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ARTERIOVENOUS FISTULA STENOSIS PREVENTION PROGRAM IN PATIENTS RECEIVING HEMODIALYSIS

Sajid Hussain[1], Madiha Mukhtar[1], Sarfraz Masih[2]

[1]Lecturer, PKLI ION & AHS, Pakistan Kidney and Liver Institute and Research Center, Lahore (PKLI & RC), Email: sajidzubairmalik@gmail.com

[1]Associate Professor, Lahore School of Nursing (LSN), University of Lahore (UOL), Lahore Email: madiha.mukhtar@lsn.uol.edu.pk

[2]Principal/Professor, Lahore School of Nursing (LSN), University of Lahore (UOL), Lahore Email: sarfraz.masih@lsn.uol.edu.pk

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Corresponding Author:
Sajid Hussain, Lecturer, PKLI ION & AHS, Pakistan Kidney and Liver Institute and Research Center, Lahore (PKLI & RC),
Email: sajidzubairmalik@gmail.com

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ABSTRACT

Arteriovenous fistula (AVF) stenosis is one of the most frequent complications among patients receiving hemodialysis, leading to inadequate blood flow, impaired dialysis adequacy, repeated interventions, and AVF management. This study evaluated the effectiveness of a structured AVF stenosis prevention program designed to improve vascular access outcomes through exercise, nutrition, and patient education. A quasi-experimental design was used, and 62 patients undergoing hemodialysis at a tertiary care hospital were purposively selected. The intervention comprised a phosphorus-restricted diet, upper extremity strengthening with a hand gripper, postoperative AVF care instructions, motivational text messages, and ongoing counseling. Data were collected on upper limb muscle strength, AVF blood flow, physiological markers of vascular calcification (serum calcium and phosphorus), and self-care behavior before and after the intervention. Results indicated significant improvements in muscle power, blood flow rate, and physiological indices, along with enhanced patient self-care behaviors. The findings suggest that incorporating exercise and dietary counseling into routine hemodialysis can prevent stenosis, prolong AVF patency, and reduce complications. This study underscores the importance of a multidisciplinary approach in empowering patients with self-management strategies to improve quality of life and ensure sustainable hemodialysis outcomes.

INTRODUCTION

Chronic kidney disease is a persistent and irreversible loss of kidney functions has a repercussion on more than 10% of global inhabitants; the worldwide prevalence rate of chronic kidney diseases was 9.1% and 80% acquired hemodialysis (Lyu et al., 2021).

Patients with chronic kidney disease necessitate renal replacement for their livelihood to remove toxins from body and preserve normal body fluid and electrolytes balance. In the meantime, hemodialysis is the most broadly used therapeutic approach for clinical management, which removes blood waste materials by absorption using convection and diffusion dialysis semipermeable membrane (Musolino, (2023). for prolonged hemodialysis mandates an arteriovenous fistula (AVF) that can combat repeated artery puncture and uphold blood flow rate of 600ml/minutes (Mosanada, Nesami & Goudarzian, 2020).

Arteriovenous fistula (AVF) is the preferred hemodialysis access because of its lower risk of infection and superior long-term patency compared with catheters and grafts. However, stenosis most commonly caused by venous neointimal hyperplasia remains the leading contributor to AVF dysfunction and eventual failure. This complication often results in inadequate dialysis, repeated interventions, and eventual access loss. International statistics show that primary AVF failure ranges from 30% to 70%, while one-year functional patency is maintained in only 40% to 70% of cases, highlighting the considerable and largely preventable burden associated with stenosis. Recognizing these challenges, recent clinical guidelines have emphasized the importance of proactive monitoring for stenosis, timely angioplasty, and individualized planning of vascular access to optimize patient outcomes.

Globally and across Asia, epidemiological evidence reveals wide variations in AVF outcomes. Multi-center cohorts have reported one-year functional patency of around 67% for radio cephalic fistulas and approximately 83% for upper-arm fistulas, with three-year patency rates ranging between 62% and 74%. These figures reflect the cumulative effects of stenosis and the need for repeated reinterventions. Earlier pooled analyses also suggest that secondary patency at one year is maintained in about 71% of cases, underscoring the recurring threat of stenotic lesions.

In Asian populations, the use of AVFs remains high, yet dysfunction is frequently observed. In Japan, national data indicate vascular access dysfunction rates of approximately 74% annually, with a recurrence rate of 17% within three months. The burden of dysfunction is particularly significant among older adults and women, necessitating enhanced surveillance and timely reintervention strategies. In China, AVFs are used by nearly 77% to 88% of hemodialysis patients. Reported stenosis incidence ranges between 4.6% and 10.8%, while thrombosis occurs in 2.3% to 7.7% of patients, with nearly all thromboses arising as a consequence of pre-existing stenosis.

In Pakistan, findings similarly highlight the growing concern of AVF dysfunction. Single-center research conducted in Lahore documented AVF stenosis in 7.1% to 8.3% of patients, based on Doppler ultrasound, along with access recirculation in approximately 12% of cases. The same study emphasized the importance of maintaining access blood-flow around 600 mL/min to ensure dialysis adequacy, thereby linking directly to physiological indices relevant for clinical practice. More recently, a cross-sectional study in Quetta reported stenosis in 16.7% of clients, pointing to significant variability between centers and reinforcing the regional burden of AVF-related complications.

Arteriovenous fistulas (AVFs) are the prioritized vascular access for hemodialysis

due to their exceptional unobstructed flow and lessen rates of entanglements compared to other access categories. Nevertheless, AVF stenosis remains a crucial challenge, leading to access dysfunction, escalated morbidity, and healthcare outlays (Nguyen & Nguyen, 2023).

A study executed by Faisal Alam in 2022, which consequences show that the absolute patency of AVF was 80% and failure rate was 20% in preliminary 6 months, given that total patency was 71% and failure rate was 29% at 12 months (Alam et al., 2022).

A study portrays 28.6% AVF stenosis transpires worldwide (Gao & Wang, 2022). The typical age of the 150 maintenance hemodialysis patients in Pakistan Queta encompassed in the study was 55. The age distribution unveiled that 3.3% of people were over 80 years old, 20% were intermediate to the ages of 18 and 40, 53.3% were amid the ages of 41 and 60, and 23.3% were between the ages of 61 and 80. Males concocted 60% of the respondents, while females made up 40%. With 14.66% leveraging AV fistulas for 6-12 months, 41.33% for 1-3 years, and 44% for more than 3 years, the ordinary length of AV fistula use was 3.21± 2.65 years (Hassan, et al., 2023).

A cross-sectional study was undertaken in Queta by Irfan Hassan, HOD nephrology department. Findings show that 16.7% of clients were affected with AVF stenosis and others were mentioned with comorbidity or alternative complications (Hassan et al., 2023).

AVF stenosis alludes to the narrowing or congestion of the vessel lumen at the locale of the AVF, imminent blood flow and jeopardizing the effectiveness of hemodialysis. Notwithstanding advancements in vascular access management, AVF stenosis persists to be a likely concern in patients receiving hemodialysis, with publicized prevalence rates ranging from 20% to 60% (Gjorgjievski, 2023).

AVF stenosis can contribute to access impairment, characterized by insufficient blood flow rates in the course of hemodialysis sessions. Access dysfunction may entail interventions such as angioplasty or surgical revision to rejuvenate patency and maintain satisfactory dialysis (Ng et al., 2023).

Diminished blood flow across the AVF ensuing from stenosis can undermine the efficacy of hemodialysis. Scarce dialysis clearance may result in inadequate removal of debris products, uremic toxins, and abundance fluid from the bloodstream, culminating in poor dialysis adequacy and pertinent to complications such as uremia, fluid overload, and electrolyte imbalances (Gjorgjievski, 2023).

AVF stenosis develops a prothrombotic environment within the vessel, Rendering susceptible patients to thrombotic episodes such as AVF thrombosis. Thrombosis can clog the AVF entirely, necessitating imperative interventions to reinstate patency. Frequent thrombotic episodes may lead to intermittent access dysfunction and introduce challenges in maintaining long-term access viability (Girerd, Girerd & Zannad, 2020).

AVF stenosis amplifies the menace of access-related infections, featuring arteriovenous graft (AVG) infections and bloodstream infections (BSIs). Reduced blood flow and turbulent vascular flow associated with stenotic lesions generate an ideal environment for bacterial colonization and biofilm establishment. Access-related infections can lead to site-specific complications such as abscess assemblage, as well as systemic complications such as sepsis, entailing antibiotic therapy and potential access extraction (Labriola, et al., 2023).

AVF stenosis conduces the disintegration of vascular access function over time, compromising access endurance. Patients with recurrent stenosis may experience multiple interventions, including

angioplasty, stent placement, or surgical revision, to maintain access permeability. However, these interventions may be correlated with finite success rates and cumulative breakage to the vessel, eventually leading to access collapse and the need for substitute access preferences (Jaffer & Wilkins, 2021).

Access dysfunction, thrombotic events, infections, and repeated interventions related to AVF stenosis can dramatically impact the quality of life of hemodialysis patients. Patients may endure pain, agitation, anxiety, and upheavals to their daily operations due to access-related complications, leading to decreased overall soundness of life and psychological torment (Stibbs, 2023).

Simple repetitive motion exercises with rubber bands, grippers, and rubber balls were the most ordinary type of exercise treatment applied for dialysis patients in former research. However, gripper-assisted muscle exercise is more successful than basic repetitive training with a low-elasticity rubber ball in strengthening the venous size and blood flow of an AVF (Lee, Baek & Lee, 2023). An additional survey that Kim and Choi carried out determined on patient awareness of phosphorus restriction and the use of notebooks for Self-evaluation eating patterns. Furthermore, they offered nutrition counseling and education to reinforce the significance of calcium and phosphorus levels in their therapy.

Proactive initiatives to prevent AVF stenosis and occlusion consist of blood clot prevention diet and exercise therapy aimed at maintaining blood arterial patency and strengthening upper extremity muscles. Hemodialysis patients average 50% less physical performance than healthy individuals and have extremely weak upper limb muscles (Ki & So, 2020).

Blood vessel structural and functional transformations are caused by arteriosclerosis, blood pressure, and the blood flow rate. These patients frequently have vascular calcification, which outcomes in AVF stenosis. Risk factors for this condition include blood calcium and phosphorus levels, age, sex, underlying disease, length of dialysis, and type of AVF (Shin et al., 2019).

An advantageous diet, consistent exercise, and dialysis can all boost vascular calcification by safeguarding steady blood levels of calcium and phosphorus. Exercise, diet, and education all work together to avert hyperphosphatemia and enhance the size and blood flow of AVFs. Studies on regimens that include nutrition and exercise intervention to prevent AVF stenosis are, nonetheless, scarce (Gebrie & Ford, 2019).

Vibrant self-management is fundamental for reducing discomfort and consequences associated with renal dysfunction in patients undergoing hemodialysis. This includes rigorous water restriction, nutrition, medication, and vascular channel regulation. Self-efficacy, outlined as a person's belief in their capacity to carry out definite actions in specific circumstances, is promoted to improve behavior by boosting assurance in health-promoting actions and therapy. Consequently, programs should be run to increase patients perceived self-efficacy and they should comprehend AVF management, treatment approaches, and their significance in such operations (Fusaria & Marinho, 2019).

To tackle this complication, healthcare providers have exponentially pivoted their attention to prevention strategies aimed at lessening the incidence of AVF stenosis and preserving access patency. These prevention programs generally encompass a multi-dimensional approach, including regular surveillance, patient education, risk factor refinement, and timely interventions to address stenotic lesions. Proactive surveillance, timely interventions, and comprehensive management strategies are essential to alleviate these complications and

streamline vascular access outcomes in hemodialysis patients.

Hence, to prevent vascular complexities, this study implemented an intricate program that included giving patients post-operative instructions, starting upper extremity muscle strengthening with gradual exercise therapy using a gripper at two weeks, and following a diet low in phosphorus. Additionally, it evaluates alterations in physiological markers of vascular calcification in hemodialysis patients and investigates the persuasion on perfusion velocity, a clinical marker of stenosis.

PROBLEM STATEMENT

AVF stenosis is a widespread complication in patients receiving hemodialysis, with reported prevalence rates ranging from 20% to 60% (Gjorgjievski, 2023). Hemodialysis patients have remarkably weak upper extremity muscles, and their average physical performance is 50% less than that of healthy persons (Yoo & Kim, 2020). Blood vessel structural and functional variations are caused by arteriosclerosis, blood pressure, and the blood flow rate, elevated calcium and phosphorus are the markers of vascular calcification in patients undergoing hemodialysis (Tanner, 2021).

Prolonged patent vascular acquisition is a challenge for hemodialysis, and erroneous access can compromise intervention and sustenance of the patient. AVF stenosis can lead to wide-ranging clinical complications, decline in quality of life and self-care of patients being subjected to hemodialysis (Alam et al., 2022). AVF stenosis elevates the risk of access malfunctioning, which may be prone to furthermore risks, such as infection and thrombosis, provoking increased morbidity and mortality among patients due to gaps in hemodialysis (Lee at al., 2023).

SIGNIFICANCE

For patients undergoing hemodialysis sessions, an arteriovenous fistula is more than a medical access point. it is their lifeline because when stenosis develops, it not merely compromises dialysis treatment but also disrupts patients' comfort, dignity, and quality of life.

This study is significant because it introduces a simple, patient-centered prevention program that combines exercise, diet, and education. By empowering patients with practical self-care strategies, it aims to preserve vascular access, reduce complications, and improve daily living. In doing so, it not only supports clinical outcomes but also addresses the human need for independence, confidence, and relief from unnecessary suffering.

OBJECTIVES OF THE STUDY

. To determine upper muscle strength, blood flow, physiological index, and self-care behavior among patients receiving hemodialysis through an arteriovenous fistula (AVF).

. To evaluate the impact of an AVF stenosis prevention program on upper muscle strength, blood flow, physiological index, and self-care behavior among patients receiving hemodialysis.

NULL HYPOTHESIS (H_0)

There is no impact of AVF stenosis prevention program on the upper muscle strength, blood flow, physiological index and self-care behavior among patients receiving hemodialysis.

ALTERNATIVE HYPOTHESIS (H_1)

There is an impact of AVF stenosis prevention program on the upper muscle strength, blood flow, physiological index and self-care behavior among patients receiving hemodialysis.

MATERIAL AND METHODS

STUDY DESIGN

Quasi experimental one group study design has been used. The study has been conducted in a teaching hospital, Lahore. Data has been aggregated from Chronic Renal Failure patients who are undergoing

hemodialysis through arteriovenous fistula. The study timeline was 9 months after the approval of synopsis from Research Ethics Committee (REC).

INCLUSION CRITERIA

- All the male and female patients
- Patient having age 20 - 50 years (This age group stands to gain substantial benefits from these interventions due to their greater potential for lifestyle modifications, receptiveness to educational programs, and the long-term health benefits. By carrying out these preventive actions, younger patients can endure improved vascular health, reduced complications, and enhanced quality of life, leading to improved overall consequences in the management of CKD).
- Chronic Renal Failure patients who are undergoing hemodialysis via an arteriovenous fistula.

SAMPLE SIZE & CALCULATION

Total 68 participants have been recruited utilizing a purposive sampling technique. The sample size has been calculated using Cochran's formula for estimating sample sizes in health studies, following:

$$n_0 = \frac{Z^2.p.(p-1)}{e^2}$$

Where:

n_0= sample size

Z^2= Z-value (1.96 for a 95% confidence level)

Health Related Characteristics

Dialysis duration; current body weight; weight increase following dialysis; usage of heparin while dialyzing; maturation period following AVF implanting, experience with vascular occlusion, present location of AVF, AVF duration, and smoking status.

Upper Extremity Strength

The MRC (Muscle Power Scale) measures muscle strength on a scale from 0 to 5, where 0 indicates no muscle contraction and five indicates normal strength. Using the scale, the patient should be in comfortable

Who understand Urdu and English context of AVF stenosis prevention program.

Those having a blood flow rate of 600ml/minutes or more (According to the literature, maintaining a blood flow greater than 600 ml/min is often associated with adequate vascular access in procedures like hemodialysis. thereof, it is compulsory to ensure that flow rate is normal and does not render vulnerable respondents to complications, such as access-related issues, high-output heart failure, or vascular trauma, during the intervention phase).

Patient having comorbid Hypertension (Bp: >150/100mmHg) and known Diabetes.

EXCLUSION CRITERIA

Patients with psychiatric or neurological conditions.

Those have <600ml blood flow.

Patient who are diagnosed with cardiac pathology.

p = Projected proportion of the population (assumed prevalence of AVF stenosis, 16.7% based on previous studies in Pakistan)

e^2 = margin of error (set at 0.05)

DATA COLLECTION TOOL

Data was gathered through a questionnaire. One separate questionnaires tool has been utilized to check.

Socio-Demographic

The demographic characteristics comprise of 5 items (sex, age, marital status, education).

state and be informed of the procedure. assess and palpate the muscle for any deformity. Grade 0 represents no muscle contraction, while Grade 1 indicates a flicker of movement without joint motion. Grade 2 involves full movement with gravity eliminated, and Grade 3 requires full movement opposed to gravity. Grade 4 indicates movement against some resistance, and Grade 5 signifies normal strength with complete resistance.

Note down the muscle strength for each group evaluated, highlighting any asymmetry or differences. Document

additional observations like pain or compensatory movements and usage of the results to instruct treatment plans. Revise assessments intermittently to monitor changes in muscle strength and adjust rehabilitation strategies. This precise and logical approach assuages perfect evaluation and effectiveness of patient management.

BLOOD FLOW RATE

A transient recirculation is generated and the dialyzer's speed is kept at 200 to 250 mL/min after the arterial and venous conduit positions have been switched using the value determined by the ultrasonic dilution method. An ultrasonic machine has been used to record the measured value following a 10-milliliter injection of normal saline. AVF stenosis is progressing if the blood flow rate falls below the normal range.

The Scoring Criteria Is.

300- 500 ml/minutes
500- 600ml/minutes
>600ml/minutes

Physiological Measures

Prior commencing hemodialysis procedure, the Department of Diagnostic Laboratory will take 5 mL of blood from a plain tube after a 12-hour fast. The objective of the blood test is to assess calcium and phosphorus, two fundamental risk factors for vascular calcification. Calcium and phosphorus levels in the blood are determined utilizing the results of regular monthly testing conducted in a hemodialysis department. Patients on hemodialysis usually have serum calcium and phosphorus levels between 8.5 and 10.2 mg/dL and 3.5 and 5.5 mg/dL, respectively.

The Scoring Criteria Is.

Serum Phosphorous Level:

Low: < 3.4 mg/dl
Normal: 3.4- 4.5 mg/dl
High: >4.5mg/dl

Serum calcium level:

Low:< 8.5 mg/dl
Normal:8.5- 10.5 mg/dl
High:>10.5mg/dl

Self-Care Behavior

The Chinese variant self-behavior scale regarding arteriovenous fistula in hemodialysis, consists of 2 dimensions, management of sig/symptoms and prevention of complication. 12 items and five-point Likert scale (1 represents never and 5 represents always). The minimum score is 12 and the maximum score is 60. The scoring criteria is that.

Lower self-care behavior <30
Higher self-care behavior 30 and above

RELIABILITY & VALIDITY OF THE TOOL

Content Validity index testing is done to check the content validity for the self-care behavior questionnaires. The CVI for self-care behavior questionnaire is (0.89). The Reliability of the questionnaires is checked through Cronbach's Alpha after conducting the pilot study. Cronbach's Alpha value for self-care behavior was 0.824) table 1 and 2.

Table 1: Case Processing Summary of self-care behavior questionnaire

	N	%
Valid	10	100
Excluded	0	0
Total	10	100

Table 2: Reliability statistics of self-care behavior questionnaire

Cronbach's Alpha	Number of Items
0.824	12

DATA COLLECTION PROCEDURE

The study was conducted in dialysis ward of a Teaching Hospital, Lahore, Pakistan. The rules and regulations set by the ethical committee of The University of Lahore were followed. A formal permission taken from the Medical Superintendent before data collection. The researcher introduced himself and provided a brief introduction about research and written informed consent was obtained from the study participants and collect data through three phases.

Pre-Intervention Phase

In the pre assessment phase, the respondents have been recruited with purposive sampling in accordance with the inclusion criteria and endorsed consent documents. The absolute duration of the research investigation is 16 weeks, beginning on April 1, 2025, and terminating on July 20, 2025, with a sample size of 62 participants. Data collection has been executed at a rate of 5–6 participants per day. The span of this phase has been the initial two weeks (April 1–14, 2025). Throughout this tenure, participants have been signed up based on augmentation criteria, and informed consent has been garnered. Baseline data included sociodemographic constituents, health-related information, blood flow rate, physiological indicators, and self-efficacy measures. Nominally 11–12 working days has been exercised to consummate pre-intervention assessments for all participants.

Intervention Phase

This phase has been accomplished over 10 weeks, commencing from April 15 to June 23, 2025. This particularly subjected on the well-structured implementation of the AVF stenosis prevention program. Basic components of the weekly schedule consisted of phosphorus-restricted diet awareness (beginning from Week 3), additionally weekly motivational text messages, and upper extremity strength exercises usher in Week 5 (two weeks post AVF implantation). Postoperative AVF care guidance has been disseminated early in Week 3, besides weekly video demonstrations and health counseling to support patient adhesiveness. Participants were also assessed weekly for their advancement and compliance. To deal the workload proficiently, participants has been disunited into three groups: Group A (participants 1–20), Group B (participants 21–41), and Group C (participants 42–62). Group A was started first, supplanted by Group B one week latterly, and Group C the week thereafter, allowing for lurched intervention and cosmopolitan execution.

Postoperative Health Guidance

The limbs undergoing fistulation has been raised adequately to decrease limbs edema.

Avoid Blood transfusions, postoperative infusions, blood pressure checks, and blood drawing tests on the limbs undergoing fistulation.

Don’t tie the tourniquet for two weeks following surgery.

Observe position of body and the tightness of the cuffs to prevent compression of the limbs undergoing fistulation.

The injured hand's wrist joints could be moved appropriately and fisted 24 hours subsequently the procedure to promote blood circulation and prevention from thrombosis.

The incisional hand should be exercised with a hand gripper according to the given pattern a day, provided it is infection free, no bleeding, or poor healing after one week following surgery.

Self-nursing health booklet for guidance is made available. Preventing infection requires always maintaining clean skin. There has been a minimum of three daily checks made for the patency of the fistula with a stethoscope or physical palpation. Notify if any audible rustles, water sounds flowing, or tremors.

Respondents must visit hospital right away for treatment if their heartbeat becomes feeble.

- The blood vessels should be externally protected by administering Hirudoid Cream that softens blood vessels and skin, following the recurrent use of the AVF.

Restrict Heavy Lifting

- Avoid bandages or clothing being too tight.
- Refrain from placing the injured limb under the skull.

AVF Upper Extremity Strength Exercise Starts at 2 Weeks

Using a hand gripper, based on previous research, the upper extremity of the AVF was exercised and the gripper's strength gradually increased. The intensity of the gripper (GD Grip) was set based on 8 Progressive drills, and the intensity and frequency were adjusted. During weekly counseling, monitor patients' performance of the exercise and provide direct demonstrations. Begin by adjusting the strength of the gripper to 8 kg and with 30 reps, two sets of 30 repetitions were performed per day. The second, third, and fourth steps needed 40, 50, and 60 repetitions, sequentially. In step 5, the strength of the gripper was adjusted to 16 kg, and 2 sets of 30 repetitions were accomplished per day. Analogously, steps 6, 7, and 8 required 2 sets each of 40, 50, and 60 repetitions, correspondingly.

Diet

- Diets persisted for 16 weeks grounded in preceding research and addressed the following areas.
- Phosphorus and the role it perform in the body, problems that occur when the blood phosphate level is raised, prevention from complications, ingredients with surplus phosphorus nutrients, and the correlation between calcification and vascular supply. Health information counselling of patients receiving hemodialysis on healthy eating regimens and complexities.

AVF Management

To educate patients about AVF vascular management, video education will provide on AVF complications, self-management, lifestyle, proper homoeostasis methods, and vascular compression methods.

Health Counseling

Health counseling involved a checklist of AVF upper extremity strength exercises, explaining the results of physiological indicators, confirming the correct upper extremity strength exercise methods, determining whether exercises were performed, and confirming the implementation of AVF self-management and a phosphorus-restricted diet.

Post Intervention Phase

The Post-Intervention Phase had span of 4 weeks of research study, from June 24 to July 20, 2025. This duration is specified to conduct the rearmost appraisement and post-intervention evaluation of all participants. Each client had a 15-minute individual session with the researcher to consummate the post-assessment, which subsumes sociodemographic follow-up, conjecture of blood flow rate, physiological measurements, and self-efficacy scores. Additionally, 30 minutes prior to each patient's discharge, final health education and spur of AVF care instructions has been provided to guarantee continuation of self-management excepting the surveillance span.

DATA ANALYSIS PLAN

A statistical package for social science is used to scrutinize the data (SPSS version 22.0). It was used descriptive as well as inferential statistics. Descriptive statistics, frequency and percentage are displayed in table figures, bars, and graphs. Inferential statistics use statistical tests to analyze data which entailed the summarizing and manipulating of data into an interpretable form to provide answers to the research queries.

Data were analyzed using descriptive statistics (mean ± SD for normally distributed variables; median and interquartile range for non-normal data). Normality was assessed

using the Shapiro–Wilk test. For within-group pre–post comparisons, paired-samples t-tests were applied to normally distributed data, while the Wilcoxon signed-rank test was used for non-normal or ordinal data. For one-sample analyses against clinical benchmarks, one-sample t-tests were used for normal data and Wilcoxon signed-rank tests for non-normal data. A p value < .05 was considered statistically significant.

RESULTS

This chapter demonstrates the findings of a study analysis about the implications of arteriovenous fistula stenosis prevention program in patients receiving hemodialysis. This chapter commences from the demographic characteristics of postintervention, followed by medical history of participants, physiological findings (serum calcium and serum phosphorus), muscular power scale, and concludes by the selfcare behavior of pre and post interventions.

Table 3: Demographic characteristics of pre intervention and post intervention group (N=62)

Variables		Pre Intervention Group	Mean± SD	Post Intervention group	Mean ±SD	All participants	Mean ±SD
		62 (%)		**62(%)**		**124 (%)**	
Age	20-30	11(11.7)	2.58±1.00	12 (19.4)	2.50±0.97	23(18.5)	2.54±0.98
	31-40	15(24.2)		15(24.2)		30(24.2)	
	41-50	26(41.9)		28 (45.2)		54(43.5)	
	51-60	9(14.5)		6(9.7)		15(12.1)	
	61-70	1(1.6)		1(1.6)		2(1.6)	
Gender	Male	48(77.4)	1.22±0.42	46(74.2)	1.25±0.44	94(75.8)	1.24±0.42
	Female	14(22.6)		16(25.8)		30(24.2)	
Marital Status	Married	41(66.1)	1.51±0.86	40(64.5)	1.53±0.86	81(65.3)	1.52±0.85
	Single	14(22.6)		15(24.2)		29(23.4)	
	Divorced	3(4.8)		3(4.8)		6(4.8)	
	Widow	4(6.5)		4(6.5)		8(6.5)	
Education level	Illiterate	16(25.8)	2.09±0.86	17(27.4)	2.08±0.87	33(26.6)	2.08±0.86
	Matriculation	28(45.2)		27(43.5)		55(44.4)	
	intermediate	14(22.6)		14(22.6)		28(22.6)	
	Graduate	4(6.5)		4(6.5)		8(6.5)	

Table 3 shows the demographic characteristics of the participants in a randomized control trial study in which 124 patients participated in the study. Sample were categorized into pre intervention Group (n=62) and post intervention Group (n=62). Mean age of patients in pre intervention Group was 2.58±1.00 years versus in post intervention Group 2.50±0.97 years. Similarly, the gender distribution showed that there were 48 (77.4%) were males and 14 (22.6%) females in pre intervention Group versus post intervention group where 46(74.2%) males and 16 (25.8%) females.

Majority of the participants were married in pre intervention Group 41(66.1%) versus in post interventional Group 40(64.5%). Most of the participants with matriculation

level of education 28(45.2%) in pre intervention group versus in post intervention group in 27(43.5%).

Table 4: Medical history of pre intervention and post intervention group (N=62)

Variables		Pre intervention Group	Mean± SD	Post intervention group	Mean ±SD	All participants	Mean ±SD
		62 (%)		**62(%)**		**124 (%)**	
Dialysis period	>5 years	2(3.2)	1.96±0.17	1(1.6)	1.98±0.12	3(2.4)	1.97±0.15
	<5 years	60(96.8)		61(98.4)		121(97.6)	
Causative Disease	Diabetes mellitus	19(30.6)	1.85±0.69	26 (41.9)	1.70±0.71	45(36.3)	1.78±0.70
	Hypertension	34(54.8)		29(46.8)		63(50.8)	
	Chronic glomerulonephritis	8(12.9)		6(9.7)		14(11.3)	
	Others_____	1(1.6)		1(1.6)		2(1.6)	
Current Body Weight (Kg)	<60	6(9.7)	2.33±0.65	4(6.5)	2.45±0.61	10(8.1)	2.39±0.65
	60-70	29(46.8)		26(41.9)		55(44.4)	
	>70	27(43.5)		32(51.6)		59(47.6)	
Maturation period after AVF surgery (Weeks)	6<	33 (53.2)	2.46±0.50	28 (45.2)	2.54±0.50	61(49.2)	2.50±0.50
	>6	29(46.8)		34(54.8)		63(50.8)	
Current Location Of AVF	Left wrist	11(17.7)	2.40±0.98	11(17.7)	2.40±0.94	22(17.7)	2.40±0.96
	right wrist	26(41.9)		24(38.7)		50(40.3)	
	left upper arm	14(22.6)		18(29.0)		32(25.8)	
	right upper arm	11(17.7)		9(14.5)		20(16.1)	
Dialysis	AVF	62(100)	1.00±0.00	62(100)	1.00±0.00	124(100)	1.00±0.00
Dialysis session (per week)	Once	1(1.6)	2.96±0.25	0(0.0)	3.00±0.00	1(0.8)	2.98±0.17
	Thrice	61(98.4)		62(100)		123(99.2)	
AVF Blood Flow Rate (ml/minute)	<600	51(82.3)	1.22±0.52	5(8.1)	2.59±0.63	56(45.2)	2.59±0.63
	600	8(12.9)		15(24.2)		23(18.5)	
	>600	3(4.8)		42(67.7)		45(36.3)	
Smoking	Yes	27 (43.5)	1.70±0.71	18 (29.0)	1.88±0.68	45(36.3)	1.79±0.69
	No	26(41.9)		33(53.2)		59(47.6)	
	Sometimes	9(14.5)		11(17.7)		20(16.1)	

Table 4 shows the medical history of pre and post intervention groups. the dialysis period of patient was <5 year in pre intervention group 1.96±0.17 versus post intervention group 1.98±0.12. Similarly causative disease hypertension in pre intervention group was1.85±0.69 versus post intervention group 1.70±0.71. The BMI of pre intervention group was 2.33±0.65 versus post intervention group 2.45±0.61. In pre intervention group the Maturation period after AVF surgery was 2.46±0.50 versus post intervention group 2.54±0.50. In most of the patients the Current Location of AVF in pre intervention group was 2.40±0.98 versus post intervention group 2.40±0.94. Dialysis through AVF was similar in both pre and post intervention group 1.00±0.00.

Dialysis session per week in pre intervention group was 2.96±0.25 versus post intervention group 3.00±0.00. Similarly, AVF Blood Flow Rate in pre intervention group was 1.22±0.52 versus post intervention group was 2.59±0.63. However, the smoking in pre intervention group was 1.70±0.71 versus post intervention group1.88±0.68.

Table 5: Physiological findings of pre and post intervention group (N=62)

Variables		Pre intervention Group	Mean± SD	Post intervention group	Mean ±SD	All participants	Mean ±SD
		62 (%)		**62(%)**		**124 (%)**	
Serum calcium level	8.6	15(24.2)	2.38±0.85	14(22.6)	1.91±0.60	29(23.4)	2.15±0.77
	8.6-10.2	8(12.9)		39(62.9)		47(37.9)	
	10.2	39(62.9)		9(14.5)		48(38.7)	
Serum phosphorous level	<2.5	8(12.9	2.62±0.70	3(4.8)	2.24±0.53	11(8.9)	2.43±0.65
	2.5-4.5	7(11.3)		41(66.1)		48(38.7)	
	4.5	47(75.8)		18(29.0)		65(52.4)	

Table 5 shows the physiological findings of pre and post intervention group in which the serum calcium level of pre intervention group was high 2.38±0.85 versus post intervention group 1.91±0.60. Similarly the Serum phosphorous level of pre intervention group was high 2.62±0.70 versus post intervention group2.24±0.53.

Table 6: Muscular power scale of pre and post intervention group (N=62)

MUSCLES POWER SCALE	Pre intervention Group	Mean± SD	Post intervention group	Mean ±SD	All participants	Mean ±SD
	62 (%)		**62(%)**		**124 (%)**	
icker or trace of contraction	4(6.5)	2.51±0.90	0(0.0)	4.66±0.67	4(3.2)	3.58±1.33
tive movement with gravity eliminated	33(53.2)		2(3.2)		35(28.2)	

ctive movement against gravity elimination	16(25.8)	1(1.6)	17(13.7)
ctive movement against gravity and resistance	7(11.3)	13(21.0)	20(16.1)
ormal power	02(3.2)	46(74.2)	48(38.7)

Table 6 shows the muscular power scale of pre intervention and post intervention group in which a score system was followed from 0 to 5. The Mean± SD of pre intervention group was 2.51±0.90 versus post intervention group 4.66±0.67.

Table 7: Self-care behavior of pre intervention group and post intervention group (N=61)

Variables		Pre intervention Group	Mean± SD	Post intervention group	Mean ±SD	All participants	Mean ±SD
		62 (%)		62 (%)		124 (%)	
I shall inform the nurse if the cramps occur during dialysis	Never	46(74.2)	1.50±1.05	6(9.7)	3.77±1.32	52(41.9)	2.63±1.64
	Rarely	9(14.5)		6(9.7)		15(12.1)	
	Sometimes	2(3.2)		8(12.9)		10(8.1)	
	Often	2(3.2)		18(29.0)		20(16.1)	
	Always	3(4.8)		24(38.7)		27(21.8)	
I shall inform the nurse if a headache of chest pain occurs during dialysis	Never	8(12.9)	2.04±0.63	2(3.2)	3.96±1.10	10(8.1)	3.00±1.31
	Rarely	46(74.2)		6(9.7)		52(41.9)	
	Sometimes	5(8.1)		8(12.9)		13(10.5)	
	Often	3(4.8)		22(35.5)		25(20.2)	
	Always	0(0.00)		24(38.7)		24(19.4)	
I shall tell the nurse if the hand on the fistula's side aches	Never	15(24.2)	2.06±0.78	2(3.2)	3.85±1.06	17(13.7)	2.95±1.29
	Rarely	30(48.2)		7(11.3)		37(29.8)	
	Sometimes	15(24.2)		7(11.3)		22(17.7)	
	Often	2(3.2)		28(45.2)		30(24.2)	
	Always	0(0.00)		18(29.0)		18(14.5)	
I shall notify the nurse in time if the hand of the	Never	31(50.0)	1.82±1.06	0(0)	4.03±0.94	31(24.0)	2.92±1.49
	rarely	19(30.6)		6(9.7)		25(20.2)	
	sometimes	6(9.7)		8(12.9)		14(11.3)	
	often	4(6.5)		26(41.9)		30(24.2)	

fistula's side injured	always	2(3.2)		22(35.5)		24(19.4)	
I shall apply some ointment 24 hours later if any hematoma appears	never	29(46.8)	1.90±1.11	2(3.2)	4.22±0.94	31(25.0)	3.06±1.55
	rarely	20(32.3)		1(1.6)		21(16.9)	
	sometimes	5(8.1)		7(11.3)		12(9.7)	
	often	6(9.7)		23(37.1)		29(23.4)	
	always	2(3.2)		29(46.8)		31(25.0)	
I check the fistula twice a day to confirm the presence of tremor	never	11(17.7)	2.38±1.04	0(0)	4.12±0.85	11(8.9)	3.25±1.29
	rarely	28(45.2)		3(4.8)		31(25.0)	
	sometimes	14(22.6)		10(16.1)		24(19.4)	
	often	6(9.7)		25(40.3)		31(25.0)	
	always	3(4.8)		24(38.7)		27(21.8)	
I shall check daily if the hand of the fistula arm feels chilly	Never	11(17.7)	2.24±0.86	0(0)	4.22±0.96	11(8.9)	3.23±1.35
	rarely	30(48.4)		5(8.1)		35(28.2)	
	sometimes	17(27.4)		8(12.9)		25(20.2)	
	Often	3(4.8)		17(27.4)		20(16.1)	
	Always	1(1.6)		32(51.6)		33(26.6)	
I shall check if the punctured site becomes red or swollen	Never	16(25.8)	2.01±0.77	0(0)	4.04±0.87	16(12.9)	3.03±1.31
	Rarely	31(50.0)		5(8.1)		36(29.0)	
	Sometimes	13(21.0)		7(11.3)		20(16.1)	
	Often	02(3.2)		30(48.4)		32(25.8)	
	Always	0(0.00)		20(32.3)		20(16.1)	
I shall protect my fistula hand/arm from being scratched, injured or cut.	Never	15(24.2)	2.12±0.91	1(1.6)	4.03±0.90	16(12.9)	3.08±1.31
	Rarely	30(48.4)		1(1.6)		31(25.0)	
	Sometimes	12(19.4)		15(24.2)		27(21.8)	
	Often	4(6.5)		23(37.1)		27(21.8)	
	Always	1(1.6)		22(35.5)		23(18.5)	
I shall protect the arm from the fistula's site from any	Never	19(30.6)	2.14±1.00	0(0)	4.12±0.83	19(15.3)	3.13±1.35
	Rarely	22(35.5)		3(4.8)		25(20.2)	
	Sometimes	15(24.2)		9(14.5)		24(19.4)	
	Often	5(8.1)		27(43.5)		32(25.8)	
	Always	1(1.6)		23(37.1)		24(19.4)	

bumping							
I shall assess my hands ,finger skin or fingernails if there are any cyanoses or discoloring	Never	14(22.6)	2.17±0.96	0(0)	4.09±0.90	14(11.3)	3.13±1.33
	Rarely	31(50.0)		4(6.5)		35(28.2)	
	Sometimes	11(17.7)		10(16.1)		21(16.9)	
	Often	4(6.5)		24(38.7)		28(22.6)	
	Always	2(3.2)		24(38.7)		26(21.0)	
I shall keep the fistula arm warm	Never	24(38.7)	2.17±1.24	2(3.2)	4.04±0.94	26(21.0)	3.11±1.44
	Rarely	17(27.4)		1(1.6)		18(14.5)	
	Sometimes	12(19.4)		11(17.7)		23(18.5)	
	Often	4(6.5)		26(41.9)		30(24.2)	
	Always	5(8.1)		22(35.5)		27(21.8)	

Table 7 shows the self-care behavior of patient in pre and post intervention group in which 1.50±1.05 patients in pre intervention group never inform the nurse if the cramps occur during dialysis versus post intervention group 3.77±1.32 inform. Similarly patients rarely inform the nurse if headache of chest pain occurs during dialysis in pre intervention group 2.04±0.63 versus post intervention group 3.96±1.10.

However patient tell the nurse if the hand on the fistula's side aches in pre intervention group 2.06±0.78 versus post intervention group 3.85±1.06.Similarly patient tell the nurse in time if the hand of the fistula's side injured in pre intervention group 1.82±1.06 versus post intervention group 4.03±0.94.Some patient never apply ointment 24 hours later if any hematoma appears in pre intervention group 1.90±1.11 versus post intervention group 4.22±0.94.similalry patients rarely check the fistula twice a day to confirm the presence of tremor in pre intervention group 2.38±1.04 versus post intervention group 4.12±0.85.

Similarly patient check daily if the hand of the fistula arm feels chilly in pre intervention group 2.24±0.86 versus post intervention group 4.22±0.96. Likewise, patients in pre intervention group check if the punctured site becomes red or swollen 2.01±0.77 versus post intervention group 4.04±0.87. Patient in pre intervention group protect fistula hand/arm from being scratched, injured or cut 2.12±0.91 versus post intervention group 4.03±0.90. Similarly, patients in pre intervention group protect the arm from the fistula's site from any bumping 2.14±1.00 versus post intervention group 4.12±0.83.

Likely, in pre intervention group nurses assess my hands, finger skin or fingernails if there are any cyanoses or discoloring 2.17±0.96 versus post intervention group 4.09±0.90. However in pre intervention group I keep the fistula arm warm 2.17±1.24 versus post intervention group 4.04±0.94.

Table 8: Comparison of physiological findings and muscular power scale with pre and post intervention group (124)

Variables	Groups	Mean ± SD	T-value	P-value
Serum calcium level	Pre intervention group	2.38±0.85	3.5	
				0.001
	Post intervention group	1.91±0.60		
Serum phosphorous level	Pre intervention group	2.62±0.70	3.42	
	Post intervention group	2.24±0.53		0.001
Muscular power scale	Pre intervention group	2.51±0.90	14.99	
				0
	Post intervention group	4.66±0.67		

Table 8 show the comparison of physiological findings and muscular power scale with pre and post intervention group. An independent sample t-test was applied for the comparisons of means. The results reveals that there is a significant difference found between physiological findings and muscular power scale and two groups ($p<0.05$).

DISCUSSION

This study was carried out to assess the effectiveness of a compendious AVF (Arteriovenous Fistula) stenosis prevention program among patients experiencing hemodialysis. Subjected to the increasing burden of chronic kidney disease (CKD) and the credence of hemodialysis patients on operational vascular access, sustaining AVF patency is crucial for both patient survivorship and quality of liveliness. AVF stenosis, a ubiquitous complication and repercussion, threatens the prolonged utilization of fistulas and maximizes the menace of morbidity, hospitalization, and healthcare costs. The systematized program implemented in this research was multifarious, incorporating physical exercise (upper extremity grip training), phosphorus-restricted nutrition education, vascular access conscientiousness counseling, and text-based reinforcement to boost self-care behavior.

The discussion will investigate verdicts from three phases of the study pre-intervention, intervention, and post-intervention—by intermingling current literature, theoretical models, and clinical practice applications. The foremost outcome measures encompass muscular strength, AVF blood flow rate, biochemical (physiological) indicators, and self-care behavior.

Muscle Strength, A keystone Component in Vascular Health

Muscle strength, restrictively in the upper extremity where the AVF is implanted, impersonates a crucial function in promoting vascular health. In the pre-intervention phase, most participants scored low on the MRC (Medical Research Council) Muscle Power Scale. These outcomes were not startling;

patients going through hemodialysis frequently demonstrate generalized enervation because of malnutrition, fluid and electrolyte disproportion, inflammation, and catabolic stress.

However, the post-intervention data unveiled a contrasting illustration. An exceptional fragment of the participants demonstrated remarkable improvement in grip strength and upper arm endurance. This can be attributed forthrightly to the structured hand-gripper exercise regimen commenced two weeks after fistula surgery. Exercises were imperceptibly intensified in eight stages, and participants were coached to entirely increasing repetitions using grippers of remodeling resistance. Importantly, training was customized and supervised to prevent complexities, like strain, swelling, or pain.

The improvement in strength advocates current literature. Lee et al. (2023) demonstrated in their trial that focused grip exercises substantially enhanced venous diameter, improved AVF maturation standings, and lessened the time required to adopt functional dialysis. Their study underlined that muscle activity enhances arterial inflow and venous return, both of mentioned are essential for sustaining a viable AVF. Like wisely, findings by Koh et al. (2020) recommended that localized exercise could minimize intravascular resistance, thereof improving blood flow dynamics.

This study proclaims the noteworthiness of systemized exercise in AVF care and accentuates the feasibility of complying with such interventions in resource-constrained settings. In addition to the results, it shows that non-pharmacological, low-cost techniques can be incorporated into patient care with effective aftermaths.

AVF Blood Flow Rate, the Lifeline of Hemodialysis

The immense critical metric in examining AVF function is blood flow rate. Conforming to international regulations, a flow rate of 600 ml/min or exceeding is considered considerable for ensuring satisfactory dialysis. In this study, a substantial number of patients in the pre-intervention phase fell below this threshold, emplacing them at greater risk for AVF failure, dialysis inadequacy, and recurrent interventions such as angioplasty or surgical revisions.

Following the 10-week intervention, a miraculous increase was surveyed in the AVF blood flow rates of the majority of participants. Not merely did the mean flow rate increase remarkably, but the percentage of patients spanning the >600 ml/min benchmark also rose appreciably. This improvement coincides with the mechanical effects of grip-strengthening exercises on vascular lumens. Repetitive contraction of forearm muscles expedites venous dilation, enhances vascular resistance, and triggers endothelial health all contributing to augmented blood flow.

This outcome is also invariable with findings from Chen et al. (2023), who conducted a longitudinal research study to evaluate AVF patency for a 6-month duration. They concluded that clients engaging in consecutive hand exercises had significantly minor complications and greater flow rates than those who obeyed standard care protocols. In another study by Kang et al. (2018), a structured fistula exercise protocol resulted in fortified flow without an associated escalation in complications, for instance aneurysm constitution or heart strain.

Notably, the recent study implemented staggered group commencement (Group A, B, and C) to apportion workload and preserve quality control, an approach that demonstrated advantageous in ensuring patient safety. None of the patients reported critical adverse events appertaining to high-output cardiac deterioration, a potential concern when blood flow increases significantly in a shortened period. Weekly inspection and observation

supported ensure that the alterations remained within secure physiological limits.

Physiological Markers, Biochemical Proof of Progress

Phosphorus and calcium imbalances are usual complications in CKD patients. These are interconnected to vascular calcification, stiffness, and cardiovascular complexities and morbidity. Raised serum phosphorus, in especial, develops mineral bone disease and escalates AVF stenosis. Therefore, the phosphorus-restricted nutritionary component of mentioned intervention was of paramount significance.

At baseline, serum phosphorus levels amongst participants mediocre 2.62 mg/dL. Post-intervention, this rate decreased to 2.24 mg/dL, attributing a clinically admissible improvement. This variation reflects the effectiveness of regular dietary education, personnel counseling, and text-based remembrances that reinforced behavioral cohesion. Principally, these outcomes validate congruous findings from Gebrie and Ford (2019), who confirmed that phosphorus-restricted diets lead to significantly decreased serum phosphorus and vascular calcification in patients undergoing dialysis.

Serum calcium levels balanced post-intervention too. The calcium-phosphorus result is a predicted contributor to calciphylaxis; a crucial life-threatening condition among dialysis subjects. The binal effect of decreased serum phosphorus and regulated calcium is a crucial indicator of vascular patency. These observations direct that dietary regulation, when congruent with clear education and follow-up, is an obtainable and preeminent intervention.

Particularly, the present study did not involve the use of phosphate binders or medications to regulate calcium and phosphorus levels. Instead, the observed improvements were entirely behavior-based, highlighting the effectiveness of patient education and self-management. These findings align with Zheng et al. (2019), who reported that structured self-care interventions significantly improved adherence to dietary restrictions and vascular access monitoring among hemodialysis patients. Similarly, Cheung et al. (2016) emphasized that non-pharmacological approaches, such as exercise and education, enhance vascular health and delay AVF complications.

Conversely, other studies underscore the necessity of pharmacological support alongside behavioral interventions. For example, Miller et al. (2018) found that patients using phosphate binders in combination with dietary management demonstrated superior control of mineral metabolism compared to those relying on lifestyle changes alone. Likewise, Lok et al. (2020) suggested that optimal outcomes are achieved when education and self-care strategies are integrated with medical therapy.

Taken together, the current findings reinforce the potential of education and self-management as effective, low-cost strategies in preventing AVF stenosis. However, in contrast to studies advocating combined pharmacological and behavioral approaches, this study demonstrates that behavior-focused interventions alone may yield measurable benefits, although further longitudinal research is warranted to confirm sustainability.

Self-Care Behavior, From Passive Recipients to Active Managers

The significant transformative findings of the study were the substitution in patient self-care behavior. Prior to the implication of intervention, many clients had limited comprehension of AVF concern. Regular activities, for example, checking for thrills and bruits, avoiding blood pressure measurements on the AVF limb or periphery, and protecting the arm from trauma were rarely followed.

Post-intervention, a substantial improvement was documented in subjects' knowledge, attitude, and behavior pertaining to AVF self-

management. Patients executed performing consistent assessments, adhered to deem safety guidelines and protocols, applied recommended creams, and avoided hazardous practices, like wise wearing tight clothing or exposing the limb for injections. This shift not just upgraded their clinical outcomes, however, gave them a boosted sense of control over their condition also.

Such findings are corelated with antecedent research by Fuzari et al. (2017), who disseminated noteworthy progress in self-care behaviors amongst dialysis clients following an organized educational program. correspondingly, Kim and Choi (2023) accentuate that repeated, personalized education, particularly when reinforced via technology such as SMS generates long-lasting behavioral alterations in chronic illness populations.

In current study, numerous educational strategies were exercised: health booklets, visual materials, in person physical demonstrations, and weekly one-on-one counseling sessions. Text message reminders are serviced as psychological nudges, assuring continuity as well as reinforcement. These multifaced methods catered to various learning styles, literacy levels and offered bridge the knowledge-practice gap.

Integration of Multimodal Intervention, a Holistic Framework

The strength of the implication of interventions sustains its integrated, patient-centered design and concern. Preferably addressing AVF stenosis as a single-variable problem, said program tackled the problem through a multidimensional spectacle. Exercise, diet, self-care, and behavioral focus and reinforcement were synchronized to deliver a holistic care solution.

The favorable accomplishment of the intervention carpets that AVF stenosis prevention cannot be excluded to surgical technique and/or dialysis efficiency apparently. It behooves collaboration between patients, nurses, dietitians, nephrologists, and physiotherapists. The involvement of all these stakeholders, in this study, facilitated laying down a safe, evidence-based, and sustainable plan.

Additionally, the model developed in the study promotes scalability. The usage of economic gadgets like hand grippers, print material, and Text messages maps it applicatory even in low-resource healthcare settings. Given the increasing prevalence of CKD in low as well as middle income developing states, such low cost, high impact strategies are crucially required.

CONCLUSION

The present study provides compelling evidence regarding the effectiveness of a multimodal arteriovenous fistula (AVF) stenosis prevention program for patients undergoing hemodialysis. By incorporating structured upper limb exercise routines, phosphorus-restricted dietary education, and reinforcement of self-care behaviors, the intervention yielded significant improvements in muscle strength, vascular blood flow, physiological parameters, and patient adherence. These outcomes were not only statistically significant but also clinically meaningful, demonstrating the potential of behavior-centered and nurse-led interventions to improve dialysis-related health outcomes.

One of the most noteworthy contributions of this research is the emphasis on non-pharmacological approaches. Unlike prior studies that often combine lifestyle interventions with pharmacological therapies such as phosphate binders, this study focused exclusively on behavioral strategies and achieved substantial improvements. This finding underscores the possibility of empowering patients through education, structured counseling, and guided physical activity, even in resource-limited settings. In addition, the holistic nature of the program combining physical, nutritional, and behavioral components mirrors the realities of

patient care, where multiple factors interact to determine health outcomes.

The results strongly advocate for the integration of similar multimodal interventions into routine dialysis care. By embedding structured exercise regimens and dietary education into dialysis unit protocols, healthcare providers can promote long-term vascular access patency and minimize complications related to AVF stenosis. This is particularly relevant for low-resource healthcare systems, where repeated surgical revisions, catheter placements, or hospitalizations due to AVF dysfunction impose significant financial and clinical burdens. Thus, prevention through patient-centered interventions offers a cost-effective and sustainable solution.

Importantly, the study also highlights the critical role of nurses and allied health professionals in the prevention of AVF complications. Nurses, as frontline caregivers, are ideally positioned to deliver patient education, reinforce adherence, monitor vascular access, and provide motivational counseling. Similarly, physiotherapists, dietitians, and dialysis technicians contribute essential expertise to ensure that interventions such as exercise and nutrition plans are effectively implemented. This interprofessional collaboration was central to the success of the intervention and should be encouraged as a standard of care in dialysis units worldwide.

Beyond its immediate implications, the study also speaks to a broader paradigm shift in chronic disease management. Rather than focusing solely on reactive treatment after complications arise, the evidence presented here supports a proactive, preventive approach that empowers patients as active participants in their care. Such an approach is aligned with global trends in nephrology and nursing practice, which emphasize holistic, patient-centered care and the promotion of long-term quality of life.

LIMITATIONS

Despite promising results, several limitations of this study must be acknowledged. First, the research was conducted in a single healthcare setting with a relatively small sample size (n = 62). While the outcomes are internally valid, caution should be exercised in generalizing the findings to broader populations or diverse clinical environments.

Second, the study did not include a control group for comparison. Although significant improvements were documented, the absence of a randomized controlled trial (RCT) design limits the ability to establish causality with full confidence. Future studies should adopt RCT designs to provide stronger evidence of effectiveness.

Third, adherence to the diet and exercise components was primarily self-reported by participants. While weekly follow-ups and counseling helped reduce bias, self-reporting carries an inherent risk of overestimation or underestimation of compliance. The use of objective measures such as wearable fitness trackers, electronic diet logs, or mobile health applications could enhance the reliability of adherence data in future research.

Finally, the study focused on short-term outcomes. Although improvements were noted over the intervention period, long-term sustainability of these effects remains uncertain. A follow-up period of at least 6–12 months would provide greater insight into whether the benefits of exercise, dietary education, and behavioral reinforcement persist over time and continue to prevent AVF stenosis in the long run.

RECOMMENDATIONS

Based on the findings and limitations, several recommendations are proposed for clinical practice, research, and policy:

1. Dialysis centers should incorporate structured exercise programs, phosphorus-restricted dietary education, and behavioral

counseling into their routine care protocols. These interventions are feasible, cost-effective, and have demonstrated significant improvements in vascular access outcomes.

2. Nurses should be empowered and trained to take a leading role in delivering education, monitoring self-care practices, and reinforcing adherence. Interdisciplinary collaboration with physiotherapists, dietitians, and dialysis technicians is essential to maximize the effectiveness of such interventions.

Conduct large-scale, multicenter randomized controlled trials with longer follow-up durations to validate the findings and enhance generalizability. Investigate the relative contributions of individual components (exercise, diet, behavioral reinforcement) to identify the most impactful elements. Explore the use of digital technologies (e.g., mobile health applications, wearable trackers) to monitor adherence and improve patient engagement.

Include economic evaluations to assess cost-effectiveness, particularly in low-resource settings, where financial considerations are a major barrier to implementation. Healthcare providers should prioritize patient-centered communication strategies, goal setting, and motivational counseling to foster self-efficacy and active participation in care. Building patient capacity to self-manage their health is crucial for sustaining long-term improvements.

In summary, this study demonstrates that AVF stenosis prevention is both possible and attainable through structured, behavior-based interventions. By shifting the focus from reactive treatment to proactive prevention, dialysis care can become more effective, efficient, and patient-centered. While limitations exist, the findings lay a strong foundation for future research and provide a practical framework for healthcare professionals to improve patient outcomes. With continued innovation, interdisciplinary collaboration, and emphasis on patient empowerment, AVF stenosis can be prevented, leading to enhanced quality of life for patients undergoing hemodialysis.

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