this result is consistent with the foreign literature.

Relationship between other reasons and arteriovenous fistula failure

This paper showed the systolic and diastolic blood pressure in the fistula failure patients was significantly lower than that in the control group, and the difference was statistically significant. Low blood pressure will lead to low blood flow through the anastomotic stoma, thus easy to form thrombus,

which had significant impact on internal fistula success. It has been reported that for the ESRD patients combined with hypertension should not reduce blood pressure excessively, proper control of ultrafiltration amount and does not exceed 2% of body weight is appropriate.

Patients with ESRD appears parathyroid hormone (PTH) increasing. 1.25–$(OH)_2D_3$ deficiency and higher phosphorus concentration caused calcium levels decreasing is an important factor in stimulating the secretion of PTH. Calcium and phosphorus metabolism disorder and PTH increasing can lead to vascular calcification occurrence, based on medial calcification. For the patients with more severe vascular calcification, the vascular intimal is easy to fall off during surgery, the white and small pieces of bone material will deposited in the vessel wall. The arteriovenous vascular compliance of such patients is poor, resulting in difficult vascular anastomosis during arteriovenous fistula surgery, and easy to form postoperative thrombosis, thus easily leading fistula occlusion. In this study, PTH levels in the experimental group was significantly higher than that in the control group, t test showed the difference was statistically significant ($p<0.05$). Logistic regression analysis showed PTH is a risk factor for fistula failure, the higher the PTH, the higher the risk of fistula failure.

In this study, the fibrinogen number in the experimental group were higher than that in the control group, but Logistic regression analysis showed that fibrinogen had no correlation with fistula occlusion, and this was not consistent with other studies which suggested that fibrinogen is a risk factor for fistula occlusion, which may be related to the small sample size of this study. Studies suggested that that fibrinogen number of long-term hemodialysis patients are often higher than normal, that may be associated with inflammation, stress and other factors. Increased fibrinogen can promote blood clotting. Fibrinogen is a very important material that involved in thrombosis. However, it still need to be further studied and discussed about the specific fibrinogen increasing that will affect the formation of intravascular thrombosis and occlusion.

There are lots of research about the cause of arteriovenous fistula occlusion, scholars found that for the dialysis patients, low blood pressure and diabetes can cause vascular thrombosis, thus leading to fistula occlusion. Some studies showed that for the long-term hemodialysis patients, the lipid is a relevant factor of fistula occlusion. However, in this study, there were no significant differences in age, hemoglobin, cholesterol and blood glucose, this maybe related with the samll sample size that can not find tha relation with fistula occlusion.

In addition, the factors of this article, there are many forward related factors that affecting arteriovenous fistula, due to limiting factor of conditions, we don not metioned in this article. How to use and protect fistula is also an important aspect of fistula life. After AVF surgery, we should appropriate exercise limbs, the patients can queeze a rubber ball with hands in order to promote blood circulation of limb. If the surgical side limb edema, the patients should have proper rest, and raise the limb until the swelling subsides slowly. If the fistula vasodilation is not obvious, the surgical limb can be treated with hot compress, the patients can also use fingers to short intermittently press the anastomotic vein that near the heart, in order to promote venous dilation. Wang et al thought that the repeatedly pulling after limbs fistula pressure is the major cause of arteriovenous fistula thrombosis [17]. During hemodialysis, arterial puncture point should away from the fistula at least 3 cm, in order to avoid damage anastomotic stoma. Planned arrangements of puncture position, and repeat and recycling application, in order to more conducive to repair blood vessels and even the expansion, and avoid the increasing of the possibility of pseudoaneurysm formation, reducing the puncture site bleeding, thus prolonging fistula application.

Conclusions

In short, arteriovenous fistula is the “lifeline” of long-term hemodialysis patients, we should reasonable choice, use and protect fistula, and correctly understand the risk factors that may lead to fistula occlusion before and after surgery, and prevent and avoid timely.

Authors’ contribution

Ding H havs made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; Gao D has been involved in drafting the manuscript or revising it critically for important intellectual content; Ding H and Gao D has given final approval of the version to be published.

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