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Maturation of Radiocephalic Arteriovenous Fistula with and without Hydro dilatation: A Study on the Diameter and Flow Volume of the Draining Vein

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ABSTRACT

Radiocephalic arteriovenous fistula (AVF-RC) is the primary vascular access in patients with end-stage chronic kidney disease undergoing hemodialysis. One of the main challenges of using AVF-RC is the failure of early maturation, characterized by inadequate diameter and flow volume of the draining vein. Hydro dilatation is a simple intraoperative technique that aims to increase the distensibility and diameter of the veins, so that it is expected to accelerate the maturation process of the fistula. This study used a retrospective cohort design involving patients with chronic kidney disease who were undergoing hemodialysis and had AVF-RC created for the first time at Yarsi Hospital between October 2023 and September 2025. Subjects were divided into two groups, namely the group with and without hydro dilatation, with 60 patients in each group. A total of 120 patients were analyzed, with a median age of 54 years, and the majority were male. The diameter of the draining vein increased significantly from preoperative to 6 weeks postoperative in all patients ($p < 0.001$). The increase in draining vein diameter at weeks 1 and 6 postoperatively was significantly greater in the hydro dilatation group than in the non-hydro dilatation group ($p < 0.001$). Hydro dilatation has a significant effect on increasing the diameter and flow volume of the draining vein of AVF-RC, particularly in the early period of maturation. This technique has the potential to improve the success of AVF maturation and can be considered as part of an intraoperative strategy for optimizing vascular access for hemodialysis.
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Keywords:
Arteriovenal fistula; hydro dilatation;
diameter vein;
volume flow;
Hemodialysis.

INTRODUCTION

Arteriovenous fistula (AVF) is the primary vascular access option for patients with end-stage renal disease (ESRD) who require long-term hemodialysis therapy. The advantages of AVF compared to arteriovenous graft (AVG) and central venous catheter (CVC) lie in the higher patency rate, lower risk of infection, and more cost-effective maintenance in the long term. Nonetheless, the main challenge in the use of AVF is early maturation failure, which can be as high as 20–50% depending on the population and the technique used. This maturation failure has direct implications for AVF primary patency and increases the risk of patients requiring additional interventions or conversion to other forms of vascular access (Bashar et al., 2016; Huber et al., 2021; Siddiqui et al., 2017; Tordoir et al., 2018; Vazquez-Padron & Allon, 2016).

The maturation process of AVF involves a series of adaptive changes in the vein used as access, including an increase in lumen diameter, thickening of the venous wall, and increased flow volume in response to post-anastomosis arterial blood flow. The 2019 Kidney Disease Outcomes Quality Initiative (KDOQI) stipulates that AVF is considered mature at 6 weeks after creation, with a vein diameter of ≥6 mm, a depth from the skin surface of ≤6 mm, and a flow volume of ≥600 mL/min. However, the achievement of these criteria is often hampered by anatomical factors, such as small vein size, venous spasm, or rigid venous walls with low distensibility (Gianesini et al., 2019; Murray & Hendley, 2020; Prionidis, 2023; Suraj, 2022; Youn & Lee, 2018).

To overcome this obstacle, one of the widely used techniques is hydro dilatation. This technique is performed intraoperatively by injecting a heparinized saline solution into the vein after proximal clamping, so that the fluid pressure causes gradual stretching of the venous wall. The purpose of this procedure is to overcome spasm, increase the lumen diameter, and simultaneously assess venous distensibility (Georgakarakos & Tasopoulou, 2021; Hirano, 2020; Jain et al., 2019; Omari et al., 2022). Compared to other augmentation methods such as primary balloon angioplasty (PBA), hydro dilatation has the advantages of simplicity, low cost, and does not require interventional radiological equipment (Wible, 2017).

This research is urgently needed given the rising global prevalence of chronic kidney disease (CKD) and the increasing demand for effective hemodialysis access. By investigating the effect of hydro dilatation on AVF maturation in a clinical setting, this study aims to contribute to the existing body of knowledge and help refine hemodialysis protocols for improving patient outcomes (Browne, 2015). Moreover, this research will shed light on the benefits of hydro dilatation beyond immediate clinical results, considering factors such as patient satisfaction, cost reduction, and decreased need for further interventions (Borghini et al., 2026; Kamal et al., 2025; Lim et al., 2026; Shaw-Battista, 2017).

The novelty of this study lies in its focus on a previously under-explored population patients with CKD undergoing radio cephalic AVF creation by comparing hydro dilatation versus non-hydro dilatation groups over a six-week postoperative period. This research offers valuable insights into the technical aspects of AVF creation, while also evaluating the broader implications for healthcare systems burdened by rising CKD rates. By analyzing both quantitative outcomes, such as draining vein diameter and flow volume, and qualitative factors such as patient well-being, this study addresses a current gap in the literature.

The primary objective of this study is to evaluate the impact of hydro dilatation on the maturation process of radio cephalic AVF in patients with CKD. Specifically, this research aims to assess the differences in draining vein diameter and flow volume between the hydro dilatation and non-hydro dilatation groups. Additionally, this study explores the potential role of hydro dilatation in improving the long-term success of AVF as a vascular access option, particularly in patients with comorbidities such as diabetes mellitus.

The expected contribution of this study lies in its ability to provide evidence for the clinical application of hydro dilatation as a standard practice in AVF creation. By demonstrating its effectiveness in improving AVF maturation rates, this research could lead to better patient outcomes, reduced healthcare costs, and a higher quality of life for individuals undergoing hemodialysis. Furthermore, the findings will offer policymakers valuable data to support the wider adoption of hydro dilatation in clinical settings.

In conclusion, this research advances the understanding of hydro dilatation's role in optimizing AVF maturation, addressing a crucial gap in the current literature. The outcomes of this study have the potential to reshape clinical practice and contribute to the development of more effective and sustainable dialysis access methods for the growing population of patients with CKD. By exploring this approach to AVF maturation, the study provides insights that could significantly improve patient care and reduce the global burden of chronic kidney disease.

METHOD

Research Design

This study had a Retrospective Cohort design, by retrospectively including patients using patient medical record data that was made AVF-RC during the study period. Place and Time of Research. This research was conducted at Yarsi Hospital for a retrospective sample; the research data collection will be taken from patients from October 2023 to September 2025. Retrospective sampling will be carried out from October 2025 to November 2025.

Population and Sample

The target population is patients with chronic and end-stage kidney failure who are moderate/will undergo hemodialysis, where AVF-RC installation with or without Hydro dilatation is carried out at Yarsi Hospital from October 2023 to September 2025. The research sample was an affordable population that met the inclusion criteria and did not include the exclusion criteria.

Inclusion and Exclusion Criteria

Inclusion Criteria: Adult patients aged >18 years with moderate/moderate end-stage chronic renal failure are undergoing hemodialysis, with the planned for the first AVF-RC for access to hemodialysis. The medical record data is complete and includes all variables studied for retrospective patients. The patient's hemodynamics are stable so that AVFRC can be made electively. The diameter of the radial artery ≥ 2.0 mm (triphasic spectrum), and the diameter of the cephalic vein ≥ 1.5 mm was known on preoperative DUS examination.

Exclusion Criteria: History of major surgery or other fistula creation in the same extremity. The presence of stenosis of the draining vein and/or feeding artery, as well as cephalic arch stenosis and/or ipsilateral central venous stenosis, or proximal venous thrombosis. Patients with systemic or local active infections (cellulitis) at the surgical site, or the presence of a hematoma at the surgical site. Failure to manufacture AVF-RC due to technical error during operation. Patients with vasculitis or malignancy. Patients with uncontrolled coagulation disorders.

How Data Collection Works and Techniques

Retrospective Data: Data source: medical records of patients with end-stage chronic kidney failure who are undergoing hemodialysis, where the first AVF-RC was performed for access to hemodialysis at the research hospital in the 24-month period prior to the start of the study. The data collected included: demographic characteristics, comorbidities, results of ultrasound mapping examinations, use and without the use of hydro dilatation, results of diameter measurements (preoperative, as well as 1 and 6 weeks postoperative), and flow draining vein volume (weeks 1 and 6 postoperatively).

Measurement of Diameter and Volume of Flow Draining Vein

Measurement of cephalic vein diameter was carried out using GE Healthcare Logic P9 doppler ultrasound. By using a linear probe on the upper extremity vascular examination setting. The frequency of the probe is set from 7 to 15 Mhz, with an inclination of no more than 60°. The patient's arm is positioned comfortably about 45° from the body, with the elbow resting on the support. The arterial flow of 28 radial antegrades was documented as high as the wrist, and the diameter of the radial artery was measured.

Hydro dilatation Techniques During AVF-RC Manufacturing

The hydro dilatation technique is based on the technique reported by Feng et al. (2023). With DUS indications and palpation of the pulse, all veins and artery locations in the forearm are given markers. The non-dominant forearm is the most appropriate location of the AVF if there is no contradiction. After local infiltration anesthesia, an incision is made about 3 cm long in the distal part of the forearm. Subcutaneous tissue is separated to expose the targeted arteries and veins.

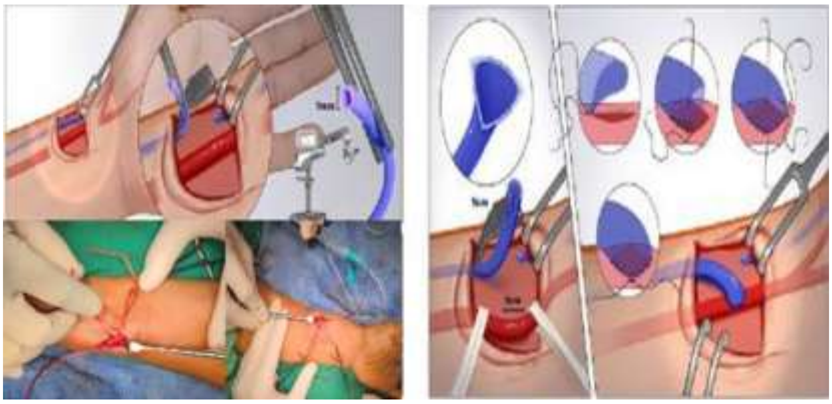

Figure 1. Hydro dilatation With NGT 3.5 Fr and End-to-Side Anastomosis of the Cephalic Vein-Radial Arteries23

After venous ligation and transection, segmental hydro dilatation is performed on the proximal segment of the vein as well as the entire length of the vein along with the forearm by pressing the finger. If there is a mural/fibrin thrombus or calcified plaque, it must be removed first before hydro dilatation. The saline volume measurement required for hydro dilatation is as follows:

Figure 2. Saline Volume Measurement for Hydro dilatation in Surgical Procedures

With the formula of the π x r2 x P tube, the normal volume of saline needed is 5.65 ml or rounded to 6 ml. 6 ml of saline-heparin is delivered through a 3.5 Fr feeding tube from the distal end of the vein, while the assistant's fingers are alternatively moved along the pathway marked prior to surgery by performing compression and venous release. Then, a 4-6 mm incision is made on the surface of the artery, and an end-to-side anastomosis is performed between the vein and the artery by stitching using Polypropylene 7-0.

Variable

Independent Variables: AVF-RC with hydro dilatation action, AVF-RC without hydro dilatation action. Bound Variables: Preoperative vein draining diameter, Diameter draining vein 1 week postoperatively, Diameter draining vein 6 weeks postoperatively, Volume flow draining vein 1 week postoperatively, Volume flow draining vein 6 weeks postoperatively.

Confounding Variables: Age, Gender, Body Mass Index, Hypertension, Dyslipidemia, Smoking, History of heart disease and arrhythmias, Use of antiplatelet/anticoagulant therapy.

Large Sample

The calculation of sample size is carried out using the sample size formula for analytical research with the following numerically bound variables:

$$n = \left(\frac{Z\alpha \times S}{d} \right)^2$$

- n = Sample size
- Sat = Alpha standard deviation = 1.96 (type I error 5%)
- d = Research precision
- S = Standard deviation

Using data from a thesis with similar bound variables by Kurniawan Eko Wibowo (2024), the following values and sample sizes were obtained.23 The precision level used is 10%. For the record, standard deviation data is taken from the result of the division between the delta range divided by 4.

Table 1. Average Values and Total of Venous Drainage Variables in Postoperative Patients

Variable	S	Ntotal
Venous draining flow volume 1 week postoperative	129,66	51
Venous flow draining volume 6 weeks postoperative	183,2	60
Venous draining diameter 1 week postoperative	0,95	5
Venous draining diameter 6 weeks postoperative	1,25	5

Based on this calculation, the sample size to be used in this study is as many as 60 samples for each group, which are obtained retrospectively.

Data Processing and Analysis Plan

Univariate: Data processing is carried out by checking the completeness and consistency of medical record data. Next, the data is encoded and entered into the SPSS statistical software version 25.0. Categorical variables are given numerical codes, e.g. 1 for "Yes" and 0 for "No", while numerical variables are distributed using Shapiro–Wilk or Kolmogorov–Smirnov normality tests. Descriptive analysis is used to describe demographic data and patient characteristics, presented in the form of mean ± standard deviation (SD) for normally distributed data or median (range) for abnormal data. Categorical data is presented as frequency and percentage (%).

Bivariate: Bivariate analysis was performed to compare the average diameter and volume of flow draining veins between the hydro dilated and non-hydro dilated groups at each measurement time point (preoperative, as well as 1 and 6 weeks postoperatively). The unpaired t-test is used for normally distributed data, while the Mann–Whitney test is used for abnormal data. Comparisons of changes in the diameter and volume of flow draining veins in the group over time were analyzed using Repeated Measures ANOVA for normal data and Friedman tests for abnormal data. All statistical tests were conducted two-way with a significance level of $p < 0.05$ and a confidence interval of 95%.

RESULT AND DISCUSSION

In this study, patient data was collected from 155 patients. A total of 9 patients during the DUS examination were known to have atherosclerosis in the area to be made AVF-RC so that they were excluded as research samples. Three patients did not come back to the BVE Research Hospital clinic for postoperative evaluation, so they were excluded as samples. And it was found that 26 patients were excluded as samples because they had failed to mature the AVF made.

Characteristics of Research Samples

Table 2. Sample Characteristics

Variable	Value
Number of samples	120
Age, median (IQR)	54,0 (19,0)
Gender, n (%)	
Male	75 (62,5)
Women	45 (37,5)
Diabetes Melitus, n (%)	38 (31,7)
Atherosclerosis, n (%)	0
Hydro dilatation subgroup, n (%)	
Without hydro dilatation	60 (50,0)
By hydro dilatation	60 (50,0)

IQR: interquartile range

Based on Table 1, it was found that the median age of the study subjects was 54 years, with most of the research subjects being male (62.5%). Subjects with Diabetes Mellitus (31.7%), and atherosclerosis (0%). In this study, the subjects were divided into groups with and without hydro dilatation, with each group of 60 subjects.

Table 3. Sample Characteristics by Group

Variable	Group		Value p
	No Hydro dilatation	By Hydro dilatation	
Age, median (IQR)	53,5 (19,5)	54,5 (19,8)	0,954
Gender, n (%)			0,572
Male	36 (60,0)	39 (65,0)	
Women	24 (40,0)	21 (35,0)	
Diabetes Melitus, n (%)	15 (25,0)	23 (38,3)	0,116
Atherosclerosis, n (%)	0	0	-

IQR: interquartile range

Based on Table 2, a bivariate analysis was carried out regarding the relationship between sample characteristics, including age, sex, history of diabetes mellitus, and history of atherosclerosis, with the presence of hydro dilatation. Based on bivariate analysis, there was no significant difference between patients with hydro dilatation or without hydro dilatation in each sample characteristic ($p > 0.05$).

Diameter of Draining Vein, as well as AVF With and Without Hydro dilatation

Table 4. Overall Diameter of Draining Vein Research Sample

Variable Median, (IQR)	Value
Preoperative vein draining diameter	2,20 (0,50)
Diameter draining vein 1 week postoperative	3,80 (0,90)
Vein draining diameter 6 weeks postoperative	5,50 (1,17)

IQR: interquartile range

Based on Table 3, the median diameter of the preoperative draining vein was 2.20 mm, the diameter of the 1-week postoperative draining vein was 3.80 mm, and the 6-week postoperative drainage vein diameter was 5.50 mm. The increase in the diameter of the draining vein from preoperative to 6 weeks postoperative illustrates the maturation process of AVF.

Based on statistical analysis in all patients, there was a significant difference between the diameter of the draining vein preoperative and 1 week postoperative (p = 0.000), between the diameter of the draining vein preoperatively and 6 weeks postoperative (p = 0.000), and between the diameter of the draining vein 1 week postoperatively and 6 weeks postoperatively (p = 0.000). The results of the Friedman test also showed a significant difference in changes in the diameter of the draining vein over time (p = 0.000).

Table 5 Overall Vein Draining Diameter Sample Research by Group

Variable Median, (IQR)	Group		Value p
	No Hydro dilatation	By Hydro dilatation	
Preoperative *vein draining* diameter	2,50 (0,58)	2,0 (0,20)	0,000*
Diameter *draining vein* 1 week postoperative	3,70 (0,88)	3,85 (1,05)	0,881
Vein *draining diameter* 6 weeks postoperative	5,05 (0,95)	5,95 (0,85)	0,000*

Based on statistical analysis in patients with hydro dilatation, there was a significant difference between the diameter of the draining vein preoperatively and 1 week postoperatively (p = 0.000), between the diameter of the draining vein preoperatively and 6 weeks postoperatively (p = 0.000), and between the diameter of the draining vein 1 week postoperatively and 6 weeks postoperatively (p = 0.000). The results of the Friedman test also showed a significant difference in changes in the diameter of the draining vein over time (p = 0.000).

Based on statistical analysis in patients without hydro dilatation, there was a significant difference between the diameter of the draining vein preoperatively and 1 week postoperatively (p = 0.000), between the diameter of the draining vein preoperatively and 6 weeks postoperatively (p = 0.000), and between the diameter of the draining vein 1 week postoperatively and 6 weeks postoperatively (p = 0.000). The results of the Friedman test also showed a significant difference in changes in the diameter of the draining vein over time (p = 0.000).

Based on Table 4, it was found that the diameter of the draining vein at week 1 postoperatively did not differ significantly between patients with and without hydro dilatation (p = 0.881), but this finding may be due to a significantly smaller baseline preoperative emptying vein diameter (p = 0.000) in patients with hydro dilatation compared to those without hydro dilatation. To better see the effect of hydro dilatation on the diameter of the draining vein, an analysis was carried out of changes in diameter increase at weeks 1 and 6 postoperatively from the preoperative value as shown in table 5.

Table 6 Changes in Overall Draining Vein Diameter Research Sample by Group

Variable Median, (IQR)	Group		Value p
	No Hydro dilatation	By Hydro dilatation	
Increased diameter *draining vein* 1 week postoperatively	1,20 (0,30)	2,00 (1,0)	0,000
Increased *vein draining diameter* 6 weeks postoperatively	2,55 (0,60)	4,10 (0,67)	0,000

Based on Table 5, it was found that the increase in vain diameter 1 week postoperatively differed significantly between patients with and without hydro dilatation (p = 0.000) and the increase in vain diameter 6 weeks postoperatively differed significantly between patients with and without hydro dilatation (p = 0.000).

Based on statistical analysis in patients with hydro dilatation, there was a significant difference between an increase in the diameter of the draining vein 1 week postoperatively and an increase in the diameter of the draining vein 6 weeks postoperatively (p = 0.000). In patients without hydro dilatation, there was a significant difference between an increase in the diameter of the draining vein 1 week postoperatively and an increase in the diameter of the draining vein 6 weeks postoperatively (p = 0.000).

Volume Flow Draining Veing, as well as AVF With and Without Hydro dilatation

Tabel 7 Volume Flow Draining Vein Overall Research Sample

Variable Median, (IQR)	Value
Volume flow draining vein 1 week postoperative	269,4 (122,4)
Volume flow draining vein 6 weeks postoperative	513,3 (196,7)

Based on Table 6, the median volume of flow draining vein 1 week postoperatively 269.4 mL/min and the median volume of flow draining vein 6 weeks postoperative 513.3 mL/min was obtained. The increase in the volume of flow draining vein up to 6 weeks postoperatively indicates the occurrence of hemodynamic adaptations that support AVF maturation.

Table 8 Flow Draining Vein Volume by Group

Variable Median, (IQR)	Subgroup		Value p
	No Hydro dilatation	By Hydro dilatation	
Volume flow draining vein 1 week postoperative	233,7 (101,8)	298,3 (110,9)	0,000
Volume flow draining vein 6 weeks postoperative	469,6 (197.2)	562,5 (212,3)	0,000

Based on statistical analysis in the group of patients who were hydro dilatation, there was a significant difference in the volume of flow draining veins 1 and 6 weeks postoperatively (p = 0.000). The results of the Friedman test also showed a significant difference in changes in flow draining vein volume over time (p = 0.000).

Based on statistical analysis in the group of patients without hydro dilatation, there was a significant difference between the volume of flow draining vein 1 and 6 weeks postoperatively (p = 0.000). The results of the Friedman test also showed a significant difference in the change in flow draining vein volume (p = 0.000). In this study, it was found that the volume of flow draining veins 6 weeks postoperatively in patients with hydro dilatation was significantly higher than in patients without hydro dilatation. The analysis of the increase in flow draining vein volume is listed in table 8.

Table 9. Increased Volume of Flow Draining Vein By Hydro dilatation Group

Variable Median, (IQR)	Hydro dilatation subgroup		Value p
	No Hydro dilatation	By Hydro dilatation	
Increased *volume of flow draining veins* 1 week postoperatively	205,9 (92,6)	276,5 (118,4)	0,000
Increased *volume of flow draining vein* 6 weeks postoperatively	439,6 (188,3)	540,3 (200,9)	0,008

Based on Table 9, it was found that the increase in flow draining volume of the vein 6 weeks postoperatively differed significantly between patients with and without hydro dilatation (p = 0.008).

Uses of AVF-RC

AVF-RC is vascular access which is the gold standard for chronic kidney disease patients who require long-term hemodialysis. AVF has a lower risk of infection and thrombosis than AVG or CVC, and has better long-term resistance. This has been confirmed by several large studies, which show the superiority of AVF patents over AVG and CVC.

AVF maturity is usually evaluated using the "Rule of 6s" criteria from Robbin et al., namely the vein diameter ≥ 6 mm, the vein depth ≤ 6 mm, and the flow volume ≥ 600 mL/min. This criterion has long been used as a predictor to determine the ready-to-use AVF for hemodialysis. However, many patients fail to achieve optimal maturation due to small vein diameters or less elastic venous walls, especially in elderly patients, Diabetes Mellitus, or with central venous stenosis. To overcome this problem, one of the techniques that began to be developed was hydrostatic dilatation, which is the gradual stretching of the veins using fluid pressure. This technique aims to enlarge the diameter of the vein and increase its distensibility so that the flow increases and the maturation of the AVF is more possible. Research by Arnold et al. (Journal of Vascular Access, 2017) shows that hydrostatic dilatation can improve venous remodeling and improve maturation success.

In this study, initial patient data was collected from 155 patients. A total of 26 patients were excluded as samples because they experienced maturation failure after the creation of AVF. This corresponds to an AVF failure rate of about 20%-50%.

Characteristics of Research Samples

In this study, the basic characteristics of the subjects showed a median age of 54 years, with the majority of participants being male (62.5%). This distribution corresponds to the epidemiology of chronic kidney failure patients undergoing AVF making, in which the age group of 50–60 years and men generally dominate the dialysis patient population according to several large cohort studies. The proportion of subjects with Diabetes Mellitus reached 31.7%, while atherosclerosis was not found in this sample. The findings are in line with the literature reporting that Diabetes Mellitus is the most common comorbid in hemodialysis patients, with a prevalence of about 30–40%, while the history of atherosclerosis usually varies more between populations and depends on the method of detection.

Differences in Diameter of Draining Vein

This study showed a significant increase in the diameter of the draining vein from the preoperative phase to 6 weeks postoperatively. The median diameter of the draining vein increased from 2.20 mm at preoperative to 3.80 mm at 1 postoperative week, and further reached 5.50 mm at postoperative 6 weeks. This progressive increase in diameter is a typical illustration of the AVF maturation process, where venous arterialization causes venous dilatation, thickening of the tunic layer of the media, and changes in compliance due to increased shear stress. Robbin et al. (2002) stated that enlargement of vein diameter is one of the main criteria for AVF maturation, along with increased flow and decrease in vain depth.

Statistical analysis of all patients showed significant differences at each time interval, both between preoperative and postoperative week 1, preoperative and postoperative week 6, and postoperative weeks 1 and 6 ($p = 0.000$ overall). The Friedman test also showed a significant difference in changes in the diameter of the draining vein over time ($p = 0.000$), indicating that the process of dilatation and venous remodeling occurred consistently during the first 6 weeks after the creation of the AVF. These findings are in line with the report of Lee et al. (2016) which stated that week's 1 to 6 postoperatively are the critical phase in which venous remodeling takes place most intensively.

In the group of patients with hydro dilatation, the entire time interval also showed a significant difference ($p = 0.000$). This supports literature such as Arnold et al. (2017), which show that hydro dilatation can increase venous elastic recoil, directly enlarge lumen diameter, and accelerate structural remodeling. Meanwhile, the group without hydro dilatation also showed significant improvement, but the pattern of increase in diameter was slower than that of the group with hydro dilatation.

The results in Table 4.4 show that the venous diameter of week 1 postoperatively did not differ significantly between patients with and without hydro dilatation ($p = 0.881$). However, this is most likely due to a significantly smaller baseline diameter in the group with hydro dilatation ($p = 0.000$). Therefore, a more precise analysis is to compare the change in diameter, not the absolute value.

Based on the analysis of the change in diameter (Table 4.5), the increase in diameter at weeks 1 and 6 postoperatively differed significantly between the groups with and without hydro dilatation ($p = 0.000$ at both time points). This shows that hydro dilatation has an additional effect in the form of an increase in venous distensions from the initial postoperative period. In both the hydro dilatation and non-hydro dilatation groups, the change in diameter between weeks 1 and 6 postoperatively remained significant (p = 0.000), confirming that venous remodeling was progressive in all patients but more optimal in the hydro dilatation group.

From the aspect of draining vein diameter, it was found that there was a significant increase from preoperative to week 1 and then to week 6 postoperatively in all patients. The median draining vein diameter increased from 2.20 mm to 3.80 mm at week 1 postoperatively and to 5.50 mm at week 6 postoperatively, with the results of the Friedman test showing significant differences between time periods (p = 0.000). These findings indicate a progressive venous remodeling process, aligned with increased flow changes, and reflecting the structural maturation of the AVF. Thus, the purpose of the study related to the difference in postoperative venous diameter in all patients has been met.

Difference in Volume of Flow Draining Vein

In this study, the median volume of flow draining vein showed a very significant increase up to 6 weeks postoperatively. The volume of flow draining vein was 269.4 mL/min at week 1 postoperatively, and reached 513.3 mL/min at week 6 postoperatively. This progressive improvement illustrates the physiological hemodynamic adaptation in the form of vasodilatation, venous wall remodeling, and increased shear stress that supports the AVF maturation process. These findings are in line with the classical theory of AVF maturation described by Robbin et al., which stated that increased venous flow is a key indicator of the success of vascular remodeling and venous preparation for hemodialysis access. In addition, the study of Dixon et al. (2019) also confirms that a significant increase in venous flow in the first 4–6 weeks is a strong predictor for long-term maturation and patency of AVF.

Statistical analysis in a group of patients with hydro dilatation showed a significant difference between weeks 1 and 6 postoperatively (p = 0.000). The results of the Friedman test also confirmed a significant change in the volume of flow draining vein (p = 0.000). These findings indicate that hydro dilatation plays a role in improving venous distensibility and facilitating faster hemodynamic adaptation, according to the report of Arnold et al (2017). Which suggests that hydro dilatation can increase vein diameter and improve vascular flow after AVF making.

In the group without hydro dilatation, increased venous flow was also statistically significant. However, this study found that the volume of flow draining veins at weeks 1 and 6 postoperatively in the hydro dilatation group increased significantly higher than in the non-hydro dilatation group. This is consistent with the concept that mechanical interventions such as hydro dilatation can accelerate venous structural changes and improve the hemodynamics of the fistula early, a finding that is also supported by the study of Lee et al. (2016) which suggests that intraoperative venous manipulation can improve early flow and improve the potential for maturation.

Overall, this study showed a significant increase in the volume of flow draining vein from the 1st postoperative week to the 6th postoperative week in all AVF patients. The median volume of flow draining vein increased by 269.4 mL/min at week 1 postoperatively, and reached 513.3 mL/min at week 6 postoperatively. The Friedman test showed an overall significant change (p = 0.000), describing the occurrence of a hemodynamic adaptation process consistent with the maturation phases of arteriovenous fistulas.

When compared between the groups of patients with and without hydro dilatation, it was found that the flow draining vein volume at week 6 postoperatively increased significantly in both groups, but the absolute value of the flow draining vein volume in the hydro dilatation group was significantly higher.

AVF Maturation Progressivity

Comparison of AVF maturity between weeks 1 and 6 postoperatively showed consistent hemodynamic dynamics in both groups. Week 1 postoperatively, the hydro dilatation group showed a greater increase in the volume of flow draining veins and achieved significantly higher values than the non-hydro dilatation group. These findings show that hydro dilatation interventions provide a significant initial effect in facilitating the adaptation of venous walls to increased arterial blood flow after AVF making.

Changes in flow draining vein volume from weeks 1 to 6 postoperatively showed a pattern of progressive improvement in both groups, each of which proved statistically significant based on the Friedman test ($p = 0.000$). Although both groups showed a consistent upward trend, in the group with hydro dilatation retained the advantage in terms of the magnitude of the increase in volume of flow draining veins. This reflects that the effect of hydro dilatation is not only short-term, but also contributes to more optimal venous remodeling in the intermediate maturation phase.

Thus, the difference in flow draining vein volume values between weeks 1 and 6 postoperatively indicated that the AVF maturation process was faster and more efficient in the group without hydro dilatation. A greater increase in vain flow draining volume from week 1 postoperatively, which then continues to week 6 postoperatively, suggests that hydro dilatation can modify venous hemodynamic responses more effectively. Thus, these findings support the role of hydro dilatation as an adjunct intervention that has the potential to increase the success of AVF maturation through blood flow optimization and venous wall adaptation response.

Overall, comparisons between weeks 1 and 6 postoperatively showed that the two main parameters of arteriovenal fistula maturation—diameter and volume of flow draining veins experienced consistent and significant improvements in both groups. However, in the group with hydro dilatation, it showed a faster maturation pattern and greater improvement, both in terms of hemodynamic and structural aspects. A more pronounced improvement in the group with hydro dilatation at 6 weeks postoperatively suggests a possible important role of hydro dilatation in accelerating venous remodeling and supporting the achievement of adequate maturation criteria.

CONCLUSION

In conclusion, this study has demonstrated the significant impact of hydro dilatation on the maturation of arteriovenous fistulas (AVF) in patients with chronic kidney disease (CKD). The results indicate that hydro dilatation significantly improves both vein diameter and flow volume, which are critical factors for successful AVF maturation. This technique not only enhances the early post-operative outcomes but also offers a promising approach to improving the long-term functionality and success of AVF, particularly in patients with comorbid conditions such as diabetes. Hydro dilatation thus proves to be an effective and cost-efficient strategy for optimizing vascular access for hemodialysis, which could lead to better patient outcomes and reduced healthcare costs in managing ESRD.

For future research, it is recommended to explore the long-term effects of hydro dilatation on AVF function, particularly in diverse patient populations with varying comorbidities. Additional studies should investigate the impact of hydro dilatation on patient quality of life, complications, and the need for further interventions, such as catheter usage or additional surgical procedures. Moreover, future studies could examine the cost-effectiveness of incorporating hydro dilatation into standard clinical practices for AVF creation, to better assess its economic benefits. A larger-scale, multicenter trial with long-term follow-up would provide a more comprehensive understanding of the role of hydro dilatation in improving the success of AVF in patients undergoing hemodialysis.

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