

Characteristics of Vascular Access Cannulation Complications in End Stage Kidney Disease Patients in West Java from 2018 to 2022: A Retrospective Observational Study

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Background: End-stage kidney disease (ESKD) is associated with a tremendous financial burden. Data in Indonesia shows an increasing number of patients with ESKD taking hemodialysis as a routine procedure every year. Establishment and maintenance of vascular access are important in the management of ESKD. Vascular complications that often arise due to hemodialysis are common and one of the main reasons for hospitalization. Cannulation complications ranged from minor hematomas to acute bleeding from pseudoaneurysms that required emergency surgical procedures. This study aims to assess the different clinicopathological characteristics of ESKD patients with vascular access cannulation complications and the surgical management related to the complications.

Materials and Methods: This research is a retrospective observational study. The research subjects in this study were ESKD patients in the vascular and endovascular surgery division of the tertiary hospital in West Java, Indonesia. There were 121 study subjects. Clinicopathological characteristics of vascular cannulation complications and surgical management are extracted from the medical record.

Results: Three major vascular complications were ruptured pseudoaneurysms 64/121 (52.9%), impending rupture pseudoaneurysms 28/121 (23.1%), and pseudoaneurysms 21/121 (17.4%). Common surgical procedures were ligation of the draining vein 47/121 (38.8%), arterial primary repair 28/121 (23.1%), and arterial patch repair 18/121 (14.9%). There was a significant relationship between symptoms of bleeding in ruptured pseudoaneurysms and bulging masses in pseudoaneurysms ($p = 0.001$). There was a significant relationship between the diameter of the vascular mass, vascular defect size, and hematoma and the type of surgical procedure taken ($p < 0.010$).

Conclusion: Ruptured, impending rupture, and pseudoaneurysms are major complications of vascular access in ESKD patients, and there was a significant relationship between the carried-out surgical procedure and the size of the vascular mass, defect, and hematoma.

Plain Language Summary: Chronic kidney failure is a particular challenge in terms of health problems in Indonesia. With the increase in kidney failure patients, the number of dialysis patients in this country has also sharply increased because blood dialysis is the main management for end-stage kidney failure. Dialysis treatment does not mean it is 100% safe; various complications can arise from the blood dialysis procedure. Many of the complications that arise are caused by problems with the blood vessels that serve as access to the dialysis machine. In this research, we aim to study the characteristics of blood dialysis complications related to blood vessel access. This study was conducted at one of the largest national hospitals in Indonesia, precisely in West Java province, which is the most populated province in Indonesia. In this study, we involved 121 end-stage kidney failure patients. This study is very important to carry out considering that around 30% of chronic kidney failure patients that were hospitalized have complications from blood vessels. We hope that this research can be used further in determining the best procedure for providing venous access for dialysis with all the limitations faced by developing countries.

Keywords: arteriovenous fistula, end-stage kidney disease, hemodialysis, pseudoaneurysm, vascular access

Introduction

End stage kidney disease (ESKD) is now widely acknowledged as one of the leading causes of death worldwide. Data from West Java, Indonesia, showed the 5-year survival rate for ESKD patients was 55%, and patients aged more than 55 years have a worse survival rate than younger patients.¹ The survival rate of patients with ESKD can be increased by undergoing hemodialysis (HD); therefore, the establishment of vascular access is very important for good and efficient HD continuity.^{2–4} Arteriovenous grafts (AVG), central venous catheters (CVC), and arteriovenous fistulas (AVF) are the three types of vascular access accessible for haemodialysis.^{3,4} For individuals with limited access choices or in an emergency setting with difficulties establishing vascular access, the superficial femoral vein or common femoral vein (CFV) may be a helpful hemodialysis access conduit.^{5–7} The most frequently used permanent vascular access is an arteriovenous fistula. The creation and maintenance of an AVF are two major challenges for the majority of hemodialysis patients.^{2–4}

Complications from vascular access are common and account for up to 36–39% of ESKD patients being hospitalized.^{2,3,8–10} The incidence of pseudoaneurysm formation is 5–60% in patients with AVF. Pseudoaneurysms can form at the artery, anastomosis site, or draining vein (matured vein in AVF). Pseudoaneurysms can form due to surgical procedures such as leakage, infection, repeated needle puncture, malpuncture of the artery, and inadequate pressure applied at the cannulation site after hemodialysis. Complications of ruptured pseudoaneurysms in AVF can cause bleeding and threaten the patient's life.^{3,8,9,11,12} Surgical management of the vascular access complication varies depending on the type of complication.^{10,11,13–15} This study aims to assess the different clinicopathological characteristics of ESKD patients with vascular access complications and the surgical management related to the complications.

Patients and Methods

Study Design and Setting

This research is a retrospective observational study in the West Java, Indonesian population, and follows the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines.^{16,17} The research subjects in this study were ESKD patients in the Vascular and Endovascular Surgery division of a tertiary general hospital in West Java from January 2018 to December 2022. The inclusion criteria for this study are ESKD patients with symptoms of an enlarged mass after cannulation at the vascular access site. We excluded vascular access complications from the arteriovenous fistula surgical procedure (leakage of anastomosis or failure of the AVF), vascular complications that were managed conservatively, patients who passed away before any surgical procedure, after intervention not related to hemodialysis, or central venous catheter (CVC) related complications. The study selection process is shown in [Figure 1](#). The hospital ethics committee approved the study before it was conducted.

Data Collection

Patient characteristics, clinicopathological data, and surgical procedure details were extracted from the medical record. Patient characteristics that were collected were age and sex. Clinicopathological data included: ESKD duration, risk factors or etiology for ESKD, hemodialysis time, subjective symptoms, diagnosis, the use of vascular access type, the location of the vascular complications, and the hemoglobin level and leucocyte count. Surgical procedure data were surgical procedure taken, vascular mass largest diameter, vascular defect size, and volume of the hematoma. The diagnoses that were obtained included: giant draining vein, ruptured pseudoaneurysm, impending ruptured pseudoaneurysm, pseudoaneurysm, and hematoma as shown in [Figure 2](#).

Definition of Variables

Some variable definitions in this study were as follows: The ESKD patient was diagnosed according to the Kidney Disease Improving Global Outcomes (KDIGO) Foundation 2012 guidelines, and end-stage kidney disease or renal failure was defined as a patient with a glomerular filtration rate less than 15 mL/min.¹⁸ The etiologies and risk factors (such as diabetes and hypertension) of the ESKD are based on the anamnesis and the nephrologist's investigation of the patient's history prior to the initiation of hemodialysis. Cannulation complications from vascular access in ESKD patients were diagnosed using the Marfen and Hapsari criteria, as shown in [Table 1](#), with ultrasound criteria as shown in [Figure 3](#). The

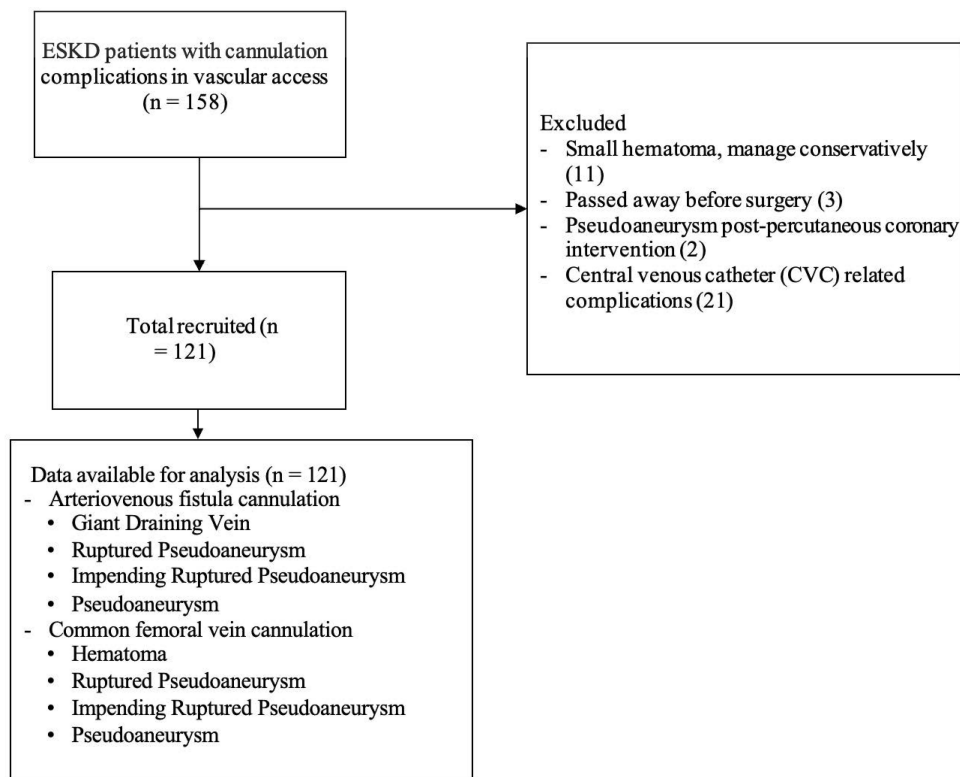


Figure 1 The flowchart of the study selection process.



Figure 2 Clinical pictures of the cannulation complications from vascular access in ESKD patients: (A) Giant draining vein shown as a long pulsatile mass in the draining vein; (B) Ruptured pseudoaneurysm covered with a blood crust; (C) Impending rupture pseudoaneurysm with tense and glistening skin; (D) Pseudoaneurysm shown as a pulsatile mass without pain or bleeding; (E) Hematoma with bruise.

surgical procedures that were used in the research subjects followed the Marfen and Hapsari flowchart of the surgical procedure for cannulation complications from vascular access in ESKD patients, as shown in Figure 4. Locations of the mass from patient complaints were divided according to the site of cannulation. The upper arm and antecubital fossa masses were caused by complications of brachiocephalic AVF, while the lower arm mass was caused by radiocephalic AVF. The vascular mass diameter was calculated from the size of the apparent mass using a caliper. The vascular defect size was measured during the operation by calculating the size of the defect vessel within a pseudoaneurysm using a sterile ruler. The volume of the hematoma was assessed by drawing the blood in the hematoma into a syringe.

Statistical Analysis

The statistical analysis of the variable was performed using SPSS 26 software (SPSS Inc., Chicago, IL, USA). Each quantitative variable is written as a percentage, and its numerical value is listed as the mean, standard deviation, median,

Table 1 Marfen and Hapsari Criteria for Cannulation Complications from Vascular Access in End-Stage Kidney Disease (ESKD) Patients

Criteria	Giant Draining Vein	Hematoma	Ruptured Pseudoaneurysm	Impending Ruptured Pseudoaneurysm	Pseudoaneurysm
Risk factors	- Recurrent hemodialysis needle puncture at the same site - Skin infection - Accidental arterial puncture - Inadequate pin point pressure after hemodialysis cannulation				
Clinical findings	Long pulsatile mass in the draining vein	Non-pulsatile mass with bruise surrounding the vascular access	Painful pulsatile mass, with active bleeding, might be covered with dried blood crust	Painful pulsatile mass, without active bleeding, with tense and glisten skin	Pulsatile mass without pain or bleeding
Ultrasound	A substantial draining vein dilatation with a diameter greater than 2 cm.	Acute hematoma without visible internal blood flow during color Doppler ultrasound.	The yin-yang sign on Doppler ultrasound denotes bidirectional flow as a result of the blood swirling within the pseudoaneurysm.		

minimum, and maximum. The Shapiro–Wilk test was used to determine the normality of the data distribution, and with a normal distribution, the comparison of the variables' means was based on the ANOVA test. The variables with zero (0) values were treated as missing values and excluded from the analysis. The p value < 0.050 indicates a significant relationship.

Results

Study Population Characteristics

As described in Table 2, 121 patients were included in the study. There were 69 women and 52 men patients. The mean age was 46.1 ± 13.41 years. The ESKD duration mean was 25.02 ± 31.3 months. The majority etiology for the ESKD was hypertension (78.5%) and both hypertension and diabetes (11.7%). Hemodialysis is mostly scheduled for two times a week (86.8%). The symptoms for cannulation complications from vascular access were a bulging mass, a painful mass, and bleeding from the mass (100%, 89.2%, and 55.4%, respectively). Most of the diagnoses were ruptured pseudoaneurysms (52.9%), impending rupture pseudoaneurysms (23.1%), and pseudoaneurysms (17.4%). The vascular access that was used for hemodialysis was mostly from the arteriovenous fistula (73.6%), and the rest was from the common femoral vein (26.4%). The location of the vascular complications was mostly at the left forearm, left antecubital fossa, and left femoral (27.3%, 26.4%, and 14%, respectively). The mean hemoglobin level and leucocyte count were 7.27 ± 1.91 g/dL

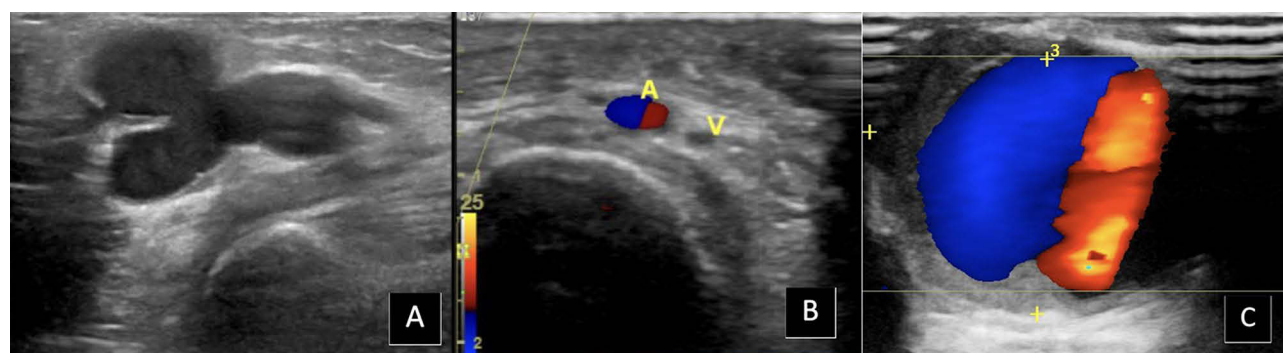
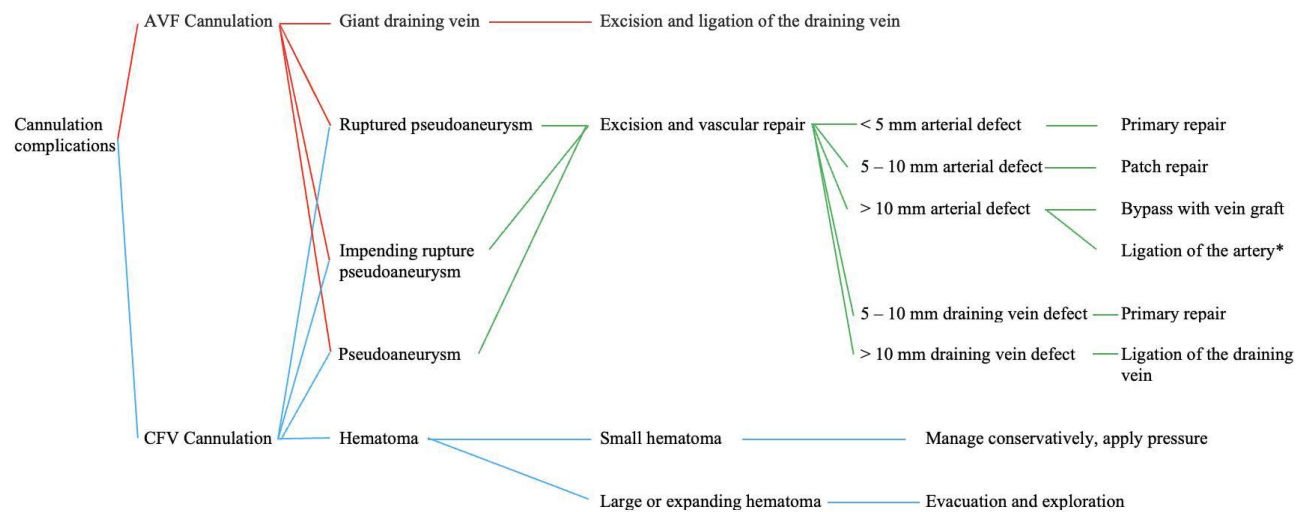


Figure 3 Ultrasound of the cannulation complications from vascular access in ESKD patients: (A) Giant draining vein shown as an enlarged draining vein more than 2 cm in diameter; (B) Acute hematoma visible as hypoechoic appearance without internal blood flow during color Doppler; (C) The yin-yang sign on Doppler ultrasound within the pseudoaneurysm.



AVF: Arteriovenous Fistula, CFV: Common Femoral Vein

*Infection or available collateral artery

Figure 4 The Marfen and Hapsari flowchart of the surgical procedure for cannulation complications from vascular access in ESKD patients.

and $11,616 \pm 6167$ / μ L. The majority of the surgical procedures for cannulation complications for vascular access were draining vein ligation, arterial primary repair, and arterial patch repair (38.8%, 23.1%, and 14.9%, respectively). The mean of the vascular mass largest diameter, the vascular defect, and the hematoma volume were 5.42 ± 3.38 cm, 8.79 ± 10.09 mm, and 87.93 ± 20 cc, respectively.

Table 2 Characteristics of Research Subjects

Variable		Proportion (%)
Age	Mean	46.1 $\pm$ 13.41 years
	Median	46 years
	Minimum	11 years
	Maximum	82 years
Sex	Man	52 (43%)
	Woman	69 (57%)
End-stage kidney disease Duration	Mean	25.02 $\pm$ 31.3 months
	Median	10 months
Risk for End-stage kidney disease	Hypertension	95 (78.5%)
	Diabetes	6 (5%)
	Hypertension and Diabetes	14 (11.7%)
	Congenital anomalies of the kidney and urinary tract (CAKUT)	1 (0.8%)
	Nephrolithiasis	1 (0.8%)
	Polycystic kidney disease	1 (0.8%)
	Preeclampsia	1 (0.8%)
	Post-Partum Cardiomegaly (PPCM)	1 (0.8%)
	Pyelonephritis	1 (0.8%)

(Continued)

Table 2 (Continued).

Variable		Proportion (%)
Hemodialysis	Once a week	9 (7.4%)
	Two times a week	105 (86.8%)
	Three times a week	7 (5.8%)
Subjective symptoms	Bleeding from the mass	67 (55.4%)
	Painful mass	108 (89.2%)
	Bulging mass	121 (100%)
Vascular access	Arteriovenous Fistula	89 (73.6%)
	Common femoral vein	32 (26.4%)
Diagnosis	Arteriovenous fistulas cannulation	
	- Giant draining vein	1 (0.8%)
	- Ruptured pseudoaneurysm	58 (47.9%)
	- Impending ruptured pseudoaneurysm	19 (15.7%)
	- Pseudoaneurysm	11 (9.1%)
	Common femoral vein cannulation	
	- Ruptured pseudoaneurysm	6 (5%)
	- Impending ruptured pseudoaneurysm	9 (7.4%)
	- Pseudoaneurysm	10 (8.3%)
	- Hematoma	7 (5.8%)
Location	Right Upper Arm	1 (0.8%)
	Left Upper Arm	10 (8.3%)
	Right Antecubital Fossa	2 (1.7%)
	Left Antecubital Fossa	32 (26.4%)
	Right Forearm	11 (9.1%)
	Left Forearm	33 (27.3%)
	Right Femoral	15 (12.4%)
	Left Femoral	17 (14%)
Hemoglobin level	Mean	7.27 ± 1.91 g/dL
	Median	7.1 g/dL
	Minimum	2.0 g/dL
	Maximum	12.0 g/dL
Leucocyte count	Mean	11,616 ± 6167 /μL
	Median	10,100 /μL
	Minimum	2140 /μL
	Maximum	40,220 /μL
Surgical procedure	Vein ligation	1 (0.8%)
	Hematoma evacuation	6 (5%)
	Draining vein repair	4 (3.3%)
	Draining vein ligation	47 (38.8%)
	Arterial ligation	10 (8.3%)
	Arterial bypass with vein graft	7 (5.8%)
	Arterial patch repair	18 (14.9%)
	Arterial primary repair	28 (23.1%)
Vascular mass diameter	Mean	5.42 ± 3.38 cm
	Median	4.0 cm
	Minimum	1 cm
	Maximum	20 cm

(Continued)

Table 2 (Continued).

Variable		Proportion (%)
Vascular defect	Mean	8.79 ± 10.09 mm
	Median	8.0 mm
	Minimum	0 mm
	Maximum	100 mm
Hematoma volume	Mean	87.93 ± 20 cc
	Median	20 cc
	Minimum	5 cc
	Maximum	1200 cc

ANOVA Analysis of Diagnosis and Subjective Symptoms, Hemoglobin, and Leucocyte

In the ANOVA analysis among diagnosis and subjective symptoms, the mean duration of bleeding from the mass and bulging mass were statistically significant ($p = 0.001$) as shown in Table 3. The diagnosis of mean differences in hemoglobin showed a significant relationship ($p = 0.001$) as shown in Table 4.

ANOVA Analysis of Surgical Procedure and Vascular Mass Diameter, Vascular Defect, and Hematoma Volume

In the ANOVA analysis among surgical procedure and vascular mass diameter, vascular defect, and hematoma volume. All of them showed a significant relationship ($p < 0.010$) as shown in Table 5.

Discussion

This is a single-center retrospective observational study describing and analyzing cannulation complications from vascular access in ESKD patients. The research subjects in this study were more women than men, and the mean age

Table 3 ANOVA Analysis Between Diagnosis and Mean Differences of Subjective Symptoms (Days)

Diagnosis	Mean of Bleeding from the Mass ($p = 0.001$)	Painful Mass ($p = 0.110$)	Bulging Mass ($p = 0.001$)
Giant draining vein	0	0	365
Hematoma	3.14 ± 5.42	6.29 ± 4.23	6.0 ± 4.24
Ruptured Pseudoaneurysm	2.14 ± 2.14	10.19 ± 10.77	20.03 ± 23.57
Impending Ruptured Pseudoaneurysm	0	21.79 ± 31.12	26.79 ± 35.49
Pseudoaneurysm	0	14.10 ± 26.57	40.29 ± 33.15

Notes: A p value < 0.05 (bolded) indicates significant differences. The variables with zero (0) values were treated as missing values and excluded from the analysis.

Table 4 ANOVA Analysis Between Diagnosis and Mean Differences of Hemoglobin and Leucocytes

Diagnosis	Mean of Hemoglobin ($p = 0.001$)	Mean of Leucocytes ($p = 0.444$)
Giant draining vein	12 ± 0	6070 ± 0
Hematoma	7.28 ± 2.25	11,460 ± 3337
Ruptured Pseudoaneurysm	6.69 ± 1.74	12,082 ± 6997
Impending Ruptured Pseudoaneurysm	8.08 ± 1.81	12,300 ± 5488
Pseudoaneurysm	7.71 ± 1.79	9602 ± 4776

Note: A p value < 0.05 (bolded) indicates significant differences.

Table 5 ANOVA Analysis Between Surgical Procedure and Mean Differences of Vascular Mass Diameter, Vascular Defect, and Hematoma Volume

Surgical Procedure	Mean of Vascular Mass Diameter in Centimeter ($p = 0.002$)	Mean of Vascular Defect in Millimeter ($p = 0.001$)	Mean of Hematoma Volume in Milliliter ($p = 0.001$)
Vein ligation	10 ± 0	10 ± 0	200 ± 0
Hematoma evacuation	7.83 ± 3.43	0.33 ± 0.81	366.67 ± 437.79
Draining vein repair	5.0 ± 3.91	8.5 ± 8.58	60.0 ± 93.45
Draining vein ligation	4.06 ± 1.81	9.85 ± 4.17	30.32 ± 33.85
Arterial ligation	4.0 ± 1.24	12.6 ± 7.12	26.0 ± 27.86
Arterial bypass with vein graft	5.57 ± 2.76	27.14 ± 32.38	171.43 ± 366.62
Arterial patch repair	6.89 ± 4.62	9.33 ± 4.32	83.33 ± 77.0
Arterial primary repair	6.61 ± 4.10	2.5 ± 1.0	129.11 ± 151.53

Note: A p value < 0.05 (bolded) indicates significant differences.

was 46 years. The data was similar in several studies that showed the prevalence of ESKD was higher in women than men, but the average was mostly in their fifties.^{19–22} Multicenter studies in Indonesia in 2018 and 2023 showed that the mean age of patients with ESKD was 44 years and the median was 52 years. There is an increasing trend in the younger population, and there were some statements that these facts correlated with higher risk in the obese population, physical inactivity, and metabolic disorders such as diabetes that are increasing in the younger population. Viral hepatitis is also one of the independent risk factors proposed to be linked with the increasing number of ESKD patients in the younger population in Indonesia.^{23,24}

In this study, the duration of ESKD before the patient developed a cannulation complication from vascular access was 25 months, or two years. According to several studies with follow-up ranging from one year to five years, a vascular access complication may appear as early as three months, with an incidence of 0.03 to 0.24 events per 1000 days. A number of factors, such as patient comorbidities, surgical technique, vessel quality, vascular access care, and vascular access monitoring, are risk factors that increase the likelihood of vascular complications but are not frequently reported.^{11,12,25–28} Data from a global report and several studies show that the etiologies of ESKD are mostly diabetic (ranging from 30 to 50%) and hypertension (27%).^{29–33} In Indonesia, hypertension is still the most common etiology for ESKD (39%), followed by diabetes (22%). In this study, the major etiology for ESKD was hypertension (78.5%), followed by both hypertension and diabetes (11.7%).³⁴ The majority of the subjects require HD twice a week (89.2%), while others require HD less than twice a week. This twice-a-week schedule usually occurs on Monday and Thursday, Tuesday and Friday, or Wednesday and Saturday. Conventional HD does not usually run on Sunday, except for emergency ESKD patients. Other countries implement thrice-weekly HD as a regular treatment for ESKD patients, and several studies stated that more frequent dialysis correlated with better hypertension and hyperphosphatemia control and had a better effect on physical health and functioning.^{35–37} Other studies also reported that a higher frequency of hemodialysis was correlated with an increase in vascular access complications.^{38,39}

The subjective symptoms of the subjects with cannulation complications from vascular access are a bulging mass, a painful mass, and bleeding from the mass (100%, 89.2%, and 55.4%, respectively). Thrombosis, oedema, bleeding, infection, clotting, pain, and an enlarged vessel (aneurysm) are common symptoms of vascular access complications.^{40–42} In this study, there was only one case of a giant draining vein. A giant draining vein is not showing signs of bleeding or pain, and there was no change in the hemoglobin. As seen in Table 4, the hemoglobin was 12 ± 0 . The subjective symptoms of bulging mass were experienced by the patient long enough (a year) before they sought medication at the hospital.

This study only describes the three major symptoms of ESKD patients experiencing vascular access cannulation complications; even with this limitation, the data show that these three symptoms are associated with each other. The first stage in the formation of a pseudoaneurysm after injury to the vascular wall is hematoma formation with turbulent blood flow, which will lead to the bulging mass whether or not it hurts. If the blood flow does not cease on its own, a wall made of the by-product of the clotting cascade will form, and if this wall ruptures, bleeding will manifest as a symptom.⁴³ In a pseudoaneurysm, necrotic cells, macrophages, and other inflammatory cells surround what's left of the intimal layer. In an aneurysm, there are three layers of the vessel wall: the intimal layer, the mid-layer (media), and the adventitia, as shown in Figure 5.

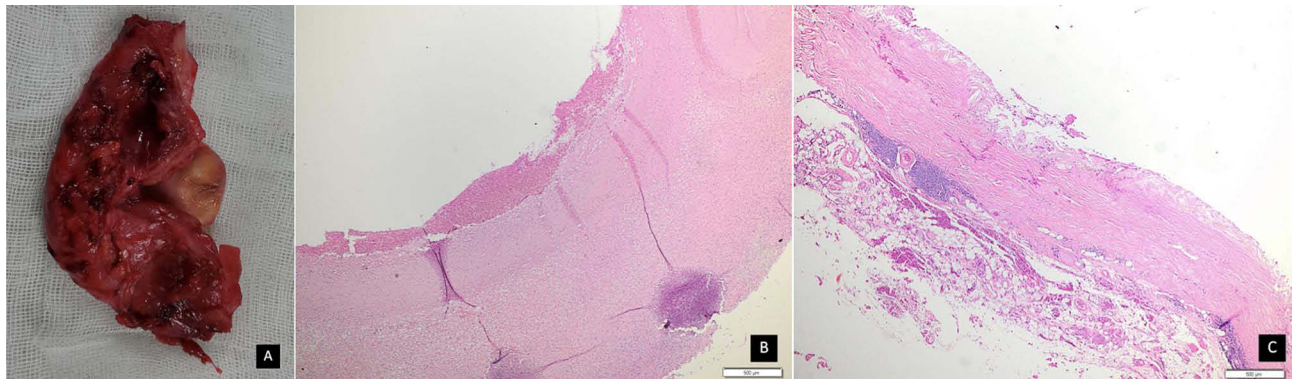


Figure 5 Excised pseudoaneurysm and histological pictures of pseudoaneurysm and aneurysm: **(A)** An excised draining vein pseudoaneurysm; **(B)** Pseudoaneurysm histological examination showed a faint vascular appearance with numerous necrotic cells, hemosiderin deposits, macrophages, and stromal fibro-collagen tissue partially hyalinized with massive scattering of inflammatory cells, including lymphocytes, polymorphonuclear leukocytes, and eosinophils; **(C)** Aneurysm histological examination showed the tunica intima with a completely erosive endothelium and a fibro-collagenous fibrous connective tissue stroma covered with inflammatory cells, lymphocytes, and histiocytes; the tunica media is composed of partially fibrotic muscle cells with a normal nucleus; and the tunica serosa consists of connective tissue accompanied by mature adipose tissue with a normal nucleus.

The ANOVA analysis showed that the mean (days) of the ESKD patients experiencing the symptom of bleeding had a significant difference with the diagnosis of hematoma and ruptured pseudoaneurysm ($p = 0.001$), this showed that patients with ruptured pseudoaneurysm came earlier to the hospital than patients with hematoma. While the mean (days) of the symptom of bulging mass had a significant difference with the diagnosis of pseudoaneurysm than other diagnoses ($p = 0.001$), this showed that patients with pseudoaneurysm who only experienced bulging mass without bleeding or pain took a longer time to seek treatment than patients with hematoma, ruptured, or impending ruptured pseudoaneurysm as shown in Table 3. The analysis between the mean differences of hemoglobin and leucocytes and the diagnosis of vascular complications is shown in Table 4. There were significant differences between the means of hemoglobin. A patient with a ruptured pseudoaneurysm had lower hemoglobin due to bleeding than other diagnoses ($p = 0.001$).

This study reported that more than a quarter of the subjects received HD through the CFV as their regular vascular access (26.4%). The use of the CFV is usually combined with the use of the upper limb's superficial veins, such as the cephalic vein at the antecubital fossa. The blood to the dialysis machine comes from the CFV cannulation, and the blood from the dialysis machine returns back to the body from the cephalic vein,⁴⁴ as shown in Figure 6. The use of the CFV as hemodialysis access is not recommended for regular use. However, in emergency settings where establishing vascular access through a central venous catheter seems difficult, the CFV can be used.^{5,45} In West Java, the CFV is usually used as vascular access for HD in the emergency patient, but previous reports showed that patients who were against the surgical procedure for the creation of an AVF or the insertion of a CVC preferred to use the CFV as routine HD access.⁴⁶



Figure 6 Cannulation of the AVF and the CFV: **(A)** The cannulation of the AVF, the outflow (red) placed on the proximal draining vein, and the inflow (blue) placed on the distal draining vein; **(B)** The cannulation of the CFV, the outflow (red) placed on the CFV, and the inflow (blue) placed on the cephalic vein.

The most common diagnosis of cannulation complications in this study combined from the AVF and CFV cannulation was ruptured pseudoaneurysm (52.9%); the second was impending rupture pseudoaneurysm (23.1%); and then pseudoaneurysm (17.4%). In our knowledge, this is the first report that categorized the diagnosis of pseudoaneurysm from vascular access into three categories: ruptured, impending rupture, and pseudoaneurysm, as described in Table 1. The purpose of the categorization was to determine the emergency procedure that needed to be taken and the possible complications that might arise for ruptured and impending rupture. Hemodialysis and surgical procedures need to be done in an emergency, while for pseudoaneurysms, the procedure can be done electively. The relationship between low hemoglobin levels and the diagnosis of ruptured pseudoaneurysm and hematoma was significant ($p = 0.001$).

As shown in Figure 4, the diagnosis of vascular complications, size, and site of the defect greatly affect the surgeon's choice of surgical procedure. Small defects in the artery or vein were repaired with simple repair, but large defects in the artery need to be repaired with bypass or ligation, while large defects in veins need to be ligated. Table 5 shows an analysis of the mean differences in vascular mass diameter, vascular defect, hematoma volume, and the surgical procedures done for the vascular complications. The analysis showed that hematoma evacuation has a significant relationship with the largest mean of vascular mass diameter ($p = 0.002$), the arterial bypass with vein graft procedure has a significant relationship with the largest mean of vascular defect ($p = 0.001$), and hematoma evacuation has a significant relationship with the largest mean of hematoma volume ($p = 0.001$). The mean of vascular diameter for vein ligation procedure is larger than other procedures, this mean that defect of the vein might resulted in larger bulging mass than the arterial defect.

The strength of this study is that, to our knowledge, this is the first study to describe the use of common femoral veins as routine vascular access in developing countries. The limitations of the study are that the data on the patient factors such as comorbidities of the patients was not collected and described, especially the comorbid of atherosclerosis and infection that greatly affected the formation of pseudoaneurysm; the data from the follow-up after the surgical procedure was not collected; and the vascular access that was used after the surgical procedure was not described. The use of the common femoral vein as vascular access needs to be studied more, as in West Java, Indonesia, it still remains an option for hemodialysis access.

Conclusion

Ruptured, impending rupture, and pseudoaneurysms are major complications of vascular access in ESKD patients, with three main symptoms: bulging mass, pain, and bleeding. The diagnosis of vascular complications is important to determine the surgical procedure and technique to repair and preserve the vascular access.

Data Sharing Statement

All data and tables used to support the findings of this study are included within the article and available upon request to the corresponding author.

Ethical Declaration

This research was carried out in accordance with the Declaration of Helsinki, and the Dr. Hasan Sadikin Hospital ethics committee approved the study with No. Ethical Approval LB.02.01/X.6.5/202/2020.

Provenance and Peer Review

Not commissioned, externally peer-reviewed.

Statements and Declarations

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors affirm that they have no known financial or interpersonal conflicts that would have appeared to have an impact on the study presented.

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