

## Article

# Evaluation of factors that may affect the outcome of radio cephalic arteriovenous fistula creation in chronic renal failure patients

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**Abstract: Background:** Radio-cephalic arteriovenous fistula (RC-AVF) is considered the preferred vascular access for dialysis, particularly in the non-dominant arm. However, elderly patients and those with comorbidities have a higher failure rate of RC-AVF. Therefore, clinical examination before surgery is crucial, and careful postoperative monitoring is necessary to overcome impaired fistula maturation. This study aims to evaluate different factors that may affect the outcome of arteriovenous fistula creation.

**Methods:** The study included patients aged 20-65 years with chronic kidney disease, without prior radio-cephalic arteriovenous vascular access intervention, from February 1, 2021, to January 31, 2022. Factors affecting the outcome were assessed, including preoperative, intraoperative, and postoperative factors. In this study, an end-to-side anastomosis technique was used with prolene 7-0 suture material in an interrupted suturing technique.

**Results:** Out of 250 patients, the highest successful AVF creation rate was observed in the 20-30 years age group (84%), followed by the 31-40 years and 41-50 years age groups (78%). The success rate was found to be higher in males (61%) than in females (39%). Moreover, the success rate of AVF had an incremental relation with the diameter of the radial artery and cephalic vein.

**Conclusion:** The success of fistula maturation is strongly correlated with postoperative monitoring. Therefore, AV fistula monitoring should begin immediately during surgery and continue in the postoperative period.

**Keywords:** Radio-cephalic arteriovenous fistula; Chronic kidney disease; Vascular access; Postoperative monitoring; Anastomosis.

## 1. Introduction

The proper functioning of an arteriovenous fistula (AVF) is crucial for hemodialysis and has become an integral part of the dialysis procedure [1]. A functioning AVF is necessary for efficient hemodialysis as it allows for the required blood flow rates and volumes to be achieved.

Hemodialysis is a common treatment for over 2 million people worldwide each year [2], and creating an AVF by vascular surgeons is the preferred method for achieving permanent vascular access [3]. A well-functioning AVF has several advantages over other types of vascular access, such as catheters or grafts, including a lower incidence of infections, longer patency, and lower healthcare costs [4].

To create an AVF, an artery and vein are surgically connected, with a peripheral fistula created first, followed by a wrist fistula (Brescia-Cimino AVF), a mid-forearm cephalic fistula, and finally a proximal forearm brachiocephalic fistula in the upper third of the forearm [5]. The AVF creation at the wrist level is the most commonly performed procedure due to its ease and accessibility [5].

However, the success rate of AVF creation varies depending on various factors such as patient age, comorbidities, and the diameter of the radial artery and cephalic vein [6]. Clinical examination is considered very important before operating on the patient, and careful postoperative monitoring also plays a crucial part in overcoming impaired fistula maturation [6].

In conclusion, creating a well-functioning AVF is an important aspect of hemodialysis, and proper patient selection, surgical technique, and postoperative monitoring are key factors in ensuring its success

## 2. Arteriovenous Fistula Maturation

### 2.1. Physiology

The maturation process involves the remodeling of an AVF, making it suitable for cannulation and allowing adequate blood flow for hemodialysis. During AVF creation, a high flow artery is connected to a low flow vein, which leads to an elevation of blood flow and a rapid increase in wall shear stress (WSS). Studies have shown that the WSS of the vein increases rapidly from 1-6 dyn/cm<sup>2</sup> to 10-70 dyn/cm<sup>2</sup> [6]. From a biological perspective, maturation is related to the response of endothelial cells to changes in WSS [7,8]. There are two approaches to rebuild the venous wall:

- A) Increased neointimal cell deposition and inward remodeling.
- B) Eccentric medial hypertrophy caused by flow-mediated dilatation, which results in outward remodeling due to increasing circumferential tension [9]. The anastomotic segment is the location of AVF stenosis that occurs most frequently after formation.

Previous intravenous puncture sites may prevent outward remodeling and serve as stenosis sites [10]. AVF maturation is influenced by a number of variables, both adjustable and non-modifiable. Age, comorbidities, blood pressure, and other patient-specific characteristics are among the non-modifiable factors. Modifiable factors are related to the state of the vasculature. The arterial and venous network topology and geometry, the length and diameter of the vein segments, the elasticity and conformance of the vessel walls, pre- and postoperative radial artery disease, and lesion factors are among the vascular variables (stenosis number, location, and severity) [11]. There are several risk factors that influence the outcome of the AVF [12]. Age and diabetes have been shown to interfere with AVF maturation and increase the risk of AVF failure significantly [13,14]. Women mostly have smaller vessels than men, which results in poorer maturation and less long-term patency. Another non-modifiable factor that influences AVF maturation is the size of the artery and vein. Tobacco smoking is a well-known risk factor for vascular disease and arteriosclerosis [15].

## 3. Materials and Methods

This prospective study included patients aged 20-65 years with chronic renal disease or incident end stage renal disease and no prior arteriovenous vascular access intervention. Patients were recruited from the plastic surgery OPD or admitted to the Department of Nephrology in a tertiary care hospital from February 1st, 2021 to January 31st, 2022. A total of 250 patients were included and categorized based on age, sex, comorbidities (such as diabetes, hypertension, peripheral vascular disease, systemic disease), history of smoking or tobacco use, obesity (BMI), drug history, and vessel wall characteristics (such as caliber of vessel, pulse volume, and vessel wall characteristics). To achieve a systemic analysis, intraoperative findings were evaluated, including branching pattern and vessel diameter of both radial artery and cephalic vein. Patients were also evaluated for postoperative findings, including any drug intake after surgery (such as heparin during dialysis or any antiplatelet drug intake), and were advised for physiotherapy and limb elevation after the surgical procedure was performed. Postoperative complications such as infection, hematoma formation, thrombosis, aneurysm, or failure of AVF were studied and analyzed. Routine outpatient visits were planned for follow-up at 1 week, 2 weeks, 4 weeks, and 10 weeks postoperatively. The success of AV fistula was considered after a 4-week postoperative period. Quantitative data were summarized and depicted on graphs and charts using descriptive statistics. Informed consent from the patient or their attendant was obtained, and a thorough physical examination of the patient was performed. Patients under the age of 20 years or over the age of 65 years were excluded from the study.

## 4. Results

A total of 250 patients underwent AV fistula creation over a period of one year in our study from 1st February 2021 to 31st January 2022. The highest successful AVF creation was found in the age group of 20-30 years (84%) followed by the age group of 31-40 years and 41-50 years (78%). The lowest success rate was

shown by the age group of 60-65 years (47%) with an overall success rate of 64% in all age groups (Figure 1). The percentage of successful AVF creation was found to be higher in males (61%) than in females (39%). Out of a total of 187 male patients, 116 were successful and 71 failed, while out of a total of 63 female patients, 25 were successful and 38 failed (Figure 2).

In our study, we analyzed the adverse effect of high BMI on the success of AVF creation. Out of 172 patients having BMI <30 kg/m<sup>2</sup>, 118 patients had successful AVF creation (68% success), and out of 78 patients with BMI >30, only 25 of them had success (32% success) (Table 1). The highest number of AV fistula failures was seen in patients who had peripheral vascular disease (75%). This was followed by patients who had hypertension alone (45%) (Table 2).

This study revealed a higher failure rate of AV fistula creation in both male and female smokers. Out of 68 male smokers and 35 female smokers, only 15 and 7 patients had successful AVF creation, respectively (22% and 14% success in males and females, respectively) (Figure 3). Smoking leads to atherosclerosis of arteries, which could be the main factor for AVF failure.

Additionally, this study found a close association between tobacco consumption and AV fistula failure. The success of AV fistula decreased in patients who were consuming tobacco or betel nut, both in males and females. Out of 150 male patients consuming tobacco, 86 of them had successful AVF creation (57% success), and only 5 female patients out of 28 who were consuming tobacco had successful AVF creation (18% success) (Figure 4).

Patients consuming drugs such as antiplatelets, anticoagulants, and statins showed a good response to AV fistula maturation in this study. Out of 64 patients taking antiplatelet drugs, 38 patients had successful AVF creation (59% success), and out of 15 patients who were taking anticoagulants, 11 of them had success (73% success). Ten patients who were on statins, six patients had successful AVF creation (60% success). We firmly believe that these drugs may alter the factors that might otherwise hamper AVF maturation. [Figure 5]

Branching pattern and vessel diameter were the intraoperative findings in this study. On careful evaluation and observation, it was found that the high success rate of AV fistula in patients having a single vein pattern rather than having multiple branches. The failure rate increases if multiple branching patterns are present. Out of 180 patients having a single vein pattern, 148 of them had successful AVF creation (82%), and out of 70 patients who were having a branching pattern, only 20 had successful AVF creation (29%). [Figure 6]

The success rate of AVF also had an incremental relation with the diameter of the radial artery and cephalic vein. [Figure 7] shows a higher success rate of AV fistula creation in patients who had vein diameter more than 2mm. Out of 87 patients with vein diameter 1-2mm had 35% success rate while patients with vein diameter >2mm had an 80% success rate.

Similarly, patients with radial artery caliber >2mm as compared to 1-2mm caliber, results showed patients with radial artery diameter >2mm had a 60% success rate, while those who had <2mm diameter were having a 40% success rate.

Chronic renal failure patients usually have higher blood pressure, and in this study, it showed that patients having higher preoperative blood pressure had a slightly better success rate. Patients those having blood pressure >140/80mmHg had a 62% success rate. [Table 3]

On counting the complications seen during this study, they were infection, hematoma, thrombosis, aneurysm, and failure. Maximum complication is of failure in total 82 patients, followed by infection in 64 patients (26%). Hematoma and thrombosis were noted in 20 (8%) and 56 (22%) patients, respectively. [Table 4]

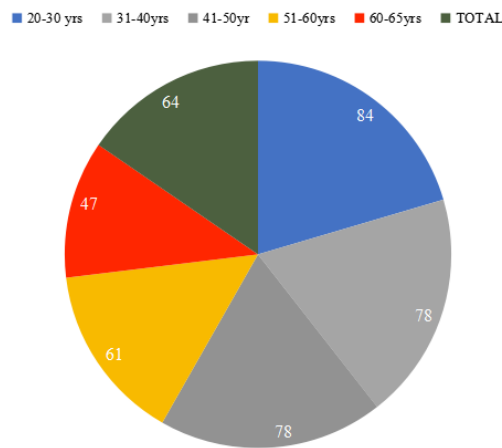


Figure 1. Showing percentage of successful Av fistulas according to age groups

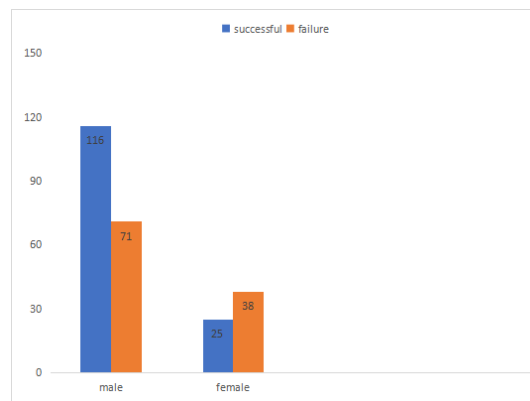


Figure 2. Bar graph showing successful and failure cases in men and female patients

Table 1. Obesity

	BMI<30kg/m <sup>2</sup>	BMI>30kg/m <sup>2</sup>
No.of patients	172	78
Successful	118	25
Failure	54	53
%Age success	68	32

Table 2. Co morbidities

Comorbidity	No. of patients	Success(percentage)	Failure(percentage)
Hypertension only	56	31 ( 55%)	25 (45%)
Diabetes mellitus only	64	52 (81%)	12 (19%)
Peripheral vascular disease(PVD) only	16	4 (25%)	12 (75%)
HTN+DM combined	136	92 (68%)	44 (32%)

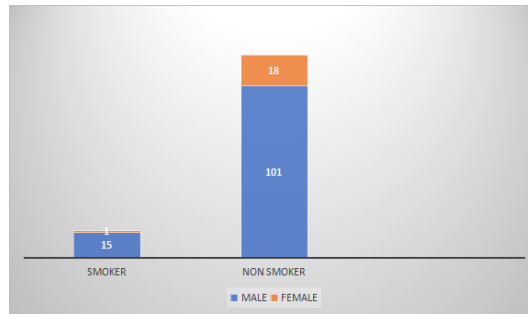


Figure 3. Shows successful cases of AVF in male and females having history of smoking

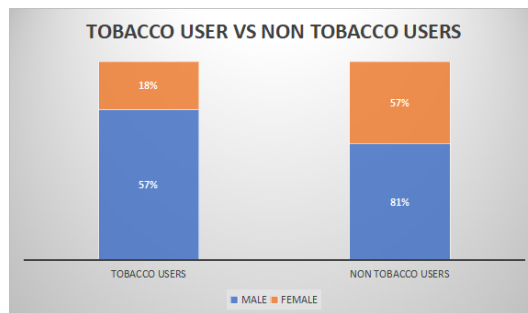


Figure 4. Shows percentage differences of av fistula success between male and female tobacco users versus non tobacco users

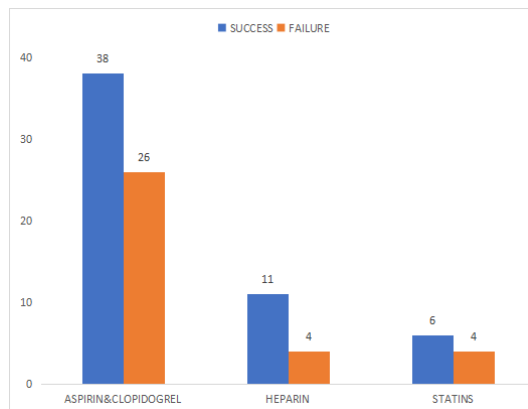


Figure 5. Shows number of successful av fistula creation in patients taking different drugs

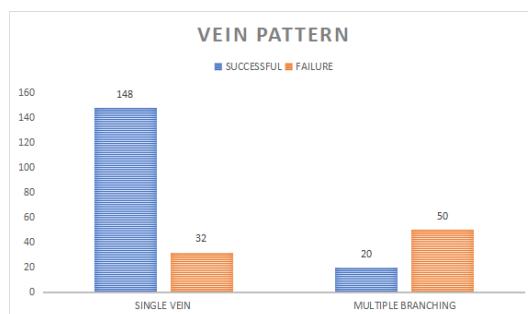


Figure 6. Showing higher rate of av fistula success in patients to have single cephalic vein pattern as compared to multiple branching pattern

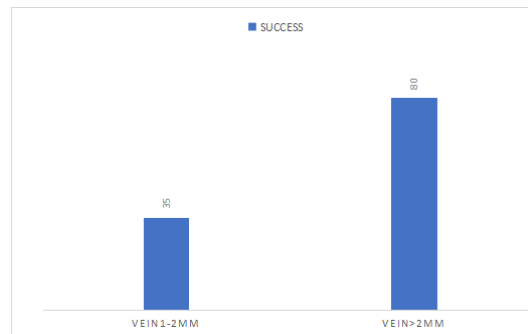


Figure 7. Showing higher success rate in patients having vein diameter >2mm

Table 3. Affect of preoperative blood pressure

Systolic BP	Diastolic BP	Patients	Percentage success
<140mm hg	<80mm hg	170	55%
>140mm hg	>80mm hg	80	62%

Table 4. Complications leading to failure

Complications	No.of patients
Infection	64
Hematoma	20
Thrombosis	56
Others(aneurysm)	0
No outcome	90

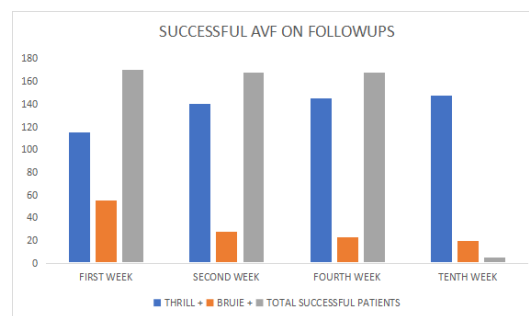


Figure 8. Explains the number of patients came for followup at first, second, fourth and tenth weeks

## 5. Discussion

Long-term hemodialysis of patients with chronic renal failure depends on maintaining a patent and functional vascular access. Our study shows that the mean age of the patients in the elderly age group (51-65 years) and the success rate of AV fistula decreases with increasing age. The study conducted by Smith GE et al. shows that radiocephalic AVF had an increased failure rate and decreased patency in elderly patients ranging from 50-70 years, specific to wrist AVFs [16]. Another finding in our study is a higher success rate in males (61%) compared to females (39%). This study is in concordance with the study of Astor BC et al., where the results show poor maturation of fistulas in females because of thinner vessels than males [17].

While studying the comorbid factors in our study, we found that diabetes does not really affect the patency of AVFs as 52 patients out of 64 diabetic patients had successful AVF patency. Our study is in concordance with the results of Sedlackk et al., who reported no significant difference between diabetic and non-diabetic patients in the outcome of AVFs [18]. It was observed in our study that 31 patients out of 56 patients who had hypertension, AVF patency was successful. This observation was parallel to the study of Siddiqui et al.,

where there was no significant effect of hypertension on AV fistula outcome [19]. It was observed that out of 250 patients with chronic renal failure in our study, 136 of them were having hypertension and diabetes both, which is compared to the study done by Aljuaid et al., where more than 40% of patients were suffering from hypertension and diabetes [20].

The effect of smoking was very detrimental to the results we found in this study, showing only 22% and 14% AVF success in males and females, respectively. This was supported by the results of Wetzig et al., who reported a significantly higher incidence of AV fistula failure in their study [21]. However, our study showed an ill effect of tobacco consumption on fistula outcome as the success rate fell from 81% to 57% in males, and only 18% success showed in females who had tobacco consumption. Obesity and BMI > 30 kg per square meter (kg/m<sup>2</sup>) showed a higher failure rate compared to low BMI < 30 kg per square meter (kg/m<sup>2</sup>) [Table 1]. This finding was similar to the results of M.R. Chan et al., whose results showed a high failure rate in patients with high BMI, i.e., >30 kg/m<sup>2</sup> [22]. Antiplatelet drugs like aspirin and clopidogrel did not show any favorable effect in this study, which is in contrast to the results of Paraskevas et al. [23]. Our study was supported by Dember LM et al., where they gave the conclusion that clopidogrel did not increase the proportion of fistula [24].

In this study, we found that heparin had good intraoperative results as 11 out of 15 patients had successful fistula creation. This result was similar to the results of Ravari H et al. who also showed positive intraoperative results with heparin [25]. A newer observation noted in this study came from the branching pattern of the cephalic vein. The single pattern vein showed better results than the multiple branching patterned vein. This could be due to the distribution of blood flow distal to the anastomosis.

The study showed better results in patients with a vein diameter >2mm. These results were similar to the study of C. Glass et al. which showed a 71% success rate in veins with a diameter >2mm as compared to a 29% success rate in veins with a diameter <2mm. Similarly, a radial artery diameter >2mm showed good results, which correlated with the study of C. Glass et al. [26]. Preoperative blood pressure >140/80 mmHg showed good results [see Table 3]. These results were similar to the studies of Culp et al. [27].

Our observations during the follow-up period of 10 weeks showed a success rate of 168 out of 250 patients who underwent fistula creation. Maturation in the study was considered the time period beyond 4 weeks. During the follow-up period, we encountered some complications such as wound infection, thrombosis, hematoma formation, and failure [see Table 4]. This study was conducted to avoid such factors that may lead to the failure of fistula maturation. Additional studies could be conducted to examine the effects of certain drugs (hypoxia-inducing drugs, statins, blood thinners, etc.) on the outcome. Various experimental studies can also be conducted to promote neointimal cell hyperplasia by hypoxia-inducible factors. In addition, interventional radiological studies could be conducted to enhance the maturation of radiocephalic AV fistulas.

## 6. Conclusion

Successful provision of vascular access is crucial for successful hemodialysis. The success of fistula maturation is closely related to monitoring at various stages. Radiocephalic fistula should be considered early, and proper planning and monitoring should begin immediately during surgery and continue postoperatively. Strategies to promote maturation through drugs have not been effective, and research into new monitoring techniques and systems should be encouraged. Avoidance of factors that may lead to AVF failure is important, and early diagnosis and management of complications is essential.

## 7. Limitations

The only limitation of our study was the lack of follow-up for some patients beyond 10 weeks postoperatively. Some patients were unable to visit our hospital from remote areas of northeast India, and other patients developed successful AV fistulas.

**Ethical approval and consent to participate:** This study was approved by the Ethics Committee of Gauhati Medical College and Srimanta Sankaradeva University of Health Sciences, Guwahati. Written informed consent was obtained from the patients and guardians of the patients.

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**Conflicts of Interest:** "Nil."

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