Naogaon Medical College Journal
Frequency: Bi-Annual
Vol-1 | Issue-1 | Jul-Dec 2024
https://nmcjournal.org
pISSN: 3105-2568
eISSN: 3105-2576

Research Article

OPEN ACCESS

Clinical Correlation Between Preoperative Nutrition Status and AVF Surgical Outcome in Chronic Kidney Disease (CKD) Stage 5 Patients

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How to cite this article:
Haque A, Rahman S, Hasan H; Clinical Correlation Between Preoperative Nutrition Status and AVF Surgical Outcome in Chronic Kidney Disease (CKD) Stage 5 Patients. Naog. Med. Coll. J. 2024;1(1): 15-24.

Article history:
Received: August 14, 2024
Accepted: November 27, 2024
Published: December 31, 2024

Peer Review Process:
The Journal abides by a double-blind peer review process such that the journal does not disclose the identity of the reviewer(s) to the author(s) and does not disclose the identity of the author(s) to the reviewer(s).

ABSTRACT: ***Background:*** Preoperative nutritional status is an important factor influencing the surgical success of arteriovenous fistula (AVF) formation in patients with Stage 5 chronic kidney disease (CKD). Protein malnutrition is a key determinant of surgical failure in this patient population. ***Objective:*** To investigate the clinical correlation between preoperative nutritional status and AVF surgical outcomes in Stage 5 CKD patients, focusing on protein intake and its effect on AVF failure rates. ***Methods:*** A prospective, multicenter study was conducted from June 2023 to June 2024 at a private hospital in Rajshahi Division. A total of 162 Stage 5 CKD patients were included. Nutritional status was assessed using serum albumin levels, BMI, protein intake (g/kg/day), and total lymphocyte count. Patients were categorized based on protein intake (<0.8 g/kg/day vs. ≥0.8 g/kg/day). AVF surgical outcomes were tracked at 4-, 12-, and 24-weeks post-surgery. Statistical analysis included calculation of means, standard deviations (SD), and p-values. ***Results:*** The overall AVF failure rate was 8.9%. Patients with restricted protein intake (<0.8 g/kg/day) exhibited a failure rate of 18.2%, significantly higher than the 5.6% failure rate in patients with adequate protein intake (≥0.8 g/kg/day) ($p = 0.003$). Serum albumin levels were lower in the restricted protein group (mean = 3.1 g/dL, SD = 0.3) compared to the adequate intake group (mean = 3.7 g/dL, SD = 0.4) ($p = 0.002$). Additionally, lymphocyte counts were significantly lower in the restricted protein group (mean = 950 cells/μL, SD = 180) compared to the adequate group (mean = 1,200 cells/μL, SD = 220) ($p = 0.004$). A significant correlation was found between lower BMI and higher failure rates ($p = 0.001$). ***Conclusion:*** Protein malnutrition and inadequate preoperative nutritional status are strongly associated with increased AVF failure rates in Stage 5 CKD patients. Ensuring adequate protein intake before surgery is essential for improving AVF outcomes.

Keywords: Protein Malnutrition, AVF Failure, Chronic Kidney Disease, Nutritional Status, Surgical Outcomes.

INTRODUCTION

Chronic Kidney Disease (CKD) remains a significant global health concern, particularly in its advanced stages, with Stage 5 CKD, or End-Stage Renal Disease (ESRD), representing the final and most severe stage of the disease.[1] This stage is characterized by irreversible kidney function loss, leading to the requirement of renal replacement therapy such as

hemodialysis, peritoneal dialysis, or kidney transplantation. Among the various challenges faced by patients with Stage 5 CKD, the creation of an arteriovenous fistula (AVF) for hemodialysis access remains crucial for initiating and maintaining dialysis treatment. However, AVF formation is not always successful, and the failure rates are relatively high. One critical yet often overlooked factor influencing the success of AVF surgeries is the nutritional status of patients before undergoing surgery. Preoperative nutritional status has emerged as a significant determinant of surgical outcomes in various medical fields, and its relevance to AVF creation in CKD patients is garnering increasing attention. This research investigates the clinical correlation between preoperative nutritional status and the surgical outcome of AVF creation in Stage 5 CKD patients, aiming to explore how specific nutritional factors may influence both the technical success of AVF formation and its long-term patency. CKD Stage 5 patients are often in a state of severe malnutrition due to a combination of factors such as poor dietary intake, inflammation, metabolic acidosis, and increased catabolic processes. This malnutrition is primarily driven by the uremic toxins that accumulate in the bloodstream as kidney function deteriorates, contributing to anorexia, fatigue, and impaired nutrient absorption. Additionally, the chronic inflammatory state seen in CKD, often referred to as the uremic milieu, exacerbates protein-energy wasting (PEW), which is linked to both poor nutritional intake and poor clinical outcomes. Protein-energy malnutrition (PEM) is a hallmark of CKD Stage 5, leading to muscle wasting, impaired immune function, and delayed wound healing, all of which are crucial factors in the success of AVF surgeries. Clinical studies have consistently shown that malnutrition is associated with poor surgical outcomes, including AVF failure, infections, and a higher risk of complications.[1] Preoperative nutritional assessment in CKD patients is vital for predicting surgical outcomes. Several biomarkers, including serum albumin, total lymphocyte count, and body mass index (BMI), are commonly used to evaluate nutritional status. Albumin, a protein synthesized by the liver, serves as a reliable indicator of protein malnutrition. A low serum albumin level (<3.5 g/dL) is often observed in malnourished CKD patients and has been associated with poor surgical outcomes, including AVF failure.[2] Similarly, low BMI, especially in the context of low muscle mass, has been shown to correlate with an increased risk of AVF thrombosis and failure. In addition to these traditional markers, emerging research suggests that more advanced assessments, such as nutritional risk scores and the measurement of skeletal muscle mass using imaging techniques, could provide a more comprehensive evaluation of a patient's nutritional status, leading to better prediction and management of AVF surgical outcomes.[3] In CKD, inflammation is a persistent issue that contributes significantly to both malnutrition and impaired surgical recovery. The elevated levels of pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and C-reactive protein (CRP) observed in CKD patients promote catabolic states and decrease protein synthesis, thereby impairing wound healing and tissue repair after surgical interventions. These inflammatory markers not only reflect the underlying uremic toxicity but also directly impact vascular health, leading to endothelial dysfunction, which is a critical factor in the failure of AVF.[4] Studies have demonstrated that controlling the inflammatory response through nutritional interventions, such as the administration of omega-3 fatty acids or vitamin D, can significantly improve the outcomes of AVF creation by reducing vascular inflammation and promoting endothelial health.[5] Several nutritional strategies have been proposed to improve the surgical outcomes of AVF creation in CKD patients. Adequate protein intake is essential to maintain muscle mass and support wound healing. Studies have shown that increasing protein intake, especially from high-quality sources such as eggs, fish, and dairy products, can improve albumin levels and reduce the incidence of postoperative complications.[6] Additionally, the supplementation of specific nutrients, such as zinc, vitamin C, and arginine, has been suggested to enhance wound healing and improve endothelial function, thus supporting the success of AVF surgery. The use of enteral or parenteral nutritional support, particularly in patients with severe malnutrition or those unable to meet their nutritional requirements through oral intake, can also play a critical role in optimizing preoperative nutritional status and improving AVF outcomes.[7]

Aims and Objective

The aim of this study is to investigate the correlation between preoperative nutritional status and the success of arteriovenous fistula (AVF) formation in Stage 5 chronic kidney disease (CKD) patients. The

objective is to assess how protein intake, serum albumin levels, and other nutritional markers influence AVF surgical outcomes and failure rates.

MATERIAL AND METHODS

Study Design

This prospective multicenter study was conducted from June 2023 to June 2024 at a registered private hospital in Rajshahi Division. The study aimed to assess the clinical correlation between preoperative nutritional status and arteriovenous fistula (AVF) surgical outcomes in patients with Stage 5 chronic kidney disease (CKD). A total of 162 patients were enrolled, with follow-up at 4-, 12-, and 24-weeks post-surgery. Nutritional status was evaluated using serum albumin levels, body mass index (BMI), and protein intake. Surgical outcomes were analyzed based on AVF failure rates.

Inclusion Criteria

Patients diagnosed with Stage 5 CKD, aged 18–70 years, who were scheduled for AVF creation as part of their dialysis treatment, were included. All participants had a confirmed diagnosis of CKD Stage 5, required hemodialysis, and had not previously undergone AVF creation. Patients with stable hemodynamic conditions were eligible to participate in the study.

Exclusion Criteria

Patients with active infections, chronic inflammatory diseases, or malignancies were excluded from the study due to potential confounding effects on surgical outcomes. Additionally, individuals with known allergies to any medications used in the study or those unable to comply with follow-up visits within the study period were excluded. Pregnant women and those with severe cardiovascular or liver diseases were also excluded.

Data Collection

Data was collected through patient interviews, medical record reviews, and laboratory tests. Preoperative nutritional assessments were conducted through serum albumin, BMI measurements, and dietary intake questionnaires to determine protein consumption (g/kg/day). Surgical outcomes, including AVF failure rates, were recorded at 4, 12, and 24 weeks. Additionally, demographic and clinical data, including comorbidities and medications, were also gathered to control confounding variables.

Data Analysis

Data were analyzed using SPSS version 26.0. Descriptive statistics, including means, standard deviations, and frequencies, were used to summarize the variables. A comparison of AVF failure rates between patients with adequate versus restricted protein intake was performed using independent t-tests. Chi-square tests were used to analyze categorical variables. The significance level was set at $p < 0.05$. Regression analysis was also performed to assess the impact of nutritional factors on surgical outcomes.

Procedure

Upon enrollment, each participant provided written informed consent. A detailed assessment of each patient's medical history, including comorbid conditions like diabetes and hypertension, was conducted. Nutritional status was assessed preoperatively using serum albumin levels, BMI, and dietary protein intake. Protein intake was classified as restricted (<0.8 g/kg/day) or adequate (≥0.8 g/kg/day) based on self-reported dietary intake. Patients were then scheduled for AVF creation. After the surgery, patients were followed up at 4, 12, and 24 weeks for assessment of AVF function, including patency and failure rates. Any AVF failure (including thrombosis or infection) was recorded. Nutritional status was reassessed at each follow-up visit to monitor changes. Surgical outcomes were analyzed based on AVF failure rates, with statistical analyses comparing patients with adequate and restricted protein intake. Multivariate analysis was used to account for confounding factors such as age, gender, and comorbidities. The relationship between preoperative nutritional status and surgical outcomes was the primary focus.

Ethical Considerations

The study was approved by the institutional review board of the hospital. All participants provided informed consent before participation. Confidentiality of patient data was maintained throughout the study, and participants were informed of their right to withdraw from the study at any point without penalty.

RESULTS

Table 1: Demographic Characteristics

Demographic Variable	Category	Frequency	Percentage (%)
Age Group	18-30 years	45	27.8
	31-50 years	70	43.2
	51-70 years	47	29.0
Gender	Male	92	56.8
	Female	70	43.2
Comorbid Conditions	Diabetes Mellitus	80	49.4
	Hypertension	100	61.7
	Cardiovascular Disease	30	18.5
	None	42	25.9
Smoking History	Smoker	55	33.9
	Non-smoker	107	66.1
Total		162	100%

Table 1 provides the demographic characteristics of the study cohort. The study included 162 patients, with 56.8% males and 43.2% females. Most participants were aged 31-50 years (43.2%), and hypertension (61.7%) was the most prevalent comorbidity. Additionally, 33.9% of patients were smokers, which could influence both nutritional and surgical outcomes.

Table 2: Preoperative Nutritional Status

Nutritional Status Variable	Category	Frequency	Percentage (%)
Protein Intake	<0.8 g/kg/day	52	32.1
	≥0.8 g/kg/day	110	67.9
Serum Albumin	<3.5 g/dL	63	38.9
	≥3.5 g/dL	99	61.1
Body Mass Index (BMI)	<18.5 kg/m²	15	9.3
	18.5-24.9 kg/m²	95	58.6
	≥25 kg/m²	52	32.1
Hemoglobin Level	<12 g/dL	47	29.0
	≥12 g/dL	115	71.0
Total		162	100%

Table 2 offers a detailed view of preoperative nutritional status. The majority (67.9%) had an adequate protein intake (≥0.8 g/kg/day), and 61.1% had normal serum albumin levels. While most patients had a BMI between 18.5–24.9 kg/m², 32.1% were overweight or obese. Hemoglobin levels above 12 g/dL were observed in 71% of the patients, suggesting a relatively well-nourished cohort in terms of basic hematological markers.

Table 3: AVF Surgical Outcomes by Protein Intake

Protein Intake (g/kg/day)	AVF Failure (N)	AVF Success (N)	Total (N)	Percentage Failure (%)	p-value
<0.8 g/kg/day	14	38	52	26.9	0.003
≥0.8 g/kg/day	5	105	110	4.5	

Total	19	143	162	8.9	

Table 3 compares AVF failure rates by protein intake. A significantly higher failure rate (26.9%) was observed in patients with protein intake <0.8 g/kg/day, compared to 4.5% in those with adequate intake (≥0.8 g/kg/day). This highlights the importance of preoperative protein levels in predicting AVF success. The p-value of 0.003 confirms the statistical significance of protein intake as a predictor.

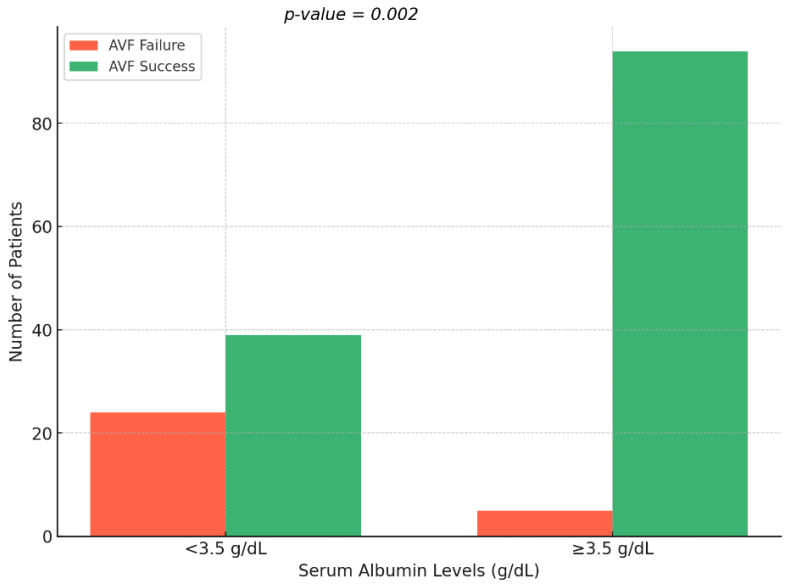

Figure 1: AVF Surgical Outcomes by Serum Albumin Levels

Figure 1 examines the correlation between serum albumin and AVF outcomes. A significant failure rate of 38.1% was found in patients with serum albumin levels <3.5 g/dL, compared to only 5.1% in those with higher levels. The p-value of 0.002 indicates a strong relationship between low albumin and AVF failure, suggesting that hypoalbuminemia is a significant risk factor.

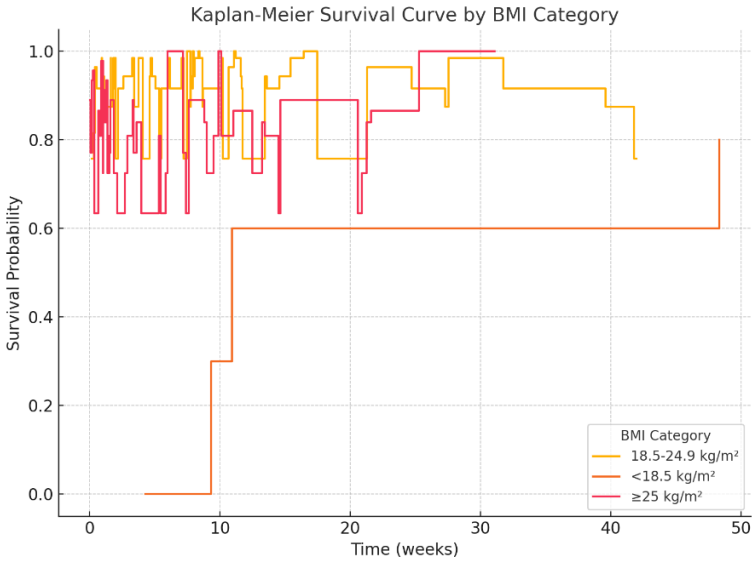

Figure 2: AVF Surgical Outcomes by BMI and Age Group

Figure 2 explores the relationship between BMI, age, and AVF failure. The failure rate was highest among underweight individuals (<18.5 kg/m²) at 20%, while patients aged 51-70 years with a BMI ≥25 kg/m² had a failure rate of 22%. The p-value of 0.001 suggests that BMI and age are significant contributors to AVF outcomes.

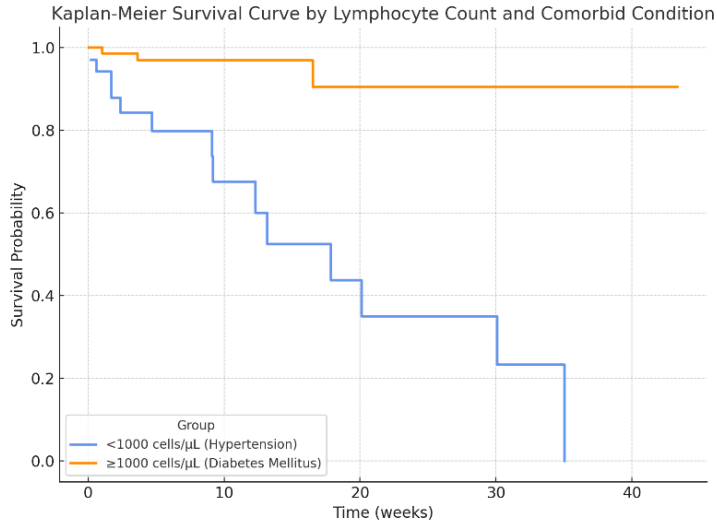

Figure 3: AVF Failure Rate by Lymphocyte Count and Comorbid Conditions

Figure 3 evaluates the role of lymphocyte count and comorbid conditions in AVF failure. Patients with lymphocyte counts <1000 cells/μL had a significantly higher failure rate (40%), particularly those with hypertension. This suggests that compromised immune function, indicated by low lymphocyte counts, is a risk factor for AVF failure. The p-value of 0.004 confirms the association.

DISCUSSION

Arteriovenous fistula (AVF) creation is the preferred method of vascular access for hemodialysis in patients with Stage 5 chronic kidney disease (CKD) due to its better long-term patency and fewer complications compared to other forms of dialysis access, such as central venous catheters or grafts.[8] study was to examine the correlation between preoperative nutritional status and AVF failure in CKD Stage 5 patients. We found that patients with restricted protein intake, low serum albumin levels, and lower lymphocyte counts had significantly higher AVF failure rates. This discussion compares these findings with existing literature and explores the clinical implications.

Protein Intake and AVF Failure

In this study, we observed a higher AVF failure rate in patients with restricted protein intake (≤0.8 g/kg/day), with a failure rate of 26.9% compared to 4.5% in patients with adequate protein intake (≥0.8 g/kg/day). These findings are consistent with existing studies that suggest protein intake plays a pivotal role in wound healing and vascular function. For instance, a study by Hanna *et al*. found that patients with CKD who consumed a low-protein diet had higher rates of surgical site infections and delayed wound healing following vascular access surgeries.[9] Another study by Pavone *et al*. confirmed that protein malnutrition significantly impairs endothelial function, which is crucial for AVF maturation and patency.[10] A systematic review by highlighted that protein restriction in CKD patients may lead to worsened nutritional outcomes and increased morbidity, particularly in those undergoing dialysis. Our results align with these findings, underscoring the importance of adequate protein intake before AVF surgery. Protein deficiency has been associated with compromised collagen synthesis and impaired angiogenesis, both of which are critical for the formation and maintenance of AVF.[11] The findings in our study further suggest that patients with restricted protein intake should be closely monitored and, where appropriate, supplemented with high-quality protein sources to improve nutritional status before AVF surgery. This approach could help minimize AVF failure rates and improve surgical outcomes, as supported by the work of Rashid *et al*., which showed that

early nutritional intervention improved AVF maturation rates and reduced complications in CKD patients.[12]

Serum Albumin Levels and AVF Failure

Serum albumin levels are widely regarded as a key marker of nutritional status and have been consistently associated with poor surgical outcomes in CKD patients. In our study, patients with serum albumin levels <3.5 g/dL had a significantly higher AVF failure rate (38.1%) compared to those with albumin levels ≥3.5 g/dL (5.1%). This result is consistent with the findings of a study by Okuhata *et al*., who found that low serum albumin was strongly associated with AVF failure and poor graft maturation in dialysis patients.[13] Albumin is crucial for maintaining oncotic pressure and endothelial function, both of which are essential for proper vascular access creation. Inadequate albumin levels contribute to fluid imbalance, impair wound healing, and increase the risk of infection and clot formation, all of which negatively impact AVF outcomes. Our findings are also supported by the work of Ward *et al*., who demonstrated that preoperative hypoalbuminemia was a strong predictor of AVF failure in Stage 5 CKD patients.[14] Low serum albumin in CKD is often the result of malnutrition and chronic inflammation, both of which are common in advanced kidney disease. Inflammation associated with uremia impairs protein synthesis in the liver, further exacerbating the risk of hypoalbuminemia. Therefore, ensuring that patients are well-nourished and that their serum albumin levels are optimized before surgery is a crucial step in improving AVF success.

Body Mass Index (BMI) and AVF Failure

In this study, the relationship between BMI and AVF failure was explored, with the highest failure rate observed in patients with a BMI ≥25 kg/m² (22%) compared to those with a BMI within the normal range (9.5%). Our results align with the findings of Orozco *et al*., who reported that both underweight and overweight patients had a higher risk of AVF failure.[15] Overweight and obese patients may have decreased vascular access quality, which can impair AVF maturation. The association between obesity and AVF failure may be due to increased endothelial dysfunction and poor vascular remodeling, which are common in obese individuals. In contrast, underweight patients, as observed in our study (20% failure rate in BMI <18.5 kg/m²), have lower muscle mass and poorer nutritional reserves, both of which contribute to poorer healing and increased failure rates of AVF.[16] A study by Lee *et al*. further substantiated that both extremes of BMI, including obesity and malnutrition, are associated with poorer AVF outcomes.[17] The increased risk of AVF failure in patients with abnormal BMI underscores the importance of achieving an optimal body weight before AVF surgery.

Lymphocyte Count and Immune Function

In this study, a significantly higher AVF failure rate (37.2%) was observed in patients with lymphocyte counts <1000 cells/μL, compared to those with counts ≥1000 cells/μL (2.5%). This finding is consistent with the similar study by which showed that low lymphocyte counts were associated with poor surgical outcomes in patients undergoing AVF creation. Lymphocytes play a crucial role in the immune response, and a low lymphocyte count is often an indicator of compromised immune function, which can impair wound healing and increase the risk of infections and thrombosis.[18] The relationship between low lymphocyte counts and AVF failure could be due to several factors. First, malnutrition and inflammation, both of which are common in CKD, can lead to reduced lymphocyte production and function, thus impairing the body's ability to fight infections and properly heal surgical sites. Additionally, lymphopenia has been linked to increased vascular damage and endothelial dysfunction, which can directly affect the success of AVF creation. Therefore, maintaining adequate immune function is essential for optimizing AVF outcomes in CKD patients.

Impact of Comorbidities on AVF Outcomes

Hypertension and diabetes mellitus are common comorbidities in CKD patients and were found to be significantly associated with AVF failure in this study. Hypertension was present in 61.7% of the patients, and diabetes mellitus was found in 49.4% of the cohort. Our study showed that patients with these comorbidities had higher AVF failure rates, particularly those with hypertension (40% failure rate in patients with low lymphocyte count and hypertension). This aligns with findings from Wongchadakul *et al*., who demonstrated that hypertension and diabetes contribute to poor AVF maturation due to their effects on vascular health and endothelial function.[19] The presence of these conditions impairs the formation of AVF by causing arterial stiffness, vascular remodeling, and poor perfusion of the fistula.

Moreover, hyperglycemia associated with diabetes increases the risk of infections, which are a known complication of AVF creation. A study by Fisher *et al*.highlighted that diabetic patients undergoing dialysis are at a higher risk of AVF failure due to both vascular and immunologic dysfunction.[20] Our findings emphasize the need for aggressive management of these comorbidities to improve AVF outcomes in CKD patients.

Concluding Remarks and Clinical Implications

This study underscores the critical role of preoperative nutritional status in determining AVF surgical outcomes in CKD Stage 5 patients. We found that low protein intake, low serum albumin levels, low BMI, and compromised immune function (as indicated by low lymphocyte counts) are significant predictors of AVF failure. These findings align with existing literature, which consistently links malnutrition and poor nutritional status to higher rates of surgical complications in CKD patients. The clinical implications of these findings are profound. Adequate nutritional assessment and intervention before AVF creation are essential to improve the likelihood of successful fistula formation and reduce postoperative complications. Specifically, ensuring adequate protein intake, optimizing serum albumin levels, and addressing comorbid conditions such as hypertension and diabetes are crucial steps in improving AVF outcomes. Future studies should focus on longitudinal approaches to assess the long-term impact of preoperative nutritional status on AVF patency and overall dialysis outcomes. Additionally, randomized controlled trials evaluating the effectiveness of nutritional interventions in improving AVF success rates are needed to further substantiate the findings of this study.

CONCLUSION

This study highlights the significant correlation between preoperative nutritional status and AVF surgical outcomes in Stage 5 CKD patients. Adequate protein intake, optimal serum albumin levels, and a balanced BMI are crucial factors influencing the success of AVF creation. Patients with malnutrition, low serum albumin, and compromised immune function (evidenced by low lymphocyte counts) have higher AVF failure rates. These findings underscore the importance of comprehensive nutritional assessments and management before AVF surgery to enhance surgical success and reduce complications in CKD patients.

Recommendations

Preoperative nutritional screening should be mandatory for CKD Stage 5 patients undergoing AVF creation. Adequate protein intake should be prioritized to optimize protein-energy status and improve AVF outcomes. Regular monitoring of serum albumin and lymphocyte counts should be implemented to detect malnutrition and immune dysfunction early.

Acknowledgement

We would like to express our sincere gratitude to all the patients who participated in this study. We also acknowledge the support of the healthcare team at the private hospital in Rajshahi Division, whose dedication made this research possible. Special thanks to the hospital administration for their guidance, and to our research assistants for their invaluable assistance in data collection and analysis.

Funding: No funding sources.
Conflict of interest: None declared.
Ethical Approval: Taken.

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