

# Integrated management to reduce fistula-related long-term complications and improve the quality of life after arteriovenous fistula surgery: A retrospective cohort study

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## Abstract

**Aim:** Proper arteriovenous fistula (AVF) management is crucial to avoid AVF complications and prolong its useful life for maintenance haemodialysis (MHD).

**Design:** Retrospective cohort study.

**Methods:** Patients on MHD who underwent AVF surgery at the Wuhan Third Hospital between January 2018 and July 2018.

**Results:** A total of 144 patients were included, with 56 in the integrated group and 88 in the routine group. There were no differences between the two groups in terms of sex ( $p = .61$ ), age ( $p = .62$ ) and type of primary kidney disease ( $p > .99$ ). At 1 year, the integrated group had significantly fewer fistula-related complications than the routine group (3.6% versus 23.9%,  $p < .001$ ). AVF functional scores were lower in the integrated group compared with the routine group ( $0.1 \pm 0.5$  versus  $0.8 \pm 0.8$ ,  $p < .001$ ). The pain scores were lower in the integrated group than in the routine group ( $1.2 \pm 0.4$  versus  $1.8 \pm 0.9$ ,  $p < .001$ ).

## KEYWORDS

arteriovenous fistula, case management, complications, disease management, renal dialysis

## 1 | INTRODUCTION

Chronic kidney disease is characterized by abnormalities of the kidney structure or function that are present for >3 months (2013). It is defined as >3 months of either a glomerular filtration rate (GFR) <60 ml/min/1.73 m<sup>2</sup> or other evidence of kidney damage such as albuminuria or abnormal kidney structure detected by imaging (2013). The most common causes include diabetes, hypertension and glomerulonephritis (Romagnani et al., 2017; Webster et al., 2017). Complications of CKD can include cardiovascular disease, hypertension, anaemia, bone disease, electrolyte abnormalities and in the end-stage, uraemia (Romagnani et al., 2017). Renal replacement

therapy remains the only option for patients with end-stage renal disease (ESRD) (2013; Inker et al., 2014).

## 2 | BACKGROUND

According to the Chinese National Renal Data System (CNRDS), there are about 553,000 patients receiving haemodialysis (HD) in China (Zhang et al., 2019). Long-term patent vascular access is a challenge for haemodialysis, and improper access can compromise treatment and survival of the patient (2006; Kumwinda et al., 2015). Since autologous arteriovenous fistula (AVF) has the advantages of fewer

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complications and a high long-term patency rate, the guidelines and expert consensus on vascular access of haemodialysis recommend autologous AVF as the preferred option for maintenance HD (MHD) patients (2006; Kumwinda et al., 2015). When using an AVF, the unplanned repeated puncture can easily lead to local scars, stenosis, induration, angiomatous dilation and other complications, which seriously affects the useful life of the AVF (Al-Jaishi et al., 2017; Bylsma et al., 2017).

The Chinese society is ageing (Smith et al., 2014), and the prevalence of diabetic nephropathy and hypertensive renal damage is increasing each year (Pan et al., 1997; Wang et al., 2018; Xu et al., 2013; Yang et al., 2010). Atherosclerosis caused by micro- and macroangiopathy in patients with diabetic nephropathy has a high incidence and more complications compared with other uraemic patients (Coentrao et al., 2015). In the presence of atherosclerosis, AVFs have higher risks of low long-term patency rate, delayed maturation and fistula dysfunction (Lee & Kim, 2017). It was shown that postoperative duplex ultrasound monitoring after AVF formation increases the rates of postoperative intervention, although it does not improve secondary patency (Nickinson et al., 2020). For hypertensive patients, reduced vascular elasticity due to hypertensive arteriosclerosis will compromise the AVF (Lee & Kim, 2017).

Therefore, proper AVF management is imperative to reduce the occurrence of scars of the skin and vascular walls and stenosis of the vessels; this could extend the useful life of the AVF (Al-Jaishi et al., 2017; 2006; Kumwinda et al., 2015; Rushing, 2010). The haemodialysis access surveillance evaluation (HASE) study revealed that ultrasound dilution technique flow measurement monthly reduced thrombotic events without significantly increasing angiographic procedures (Salman et al., 2020). Meanwhile, integrated management has also been applied, which aims at optimizing the workflow of the blood purification centre, improving work efficiency, reducing work-related risks and continuously improving quality. It is reported that a dedicated vascular team can help early identify complications and improve vascular access outcome (Raza et al., 2019). Therefore, a practical, scientific, comprehensive, dynamic, open and information-based integrated management system was established. Previous studies did not examine the comprehensive management of AVF and long-term follow-up of venous access in the setting of this integrated care.

## 2.1 | Research question

Could a comprehensive, dynamic and open integrated management system for AVF reduce the associated complications?

## 3 | THE STUDY

### 3.1 | Design

This was a retrospective cohort study of patients on MHD, who underwent AVF surgery at the Wuhan Third Hospital between January

2018 and July 2018. Integrated nursing was first implemented in only one HD ward at the hospital. The patients were assigned to the routinely or integratedly managed wards according to availability at admission, and were followed up in the same ward thereafter. All patients were allocated to one of the two groups, according to whether integrated management was performed during nursing.

### 3.2 | Ethical considerations

This study was approved by the Ethics Committee of Wuhan Third Hospital. Informed consent was waived due to the retrospective nature of the study.

### 3.3 | Participants

Inclusion criteria were as follows: (a) 18–70 years of age; (b) treated by MHD; (c) autologous AVF of the forearm; (d) regular weekly dialysis, good compliance and communication, and normal cognitive state; and (e) normal coagulation and platelet indices. Exclusion criteria were as follows: (a) mental or psychological diseases; (b) severe organ failure and dyscrasia; (c) peripheral vascular diseases; or (d) loss to follow-up or death within 1 year of follow-up after AVF surgery.

### 3.4 | Routine management

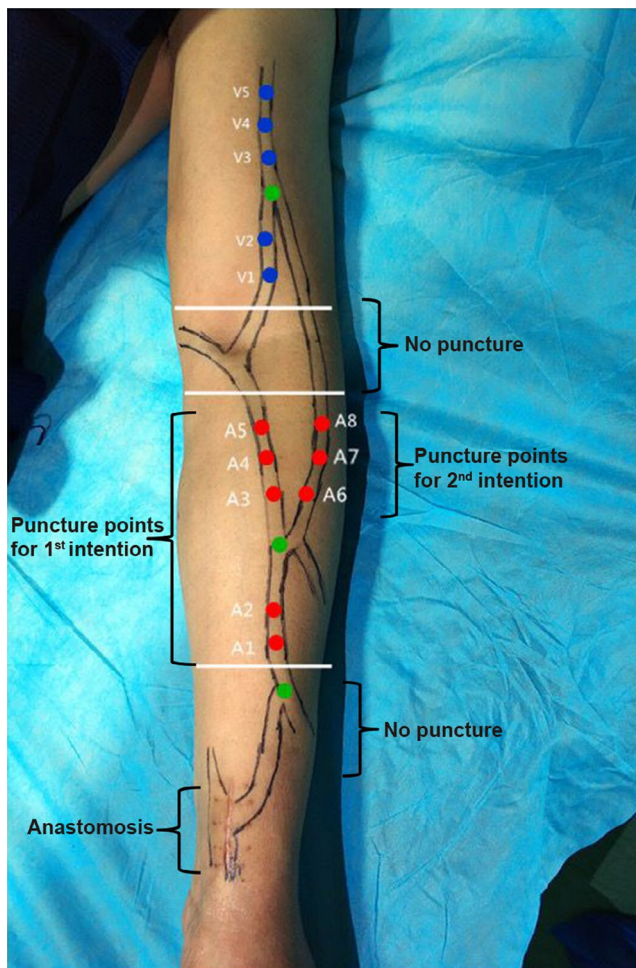
Before HD, the routine evaluation of the AVF was performed. In addition, physical examination was performed to determine the patency of the fistula, including visual examination (presence of redness, oozing and induration at the puncture site), palpation (direction, throb and tremor intensity of the fistula) and auscultation (vascular murmurs and tones of the fistula). Afterwards, the routine group underwent AVF HD access by the routine rope ladder puncture method. Arterial and venous centripetal punctures were performed, and the distance between the two needles was >4 cm. A 17 G venous fistula puncture needle was used, and the insertion angle was 20°–30° with the skin. The distance between two dialysis puncture points was about 0.5–1.0 cm. Each puncture was performed in sequence, and 3–5 equidistantly arranged puncture points were determined in a stepwise manner. When all puncture points were used for one time in sequence, the puncture sequence was repeated from the first puncture point.

### 3.5 | Integrated management

The intervention group received the integrated management for the arteriovenous fistula. The integrated management nursing team was led by the head nurse, with the participation of specialist nurses and specialist physicians. The integrated management plan included

the following: (a) evaluation of the arteriovenous fistula before use, including the drawing of a map arteriovenous puncture under the guidance of colour Doppler ultrasound, which was used for each AVF puncture; (b) use of arteriovenous fistula; (c) regular monitoring of the arteriovenous fistula; (d) maintenance of the arteriovenous fistula; and (e) special health guidance for arteriovenous fistula.

**Arteriovenous fistula evaluation before use.** After performing the same AVF evaluation as in routine management, ultrasound was used to make a puncture map and plan for the planned puncture. AVF puncture was performed with the rope ladder puncture method under B-mode ultrasound. The basic puncture methods were the same as in the routine group. The new fistula of the integrated group was observed and evaluated by colour Doppler ultrasound before use. The lumen width, depth from the skin, blood flow, vascular shape, presence or absence of vascular branches, and accompanying artery were evaluated. Vessels with a smooth shape and over 10 cm in length were marked and photographed on the body surface in the form of drawings (Figure 1). A mapping software was used to determine and design the puncture points and mark point location according to the length of the available blood vessels. Three to six puncture points were marked for arteries and veins, according to the



**FIGURE 1** Mapping of the blood vessels. Vessels with a smooth shape and over 10 cm in length were marked and photographed on the body surface in the form of drawings

order of a/v1, a/v2, a/v3, etc. The distance between the two points was 0.5–1 cm. The first puncture point of the artery was >3 cm away from the orifice of the fistula, avoiding the area 5 cm above and below the middle of the elbow and the junctions of the vascular branches. The designed photographs were printed and pasted on the home page of the patient's medical records.

**Use of the arteriovenous fistula.** The primary nurse strictly referred to the design map and performed rope ladder puncture in the order of a/v1, a/v2, a/v3, etc. The puncture needle was inserted into the skin at an angle of 20°–30°, and the puncture site was recorded on the puncture record table.

**Regular monitoring of the arteriovenous fistula.** The results of the physical examination and colour Doppler ultrasound of the AVF were logged into the computer to establish an electronic file for AVF information-based evaluation, and the physical evaluation data, colour Doppler ultrasound data, functional fistula score, and other related data were compared and analysed for early identification and treatment of fistula-related complications. The arteriovenous fistula monitoring was divided into daily monitoring and quarterly monitoring. Routine monitoring was completed before and after each arteriovenous fistula puncture. Before each fistula puncture, the puncture site was inspected for redness, bleeding, induration, etc., and palpated to find out the direction of the fistula blood vessel and the intensity of pulsation and tremor. A stethoscope was used to auscultate the murmur volume, clarity and tone along the internal fistula blood vessel. After dialysis, the time of fistula compression was noted. Quarterly monitoring was conducted every 3 months. Colour Doppler was used to understand the internal conditions of blood vessels, including the presence or absence of stenosis and thrombosis, and to measure the blood flow of the arteriovenous fistula. Early detection of complications of arteriovenous fistulas is convenient for timely resolution.

**Maintenance of the arteriovenous fistula.** Regular monitoring of the vascular access facilitates the early detection of complications of vascular access and allows for early intervention. If fistula stenosis or the fistula blood flow <500 ml/min were observed, the dialysis venous pressure was increased, the puncture was difficult, and the dialysis sufficiency was reduced. Therefore, intervention methods, such as balloon dilatation and surgery, were undertaken when needed.

**Special health guidance for arteriovenous fistula.** On the basis of basic health guidance, the health guidance of for arteriovenous fistula described each stage of integrated management. One nurse was responsible for the health education of six patients and their families. The daily care of the patients with arteriovenous fistulas was carried out through conversations, pictures and videos, and the patients and their families were evaluated using questionnaires.

### 3.6 | Basic health guidance

Both the routine group and the integrated group received the same basic health guidance before and after HD.

For preoperative health guidance, the patient was told to protect the arm undergoing fistulization, and not to receive arterial and venipuncture on it. The skin of the arm undergoing fistulization had to be kept clean. Scratch or bruise of the skin had to be avoided to prevent postoperative infection. Anticoagulants were discontinued 5–7 days before surgery to avoid bleeding during or after surgery. The arm undergoing fistulization had to be washed thoroughly with soapy water before surgery. The fingernails had to be cut short.

For postoperative health guidance, the limbs undergoing fistulization was properly raised to reduce limb oedema. Postoperative infusion, blood transfusion, blood drawing test and blood pressure measurement of the limbs undergoing fistulization were avoided. The tourniquet was prohibited within 2 weeks after surgery. The body posture and the tightness of the cuffs were noted to avoid compression of the limbs undergoing fistulization. At 24 hr after surgery, appropriate fisting and wrist joint movements of the affected hand could be made to promote blood circulation and prevent thrombosis. After 1 week of surgery, in the absence of infection and bleeding and with good healing, the affected hand was trained with a rubber band or ring several times a day, 3–5 min each time. A tourniquet or sphygmomanometer cuffs could be used on the upper arm 2 weeks after surgery, and the hand on the affected side made fist or held a ball, 1–2 min each time, which could be repeated 10–20 times a day.

Health guidance for self-nursing was provided. The skin had to be kept clean at any time to prevent infection. The patency of fistula was regularly checked by hand touch or stethoscope for no less than three times a day. A clear rustle, running water sound or tremor sense had to be noted. If the pulsation was weakened or silent, the patients were instructed to immediately present to the hospital for treatment. After the normal use of the AVF, Hirudoid Cream that soften blood vessels and skin was externally applied to protect the blood vessels. Heavy lifting had to be avoided. Clothes or bandages that were too tight had to be avoided. Putting the affected limb under the head had to be avoided. Food hygiene had to be noted to avoid collapse and hypotension caused by diarrhoea and other reasons, leading to AVF occlusion.

### 3.7 | Assessment

Colour Doppler ultrasound was performed at 1 year after AVF surgery to examine the presence or absence of complications, including fistula stenosis, aneurysm formation and thrombosis (Mudoni et al., 2016). The AVF functional assessment scale by the Department of Nephrology of Haidian Hospital was used to assess AVF function. No manifestation was scored as 0; hearing a high-pitched tone in the stenosis area was scored as 1 point; elevated venous pressure was scored as 1 point; autologous AVF was scored as 1 point; artificial blood vessel was 2 points; areas with obvious stenosis were scored as 2 points; prolonged haemostatic time was 2 points; insufficient puncture blood flow in the direction of the anastomotic stoma was 5 points; decreased arterial pressure was 1 point; when tremor weakened, the autologous AVF was scored as 2 points, while the artificial

**TABLE 1** Demographic and clinical information

Characteristics	Routine (n = 88)	Integrated (n = 56)	p
Age (years), mean $\pm$ SD	58.8 $\pm$ 10.8	59.4 $\pm$ 9.4	0.622
Sex (male), n (%)	53 (60.2)	31 (55.4)	0.610
Primary kidney disease, n (%)			
Hypertensive renal damage	37 (42.0)	22 (39.2)	0.997
Diabetic nephropathy	31 (35.2)	20 (35.7)	
Primary glomerular disease	13 (14.7)	9 (16.1)	
Obstructive kidney disease	4 (4.5)	3 (5.4)	
Renal interstitial disease	3 (3.4)	2 (3.6)	

Abbreviations: SD, standard deviation.

blood vessel was 3 points; swelling on the fistula side was recorded as 1 point. A total score of >3 points indicated high risk, and ultrasound and angiography were needed; >6 points indicated the need for interventional therapy.

The visual analog scale/score (VAS) was used to assess the degree of pain (Hawker et al., 2011). A 10-cm transverse line was plotted on the paper. One end of the line was 0, indicating no pain; the other end was 10, indicating the worst imaginable pain. The patient was told to make a mark on the line according to their degree of pain. 0–3 points indicated mild pain, 4–6 points moderate pain and 7–10 points of severe pain.

### 3.8 | Data analysis

SPSS 19.0 (IBM Corp., Armonk, NY, USA) was used for statistical analyses. The continuous variables were presented as means  $\pm$  standard deviations (SD), and comparisons between groups were performed by independent samples *t* test. Categorical variables were presented as frequencies and percentages and analysed using the chi-square test. *p*-values <0.05 were considered statistically significant.

## 4 | RESULTS

### 4.1 | Characteristics of the patients

During the study period, 189 patients underwent AVF surgery; 40 with peripheral vascular diseases were excluded, and five were lost to follow-up. Therefore, 144 patients on MHD were included. In the integrated group (*n* = 56), the mean age was 59.4  $\pm$  9.4 years, with 31 males and 25 females; in the routine group (*n* = 88), the mean age was 58.8  $\pm$  10.8 years, including 53 males and 35 females. There were no significant differences between the two groups in terms of sex (*p* = .61), age (*p* = .62) and type of primary kidney disease (*p* > .99) (Table 1).

## 4.2 | Outcomes at 1 year

At 1 year, the integrated group had significantly fewer fistula-related complications than the routine group (3.6% versus. 23.9%,  $p < .001$ ). The AVF functional scores were lower in the integrated group compared with the routine group ( $0.1 \pm 0.5$  versus.  $0.8 \pm 0.8$ ,  $p < .001$ ). The pain scores were lower in the integrated group than in the routine group ( $1.2 \pm 0.4$  versus.  $1.8 \pm 0.9$ ,  $p < .001$ ) (Table 2).

## 5 | DISCUSSION

Proper AVF management is crucial to avoid AVF complications and prolong its useful life for MHD (Al-Jaishi et al., 2017; 2006; Kumwinda et al., 2015; Rushing, 2010). This study examined the effect of the implementation of a comprehensive, dynamic and open integrated management system of AVF from the preoperative evaluation to the postoperative rehabilitation of AVF and regular monitoring during AVF use. The results suggest that the integrated management of vascular access could alleviate the pain during AVF puncture and effectively monitor AVF function for early identification of complications and interventions.

Proper vascular access with good function is the "lifeline" for patients on HD. According to the report of the US Renal Data System, the annual cost of vascular access-related complications in the United States accounts for 17% of the total costs of HD, and hospital visits due to vascular access-related diseases account for 25% of those costs and hospitalization due to vascular access-related diseases accounts for 50% of those costs. Furthermore, approximately 33% of the total costs for ESRD in medical institutions are used for the establishment and maintenance of haemodialysis vascular access (Saran et al., 2020). Establishing a stable and reliable vascular access is an essential prerequisite for the successful completion of blood purification (Chen, 2013). In the past 5 years, domestic and foreign literature reported that the infection rate of the arteriovenous fistula was 1%-5%. The use rate of the first dialysis arteriovenous fistula is 15%-50%, and the rate of arteriovenous fistula thrombosis is 0.25 to 0.50 times per patient-year (Leon et al., 2008; Yan et al., 2012, 2015; Zhang et al., 2016). The short life span, poor quality and many complications are the main problems facing the patients. The reasons are not only related to inadequate preoperative evaluation, inappropriate selection of surgical methods, but also the lack of postoperative

**TABLE 2** Outcomes at 1-year follow-up between the two groups

Characteristics	Routine (n = 88)	Integrated (n = 56)	p
Complications of fistula, n (%)	21 (23.9)	2 (3.6)	<.001
Fistula functional score, mean $\pm$ SD	$0.8 \pm 0.8$	$0.1 \pm 0.5$	<.001
VAS pain score, mean $\pm$ SD	$1.8 \pm 0.9$	$1.2 \pm 0.4$	<.001

Abbreviations: SD, standard deviation; VAS, visual analog scale.

monitoring methods, and the irregular use or maintenance of arteriovenous fistula.

Patients on maintenance haemodialysis are dialysed 2-3 times a week and need to receive a high frequency of arteriovenous fistula puncture. In the actual clinical work, some nurses pursue the success rate of one-time puncture and often change to the rope ladder puncture pattern of arteriovenous fistula into the regional puncture. Over time, an arteriovenous fistula is prone to complications such as stenosis, thrombosis and aneurysm. In this study, we established integrated arteriovenous fistula management centred on B ultrasound-guided arteriovenous fistula puncture map and arteriovenous fistula monitoring. After creating the arteriovenous fistula, the patient entered our integrated management of arteriovenous fistula. We emphasize that the use of the arteriovenous fistulas is strictly planned according to the puncture map, which increases the area of puncture rotation. This allows each puncture wound to be repaired for at least 2 weeks, which can avoid repeated punctures over a short time. These methods help tissue healing and repair, enhance tissue elasticity, allow arteriovenous fistula blood vessels to be evenly expanded and reduce the occurrence of arteriovenous fistula complications. The monitoring of arteriovenous fistula includes daily monitoring and regular monitoring. The daily monitoring is mainly based on physical examination and is evaluated before and after each puncture. Regular monitoring is conducted once every 3 months, mainly using B-mode ultrasound monitoring.

Regular monitoring is conducive to the early detection of complications of arteriovenous fistula and early treatment. In this study, the intervention group had five cases of arteriovenous fistula stenosis early through regular monitoring, allowing for timely intervention to avoid the occurrence of complications such as arteriovenous fistula occlusion. In this study, after 1 year of follow-up, the complications of arteriovenous fistula in the intervention group were significantly lower than those in the conventional group, and the functional score of the arteriovenous fistula was lower than that in the conventional group, suggesting that integrated fistula management can effectively reduce the incidence of complications of arteriovenous fistula and prolong the life of arteriovenous fistula.

In this study, the pain score of the intervention group was also lower than that of the conventional group. On the one hand, it was associated with fewer complications of arteriovenous fistula, and the pain caused by the complications was reduced. On the other hand, health education covers the entire integrated management, and there is much communication between doctors and patients. The patients have full trust in medical care, so the anxiety before arteriovenous puncture can be relieved, and the pain caused by puncture is also reduced. Therefore, the patient satisfaction rate increased significantly.

## 5.1 | Limitations

This study had some limitations. It was performed at a single centre, and there was no randomization. All assessments were based on the



routine parameters collected in the charts, and no quality control could be done.

## 6 | CONCLUSION

The integrated management based on the management of vascular access can alleviate the pain during AVF puncture and effectively monitor AVF function for early identification of complications and interventions, significantly reducing the incidence of AVF-related complications in MHD patients. Thus, such a nursing approach could have profound significance for the long-term maintenance of AVF.

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None.

## CONFLICT OF INTEREST

The authors declare that they have no competing interests.

## AUTHORS' CONTRIBUTIONS

MN, DL: conceived and designed the experiments. MN: performed the experiments. MN, DL, GY, TZ, LL: analysed and interpreted the data. MN, GY, TZ, LL, FP: contributed reagents, materials, analysis tools or data. MN, DL, GY: wrote the paper. All authors read and approved the final manuscript.

## ETHICAL APPROVAL

This study was approved by the Ethics Committee of Wuhan Third Hospital.

## PATIENT CONSENT

Informed consent was waived due to the retrospective nature of the study.

## DATA AVAILABILITY STATEMENT

All data generated or analysed during this study are included in this published article.

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