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Profile of Primary Arteriovenous Fistula Failure in End-Stage Renal Disease Patients on Hemodialysis at Dr. Soetomo General Academic Hospital, Surabaya

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ABSTRACT

Introduction: Primary arteriovenous fistula failure in Indonesia is still relatively high, and end-stage renal disease patients are prioritized to have arteriovenous fistula as their main vascular access for hemodialysis. This study aimed to determine the primary arteriovenous fistula failure profile in end-stage renal disease patients on hemodialysis at Dr. Soetomo General Academic Hospital, Surabaya.

Methods: This was a descriptive retrospective study. The population was primary arteriovenous fistula failure patients. A total sampling method was used from the medical records of Dr. Soetomo General Academic Hospital, Surabaya, from January 2021 until January 2023. The research variables were gender, age, diabetes mellitus (DM) history, hypertension (HTN) history, duration of catheter double-lumen (CDL) usage before arteriovenous fistula placement, incidence of early thrombosis, and incidence of maturation failure. Data was analyzed with Microsoft Excel 2018.

Results: There were 28 primary arteriovenous fistula failure cases from 580 surgical procedures performed in the research period (4.8%). The dominant results were: 15 female patients (54%), 25 non-elderly patients (89%), 16 non-DM patients (57%), 14 patients in both HTN and non-HTN (50%), 20 prolonged CDL patients (71%), followed by 7 patients that did not use CDL (25%), 28 maturation failure patients (100%), and 18 non-early thrombosis patients (64%).

Conclusion: Female gender, duration of CDL usage, and maturation failure were the more prominent characteristics in this research profile. Meanwhile, the less prominent characteristics were old age, DM history, HTN history, and early thrombosis.

Highlights:
1. Arteriovenous fistula is preferred for dialysis vascular access.
2. Twenty-eight (4.8%) cases had primary arteriovenous fistula failure.

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Introduction

End-stage renal disease (ESRD) is still prevalent in Indonesia. According to the 11th Indonesian Renal Registry, 132,142 patients suffered ESRD in 2018.[1] Furthermore, their report showed that 99% of all renal replacement therapy is hemodialysis.[1] Following the fistula first initiative, arteriovenous fistula (AVF) became the gold standard for vascular access in hemodialysis patients. Although there is other permanent vascular access such as peritoneal dialysis (PD), it has many disadvantages, such as lack of trained health personnel and facilities in rural areas, inadequate reimbursements, and lack of knowledge from the public, making AVF more preferred in Indonesia.[2]

Primary AVF failure can be defined as early thrombosis (<24 hours post-surgery) or maturation failure (inability to cannulate for hemodialysis within 3 months of its creation).[3] Although there is no national epidemiological data regarding the prevalence of primary AVF failure in Indonesia, according to the research results from several hospitals in Indonesia by Tjang, *et al*. (2018), Darwis, *et al*. (2019), and Ismail, *et al*. (2021), each respective study's prevalence for primary AVF failure were 12%, 30.7%, and 27%, which could roughly be implied that the prevalence of primary AVF failure in Indonesia was around 23.24%.[4–6] There is no national survey on the prevalence of primary AVF failure. However, a similar study stated that the prevalence of primary AVF failure at a tertiary hospital in Yogyakarta, Indonesia, in 2021 was 27%.[6] According to the study regarding the association of primary AVF failure with mortality in hemodialysis patients from a total sample of 501 patients by Yap, *et al*. (2021), compared to patients with non-primary AVF failure, patients with primary AVF failure had a considerably increased risk of overall mortality (p=0.023).[7]

The debate about which risk factors promote primary AVF failure is still ongoing. Old age (>65 years old), female gender, history of diabetes mellitus (DM), and prolonged use of catheter double-lumen/CDL (>3 weeks) are found to be significant risk factors of primary AVF failure.[6,8–10] One study highlighted the effect of prolonged CDL use in elderly patients before AVF placement, which resulted in bloodstream infection, which led to intimal hyperplasia, which then caused either thrombosis or vascular stenosis, which eventually resulted in primary AVF failure.[11] Other studies found that a history of hypertension (HTN) significantly lowers the chance of primary AVF failure.[12,13] Furthermore, one study found that male patients are more likely to experience primary AVF failure compared to their female counterparts.[3] There is no study on the profile of primary AVF failure in ESRD patients on hemodialysis at Dr. Soetomo General Academic Hospital, Surabaya. This study aimed to determine the profile of primary AVF failure in ESRD patients on hemodialysis at Dr. Soetomo General Academic Hospital, Surabaya, from January 2021 until January 2023 regarding age, gender, history of DM, history of HTN, duration of CDL usage before AVF placement, the incidence of early thrombosis, and incidence of maturation failure.

Methods

This descriptive retrospective study aimed to determine the primary AVF failure profile in ESRD patients on hemodialysis at Dr. Soetomo General Academic Hospital, Surabaya, from January 2021 to January 2023. Descriptive means to describe the characteristics of participants. Retrospective means the outcome of interest has already occurred when participants enrolled, and the data are collected from medical records with no follow-up.[14] This study had received ethical clearance approval from the Ethics Committee of the Faculty of Medicine, Universitas Airlangga, and Dr. Soetomo General Academic Hospital, Surabaya (no. 1097/LOE/301.4.2/X/2022) on 24 October 2022.

The study population consisted of ESRD patients on hemodialysis with primary AVF failure at Dr. Soetomo General Academic Hospital, Surabaya, from January 2021 until January 2023. The sampling method used was total sampling for patients who met the inclusion criteria. The inclusion criteria were patients ≥18 years old and not pregnant. Samples who experienced secondary AVF failure (failure to cannulate after the first hemodialysis cannulation with AVF) and patients with incomplete data records were excluded.

The independent variables were age, gender, history of DM, history of HTN, and duration of CDL usage before AVF placement. Meanwhile, the dependent variables were the incidence of early thrombosis and maturation failure. Variables were collected from Dr. Soetomo General Academic Hospital, Surabaya, medical records with no follow-up, processed, and analyzed using Microsoft Excel 2018.[15] Data was presented as frequencies and percentages.

Results

Prevalence of Primary Arteriovenous Fistula Failure

Based on Table 1, this study found 28 patients with primary AVF failure out of 580 patients with an AVF from January 2021 until January 2023.

Table 1. Characteristics of patients with primary arteriovenous fistula failure

Characteristics	n	%
Age		
Non-elderly (18-65 years old)	25	89%
Elderly (>65 years old)	3	11%
Gender		
Male	13	46%
Female	15	54%
History of diabetes mellitus		
Positive	12	43%
Negative	16	57%
History of hypertension		
Positive	14	50%
Negative	14	50%
Duration of catheter double-lumen		
Did not use catheter double-lumen	7	25%
Non-prolonged (≤3 weeks)	1	4%
Prolonged (>3 weeks)	20	71%
Incidence of early thrombosis		
Positive	10	36%
Negative	18	64%
Incidence of maturation failure		
Positive	28	100%
Negative	0	0%

Source: Research data, processed

Age of Patients with Primary Arteriovenous Fistula Failure

According to Table 1, the dominating age group in this study was non-elderly (18-65 years old), with 25 patients (89%). The average age of all primary AVF failure patients was 48 years old.

Gender of Patients with Primary Arteriovenous Fistula Failure

From Table 1, there were slightly more female patients than male patients, as many as 15 patients (54%).

History of Diabetes Mellitus in Patients with Primary Arteriovenous Fistula Failure

Table 1 shows that surprisingly, more non-diabetic patients developed primary AVF failure than patients with a positive history of DM. There were 16 patients with a negative history of DM (57%).

History of Hypertension in Patients with Primary Arteriovenous Fistula Failure

Table 1 shows that the same number of patients experienced primary AVF failure, whether they had a positive or negative history of HTN. Each group had 14 patients (50%).

Duration of Previous Catheter Double-Lumen Usage in Patients with Primary Arteriovenous Fistula Failure

Based on Table 1, most primary AVF failure patients used CDL for a prolonged amount of time (>3 weeks), as many as 20 patients (71%). Next were 7 patients who did not use CDL before AVF (25%). Lastly, there was only 1 patient who did not use their CDL for a prolonged amount of time (≤3 weeks) (4%).

Table 2. Duration of catheter double-lumen usage in patients with primary arteriovenous fistula failure

Duration	n	%
Did not use catheter double-lumen	7	25%
≤3 weeks	1	3.5%
4 weeks	5	18%
5 weeks	1	3.5%
6 weeks	2	7%
8 weeks	3	11.5%
10 weeks	1	3.5%
12 weeks	4	14%
14 weeks	1	3.5%
16 weeks	1	3.5%
20 weeks	1	3.5%
36 weeks	1	3.5%
Total	**28**	**100%**

Source: Research data, processed

According to Table 2, most patients who prolonged their use of CDL used it for 4 weeks, as many as 5 patients (18%), followed by 4 patients who used it for 12 weeks (14%). The longest a patient used their CDL was 36 weeks (3.5%).

Incidence of Early Thrombosis in Patients with Primary Arteriovenous Fistula Failure

Table 1 shows that 10 patients (36%) suffered early thrombosis. The dominant group comprised 18 patients (64%) with a negative early thrombosis history.

Incidence of Maturation Failure in Patients with Primary Arteriovenous Fistula Failure

Based on Table 1, every patient that experienced primary AVF failure had maturation failure in this study (100%).

Table 3. Characteristics of patients with early thrombosis in primary arteriovenous fistula failure

Characteristics	Positive		Negative	
	n	%	n	%
Age				
Non-elderly	9	32%	16	57%
Elderly	1	4%	2	7%
Gender				
Male	5	17.5%	8	29%
Female	5	17.5%	10	36%
History of diabetes mellitus				
Positive	3	10%	9	32.5%
Negative	7	25%	9	32.5%
History of hypertension				
Positive	4	14%	10	36%
Negative	6	21%	8	29%
Duration of catheter double-lumen				
Did not use catheter double-lumen	2	7%	5	18%
Non-prolonged	0	0%	1	4%
Prolonged	8	28%	12	43%

Source: Research data, processed

Age of Patients with Early Thrombosis in Primary Arteriovenous Fistula Failure

According to Table 3, 9 early thrombosis patients were non-elderly (32%), while only 1 was elderly (4%).

Gender of Patients with Early Thrombosis in Primary Arteriovenous Fistula Failure

Table 3 shows that the number of early thrombosis patients in the male and female groups was the same, at 5 patients each (17.5%).

History of Diabetes Mellitus in Patients with Early Thrombosis in Primary Arteriovenous Fistula Failure

Table 3 shows that as many as 7 early thrombosis patients (25%) were non-diabetic. Meanwhile, only 3 early thrombosis patients had a positive history of DM (10%).

History of Hypertension in Patients with Early Thrombosis in Primary Arteriovenous Fistula Failure

Table 3 shows that most early thrombosis patients had a negative history of HTN, amounting to 6 patients (21%). Other than that, 4 patients had a positive history of HTN (14%).

Duration of Previous Catheter Double-Lumen Usage in Patients with Early Thrombosis in Primary Arteriovenous Fistula Failure

Table 3 shows that 8 patients (28%) of early thrombosis patients used their CDL in a prolonged manner (>3 weeks). Following this was the group of early thrombosis patients who did not use a CDL before AVF, as many as 2 patients (7%). Lastly, there were no early thrombosis patients who used their CDL in a non-prolonged manner (0%).

Discussion

This study showed the prevalence of primary AVF failure in ESRD patients on hemodialysis at Dr. Soetomo General Academic Hospital, Surabaya, as many as 28 cases or 4.8% of all AVF procedures performed from January 2021 until January 2023. A similar study showed an even higher prevalence at a tertiary hospital in Yogyakarta, Indonesia, at as much as 27%.[6] This could be because of the hospital's higher authority in Yogyakarta. In contrast, their hospital is a national-level reference hospital, whereas the hospital where this study was conducted is only a regional-level reference hospital.

This study found that there were more non-elderly patients than elderly primary AVF failure patients, as many as 25 cases or 89% of all primary AVF failure cases, and the average age was 48 years old. This finding is in line with the findings of Ismail *et al*. (2021), where not a single primary AVF failure patient was in the elderly category, and the average age was also the same in this study, which was 48 years old.[6] However, another study showed that elderly females (>65 years old) had a higher risk of developing primary AVF failure (p=0.0026).[16] Furthermore, a study by Wen, *et al*. (2019) showed that both old age (p=0.031) and female gender (p= 0.025) were independent risk factors for primary AVF failure.[10] The difference between these studies is perhaps due to the differences in research designs. This study and the study by Ismail, *et al*. (2021) used a cross-sectional study design, whereas Venkatnarayanan et al. (2020) (12 weeks and 24 weeks post-surgery) and Wen *et al*. (2019) (6-, 12-, and 24-months post-surgery) did follow-ups with their patients and could likely have a more accurate description of primary AVF failure patients' characteristics.[6,10,16]

In this study, the female gender was discovered to be the dominating gender, although not by a lot in primary AVF failure patients, as much as 15 cases or 54% of all primary AVF failure cases. This finding, however, is slightly different from Ismail, *et al*. (2021), where the gender ratio was 1:1, or the same between males and females.[6] Satam, *et al*. (2023) tested their hypothesis that anatomic and physiologic gender disparities might explain reduced maturation.[17] From their study, they found that the bigger postoperative arterial diameter in males (4.8±0.8 vs. 5.3±0.9 mm, p=0.039) was correlated with better maturation and a higher fistula inflow velocity, particularly in the humerus (747.0±570.4 vs. 1,117.1±471.3 cc/min, p=0.003), whilst in females, there was a significantly lower circulating monocyte count (8.5±2.0 vs. 10.0±2.6%, p=0.0168), suggesting that a difference in anatomical and physiological aspect might play a bigger role in AVF maturation between gender.[17] However, a study from the same hospital settings as this study by Saphira, *et al*. (2023) showed no significance between artery (p=0.922) and vein diameter (p=0.769) with the success rate of AVF surgery at Dr. Soetomo General Academic Hospital, Surabaya.[18] Furthermore, Dewi, *et al*. (2019) found that preoperative Doppler ultrasound assessment of flow-mediated dilatation (FMD) abnormality showed no association with AVF maturation success (p=1.00).[19] Unfortunately, this study could not include the results of the Doppler ultrasound and complete blood count in the profile because not all patient medical records at Dr Soetomo General Academic Hospital, Surabaya, did these diagnostic parameters.

Regarding the history of DM, this study surprisingly found more non-diabetic primary AVF failure patients, as many as 16 cases or 57% of all primary AVF failure cases. This finding is not aligned with the findings of Ismail *et al*. (2021), where a history of DM was a significant risk factor for primary AVF failure (p=0.004) even though more non-diabetics experienced primary AVF failure in their study (45 cases vs 9 cases).[6] This is perhaps due to the difference in study samples where their study included patent AVF patients in their analysis, whilst this study only included primary AVF failure patients. Furthermore, a meta-analysis by Yan, *et al*. (2018), with a total of 4,067 samples from 23 studies, found a history of DM to be significant (p<0.001).[8] However, a study from the same hospital setting as this study by Putra, *et al*. (2024) showed no significant difference in the durability of AVF patency between DM and non-DM patients (54.51 vs 56.20 days) due to infection or obstruction at Dr. Soetomo General Academic Hospital, Surabaya.[20] To add to the discussion, two previous studies with the same research location as this study, Dr. Soetomo General Academic Hospital, Surabaya, found two different conclusions regarding the correlation between DM and HTN. According to Sutadji, *et al*. (2023), most patients with type 2 DM in Dr. Soetomo General Academic Hospital, Surabaya, also had a history of HTN (OR=3.801, 95% CI=1.875-7.706, p<0.05).[21] Meanwhile, based on the findings of Ong (2022), the type 2 DM patients did not have a history of HTN (77.8%).[22] However, both studies found a similar result regarding the correlation between DM and dyslipidemia, which could suggest that a history of dyslipidemia may be present in primary AVF failure patients with a history of DM. Sutadji, *et al*. (2023) found that type 2 DM patients had a significantly low high-density lipoprotein (HDL) level (OR=3.356, 95% CI=1.650-6.827, p<0.05), a common predictor for dyslipidemia.[21] This finding aligns with Ong (2022), which found a direct correlation between type 2 DM and a higher occurrence of dyslipidemia (94.3%).[22]

This study concluded that the number of primary AVF failure patients with a positive and negative history of HTN was the same, as much as 14 cases each or 50% of all total cases of primary AVF failure, respectively. This finding aligns with Ismail, *et al*. (2021), where there was no significant correlation between primary AVF failure and a history of HTN (p=0.6).[6] Furthermore, Bahrami-Ahmadi, *et*

al. (2022) found that a positive history of HTN decreased the risk of primary AVF failure (OR, -2.67; 95% CI, -0.97 to -7.36, p=0.061).[13] The same result was also seen in an older study by Rezapour, *et al*. (2018), where primary AVF failure and HTN had a significant inverse relationship (Spearman's ρ=-0.160, p=0.005).[12] According to Kusnanto, *et al.* (2019), progressive muscle relaxation (PMR) positively impacted patients receiving hemodialysis regarding anxiety, blood pressure, and pulse.[23] Furthermore, superior therapeutic communication skills have been linked with better hypertensive patient care, according to Prasasta, *et al*. (2022).[24]

Lastly, in this study, prolonged duration of CDL usage before AVF surgery (>3 weeks) was the most dominant group, with as many as 20 cases or 71% out of all primary AVF failure cases. Most patients that prolonged their use of CDL used it for 4 weeks, as many as 5 patients (18%). This discovery aligns with the findings of Wongmahisorn (2019), where in his study, patients who had never used any central venous catheter (CVC) only had a primary AVF failure rate of 25.3%, while patients who had previously used tunneled and non-tunneled CVC were at a higher primary AVF failure rate (34.8% and 45.3%, respectively).[25] He suggested that non-tunneled CVC types should not be used beyond the recommendations of the Kidney Disease Outcomes Quality Initiative (KDOQI) Clinical Practice Guideline for Vascular Access: 2019 Update, i.e. >3 weeks.[26] In addition, Wen, *et al.* (2019) also showed that extended temporary catheter retention (57.59±49.66 days) was a significant risk factor for primary AVF failure (p=0.020).[10] Furthermore, based on the findings of Kazakova, *et al*. (2020), patients who started hemodialysis with CDL had a higher incidence of bloodstream infection that could potentially lead to intimal hyperplasia, which could potentially cause vascular stenosis and thrombosis, which could end up as primary AVF failure if the patients ever decided to switch to AVF from a prolonged use of CDL.[11] However, their study only used the elderly ESRD population, which might be biased to that specific age group.[11] In addition, according to the study by Sulistyaningsih, *et al*. (2022), which was also conducted in Dr. Soetomo General Academic Hospital, Surabaya, direct puncture is usually preferred as vascular access by medical staff and patients while waiting for AVF maturation which leads to a higher risk of the most common complications in regular hemodialysis patients, iatrogenic pseudoaneurysm, due to improper healing from the punctured artery.[27] They found that 9.6% of iatrogenic pseudoaneurysms cases resulted in AVF takedown due to difficult bleeding control or by infections requiring aggressive debridement, while the rest only required primary artery repair.[27]

To add to the discussion, Putra *et al*. (2023) found that in non-tunneled CDL users, the risk of thrombosis due to repeated catheterization and cases of infection at the catheter site was higher in patients with a history of DM than in non-diabetics.[28] Furthermore, Bara, *et al*. (2022) and Putra, *et al*., (2023) found that the location of the CDL insertion site also played a role in the risk of complications.[29,30] They found that the CDL insertion site in the internal jugular vein site lasted the longest, while the femoral vein site had the highest infection and thrombosis complication rate.[29,30] According to the literature review by Dananto, *et al*. (2022), aside from the CDL insertion tip, its catheter tip placement also affected developing recirculation, which is a condition when the dialyzed blood re-enters the systemic circulation without a full equilibration which could lead to intimal hyperplasia that leads to vascular stenosis and thrombosis which ends in primary AVF failure.[31] Their study showed that the catheter tip placement in the upper area (right atrium, superior vena cava, or cavoatrial junction) had a more promising outcome compared to the lower area (inferior vena cava or external iliac vein).[31] Aside from its duration, CDL seems to carry many potential risk factors for primary AVF failure, which should be explored in future studies.

Strength and Limitations

From this study, a profile about primary AVF failure in ESRD patients on hemodialysis at Dr. Soetomo General Academic Hospital, Surabaya, is known. This study is limited due to its design being a retrospective study with no follow-up, meaning potential external factors not written in the medical records are not included in the profile, and future studies should aim to expand from this limitation.

Conclusion

In conclusion, the following is the primary arteriovenous fistula failure profile in end-stage renal disease patients on hemodialysis in Dr. Soetomo General Academic Hospital, Surabaya. Primary AVF failure was more common in females than males and more common in the non-elderly than the elderly. Furthermore, fewer DM patients were experiencing primary AVF failure than non-DM patients. Hypertension patients and non-HTN patients had equal primary AVF failure incident rates. Most patients who prolonged their use of CDL before AVF placements had primary AVF failure. Lastly, the main etiology for primary AVF failure was maturation failure instead of early thrombosis. Future research should expand on the limitations of this study.

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Conflict of Interest

The authors declared there is no conflict of interest.

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Ethical Clearance

This study had received ethical clearance from the Ethical Committee for Health Research Dr. Soetomo General Academic Hospital, Surabaya (No. 1097/LOE/301.4.2/X/2022) on 24-10-2022.

Authors' Contributions

Designed the study and drafted the manuscript: MOR. Collected data and performed background literature review: MOR. Supervised results and discussion: YES, WW, and HS. All authors reviewed and approved the final version of the manuscript.

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