Eur J Transl Myol 34 (2) 12422, 2024 doi: 10.4081/ejtm.2024.12422

Research on comprehensive analysis of patient comfort and complication rate using haemodialysis indwelling needles in AVF puncture in haemodialysis treatment

Guihong Jin, Jianmin Gu, Yan Zhang, Shidan Ren

Blood Purification Center of Pingyang County Traditional Chinese Medicine Hospital, Zhejiang University of Traditional Chinese Medicine, Wenzhou, Zhejiang, China.

Abstract

Traditional needles for haemodialysis access can cause complications and discomfort. Indwelling needles may have advantages, but their efficacy needs to be investigated. Our study sought to compare the safety and efficacy of indwelling needles to traditional needles for haemodialysis access. A single-center retrospective study at the Pingyang County Hospital of Traditional Chinese Medicine included 70 haemodialysis patients. The intervention group used indwelling needles, whereas the control group used traditional needles. The rate of complications, limb mobility, blood chemistry, puncture success rates, operation times, haemostasis times, pain and comfort scores, and internal fistula failure rates were all compared. Overall, complication rates were slightly higher in the control group, but not statistically significant. Both groups improved their limb mobility and blood chemistry, but there were no significant differences. The intervention group had significantly higher puncture success rates (88.4% *vs*. 80.0%), shorter operation times (65.4 *vs*. 72.3 seconds), and faster haemostasis times (23.7 *vs*. 28.2 seconds) than the control group. Patients in the intervention group experienced less pain (3.7 *vs*. 4.2) and more comfort (8.1 *vs*. 7.5). The intervention group had slightly lower internal fistula failure rates (2.9% *vs*. 5.7%), but the difference was not statistically significant. Indwelling needles appear to improve puncture efficiency and patient comfort during hemodialysis.

Key Words: haemodialysis, indwelling needle, traditional needle, puncture, failure and complication.

Eur J Transl Myol 34 (2) 12422, 2024 doi: 10.4081/ejtm.2024.12422

Introduction

Haemodialysis consists of an extracorporeal procedure used in cleansing of the blood through the elimination of the products of uraemic retention solutes through a semi-permeable membrane. Conventionally, dialysis membranes were categorised based on their composition (cellulose or non-cellulose membranes) and permeability to water (low flux versus high flux membranes).[1] One of the significant limitations in reporting the clinical outcomes of patients treated with haemodialysis is the absence of a recognised standard haemodialysis outcome that are specific to the caregivers and patients. In the last 4 years, there have been significant efforts in identifying the key outcomes significant to patients and requires priority during monitoring, reporting and interventions in haemodialysis.[2]

An efficient dialysis therapy is dependent on a properly well-functioning access to the vascular system. Vascular access can be characterised based on native Arteriovenous Fistula (AVF), Central Vein Catheters (CVC) or Arteriovenous Grafts (AVG). The choice of AVF often lead to lower rates of complications, higher rates of patency, increased survival outcomes compared to other techniques such as AVG and CVC. The utilisation of central venous catheters increases the process of rapid dialysis and offers alternative routes for access to the vascular system.[3] However, the use of catheters is associated with higher rates of infection and secondary complications in chronic kidney disease.

Adequate and sufficient maintenance of haemodialysis involves a repeated access to the circulation. Significant

complications within the vascular access remains a critical challenge in patients diagnosed with End-Stage Renal Disease (ESRD). The presence of Arteriovenous Fistulae (AVF) constructed and designed using native vessels, vascular grafts and central venous catheter offers the best and permanent access due to the lower incidences of the occurrence of stenosis, infection and thrombosis.[4] The radiocephalic AVF designed by the Brescia-Cimina is a significant and first choice for access to the vascular system.[5] A dysfunctional fistula is one of the major reasons leading to a second thought of an intervention and frequent hospitalisations associated with increased medical costs. Some of the common complications include formation of aneurysms, hypertension in the venous system, vascular steal syndrome, haemorrhage, neurological disorders and infections.[6]

The commonly used puncture needles during haemodialysis puncture include disposable ordinary steel needles and haemodialysis indwelling needles. Among them, ordinary steel needles are the most widely used.[7] Most of our countries use steel needles for puncture routinely. However, steel needles are hard in texture and can cause internal fistula damage. The formation of vascular intima stimulates blood vessel stenosis and intimal hyperplasia. If used for a long time, the incidence of puncture complications such as pseudoaneurysm, thrombosis, and subcutaneous hematoma increases. Most maintenance haemodialysis patients are malnourished and have weakened tissue and organ functions. Dialysis indwelling needles are made of special polymer biomaterials and have many advantages such as good biocompatibility and minimal puncture damage, and can extend the life of the AVF.

Recently, there is an increasing proportion of individuals who commence haemodialysis at 75 years and 75% of them presents five or more comorbidities with more than 90% having cardiovascular diseases.[8,9] In 1966, when Cimino and Brescia coined the term radio-cephalic fistula, the average age of patients was 43 years with most of them having chronic cases of glomerulonephritis. A study by Lok *et al*.[10] suggested that in pre-operative cases, the clinical prediction used to determine the probability of failure of fistulas was old age who were categorised in the risk category of "failing to mature". Therefore, it is often recommended to avoid placing unnecessary AVF in the elderly population whose life expectancy is low.

Although haemodialysis indwelling needles have been widely used, their application in China is still limited due to the relatively high difficulty of puncture, the relatively long puncture time for nurses, and the impact of economic factors. In addition, clinical studies on the severity of pain and the adequacy of haemodialysis using metal rigid needles and indwelling needles for dialysis need to be further explored. Secondly, there is no unified standard in China regarding the retention time and sealing method of indwelling needles for dialysis. Thus, our main objective is to compare the levels of patient comfort and rate of complications using haemodialysis indwelling in AVF.

Materials and Methods

Study design and sample size

Our retrospective study was conducted at the Pingyang County Hospital of Traditional Chinese Medicine involving 70 patients with chronic renal insufficiency and required maintenance haemodialysis treatment for newly constructed AVFs at our hospital from July 2023 to June 2024.

Eligibility criteria

The following eligibility criteria was adopted for including and excluding patients from the study.

Inclusion criteria

i) Participants who were diagnosed with stage 3, or 4, or 5 chronic kidney disease and were required to undertake a haemodialysis in order to maintain life with a dialysis frequency of at least thrice per week. The eGFR threshold was set to < 30 ml/min/1.73m² for the commencement of dialysis; ii) patients who were extensively evaluated using colour Doppler ultrasound after the establishment of AVF to maturity in vascular access within 90 days. AVF maturity was based on a puncture flow rate exceeding 300 ml/min, absence of or minor stenosis or aneurysms on ultrasound and ability to sustain haemodialysis without blood clots or blood flow problems; iii) patients who provided informed consent and agreed to participate in the study.

Exclusion criteria

i) Patients who were diagnosed with more than 50% venous stenosis and confirmed by digital subtraction angiography (DSA) as affecting access to the jugular and subclavian veins; ii) patients whose blood pressure was lower than 90/60 mmHg based on haemodynamic stability during puncture. Also, patients on antihypertensive medications were excluded from study; iii) patients whose diagnosis presented malignant tumours (active and untreated cancers with poor prognosis), severe infections (active systemic infections that require frequent hospitalisations) and possibility of heart failure according to New York Heart Association (NYHA) Class III or IV heart failure; iii) patients with poor compliance and presence of mental or cognitive dysfunctions with a Mini-Mental State Examination (MMSE) score <24 in cognitive impairment.

Treatment and intervention

The random number table technique was used to divide the patients into two groups of control and intervention (see Figure 1). Single blinding was used to ensure that patients were blinded to the type of needle used.

In the control group (using ordinary steel needles), before puncture, the patient's skin condition was carefully checked at the puncture site, selecting a blood vessel with smooth veins, clear veins, and good elasticity. Then, the principles of the rope ladder method were followed and a routine disinfection with the bevel of the needle pointing upward was performed.

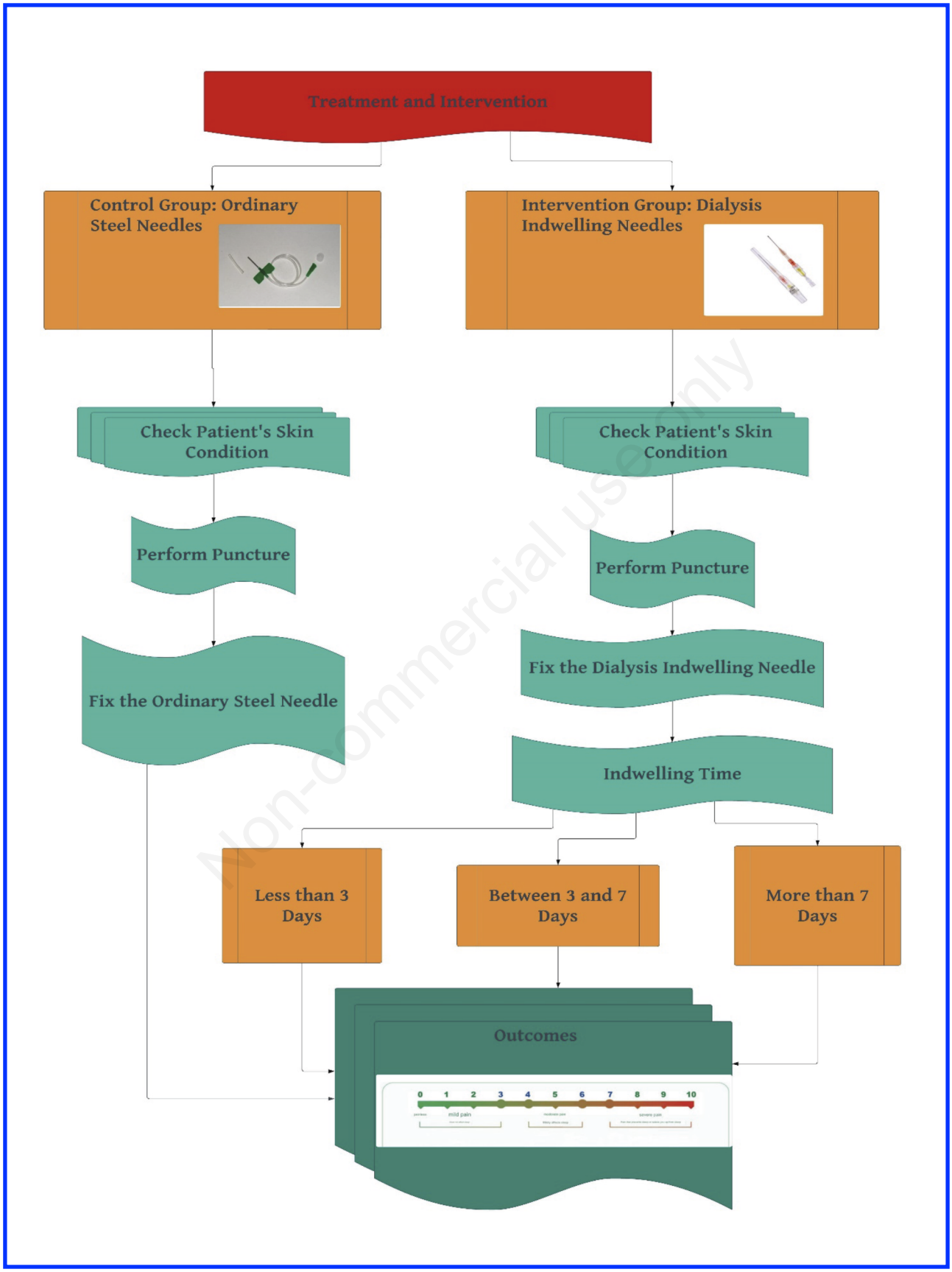

Figure 1. *An illustration flowchart of the treatment and intervention process.*

It was recommended to avoid tying a tourniquet during puncture. Initially, the three-point fixation method and puncture the artery was used followed by a puncture on the vein using centripetal puncture. The device for puncture was an ordinary steel needle which was pre-flushed with physiological saline. When puncturing, the puncture needle was at an angle of 25-30° to the skin. After entering the blood vessel, the angle was lowered and the needle inserted into the blood vessel in a parallel manner. It is advised that the needle should be inserted into the blood vessel at least 2/2 3. Finally, use tape to fix the ordinary steel needle.

In the intervention group (using dialysis indwelling needle), before puncture, the patient's skin condition was carefully examined before selecting a blood vessel with clear veins, and good elasticity. The, following the principles of the rope ladder a routine disinfection was performed. The bevel of the needle tip was placed upwards and no tourniquets were tied during the puncture. A three-point fixation method was used by initially puncturing the artery first and then puncturing the vein using centripetal puncture. A dialysis indwelling needle was then placed at an angle of 30° to the skin during puncture. After entering the blood vessel, pause for a moment. After blood returns, lower the angle and push the hose of the indwelling needle. At the same time, lift out the puncture needle core and fix it with a transparent dressing. In the intervention group, the retention time of patients was further divided into subgroups of less than 3 days, between 3 to 7 days, and more than 7 days.

Procedure

At the department of kidney and urology, trained professionals documented the success of each attempted haemodialysis puncture (using both standard steel needles and dialysis indwelling needles of specified brands/models) based on visual confirmation of needle placement within the blood vessel and sustained blood return. Punctures were deemed successful if the needle remained functional throughout the dialysis session, without needing replacement due to clotting or dislodgement. The puncture success rate was then calculated as the number of successful punctures divided by the total number of attempted punctures in each group. Also, they conducted regular clinical assessments including palpation for tremor/pulse, auscultation for murmurs, and measurement of maximum dialysis blood flow using Doppler ultrasound.

Doppler ultrasound and angiography were used to monitor signs of complications such as haematoma, thrombosis, pseudoaneurysms, stenosis, puncture injuries, and occlusions. Also, the time from initial skin puncture to needle securement (puncture operation time) and the time to achieve complete bleeding control (haemostasis time) were recorded using stopwatches. Patients rated their puncture pain using the Visual Analog Scale (VAS), marking a score between 0 (no pain) and 10 (worst imaginable pain) on designated scoring sheets after the procedure. Lastly, the subjective feeling of the puncture site (the movement of the arm along the plane of the bed, the physical feeling of the puncture instrument, the indwelling of the puncture instrument) during the dialysis process from the completion of puncture to the time of needle removal in each group of patients was recorded with the overall score between 0 and 10, with 0 indicating comfort, 10 points indicates extreme discomfort, and patients score based on their subjective feelings.

The levels of blood urea nitrogen (BUN), serum creatinine (Scr), and Kt/V index (Kt/V= - Ln (R - 0. 008 ×t) +(4 - 3×R) ×uF/w. Ln represents the natural logarithm, R= (BuN after dialysis)/ (BuN before dialysis), t=dialysis time, uF represents the ultrafiltration volume, and w represents the patient's weight after dialysis) were obtained and recorded. Lastly, a 5- point method was used to evaluate the limb mobility of patients in each group. If they were completely unable to move it was scored as 0 points. However, if they moved a little (bending < 15 °), they scored 1 point. If they moved to a large extent (curvature 15-45º), they scored 2 points; if they moved to a large extent (flexion > 45º), they scored 3 points and free movement was scored 4 points

Outcomes and statistical analysis

The treatment outcomes involved the success rates of punctures, internal failure rate of fistula, presence of complications, time taken during puncture and haemostasis, puncture pain, comfort during dialysis, adequacy of dialysis and mobility of limbs. All the treatment outcomes and associated data were analysed using GraphPad Prism version 9.5.1 and MS Excel. The statistical significance was at $p < 0.05$.

Results

We found that participants in the control group (n=35) were slightly older than those in the intervention group (n=35), with an average age of 62.5 years (SD 8.7) vs. 60.8 years (SD 9.2), respectively. Both groups had a mix of genders, with the control group comprising 57.1% male and 42.9% female, while the intervention group had 51.4% male and 48.6% female (see Figure 2).

In Table 1, the control group exhibited a puncture success rate of 80.0% (SD 5.4), a mean puncture operation time of 72.3 seconds (SD 14.8), and a mean haemostasis time of 28.2 seconds (SD 8.1). On the other hand, the intervention group, when considered as a whole, demonstrated higher puncture success rates (88.4%, SD 4.1), shorter mean puncture operation times (65.4 seconds, SD 12.5), and decreased mean haemostasis times (23.7 seconds, SD 7.2) compared to the control. Further analysis within the intervention group based on the duration of the intervention revealed that subgroups with interventions less than 3 days, between 3-7 days, and more than 7 days all exhibited improved puncture success rates and reduced operation and haemostasis times.

In Table 2, the control group reported a mean VAS pain score of 4.2 (SD 1.8) and a mean comfort score of 7.5 (SD 1.2). In contrast, the intervention group, when considered overall, displayed lower mean VAS pain scores (3.7, SD 1.5) and higher mean comfort scores (8.1, SD 1.1) compared to the control group. Subgroup analysis based on the duration of intervention demonstrated consistent trends, with lower pain scores and higher comfort scores for interventions less than 3 days, between 3-7 days, and more than 7 days.

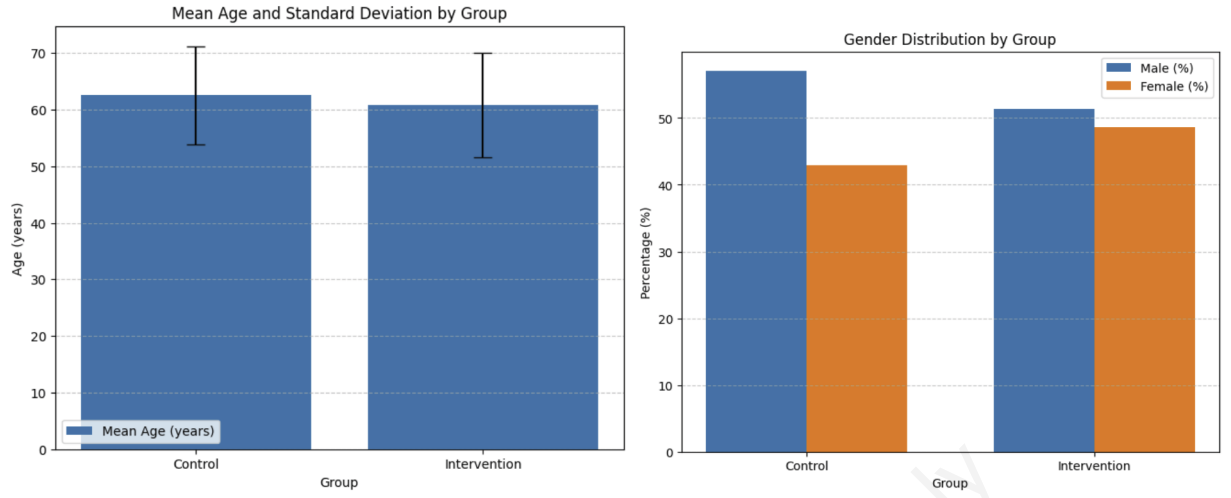

Figure 2. *The distribution of participants by age and gender.*

Table 1. *Puncture success rate and puncture operation/haemostasis time.*

Group	Puncture success rate (%)	Mean puncture operation time (sec)	Mean haemostasis time (sec)
Control	80.0 (5.4)	72.3 (14.8)	28.2 (8.1)
Intervention (Overall)	88.4 (4.1)	65.4 (12.5)	23.7 (7.2)
Intervention (Less than 3 days)	89.2 (3.8)	64.8 (11.9)	23.1 (6.9)
Intervention (Between 3-7 days)	88.8 (4.6)	66.2 (13.2)	24.3 (7.6)
Intervention (More than 7 days)	87.5 (5.2)	67.1 (14.1)	25.0 (8.3)
p-value (Intervention *vs* control)	0.002	0.014	0.008
F-value (Intervention subgroups)	1.54	1.23	0.98
df (Intervention subgroups)	2, 84	2, 84	2, 84

Table 2. *Analysis of puncture pain and dialysis comfort.*

Group	Mean VAS pain score (SD)	Mean comfort score (SD)
Control	4.2 (1.8)	7.5 (1.2)
Intervention (Overall)	3.7 (1.5)	8.1 (1.1)
Intervention (Less than 3 days)	3.6 (1.4)	8.2 (1.0)
Intervention (Between 3-7 days)	3.8 (1.6)	8.0 (1.2)
Intervention (More than 7 days)	3.9 (1.7)	7.9 (1.3)
p-value (Intervention *vs* control)	0.021	0.004
t-value (Intervention *vs* control)	3.12	4.78
df (Intervention *vs* control)	86	86

In Table 3 and Figure 3, the control group, consisting of 35 cases, reported a 11.4% internal fistula failure rate (4 cases), with a mean time to failure of 60±18 days. In the overall intervention group (n=35 cases), the internal fistula failure rate was lower at 5.7% (2 cases), with a mean time to failure of 90±22 days. Subgroup analysis based on the duration of intervention revealed varying failure rates and mean times to failure. The intervention subgroup with a duration less than 3 days (11 cases) reported a 9.1% failure rate (1 case), with a mean time to failure of 85±25 days. The subgroup with a duration more than 7 days (12 cases) exhibited an 8.3% failure rate (1 case), with a mean time to failure of 100±20 days.

Table 3. *Internal fistula failure rate.*

Group	n	Internal fistula failure (%)	Mean time to failure (days)	SD
Control	35	4 (11.4)	60	18
Intervention (Overall)	35	2 (5.7)	90	22
Intervention (Less than 3 days)	11	1 (9.1)	85	25
Intervention (Between 3-7 days)	12	0 (0)	N/A	N/A
Intervention (More than 7 days)	12	1 (8.3)	100	20
p-value (Intervention *vs* control)	0.327	-	-	

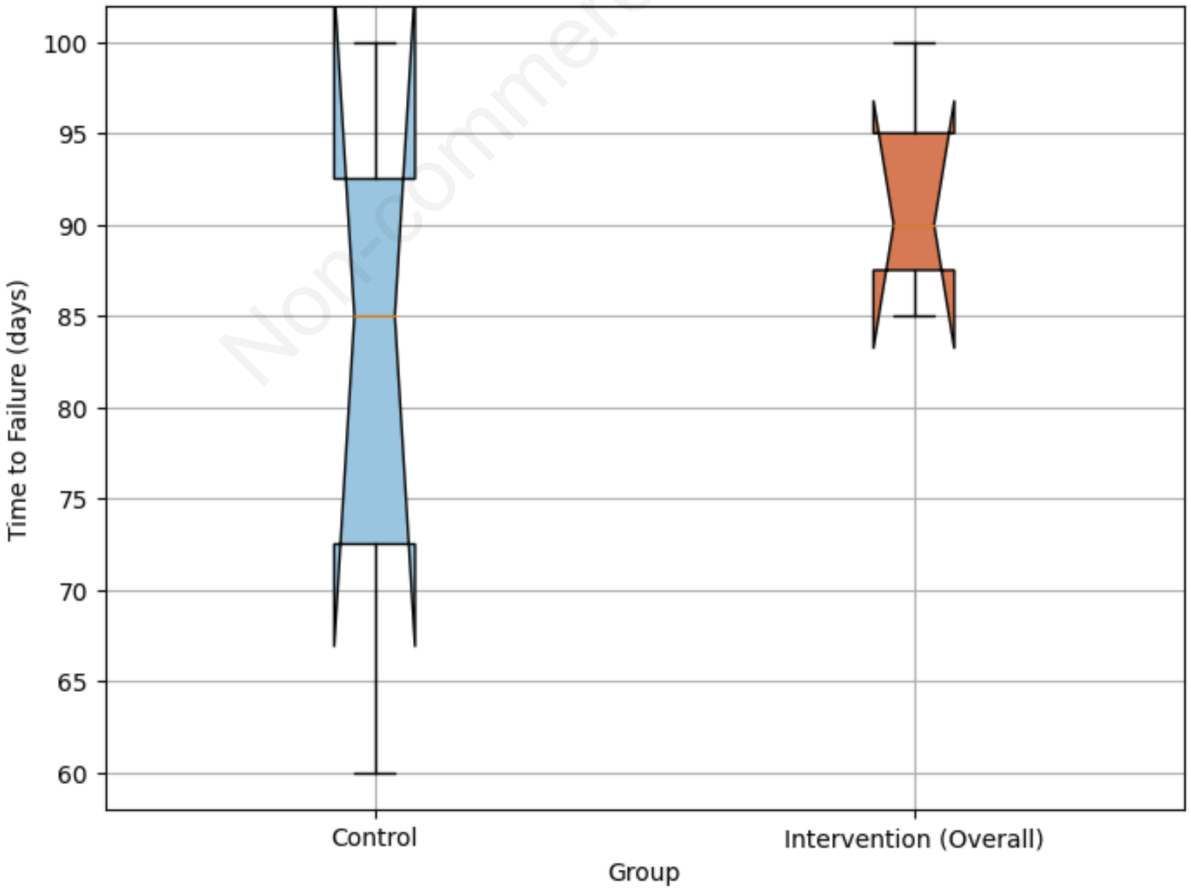

Figure 3. *A boxplot showing the distribution of mean time to failure in the control and intervention groups.*

In Table 4, patients in the control group displayed higher pre-dialysis BUN (70 mg/dL, SD 10) and Scr (1.8 mg/dL, SD 0.2) compared to the intervention group (BUN: 68 mg/dL, SD 9; Scr: 1.7 mg/dL, SD 0.2). Post-dialysis levels also showed improvement in both groups, with the intervention group achieving slightly lower BUN (38 mg/dL, SD 7) and Scr (1.1 mg/dL, SD 0.1) compared to the control group (BUN: 40 mg/dL, SD 8; Scr: 1.2 mg/dL, SD 0.1). The Kt/V ratio, reflecting overall dialysis efficiency, was similar across groups (control: 1.5, SD 0.3; intervention: 1.6, SD 0.2), suggesting equivalent effectiveness in removing waste products. Subgroup analysis within the intervention group revealed no significant differences in pre- or post-dialysis levels or Kt/V based on time to intervention.
In Table 5 and Figure 4, In the control group, 5.7% had no movement (Score 0), 14.3% had limited movement

Table 4. *Adequacy of dialysis based on BUN, Scr and Kt/V ratio.*

Group	Pre-Dialysis BUN (mg/dL) M (SD)	Post-Dialysis BUN (mg/dL) M (SD)	Pre-Dialysis Scr (mg/dL) M (SD)	Post-Dialysis Scr (mg/dL) M (SD)	Kt/VM (SD)
Control	70 (10)	40 (8)	1.8 (0.2)	1.2 (0.1)	1.5 (0.3)
Intervention (Overall)	68 (9)	38 (7)	1.7 (0.2)	1.1 (0.1)	1.6 (0.2)
Intervention (Less than 3 days)	69 (8)	37 (6)	1.8 (0.2)	1.1 (0.1)	1.6 (0.2)
Intervention (Between 3-7 days)	67 (10)	39 (8)	1.7 (0.2)	1.1 (0.1)	1.5 (0.3)
Intervention (More than 7 days)	68 (9)	38 (7)	1.7 (0.2)	1.1 (0.1)	1.6 (0.2)

Table 5. *Assessment of differences in limb mobility scores.*

Group	N	Score 0 (no movement) (%)	Score 1 (limited movement) (%)	Score 2 (moderate movement) (%)	Score 3 (good movement) (%)	Score 4 (full movement) (%)
Control	35	2 (5.7)	5 (14.3)	12 (34.3)	10 (28.6)	6 (17.1)
Intervention (Overall)	35	1 (2.9)	3 (8.6)	15 (42.9)	11 (31.4)	5 (14.3)
Chi-Square	-	1.78	2.13	2.03	1.42	2.41
p-value	-	0.182	0.344	0.362	0.234	0.12

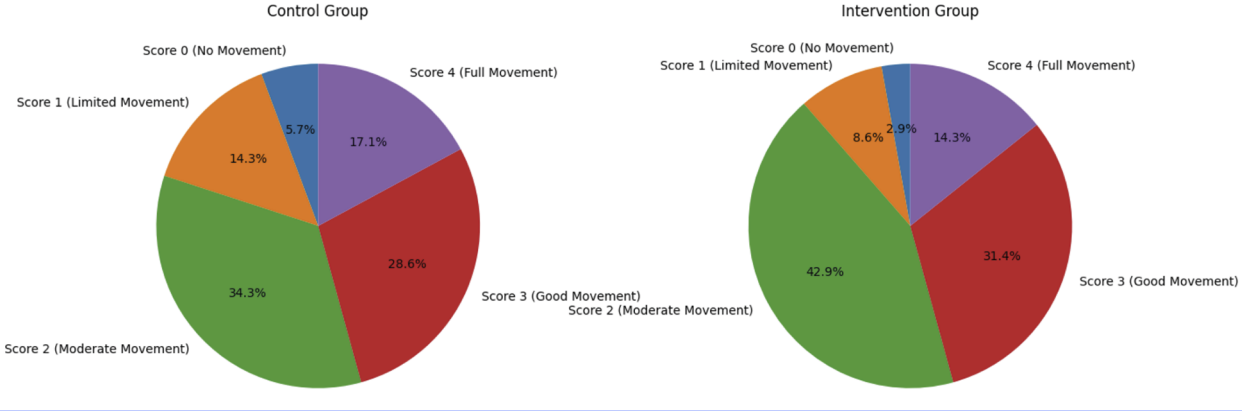

Figure 4. *Differences in the scores of limb mobility in the control and intervention groups.*

(Score 1), 34.3% demonstrated moderate movement (Score 2), 28.6% achieved good movement (Score 3), and 17.1% had full movement (Score 4). The intervention group showed slight improvements, with 2.9% experiencing no movement, 8.6% exhibiting limited movement, 42.9% presenting moderate movement, 31.4% achieving good movement, and 14.3% demonstrating full movement. While statistical tests suggested some potential trends, overall differences in limb mobility between groups were not statistically significant.

In Table 6 and Figure 5, the control group experienced a slightly higher rate of complications compared to the intervention group. Specifically, the control group had a 5.7% incidence of subcutaneous hematoma, 2.9% incidence of thrombosis, 2.9% incidence of vascular stenosis, 8.6% incidence of puncture injury, and 2.9% incidence of vascular occlusion. In contrast, the intervention group experienced a 2.9% incidence of subcutaneous hematoma, 0% incidence of thrombosis, pseudoaneurysm, or vascular stenosis, 5.7% incidence of puncture injury, and 0% incidence of vascular occlusion. While the control group displayed a higher overall complication rate, the observed differences were not statistically significant.

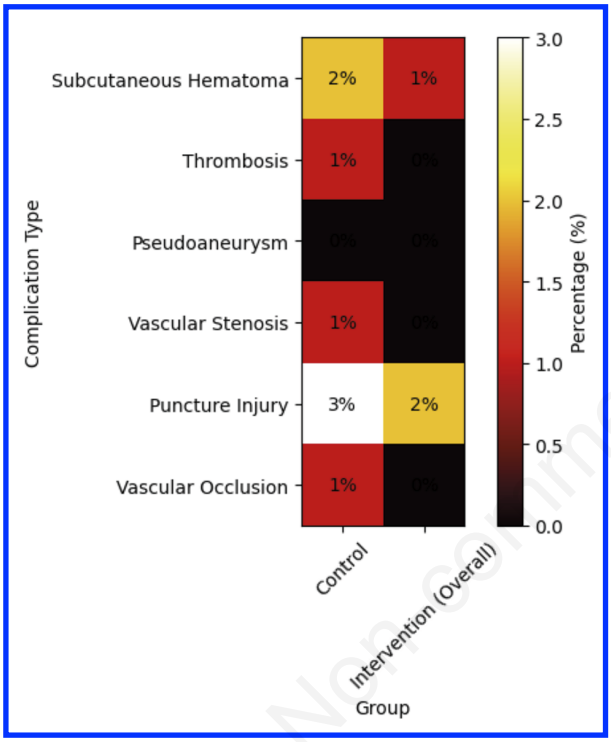

Figure 5. *A heatmap of the rates of complications reported in the control and intervention groups.*

Discussion

The study compared the use of indwelling needles with traditional needles for haemodialysis access, while the control group experienced a slightly higher overall complication rate, including thrombosis and puncture injury, the differences were not statistically significant. Both groups showed improvements in limb mobility and blood chemistry levels after dialysis, with no significant differences attributable to the needle type. However, the intervention group displayed significantly improved puncture success rates, shorter operation times, and reduced haemostasis times compared to the control. Additionally, patients in the intervention group reported lower pain scores and higher comfort scores during dialysis. Internal fistula failure rates were slightly lower in the intervention group overall, but there were no statistically significant differences between the groups.

Our study proposes with the improvement of the development level of modern science and technology, blood purification operation technology has been continuously optimized that. Similalrly, according to Dogra *et al.*[11] and Kashima and Ninomiya[12] the treatment safety, comfort and long-term survival rate of maintenance haemodialysis patients have also been significantly improved. One of the significant issues in haemodialysis is how choose a pathway that can be used for a long time and maintain good blood flow.[13] The Standardized Outcomes in Nephrology in Haemodialysis (SONG-HD) carried out a five-phase mixed methods study consisting of a Delphi survey of 1,181 participants (composed of 979 health professionals, and 220 patients and caregivers) across 73 countries and found that there were four essential outcome aspects of haemodialysis involving fatigue, cardiovascular diseases, vascular access

Table 6. *The rates of complications reported in the control and intervention groups.*

Group	N	Subcutaneous hematoma (%)	Thrombosis (%)	Pseudoaneurysm (%)	Vascular stenosis (%)	Puncture injury (%)	Vascular occlusion (%)
Control	35	2 (5.7)	1 (2.9)	0 (0)	1 (2.9)	3 (8.6)	1 (2.9)
Intervention (Overall)	35	1 (2.9)	0 (0)	0 (0)	0 (0)	2 (5.7)	0 (0)

and rates of mortality that should be reported in all clinical trials of patients subjected to haemodialysis.[14-16]

Our findings showed that haemodialysis indwelling needles were effective compared to conventional steel needles. These findings were consistent with previous studies[17,18] who suggested that at present, the commonly used puncture needles during HD puncture include disposable ordinary steel needles and haemodialysis indwelling needles with ordinary steel needles are the most widely used. However, steel needles are hard in texture and can cause internal fistula damage. Our study observed a higher rate of complications in the use of conventional needles compared to indwelling needles. Similarly, Chen and Lin[19] showed that the emergence of various puncture complications will cause the internal fistula function to be lost or incomplete. In addition, most haemodialysis patients are malnourished and have weakened tissue and organ functions. Additionally, appropriate puncture tools are of great significance in reducing puncture complications, prolonging the service life of internal fistulas, reducing the failure rate of internal fistula establishment and the patient readmission rate.[20,21] Suitable puncture tools can also reduce the workload of nursing staff and ensure the quality of care and work efficiency.

Our analysis suggests that dialysis indwelling needles reduces pain and patient discomfort. Vachharajani *et al*.[22] showed that dialysis indwelling needles have many application advantages, for instance, the tubing of dialysis indwelling needles is soft in texture and has higher biocompatibility, thus, it hardly damages the inner wall of blood vessels and effectively avoids the allergy problems of traditional puncture needles and reduce patient discomfort. Moreover, they can effectively avoid the problem of insufficient blood flow caused by traditional puncture needles sticking to the blood vessel wall. In proximal access, the 12-month reported patency rate is 70% to 84%.[23,24] Prior to the use of AVF, a waiting time is recommended to ensure effective structural adjustments of the vein walls and "arterialization" due to the effects of turbulent flow. Previous studies have suggested that the commonly observed complications of AVF are related to an inadequate maturation of AVF, stenosis, aneurysms, infections, thrombosis, high flow rate AVF and steal syndrome resulting from ischaemia.[6,25,26] Failure of the AVF is mostly associated with stenosis of the artery of the vein. However, these complications can be corrected through endovascular or surgical techniques; thus, shorter segments resulting from stenosis can be treated using percutaneous transluminal angioplasty while surgical replacements are the recommended standards in extensive stenotic segments.

We propose that indwelling needles are efficacious and safe compared to traditional steel needles. It is because indwelling needle hose can withstand the patient's small range of movement and will not puncture the AVF wall when the patient moves unlike the steel needle. Furthermore, the puncture wound using an indwelling dialysis needle is smaller and can reduce the puncture damage to the inner wall of the vein and extend the service life of the arteriovenous fistula.[22,27] Performing AVF directly on the wrist is the standard for vascular access.[28] The rates of patency for distal access according to the literature lies between 56% and 79% after 12 months.[29,30] Treatment by proximal AVF has the significant advantages of using the main caliber autologous materials that increases the process of developing the access and subsequent intravenous cannulation required for using the access.[31] Additionally, the caliber autologous material leads to higher patency rates than distal ones.[32] However, it is often associated with higher rate of complications, for example, steal syndrome and arterial changes in the cardiac output.

Our findings observed a 2.9% case of subcutaneous haematoma in the use of indwelling needle compared to 5.7% cases of subcutaneous haematoma in traditional steel needles. Similarly, Letachowicz *et al*.[33] conducted a comparative analysis of the occurrence of hematoma in 19 patients who were punctured with metal rigid needles (16G) and 20 patients who were punctured with indwelling needles for dialysis (17G). Their findings showed that punctures with indwelling needles for dialysis There were 299 cases in total, among which 5 patients had hematoma. There were 250 cases of metal needle puncture, among which 12 patients had hematoma. In contrast, when a steel needle is used for puncture during haemodialysis, the sharp tip of the steel needle may cause hematoma in the surrounding tissue due to the patient's activities during the treatment.

We observed a significant reduction in pain on the VAS scores in the intervention group compared to the control group. A previous comparative study by Darbas Barbe *et al*.[34] the puncture pain of 14 patients after 12 punctures of indwelling needles for dialysis and 12 punctures of metal rigid needles. The Visual Analogue Scale (VAS) evaluation results showed that the pain of using indwelling needles for dialysis was better. Indwelling needle puncture can reduce the puncture pain of patients, but the McGill Pain Questionnaire did not produce the same results. In contrast, Ocaña *et al*.[35] showed that showed that compared with ordinary metal steel needles, the pain of puncture using dialysis indwelling needles during haemodialysis is high. Lastly, Marticorena *et al*.[7] showed that there was no statistically significant difference in the adequacy of haemodialysis using ordinary metal steel needles and indwelling dialysis needles for puncture.

Our findings on adequacy of haemodialysis showed that patients in the control group displayed higher pre-dialysis BUN and Scr compared to the intervention group. Subgroup analysis within the intervention group revealed no significant differences in pre- or post-dialysis levels or Kt/V based on time to intervention. Zhang *et al*.[36] showed that compared with the metal steel needle group, the dialysis indwelling needle group had higher haemodialysis adequacy. This may be because the dialysis indwelling needle is designed with a flat head and a side hole, and the indwelling needle material is polytetrafluoroethylene, which can stretch under the influence of body temperature. In addition, the longer length allows the indwelling needle to have better compliance within the blood vessel so it has higher adequacy of haemodialysis. Nalesso *et al*.[37] postulated that when using an indwelling needle for dialysis to puncture an internal fistula, the back end of the indwelling needle is designed with a hemostatic valve so

when the needle enters the blood vessel, blood will not flow back to the outside of the indwelling needle. This design allows great convenience and safety. Simultaneously, when pulling out the inner needle core when dialysis is completed, it can prevent blood leakage and avoid infection. Therefore, the use of indwelling needles for dialysis is helpful in reducing the risk of needle stick injuries.

Chen *et al.*[38] found through a self-controlled study that the incidence of needle stick injuries using ordinary steel needle punctures was significantly higher than that of indwelling needles for dialysis. Similarly, Yin *et al.*[39] showed that that conventional buttonholes are prone to the "three same" deviation phenomenon, and the use of indwelling needles for dialysis can help patients shape the puncture needle eye into a buttonhole. Therefore, compared with conventional buttonholes, the buttonholes shaping success rate is higher. Thus, compared with ordinary metal rigid needles, indwelling needles for dialysis can reduce the risk of hematoma and needle stick injuries.

Our findings were aligned with previous studies who have postulated that AVF should be planned at least 30 or 60 days before conducting prior to the procedures of haemodialysis.[40] This timeframe is critical for the maturation of the vascular access; therefore, a correct procedure should encompass the preoperative phase, operative phase and a post-operative phase. Furthermore, it is critical to perform a critical and instrumental evaluation to determine the most effective vascular access, technical competencies and requirements coupled with the correct follow-up in handling complications in the early phases. It is crucial to preserve and maintain the vascular system by avoiding the withdrawal of blood or infusions into the intravenous system through the arms and forearms, rather than using the hand veins for these purposes.

Conclusions

Our findings suggest that while the intervention did not significantly impact complication rates or fistula failure, it may offer benefits in terms of puncture efficiency and patient comfort during dialysis. Further research is needed to confirm these findings and explore the long-term implications of using indwelling needles for haemodialysis access. At present, haemodialysis indwelling needles have been widely used in the world. However, due to the relatively high difficulty of puncture, the relatively long puncture time for nurses, and the impact of economic factors, their application in China is still limited and needs to be confirmed by more research. Which sex is better or worse remains to be further explored. In addition, there is no unified standard in China regarding the retention time and sealing method of indwelling needles for dialysis, and further exploration is needed.

List of abbreviations:

AVF, Arteriovenous Fistula
CVC, Central Vein Catheters
AVG, Arteriovenous Grafts
ESRD, End-Stage Renal Disease
eGFR, Estimated Glomerular Filtration Rate
DSA, Digital Subtraction Angiography
NYHA, New York Heart Association
MMSE, Mini-Mental State Examination
BUN, Blood Urea Nitrogen
Scr, Serum Creatinine

Conflict of interest

The authors declare no potential conflict of interest, and all authors confirm accuracy.

Ethics approval

Approval was obtained from the Ethics Committee of Pingyang County Traditional Chinese Medicine Hospital with approval number:sh2023210A.

Informed consent

All patients participating in this study signed a written informed consent form for participating in this study.

Patient consent for publication

Written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

Availability of data and materials

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

Corrisponding Author

Guihong Jin, Blood Purification Center of Pingyang County Traditional Chinese Medicine Hospital, Zhejiang University of Traditional Chinese Medicine, Wenzhou 325400, Zhejiang, China.
ORCID ID: 0009-0009-3362-5975
E-mail: 13506775969@163.com

Jianmin Gu
ORCID ID: 0009-0005-9653-2515
E-mail: 412771282@qq.com

Yan Zhang
ORCID ID: 0009-0004-7844-1698
E-mail: 409579729@qq.com

Shidan Ren
ORCID ID: 0009-0004-9548-0111
E-mail: renshidan@163.com

References

1. Ronco C, Clark WR. Haemodialysis membranes. Nature Rev Nephrol 2018;14:394-410.
2. Tong A, Manns B, Hemmelgarn B, et al. Establishing core outcome domains in hemodialysis: report of the Standardized Outcomes in Nephrology–Hemodialysis (SONG-HD) consensus workshop. Am J Kidney Dis 2017;69:97-107.
3. Sahasrabudhe P, Patil S, Dighe T, Panse N. Retrospective analysis of 271 arteriovenous fistulas as vascular

access for hemodialysis. Indian J Nephrol 2013; 23:191.
4. Clark WR, Hamburger RJ, Lysaght MJ. Effect of membrane composition and structure on solute removal and biocompatibility in hemodialysis. Kidney Internat 1999;56:2005-15.
5. Feola A, Giugliano P, La Sala F, et al. Fatal hemorrhage from arteriovenous dialysis access site: A case report. Acta Medica 2018;34:159.
6. Bin-ayesh HN, Alhussein SH, Alahmari NF, et al. Review on Arteriovenous Fistula Techniques and Complications. Entomol Appl Sci Letters 2021;8:105-13.
7. Marticorena RM, Dacouris N, Donnelly SM. Randomized pilot study to compare metal needles versus plastic cannulae in the development of complications in hemodialysis access. J Vascular Access 2018;19: 272-82.
8. Weigert A, Drozdz M, Silva F, et al. Influence of gender and age on haemodialysis practices: a European multicentre analysis. Clinical Kidney J 2020;13:217-24.
9. Chan K, Moe SM, Saran R, Libby P. The cardiovascular–dialysis nexus: the transition to dialysis is a treacherous time for the heart. Eur Heart J 2021;42: 1244-53.
10. Lok CE, Allon M, Moist L, et al. Risk Equation Determining Unsuccessful Cannulation Events and Failure to Maturation in Arteriovenous Fistulas (REDUCE FTM I). J Am Soc Nephrol 2006;17:3204-12.
11. Dogra PM, Nair RK, Sood V, et al. Pneumoperitoneum needle vs. introducer needle: Comparison of complications and short-term outcomes in percutaneously inserted peritoneal dialysis catheters in naïve abdomens. Therapeut Apher Dialysis 2022;26:212-9.
12. Kashima Y, Ninomiya S. Hemodialysis efficiency management from the viewpoint of blood removal pressure. Therapeutic Apher Dialysis 2021;25:152-9.
13. Yin J, Tian Z, Li P, et al. A time-saving method of creating AVF buttonholes: indwelling trocar technique. J Clin Nurs 2022;31:3102-9.
14. Evangelidis N, Tong A, Manns B, et al. Developing a Set of Core Outcomes for Trials in Hemodialysis: An International Delphi Survey. Am J Kidney Dis 2017;70:464-75.
15. Viecelli AK, Tong A, O'Lone E, et al. Report of the Standardized Outcomes in Nephrology–Hemodialysis (SONG-HD) consensus workshop on establishing a core outcome measure for hemodialysis vascular access. Am J Kidney Dis 2018;71:690-700.
16. Ju A, Teixeira-Pinto A, Tong A, et al. Validation of a Core patient-reported outcome measure for fatigue in patients receiving hemodialysis: the SONG-HD fatigue instrument. Clin J Am Soc Nephrol 2020;15: 1614-21.
17. Wei Z, Han X, Zhi Y, et al. Clinical application of peritoneal dialysis catheterization without capsular puncture technique. BioMed Res Internat 2022;2022:1-6.
18. Swinnen JJ, Baker L, Burgess D, et al. Changing the peritoneal dialysis access algorithm with a precise technique of percutaneous Seldinger PD catheter placement. J Vascular Access 2022;23:615-23.
19. Chen Y-T, Lin S-L. A clinically relevant murine model of peritoneal fibrosis by dialysate and catheters. J Visualized Experiments 2022:63901.
20. Baetens TR, Rotmans JI, Van Der Meer RW, Van Rijswijk CS. A novel technique to restore access in patients with central venous occlusion using the Surfacer® Inside-Out® Access Catheter System. J Vascular Access 2020;21:778-82.
21. Peng J, Lin H, Cai C, et al. New method of internal fixation in laparoscopic Tenckhoff catheter placement. Sem Dialysis 2022;35:498-503.
22. Vachharajani TJ, Wong L, Niyyar VD, et al. Buttonhole cannulation of arteriovenous fistulas in the United States. Kidney360 2020;1:306-13.
23. Hull JE, Jennings WC, Cooper RI, et al. The pivotal multicenter trial of ultrasound-guided percutaneous arteriovenous fistula creation for hemodialysis access. J Vascular Intervent Radiol 2018;29:149-58.e5.
24. Canaud B, Ponce P, Parisotto MT, et al. Vascular access management for haemodialysis: a value-based approach from NephroCare experience. In: E. Berezin A, ed. Vascular Access Surgery - Tips and Tricks: IntechOpen; 2019.
25. Al-Jaishi AA, Liu AR, Lok CE, et al. Complications of the arteriovenous fistula: a systematic review. J Am Soc Nephrol 2017;28:1839-50.
26. Kaygın MA. Our experiences with hemodialysis arteriovenous fistula aneurysm. Turkish J Vascular Surg 2020;29:121-6.
27. Ratnam L, Karunanithy N, Mailli L, et al. Dialysis access maintenance: plain balloon angioplasty. Cardio-Vascular Intervent Radiol 2023;46:1136-43.
28. Polimanti AC, Fürst RVDC, Galego SJ, et al. Influence of intraoperative findings on immediate flow through radial-cephalic arteriovenous wrist fistulas for hemodialysis access. Jornal Vascular Brasileiro 2018;17: 208-14.
29. Leapman SB, Boyle M, Pescovitz MD, et al. The arteriovenous fistula for hemodialysis access: gold standard or archaic relic? Am Surg 1996;62:652-6; discussion 6.
30. Wolowczyk L, Williams AJ, Donovan KL, Gibbons CP. The Snuffbox arteriovenous fistula for vascular access. Eur J Vasc Endovasc Surg 2000;19:70-6.
31. Al Shakarchi J, Garnham A. 16 Central venous and dialysis access. Vascular and Endovascular Surgery E-Book: Companion to Specialist Surgical Practice. 2023:242.
32. Dawoud D, Lok CE, Waheed U. Recent advances in arteriovenous access creation for hemodialysis: new horizons in dialysis vascular access. Adv Chronic Kidney Dis 2020;27:191-8.
33. Letachowicz K, Kusztal M, Gołębiowski T, et al. Use of plastic needles for early arteriovenous fistula cannulation. Blood Purification 2015;40:155-9.
34. Darbas Barbe R, Franco K, Sancho C, et al. Vascular access puncture using fistula catheter: Effect on the patient's pain and adequacy of hemodialysis. 2015. Available from: https://www.researchgate.net/publication/286861913_Vascular_access_puncture_using_fistula_c

atheter_Effect_on_the_patient's_pain_and_adequacy_of_hemodialysis
35. Ocaña O, Estaire J, Sanz B, et al. Fistula catheter: a new alternative in venous access puncture. Revista de la Sociedad Española de Enfermería Nefrológica 2010;13: 105-11.
36. Zhang Z, Petersen L, Bible J, et al. Needle angle matters: an investigation of the effect of needle angle on hemodialysis cannulation skill. Kidney360 2023;4: 962-70.
37. Nalesso F, Garzotto F, Muraro E, et al. Fistula cannulation with a novel fistula cannula: a review of cannulation devices and procedures. Blood Purification 2018;45:278-83.
38. Chen J, Zhou M, Zeng K, et al. The risk factors of autogenous arteriovenous fistula dysfunction in maintenance hemodialysis patients and the curative effect of personalized nursing. Am J Translat Res 2021;13:5107.
39. Yin H, Zhou C, Yu H, Ren W. The beneficial effects of the buttonhole technique used for the cannulation of arteriovenous fistula among hemodialysis patients: a literature review. Am J Nurs 2020;10:185-90.
40. Santoro D, Benedetto F, Mondello P, et al. Vascular access for hemodialysis: current perspectives. Internat J Nephrol Renovasc Dis 2014:281.

Disclaimer

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article or claim that may be made by its manufacturer is not guaranteed or endorsed by the publisher.

Submitted: 24 February 2024.
Accepted: 12 March 2024.
Early access: 30 April 2024.