



The Association of Lower Perioperative Mean Arterial Pressure and Primary Failure in Distal Radiocephalic Arteriovenous Fistula Operations

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Abstract

Introduction: Arteriovenous fistula (AVF) is the recommended vascular access type for hemodialysis-dependent patients. Although the patency rates are respectable, primary failure is still a challenge. We aimed to investigate the association between lower perioperative mean arterial pressure and primary failure in distal radiocephalic AVF operations.

Methods: A total of 141 patients who underwent distal radiocephalic AVF operation were retrospectively investigated (70 females, mean age: 48.0±5.5). The patients were divided into two groups according to the average value of the perioperative mean arterial pressure measurements. Risk factors were compared between groups.

Results: No difference was found between groups in terms of baseline characteristics and risk factors. The primary failure was found to be higher in the lower perioperative mean arterial pressure group (17% vs. 34%, p=0.030). Risk factors for primary failure were taken into univariate logistic regression analysis, and none were found significant.

Discussion and Conclusion: Our study revealed that lower mean arterial pressure in the perioperative period is associated with a higher primary failure rate for distal radiocephalic AVFs.

Keywords: Arteriovenous fistula; Blood pressure; Hypotension; Primary failure.

Arteriovenous fistula (AVF) is the recommended vascular access type for hemodialysis-dependent patients^[1]. Hemodialysis catheters and arteriovenous grafts are the other alternatives for vascular access; however, they carry a higher risk of thrombosis and infection compared to AVFs^[2]. Due to the principle of vein preservation, creation of an AVF at the most possible distal site is recommended as an initial vascular access procedure. Distal radiocephalic AVF at the carpal region

(Brescia–Cimino) is the first choice for AVF creation, since it grounds less complications, and has higher patency rates^[3].

Although the patency rates of distal radiocephalic AVFs are high, primary failure is still a challenge in a significant proportion. When the current literature is reviewed, the primary failure rate in distal AVF has been reported to be between 20% and 26%^[3,4]. Juxta-anastomotic thrombo-

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sis plays the most critical role in primary failure of AVFs^[5]. Advanced age, female gender, diabetes mellitus, smoking, and diameters of the target artery and vein are also held responsible for the primary failure of AVF^[6-8]. Another reason for primary failure is lower blood pressure, which is common in this specific patient group. It was first mentioned by Wetzig et al.^[8] that hypotension could precipitate the primary failure of AVF. However, the number of studies revealing this association is quite limited.

In this study, we aimed to investigate the association between lower perioperative mean arterial pressure and primary failure in hemodialysis-dependent patients who especially underwent distal radiocephalic AVF creation operations.

Materials and Methods

We retrospectively investigated a total of 312 patients who underwent AVF surgery for hemodialysis between January 2020 and December 2020 at our institution. All data were obtained from the hospital's digital data recording system and patients' file records. Patients who underwent primary distal radiocephalic AVF between ages 18 and 65 years were included in the study. Patients who have had AVF operations performed under general anesthesia (where there may be blood pressure imbalances or hypotension due to the anesthetic agent), had secondary AVF operations, were intervened due to AVF complications, had AVF surgery at other sites than distal radiocephalic, and have had radial artery and/or cephalic vein (measured under tourniquet) <2 mm in diameter under duplex ultrasonography and whose data could not be accessed were excluded from the study. One hundred and forty-one patients who met these criteria were included in our study.

Measurement of Arterial Blood Pressures

Systolic, diastolic, and mean arterial pressures were measured in the supine position in the pre-operative, intraoperative, and post-operative periods (3 times in total). The blood pressures were measured using oscillometric (non-invasive) technique by a cardiovascular surgeon after a 10-min minimum resting period in the supine position. The pre-operative measurement was performed 1 h prior to the operation, the second measurement (intraoperative) was made on the operating table just before the operation, and the last measurement (post-operative) was made 1 h following the operation in the ward. The mean values of the systolic, diastolic, and mean arterial pressures which were obtained from all three measurements were taken into account for statistical analysis.

On the operation day, hypotensive patients (systolic blood pressure <90 mmHg) who were detected during the pre-operative measurement were not taken into the operation on the same day as a routine practice at our clinic. The lower blood pressure is defined as mean arterial pressure <90 mmHg (average of the perioperative measurements). The patients were divided into two groups: Group 1 was the patients with a total perioperative mean arterial blood pressure of 90 mmHg and above and Group 2 was the patients with a mean arterial blood pressure below 90 mmHg. The operations were performed in a single center by a dedicated vascular team for AVF surgery. Pre-operative arterial and venous mapping was performed by the operating vascular surgeons in a vascular laboratory at least 1 day before the operation.

Table 1. Baseline characteristics of the patients

	Group 1 (MAP ≥90 mmHg) (n=106)	Group 2 (MAP <90 mmHg) (n=35)	p
Gender (female)	55 (52%)	19 (54%)	0.805 ^a
Age	47.1±14.0	46.1±13.6	0.692 ^b
DM	46 (43%)	14 (40%)	0.725 ^a
Smoking	40 (38%)	12 (34%)	0.714 ^a
Peripheral arterial disease	45 (43%)	16 (46%)	0.736 ^a
Low ejection fraction (EF<%40)	19 (18%)	5 (14%)	0.619 ^a
Radial artery diameter (mm)	2.29±0.10	2.30±0.08	0.885 ^b
Cephalic vein diameter (mm)	2.91±0.12	2.94±0.14	0.246 ^b
Primary failure	18 (17%)	12 (34%)	0.030 ^a

DM: Diabetes mellitus; EF: Ejection fraction; MAP: Mean arterial pressure; ^a: Chi-square test; ^b: Independent samples t-test.

Table 2. Mean blood pressure measurements of the patients

	Group 1 (MAP ≥90 mmHg) (n=106)	Group 2 (MAP <90 mmHg) (n=35)	p
Systolic AP (mmHg)	136±12	100±6	<0.001 ^a
Mean AP (mmHg)	109±8	80±8	<0.001 ^a
Diastolic (mmHg)	95±9	69±10	<0.001 ^a

AP: Arterial pressure; MAP: Mean arterial pressure; ^a: Independent samples t-test.

Surgical Technique

All operations were performed under local anesthesia and in the non-dominant arm. The AVFs were created with end-to-side continuous suture anastomosis technique (Propilen, 7/0, 8 mm round, polypropylene suture, Dogsan, Istanbul, Turkey) between the distal radial artery and the cephalic vein in the carpal region. The patients were not heparinized before or during the procedure.

The patients were discharged on either the day of the operation or on the post-operative day 1. The patients were evaluated by physical examination and vascular ultrasound postoperatively on the 1st- and 4th-week follow-ups. The primary outcome of the study was primary failure rate (no bruit and/or no trill on physical examination and/or ultrasonographic measurements) on the first 4-week follow-up.

Ethical approval was obtained from the Ethics Committee of Istanbul Medeniyet University, Faculty of Medicine (2020/0471). Informed consent was obtained from the patients. The study procedures were adhered to the guidelines of the Declaration of Helsinki.

Statistical Analysis

Statistical analysis was performed using the Jamovi version 1.6.23 solid software (<https://www.jamovi.org>). Continuous variables were given as mean±standard deviation and categorical variables were given as number and percentage. Nominal variables were compared by using the Chi-square test, and continuous variables were compared by using independent variables t-test. Risk factors for primary failure were taken into univariate logistic regression analysis. $p<0.05$ was considered statistically significant.

Results

Among the 141 included patients, 106 were in Group 1 (perioperative mean arterial pressure ≥90 mmHg), and 35 were in Group 2 (perioperative mean arterial pressure <90 mmHg). Seventy (52.5%) patients were female. The mean age was 48.0±5.5. Diabetes mellitus was observed in 60 (42.6%) patients, and 61 (43.3%) patients had peripheral arterial disease. The number of smoker and/or ex-smoker patients was 52 (36.9%).

The groups were compared in terms of gender, age, diabetes mellitus, smoking, peripheral arterial disease, and low ejection fraction; all were similar between the two groups (Table 1). The radial arterial diameter and cephalic vein diameter were also taken into account as parameters which could affect the outcomes, and both were similar. Primary failure was observed in totally 30 (21.3%) patients. Patients in Group 1 had a lower primary failure rate than in Group 2 (17% vs. 34%).

The mean arterial blood pressure was 109±8 mmHg in Group 1 and 80±8 mmHg in Group 2 (Table 2). Univariate logistic regression analysis was performed for each risk factor, to investigate their own effects on primary failure (Table 3). None of the risk factors were found to be statistically significant.

Table 3. Univariate logistic regression analysis of risk factors for AVF primary failure

	OR	CI (95%)	p	R²Nagelkerke
Age	1.001	(−0.028)–0.030	0.952	0.000
Gender (female)	0.908	(−0.863)–0.670	0.805	0.000
DM	0.870	(−0.917)–0.638	0.725	0.001
PAD	1.142	(−0.636)–0.901	0.736	0.001
Low EF (EF<40%)	0.763	(−1.340)–0.799	0.620	0.003
Smoking	0.861	(−0.951)–0.651	0.714	0.001
Mean arterial pressure (MAP ≥ 90 mmHg)	2.551	0.073–1.800	0.033	0.047
Radial artery diameter	1.339	(−3.610)–4.200	0.884	0.000
Cephalic vein diameter	5.922	(−1.220)–4.780	0.245	0.014

AVF: Arteriovenous fistula; CI: Confidence interval; DM: Diabetes mellitus; OR: Odds ratio; PAD: Peripheral arterial disease.

Discussion

Lower perioperative mean arterial pressure (mean arterial pressure <90 mmHg) is found to be associated with a higher primary failure rate on distal radiocephalic AVF when compared with higher blood pressure (mean arterial pressure $\geq$ 90 mmHg) patients.

The pre-dialysis and interdialytic hypotension is found to be associated with AVF thrombosis and poor survival rates in patients who are already under hemodialysis treatment^[9-11]. However, the association between perioperative lower blood pressure and primary failure of AVF was underinvestigated in the literature. Pandey et al.^[12] reported that the pre-operative lower blood pressure is associated with higher rates of early AVF failure. Since perioperative lower blood pressure is a modifiable risk factor, the role of this medical condition in primary failure is multifactorial. Lower blood pressure precipitates the occurrence of juxta-anastomotic thrombosis due to low blood flow in the inflow artery^[12,13]. Diastolic blood pressure and mean arterial pressure are held more responsible for incidence of early AVF failure than systolic blood pressure^[12]. AVF itself could precipitate hypotension due to an adaptation mechanism secondary to both arteriovenous shunting and also a reduction in peripheral vascular resistance,^[14-16] but it is not probable to occur before maturation of an AVF. Properly hydrating the patients could be considered an option to avoid lower blood pressure^[3]. If blood pressure levels do not improve despite hydration, rescheduling the operation would be the reasonable option.

Advanced age and female gender are found to be associated with primary failure^[17]. Arteriosclerosis, especially in the elderly, could play an essential role in primary failure. Another reason for that is the increasing incidence rates of diabetes mellitus with advanced age^[3]. Although the role of gender in AVF maturation is unrevealed; Siddique et al.^[18] found that achieving mature AVF is twice more likely in the male gender than the female gender. The most probable explanation of this variance is that women have smaller vessel diameters.

Diabetes mellitus accounts for 44% of the hemodialysis-dependent patients^[3]. It is the most common underlying cause of peripheral arterial disease, arteriosclerosis, and end-stage renal disease^[3]. Diabetic patients are more prone to infections, and the wound healing is impaired in these patients. Diabetes mellitus is associated with poor rates of AVF maturation^[19]. The association is not as clear between smoking and primary failure. One study showed

that smoking is independently associated with primary failure of AVF,^[19] but no other association is shown in another study^[18]. The patient groups in our study were similar in terms of diabetes mellitus and smoking. Univariate logistic regression analysis showed no statistical difference on primary failure for both diabetes mellitus and smoking.

Peripheral arterial disease is associated with primary failure of AVF^[20]. It is difficult to determine what the primary reason for this association is, since peripheral arterial disease is correlated with advanced age, diabetes mellitus, smoking, and end-stage renal disease^[21,22]. All of these factors may contribute to this correlation, but the primary explanation is the reduction of arterial blood flow due to peripheral arterial disease. Percutaneous balloon angioplasty of the inflow artery could be performed in cases with arterial stenosis^[3].

According to "Vascular Access: 2018 Clinical Practice Guidelines of the European Society for Vascular Surgery," it is recommended to perform arterial and venous mapping by duplex ultrasonography to the patients who are candidates for AVF creation^[3]. A minimum artery and vein diameter of 2 mm is recommended for distal radiocephalic AVF per the same vascular access guideline. It is practicable to make the measurements under tourniquet^[23]. Yan et al.^[13] reported that vein diameter and low mean arterial blood pressure in the pre-operative period were found to be independent risk factors for the primary failure during the first 7-day period in Brescia-Cimino fistulas; however, they did not report the same association for arterial diameter.

The role of ejection fraction in primary failure is uncertain. Farrington et al.^[24] reported that the higher left ventricular ejection fraction is associated with higher unassisted AVF maturation rates. On the other hand, the cardiovascular effects of the AVF, which start with hypotension in response to decreased peripheral vascular resistance, may lead to heart failure^[14]. The patient groups in this study were similar in terms of their ejection fractions evaluated by echocardiography. Further studies are needed to reveal the effect of AVF to cardiovascular hemodynamic condition in chronic renal failure patients.

Along with studies reporting negative effects of systemic heparinization on the outcomes of AVF surgery due to increased bleeding risk,^[3] there are also studies reporting that it is associated with increased rates of AVF maturation^[25]. In our institutional protocol, we did not use systemic heparinization in distal radiocephalic AVF operations.

Limitations

The major limitation of the study is its retrospective design. Although it seems like a limitation that the study includes patients from a single center, it also makes the study compelling since the operations were performed by a dedicated vascular team and also because this eliminates the surgeon-related factors. Considering we excluded all the patients with hypotension in the pre-operative period from the study, we did not analyze the patients in terms of anti-hypertensive medication.

Conclusion

Vascular access is the access of life for hemodialysis-dependent patients. Achieving high maturation and patency rates is very important for this patient group. Our study revealed that lower mean arterial pressure in the perioperative period is associated with a higher primary failure rate for distal radiocephalic AVFs. All other variables which were claimed to be risk factors for primary failure in the literature were not found to be statistically significant in the univariate logistic regression analysis. Further studies are needed to reveal the association between lower blood pressure and primary failure.

Ethics Committee Approval: Ethical approval was obtained from the Ethics Committee of Istanbul Medeniyet University, Faculty of Medicine (2020/0471). Informed consent was obtained from the patients. The study procedures were adhered to the guidelines of the Declaration of Helsinki.

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