

Arteriovenous Fistula (AVF) Creation Surgery in the Light of Kidney Disease Outcomes Quality Initiative (KDOQI) Guidelines at a Tertiary Care Hospital

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ABSTRACT

Objective: To review the Arteriovenous Fistula (AVF) creation surgery in the light of Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines.

Study Design: Prospective analytical study.

Place and Duration of Study: Combined Military Hospital Rawalpindi, Pakistan from Jul 2023 to Sep 2024.

Methodology: A total of 404 patients with End-Stage Renal Disease (ESRD) requiring hemodialysis were operated upon for Arteriovenous Fistula (AVF). They were followed up for six dialysis sessions post-surgery. The adequacy and post-op complications of AVFs were evaluated using clinical examination, duplex ultrasound, and urea-based methods up till six dialysis. AVFs were created using standard end-to-side technique.

Results: There were 404 patients in our study, with an 88.02% follow-up rate, the mean age of population was 57.36. AVF adequacy for maturation was achieved in 84.9% patients within six weeks, and most fistulas demonstrated sufficient blood flow rates for dialysis. Out of these, 73(18.1%) of fistulas were non-functional with 54 primary (13.4%) and 19 early (4.7%), with thrombosis being a common complication. No standard cannulation technique, nor ultrasonography was used. Radio-cephalic fistula was the most common to fail. Of the early failures, thrombosis was the most common complication (n=14, 42.4%) followed by pseudoaneurysm (n=9, 27.3%).

Conclusion: Pre-dialysis referral, detailed patient planning, and continuous clinical and radiological monitoring are crucial for improving fistula success outcomes. The classic "rule of six" for AVF success is good but clinicoradiological judgement is superior, advocating for a more tailored approach.

Keywords: Arteriovenous Fistulas, Cannulation, Dialysis, End Stage Renal Disease, Rule of Six.

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INTRODUCTION

There is a steep increase of end stage renal disease (ESRD) in Pakistan necessitating urgent need for improved awareness, prevention strategies, and healthcare resources to combat the rising burden of chronic kidney disease, as well as capacity building for renal transplant and vascular access.¹ This increase is largely due to the rampant prevalence of hypertension and diabetes mellitus.² These, along with other relatively less common conditions, are significant risk factors that can lead to ESRD, requiring arteriovenous access. For this, the focus is usually on providing the gold standard access for patients with ESRD.³ Patients typically begin with a central venous access approach before transitioning to an arteriovenous fistula (AVF) for long-term vascular access, after that the most important aspects of managing ESRD is the timely conversion from central venous access (Double lumen

catheters, tunneled catheters) to an arteriovenous fistula.⁴ An AVF is beneficial for patients requiring long-term hemodialysis, as it offers a more reliable, safer and having less complication access point, compared to central venous catheters.

Saving the arm, and subsequently the vein, from unnecessary interventions is an important consideration when planning for AVFs.⁵

Following development, a fistula needs to be examined for problems, functionality, or maturity using a variety of evaluation guidelines. The maturity assessment currently follows several guidelines, but research shows that the "rule of six" is still the most accurate indicator of maturity.⁶ Our goals were to determine any issues, verify functionality, and gauge fistula maturity with respect to Kidney Disease Outcomes Quality Initiative (KDOQI) Guidance. The current study aimed to identify patterns and gaps in clinical practice regarding AVF formation for hemodialysis, following KDOQI guidelines, by

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evaluating outcomes from the initial visit to the sixth hemodialysis session.

METHODOLOGY

This prospective analytical study was conducted at Combined Military Hospital Rawalpindi, Pakistan, from July 2023 to September 2024, after obtaining approval from the Hospital Ethical Research Evaluation Committee (number IRB/555/2023).

Inclusion Criteria: Patients of either gender, aged between 40 to 80 years, diagnosed with chronic kidney disease (CKD) who required maintenance hemodialysis and the creation of an arteriovenous fistula (AVF) were included.

Exclusion Criteria: Patients with AVFs created at other centers, and those with arteriovenous grafts instead of fistulas, complex fistulas, lower limb fistulas and redo cases were excluded.

Sample size was calculated using OpenEpi calculator, using a 74.7% success rate for arteriovenous fistulas.⁷ The required sample size was 291, but we recruited 404 patients for better generalizability of the results, using non-probability consecutive sampling.

Each patient had preoperative vein mapping in the vascular laboratory and operation theatre by a vascular surgeon, with veins ≥ 2 mm selected for fistula creation. Parameters such as vessel diameter, continuity, compressibility, and the presence of tributaries were assessed. Central vein occlusion was excluded in patients with history of temporary access on the same side.

All AVFs were created on the non-dominant arm using the end-to-side technique to protect the function of the dominant arm and prevent damage to dominant arm in cases of complications. During surgery, all large, high-flow, or competing veins were ligated to prevent venous steal syndromes.

Postoperative cases were monitored for bleeding, thrill, stealing veins, blood flow, patency, diameter, below skin level and maturity.

The adequacy of the AVFs was evaluated through clinical examination, duplex ultrasound, and dialysis adequacy indices. The efficacy of dialysis was measured by the KT/V method, where K represents urea clearance, T is dialysis time, and V is the volume of distribution of urea in the body. Complications related to the AVFs were also recorded and analyzed throughout the follow-up period till six dialysis sessions.

Patients were followed for six dialysis sessions post-procedure to assess outcomes.

Data was analyzed by Statistical Package for Social Sciences (SPSS) Statistics version 27. For qualitative variables frequencies and percentages were calculated while mean and standard deviation was calculated for continuous variables. A *p*-value of 0.05 or less was regarded as significant.

RESULTS

A total of 459 patients consented to participate in this study, with a follow-up rate was 88.02%, indicating that 404 patients were successfully monitored and followed. The mean age of the patients was 57.36 years (range= 40 to 77 years), suggesting a predominantly middle-aged to older population, which aligns with typical demographics for individuals requiring dialysis. In terms of gender distribution, there were 233(57.7%) male patients, and 171(42.3%) female patients, indicating a higher prevalence of dialysis needs among males in our study. The data was also calculated for the dialysis status of the patients, with 91(22.5%) being pre-dialysis and 313 patients (77.5%) already undergoing dialysis, highlighting decrease referral of pre-dialysis patients for AVFs. Comorbidities are prevalent in ESRD patient population, with 183(45.3%) patients having hypertensin, 79(19.6) patients diagnosed with diabetes mellitus. Out of the patients, 73(18.1%) had both diabetes and hypertension, while 37(9.2%) had diabetes, hypertension, and coronary artery disease shown in Table-I. Other less common diseases such as polycystic kidney diseases, autoimmune diseases leading to ESRD were 32(7.9%). On examining the types of AVFs created, 246 (60.9%) patients were having radial-cephalic fistulas (RCF), 137(33.9%) patients had brachial-cephalic fistulas (BCF), and 21(5.2%) patients underwent two-staged basilic vein translocations (BVTs). On applying components of rule of six, 62(15.3%) patients achieved a fistula caliber of 6 mm, while 215(53.2%) patients had a caliber between 4-6 mm, and 127(31.4%) patients had a caliber of less than 4 mm, indicating that a substantial number of fistulas did not reach the desired caliber of greater than 6 mm, at the time of dialysis and maturity periods but enough diameter to do adequate dialysis. Flow rates were categorized, with 117(29.0%) patients having a flow rate of less than 600 ml/min, 206 (51%) falling within the ideal range of 600-1500 ml/min, and 81(20%) patients exceeding 1500 ml/min. Most fistulas appeared to have adequate flow rates for dialysis. A

handful 343(84.9%) patients had fistulas that matured within six weeks, while 61(15.1%) patients took longer than six weeks to mature. All the AVFs were of adequate length of greater than 6 cm and 368(91.1%) were <6 mm below the skin (Table-II). The data on cannulation techniques shows a variety, with no standard one followed, the Buttonhole technique used in 121(30.0%) cases, the Stepladder technique in 163(40.3%), cases and a mixed technique or unsure method in 120(29.7%) patients. Failure rates are of a significant concern in every surgery. The effectiveness of a fistula was checked after surgery at fixed intervals. Fistulas that allowed proper dialysis were called "functional." Those that couldn't were "non-functional." Non-functional fistulas were split into two groups: Primary non-functional: those couldn't be used for dialysis at all after creation, and early failures: Those worked for dialysis but failed before completing six sessions. Functional fistulas were those that lasted for more than six dialysis sessions. A total of 73(18.1%) were unable to function properly before six sessions of hemodialysis and the remaining 331(81.9%) were functional well beyond six sessions (Table-III). Out of 73 total non-functional 54(74.0%) patients experienced primary non-functional fistulas and 19(26.0%) were early failures, 34(62.96%) were salvaged of primary non-functional fistulas with proactive surgical and endovascular approach, 14(25.93%) patients among primary non-functional were created alternative fistulas, and remaining were left on catheters. Among the 54 primary non-functional cases thrombosis was a relatively common issue, affecting 37(68.5%) patients, while 9(16.7%) patients developed pseudoaneurysms, and another 8(14.8%) patients experienced surgical site infections. Moreover, of the 54 patients, 18(33%) had triple diseases i.e. hypertensin, diabetes mellitus, and coronary artery diseases; 16(30%) had double diseases i.e. hypertension and diabetes mellitus; while 16(30%) had diabetes mellitus; and 4 (7%) had hypertension (Table-IV)

Table-I: Comorbidities in End Stage Renal Disease (ESRD) Patients (n=404)

Parameter	n (%)
Hypertension (HTN)	183 (45.3 %)
Diabetes mellitus (DM)	79 (19.6%)
Other	32 (7.9%)
02 comorbidities (DM/HTN)	73 (18.1%)
03 comorbidities (DM, HTN, CAD)	37 (9.2%)

*DM: Diabetes Mellitus, HTN: Hypertension, CAD: Coronary Artery Disease

Early failures of fistulas were defined as those losing patency within the first six hemodialysis

sessions, affected 19(26.0%) of the total failures. Among the early failures, thrombosis was again the leading complication, affecting 14(42.4%) patients, while 9(27.3%) developed pseudoaneurysms, with 7(21.2%) in buttonhole, 2(6.1%) in stepladder techniques.

Table-II: Post-Operative Characteristics (Rule of Six) for Arteriovenous Fistulas (n=404)

Parameter	n (%)
Caliber > 6 mm achieved	62(15.3%)
Caliber 4-6 mm achieved	215(53.2%)
Caliber <4 mm achieved	127(31.4%)
Flow <600 ml/min	117(29.0%)
Flow 600-1500 ml/min	206(51.0%)
Flow >1500 ml/min	81(20.0%)
Below skin vein <6 mm	368(91.1%)
Below skin vein >6 mm	36(8.9%)
Fistulas matured within 6 weeks	343(84.9%)
Fistulas took >6 weeks to mature	61(15.1%)
Usable length >6 cm for dialysis	404(100%)

Table-III: Functionality up to Six Hemodialysis Sessions (n=404)

Parameter	n (%)
Total Non-Functional	73(18.1%)
Primary non-functional fistulas	54(13.4%)
Early failures (<6 hemodialysis)	19(4.7%)
Functional (>6 hemodialysis)	331(81.9%)

Table-IV: Comparison of Kidney Disease Outcomes Quality Initiative KDOQI Guidelines and Study Results for Fistula Maturity and Functionality Parameters (n=404)

Parameters	KDOQI Guidance	Study Results	Remarks
Pre-dialysis (%)	More than post-dialysis	More post-dialysis	Below Recommended
Mapping	All	Done in All	Aligned
Caliber	>6 mm	15.3% >6 mm, 53.2% 4-6 mm	Majority < 6 mm, Needs Long-term follow-up
Flow	600-1500 ml/min	51% within range	Can be improved with exercise
Maturation	Within 6 weeks (60-70%)	84.9% matured	Aligned
Depth	6 mm	91 % Aligned	Aligned
Nonfunctional (%)	15%	18.1%	Could reduce with patient selection
Functional (%)	85 %	81.9 %	Mostly Aligned
Length	>6 cm	100% >6 cm	Aligned
Surveillance	All	All	Aligned
Fistulas	Distal > Proximal	60.9%	Aligned but improvable
Cannulation	Mixed methods	Stepladder 40.3%, buttonhole 30%	No preference, standardization needed
Ultrasound use for Cannulation	Recommended	Not used	Recommended for adoption
Multimorbidity	Increased failure chances	Increased failure	Right Access for the right patient

DISCUSSION

An arteriovenous fistula (AVF) remains the best option for vascular access in patients with ESRD, but it requires continuous follow-up to ensure it matures fully and remains patent. Studies have shown regular

medical visits, and a proactive approach improved its patency and reduce complications, and most patients had regular follow-ups and examinations, aligned with KDOQI.⁸

Studies have shown that creating permanent access for dialysis before it's needed is good for patients.⁹ There is a need to refer patients early and act quickly to set up permanent access for those with end-stage kidney disease.

In our study, we found similar risk factors for ESRD, like being male, older age, diabetes, and high blood pressure, to other studies.¹⁰ Multimorbidity is also a problem in these patients. KDOQI suggests that multi-morbidity increases fistula failure rates, and advocates for tailoring the approach to each patient. This shows the need to increase community-level screening to catch these risk factors at early stages and prevent the disease from reaching its final stage by controlling hypertension, diabetes etc.

Our study confirmed what earlier research suggests that radio-cephalic fistulas (farther away from the heart) fail more often than brachiocephalic fistulas (closer to the heart).¹¹ Moreover, more comorbidities in a patient lead to higher chances of fistula failure, as depicted by multimorbidity and fistula failure rates. Diabetic AVFs fail more often than compared to those in patients with high blood pressure.

The study emphasizes that while the rule of six for arteriovenous fistula success is important, clinicoradiological judgment is paramount.¹² Fistula maturation is assessed by signs such as a palpable thrill, audible bruit, adequate flow of ranging 400-600 mL per minute, vein diameter of 4-6 mm, suitable depth, and absence of stenosis on Doppler ultrasound. If these criteria are unmet, exercise can improve an immature fistula, while further workup is needed for a complicated fistula.

All the three types of canulations are recommended by KDOQI. In our study, we found that the Stepladder techniques for cannulation in hemodialysis patients are slightly, and have a smaller number of complications. However, some studies disagree or show limited evidence for either technique being superior.^{13,14}

The cannulation technique is made easier by a long vein segment and its closeness to the skin, in the study, the vein was at greater than 6 cm long and most were distanced within 6 mm of the skin, which is

suitable and easy for fistula cannulation, again aligned with KDOQI guidance.

A proactive approach and screening are recommended by KDOQI is essential, to assess the risk to the fistula failure. Early intervention is crucial to save it, as supported by other studies.¹⁵ Using the same approach, 34(63%) out of 54 primary non-functional fistulas were successfully salvaged. For those not salvaged, new fistulas were created for early cannulation and hemodialysis. Patients who couldn't get new fistulas due to comorbidities, old age, or frailty were dialyzed with double lumen catheters or tunneled catheters, emphasizing right access for right patient. even of the early failures, 10(52.63%) out of 19 fistulas were successfully salvaged due to early reporting, availability of surgeon and acting according to the need of problem.

Studies have shown experience and facilities have a definite role in the success of AVF surgery.¹⁶ All the surgeries were performed either by a senior consultant vascular surgeon himself or under his direct supervision during the surgery and post-operative screening.

This analytical study revealed important insights into patient demographics, surgical outcomes, and complications. The high prevalence of comorbidities among the patient population underscores the need for careful patient selection and management strategies, not only for concomitant diseases, but also for fistula surgeries. The successful maturation and functionality rates of the fistulas are encouraging, yet the significant percentages of the causes of complications such as thrombosis and pseudoaneurysms indicate areas for improvement in surgical techniques and postoperative care. Continuous monitoring and education on cannulation techniques will be essential to enhance patient outcomes and reduce failure rates in AVFs management.

Some studies also show the effect of exercise on maturity of fistula, the high level of maturity at the time of cannulation was due to exercise, which was advised to all patients.¹⁷

Ultrasound guided (USG) cannulation for permanent access is superior, not only for routine but also for difficult situations.^{18,19} No one in our study was doing ultrasound guided cannulation, but we recommend USG cannulation for better outcomes.

Research has also shown that early placement of an arteriovenous fistula (AVF) can enhance estimated

glomerular filtration rate (eGFR), potentially delaying the need for hemodialysis.²⁰ Therefore, timely AVF creation in pre-dialysis patients is particularly valuable, especially in a resource-limited setting like Pakistan.²¹

LIMITATIONS OF STUDY

Being a single-centre study with a relatively small sample size limits our generalizability.

CONCLUSION

Pre-dialysis referral, detailed patient planning, and continuous clinical and radiological monitoring are crucial for improving fistula success outcomes. The classic "rule of six" for AVF success is good but clinicoradiological judgement is superior, advocating for a more tailored approach.

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Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

MI & AMB: Conception, study design, drafting the manuscript, approval of the final version to be published.

RK & MS: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

AA & AB: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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