RESEARCH ARTICLE

Arteriovenous Access Outcomes and Risk of Major Cardiovascular Events in Patients with Reduced Ejection Fraction: A Retrospective Cohort Study

Nehal Naseer,[1] Nadeem Ahmed Siddiqui,[2] Fareed Ahmed Shaikh,[3] Mohammad Zakriya[4]

Abstract

Objective: To evaluate the impact of ejection fraction on arteriovenous fistula maturation and patency, and to determine the incidence of major adverse cardiovascular events in end-stage renal disease patients undergoing arteriovenous fistula formation.

Method: The retrospective cohort study was conducted at Aga Khan University Hospital, Karachi, and comprised data of patients who underwent arteriovenous fistula creation between January 2015 and December 2020. Using the American College of Cardiology guidelines, the patients were categorised into normal ejection fraction group A and abnormal ejection fraction group B, with the latter further divided into mild, moderate and severe dysfunction subgroups. Data on demographics, procedural details, arteriovenous fistula patency, and major adverse cardiovascular events within one year postoperatively were analysed. Data was analysed using Stata version 15.

Results: Of the 127 patients, 92(72.4%) were in group A; 47(51.08%) females and 45(48.91%) males with mean age 58.8 ± 13.3 years. The remaining 35(27.6%) patients were in group B; 24(68.6%) males and 11(31.43%) females with mean age 57.9±14.7 years. Arteriovenous fistula patency rates were comparable between the groups; 75(81.5%) in group A and 31(88.6%) in group B. Major adverse cardiovascular events rates were significantly higher in group A 36(39.1%) compared to group B 16(12.6%) ($p>0.05$). Stroke occurred exclusively in group A 6(6.5%), while non-ST elevation myocardial infarction was the most common cardiac event; 15(16.3%) in group A and 7(20%) in group B.

Conclusion: Preoperative ejection fraction did not significantly impact arteriovenous fistula patency in end-stage renal disease patients, but increasing ejection fraction dysfunction could trend towards lower patency. The higher major adverse cardiovascular events risk in normal ejection fraction patients suggested a complex interplay of factors requiring further investigation.

Key Words: End-stage renal disease, AVF patency, Ejection fraction, MACE, Haemodialysis access.

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Introduction

Patients with end-stage renal disease (ESRD) require arteriovenous fistula (AVF) or arteriovenous graft (AVG) as arteriovenous access for haemodialysis throughout their lifetime post-diagnosis.[1] If the access point does not mature properly, it can lead to serious clinical consequences, requiring additional surgeries or alternative access methods.[2]

One important determinant in access maturation is patients' cardiac function, particularly left ventricular ejection function (LVEF).[3] The American College of Cardiology (ACC) classifies ejection fraction (EF) into four categories: normal = LVEF 50-70% (midpoint 60%), mild dysfunction = LVEF 40-49% (midpoint 45%), moderate dysfunction = LVEF 30-39% (midpoint 35%), and severe dysfunction = LVEF <30%.[4] Studies have demonstrated that impaired haemodynamics associated with decreased LVEF negatively impact dialysis access maturation rates, as low cardiac output impairs fistula maturation and increases the risk of thrombosis.[5] Furthermore, patients with low LVEF pose increased risk for major adverse cardiovascular events (MACE)[6], which further complicates outcomes of dialysis access surgeries.

However, less work has been done on the impact of low LVEF on the patency of arteriovenous (AV) access. Studies have shown mixed results[7], with some demonstrating low patency in low EF patients[8], while others showing no significant difference. To date, studies have not been carried out particularly examining the effect of different EF categories, as defined by ACC guidelines, on the maturation failure of AVF and AVG.

The current study was planned to investigate the effect of EF on AV access maturation failure, and to examine the incidence of MACE in these patients.

Materials and Methods

The retrospective cohort study was conducted at the Department of Vascular Surgery of Aga Khan University

[1-4]Section of Vascular Surgery, Aga Khan University Hospital, Karachi, Pakistan
Correspondence: Nehal Naseer. **Email:** nehal.naseer@aku.edu
ORCID ID: 0009-0000-8882-4722

Hospital (AKUH), Karachi, and comprised data of patients who underwent AVF or AVG formation from January 2015 to December 2020. The sample was raised using non-probability consecutive sampling technique. All procedures had been performed by consultant vascular surgeons. Patients undergoing revision of a prior haemodialysis access, those who were lost to follow-up within one year post-procedure, and those with low EF but without an echocardiogram available in the hospital records were excluded.

Using the ACC guidelines[4], the patients were categorised into normal EF group A and abnormal EF group B, with the latter further divided into mild, moderate and severe dysfunction subgroups.

Ethical exemption was obtained from the institutional ethics review committee, and patient data was anonymised to maintain confidentiality.

Data was collected using a structured proforma that included patient demographics (age, gender, and body mass index [BMI]), comorbidities (diabetes mellitus [DM], hypertension [HTN], ischaemic heart disease[IHD], atrial fibrillation [AF] and heart failure[HF]), and American Society of Anaesthesiologists (ASA) classification. Operative variables included access type (radiocephalic, brachiocephalic, basilic transposition, arteriovenous bridge graft [AVBG], or lower limb), access site (left or right), and type of anaesthesia used (local, general or regional block). Perioperative blood parameters, such as haemoglobin (Hb) and haematocrit (Hct) levels, at the time of AVF creation were also recorded.

Postoperative complications, including thrombosis, stenosis, infection, haematoma, dehiscence, steal syndrome and anastomotic issues, were recorded. Patency of the fistula at 1-year follow-up and the total duration of follow-up in months were documented.

As this was a retrospective study, follow-up was primarily done through patient file review. Where necessary, telephone calls were made to verify missing or unclear data. A structured questionnaire was used during follow-up to collect information on post-operative MACE (myocardial infarction [MI], stroke or death), time to MACE (in months), and postoperative cardiac complications (HF, stable/unstable angina, non-ST elevation myocardial infarction [NSTEMI], ST elevation myocardial infarction [STEMI] and stroke).

Data was analysed using Stata 15. Baseline differences between the cohorts were analysed using chi-square tests for categorical variables, and Fisher exact test was used where the expected cell count was <5. Results were presented as means ± standard deviation (SD) for continuous variables, and as frequencies and percentages for categorical variables. P<0.05 was considered statistically significant.

Results

Of the 127 patients, 92(72.4%) were in group A; 47(51.08%) females and 45(48.91%) males with mean age 58.8 ± 13.3 years. The remaining 35(27.6%) patients were in group B; 24(68.6%) males and 11(31.43%) females with mean age 57.9±14.7 years.

BMI was marginally higher in group A 27.5±4.6kg/m^2 compared to group B 26.3±3.4kg/m^2. Within group B, 14(40%) patients were in the mild EF category, 9(25.7%) in moderate category, and 12(34.3%) in the severe category.

DM was present in 66(71.7%) group A patients compared to 25(71.4%) in group B, while HTN was observed in 87(94.6%) group A and 35(100%) group B patients. AF was

Table-1: Demographic and clinical characteristics of the patients.

Characteristics (n=127)	Frequency (%)	
	Normal EF n=92	**Abnormal EF n=35**
Age (Mean ± SD)	58.8 ± 13.3	57.9 ± 14.7
Gender		
Male	45 (48.91)	24 (68.57)
Female	47 (51.08)	11 (31.43)
BMI (Mean ± SD)	27.5 ± 4.6	26.3 ± 3.4
Comorbidities		
Existing heart failure	1 (1.08)	3 (8.57)
Diabetes mellitus	66 (71.73)	25 (71.43)
Hypertension	87 (94.56)	35 (100)
Atrial fibrillation	4 (4.34)	2 (5.71)
Ischaemic heart disease	49 (53.26)	25 (71.43)
ASA class		
I	41 (44.56)	19 (54.29)
II	0 (0.0)	0 (0.0)
III	51 (55.43)	11 (31.43)
IV	0 (0.0)	4 (11.43)
V	0 (0.0)	1 (2.86)
Patients on haemodialysis		
	33 (35.87)	14 (40)
Type of AVF		
Radiocephalic	13 (14.13)	6 (17.14)
Brachiocephalic	29 (31.52)	13 (37.14)
Basilic transposition	37 (40.22)	12 (34.29)

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AVBG	13 (14.13)	3 (8.57)
Lower limb	0 (0.0)	1 (2.86)
AVF site		
Left	68 (73.91)	20 (57.14)
Right	24 (18.9)	15 (42.86)
Blood parameters at the time of AVF creation		
Haemoglobin	9.9 ± 1.3	10.1 ± 1.8
Haematocrit	31.0 ± 4.3	31.6 ± 5.5
Type of anaesthesia		
L/A	44 (47.82)	20 (57.14)
G/A	41 (44.57)	12 (34.29)
Block	7 (7.61)	3 (8.57)
AVF complication		
Thrombosis/non-functional	4 (4.35)	4 (11.43)
Stenosis	21 (22.83)	7 (20)
Infection/hematoma/dehiscence	7 (7.61)	1 (2.86)
Steal syndrome	2 (2.17)	0 (0.0)
Anastomotic leak/rupture	1 (1.09)	1 (2.86)
Patency of fistulas within 1 Year	75 (81.52)	31 (88.57)
Follow-up of patients, in months (Mean ± SD)	22.8 ± 24.7	17.8 ± 19.9
Post-operative MACE	36 (39.13)	16 (12.6)
Gap between AVF formation and MACE, in months (Mean ± SD)	15.3 ± 15.1	16.6 ± 22.0
Post-operative cardiac complications		
Heart failure	4 (4.34)	2 (5.71)
Stable Angina	2 (2.17)	2 (5.71)
Unstable Angina	6 (6.52)	5 (14.29)
NSTEMI	15 (16.30)	7 (20)
STEMI	4 (4.35)	1 (2.85)
Stroke	6 (6.52)	0 (0.0)

EF: Ejection fraction, AVF: Arteriovenous fistula, MACE: Major adverse cardiovascular events, AVBG: Arteriovenous bridge graft, L/A: Local anaesthesia, G/A: General anaesthesia, NSTEMI: Non-ST elevation myocardial infarction, STEMI: ST elevation myocardial infarction, SD: Standard deviation, BMI: Body mass index, ASA: American Society of Anaesthesiologists.

the case in 4(4.43%) group A and 2(5.71%) group B patients.

Most AVFs were created on the left side in 68(73.9%) group A and 20(57.1%) group B patients.

Local anaesthesia was used in 44(47.8%) group A and 20(57.1%) group B cases.

AVF patency rates were comparable between the groups; 75(81.5%) in group A and 31(88.6%) in group B.

Table-2: Association of ejection fraction with AVF patency.

	pre EF normal?		
Patency	No	Yes	Total
No	4 5.8 11.43	17 15.2 18.48	21 21.0 16.54
Yes	31 29.2 88.57	75 76.8 81.52	106 106.0 83.46
Total	35 35.0 100.00	92 92.0 100.00	127 127.0 100.00

AVF: Arteriovenous fistula, **EF**: Ejection fraction.

Table-3: Association of AVF patency with different EF categories.

	pre EF normal?		
Patency	No	Yes	Total
No	4 5.8 11.43	17 15.2 18.48	21 21.0 16.54
Yes	31 29.2 88.57	75 76.8 81.52	106 106.0 83.46
Total	35 35.0 100.00	92 92.0 100.00	127 127.0 100.00

AVF: Arteriovenous fistula, **EF:** Ejection fraction.

In terms of complications, thrombosis or dysfunction occurred in 4(4.3%) group B and 4(11.43%) group B patients, while 21(22.8%) patients in group A experienced stenosis compared to 7(20%) in group B.

MACE rates were significantly higher in group A 36(39.1%) compared to group B 16(12.6%) (p>0.05). Stroke occurred exclusively in group A 6(6.5%), while NSTEMI was the most common cardiac event; (15(16.3%) in group A and 7(20%) in group B (Table 1).

The relationship between preoperative EF and AVF patency was assessed across different EF categories (Table 2).

The highest proportion of successful AVF creation 14(100%) was seen in patients with mild EF dysfunction, followed by those with moderate dysfunction 8(88.89%), normal EF 75(81.52%), and severe dysfunction 9(75%) (Table 3). The relationship between preoperative EF categories and AVF patency was not statistically significant (p>0.05).

Discussion

The primary objective of the current study was to assess whether preoperative LVEF, as classified by the ACC guidelines[4], influences the patency of AVF at one year follow-up. The results showed no significant association between the EF category (normal, mild dysfunction, moderate dysfunction, or severe dysfunction) and the overall success of AVF patency. Patients in the normal EF group had an 81.5% patency rate, while the abnormal EF group had a slightly higher patency rate of 88.6%. Notably, the mild dysfunction subgroup exhibited a 100% patency rate. In contrast, the moderate and severe dysfunction subgroups had patency rates of 88.9% and 75%, respectively.

Although the abnormal EF group showed slightly higher patency rates compared to the normal EF group, statistical tests indicated no significant difference in AVF patency based on EF categories (p=0.250). This suggests that, while low EF might theoretically affect haemodynamics and reduce blood flow to the access site, it does not appear to substantially impact the ability of AVFs to mature and remain patent within the first year. However, a trend within the abnormal EF group was observed; while the severity of EF dysfunction increased, AVF patency tended to decrease. While this trend was not statistically significant, it points to the possibility that more severe cardiac dysfunction may have a negative impact on AVF maturation.

These findings are supported by existing medical literature that has shown mixed results regarding the impact of EF on AVF outcomes.[8] One possible explanation for the lack of significant findings may be the compensatory mechanisms that the body employs to maintain circulation and ensure adequate perfusion to dialysis access sites even in the presence of low EF.[9] Furthermore, the high prevalence of comorbidities, such as DM and HTN, in both groups might have had a more significant influence on AVF maturation, potentially overshadowing the role of EF alone.[10]

As expected, comorbidities were highly prevalent in both groups, with no significant differences between the normal and abnormal EF cohorts. These findings emphasise the importance of cardiovascular risk factors in ESRD patients, as both DM and HTN have been previously shown to negatively affect AVF maturation rates.[11] The procedural characteristics, including the left-sided placement of AVFs and the use of local anaesthesia, were also similar between the two groups, further suggesting that procedural techniques were not a significant confounding factor in the current study.

In contrast to the findings on AVF patency, the incidence of MACE during the follow-up period was notably different between the two current groups. Normal EF group had a significantly higher rate of postoperative MACE at 39.1% compared to the abnormal EF group at 12.6%(p=0.05). Notably, stroke occurred exclusively in the normal EF group 6(6.5%), while the abnormal EF group did not experience any case of stroke. These findings underscore the increased cardiovascular risk associated with low EF, as low LVEF is a well-documented predictor of adverse cardiovascular events.[6]

The higher rate of MACE in the normal EF group is somewhat surprising, as one might expect that patients with low EF would have higher cardiovascular morbidity. However, this can be explained by the fact that patients with low EF might already be managed more aggressively with medical therapies, such as beta-blockers or angiotensin-converting enzyme (ACE) inhibitors, potentially reducing their risk of further events. Additionally, the higher rates of NSTEMI observed in both groups indicate that the overall burden of cardiovascular disease in this cohort was significant, which aligns with findings from other studies indicating the high cardiovascular morbidity of ESRD patients.[11]

While the current study provides valuable insights, it has a few limitations. The retrospective design of the study is limited by the quality and completeness of the available data. The small sample size in certain subgroups, such as those with severe EF dysfunction (n=12), reduces the statistical power of the analysis. Also, the study did not account for other potential confounders that could influence AVF outcomes, such as vascular anatomy, presence of peripheral arterial disease, or use of antiplatelet therapy.

Conclusion

While no significant association was found between EF and AVF patency, the increased risk of MACE in patients with low EF highlights the importance of cardiovascular risk management in ESRD patients.

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