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Assessment of the performance of vascular access for hemodialysis

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Abstract

Background: Life and quality of life on hemodialysis depends on adequate vascular access. An autogenous arteriovenous fistula (AVF) has the best performance, while the use of a central venous catheter (CVC) may have a negative impact on fistula performance and may be associated with increased systemic inflammation. Our objective is to evaluate the performance of vascular accesses in patients undergoing a chronic hemodialysis program.

Methods: This is an observational, cross-sectional, and descriptive study that included patients on chronic hemodialysis for more than 90 days. Patients with an acute systemic inflammatory disease and those with acute cardiovascular illness were excluded. Clinical data, dialysis session parameters, and serum levels of inflammatory markers were evaluated.

Results: A total of 91 patients were evaluated, 59 (65%) had an AVF and 32 patients (35%) had a CVC. The adequacy rate was 67%; being 67.8% with AVF and 65.6% with CVC. Among the causes of AVF inadequacy, the ones that presented the highest prevalence ratio (PR) were non-mature AVF (PR: 4.055; 95% CI: 2.017–8.151), pseudoaneurysm (PR: 6.580; 95% CI: 3.723–11.629) and presence of hematoma (PR: 4.360; 95% CI: 2.125–8.946), $p < 0.001$. Among the catheter group, the causes of inadequacy with the highest PR were the presence of access thrombosis, indicating the use of thrombolytics (PR: 11.103; 95% CI: 4.746–25.977; $p < 0.001$) and infection (PR: 2.984; 95% CI: 1.293–6.889; $p = 0.010$). Median primary AVF patency was 72 months compared to 7 months of catheters ($p < 0.001$). There was no significant difference in serum inflammatory markers between the two groups.

Conclusions: Adequacy rates of vascular accesses did not differ between the groups, but the primary and functional patency of AVF is 10 times higher than that of catheters. Infection in dialysis catheters is associated with worse access performance. There was no association between systemic inflammation and vascular access.

Keywords

Vascular access, hemodialysis, arteriovenous fistula, central venous catheter, chronic kidney disease, inflammatory markers, ultrasound monitoring

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Introduction

Chronic kidney disease (CKD) is a worldwide public health problem, with an estimated global prevalence in 2017 of 9.1% and an estimated mortality of 1.2 million people.[1,2]

According to the KDOQI (Kidney Disease Outcomes Quality Initiative), patients with kidney failure should have an *End-Stage Kidney Disease Life-Plan*, an individualized plan for renal replacement therapy.[3] Hemodialysis vascular access is through a central venous catheter (CVC), an arteriovenous fistula (AVF), or a prosthetic arteriovenous graft (AVG). Autogenous AVF is the first choice,[4] followed by prosthetic AVGs. The last option is a catheter.[4] The best patency rates and lowest rates of infection, reintervention, morbidity and mortality are with AVF.[5–7] CVCs

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may be non-tunneled (short-term) or "permanent" tunneled catheter.[3,4]

An adequate access must be functional, enabling an effective dialysis session over a period of at least six sessions for 30 days, with blood flow of at least 300 mL/min during the session. It must be a mature AVF, cannulated by two needles and without signs of dysfunction, or by a central venous catheter without signs of dysfunction.[4] To be considered mature an AVF must also be easily compressible, with a palpable thrill, and an audible murmur. Echo-Doppler velocimetric parameters of a mature AVF are vein diameter greater than 6 mm, fistula flow greater than 600 mL/min, and vein depth in relation to the dermal surface of less than 6 mm.[4,8] AVF dysfunctions can be stenotic (thrombosis or hemodynamically significant stenosis) or non-stenotic (steal syndrome, pseudoaneurysm, hematoma, or infection).[3]

CVC is an alternative access, preferably tunneled, and it is acceptable to use non-tunneled CVC for up to 2 weeks.[3] In our institution, the non-tunneled CVC is used in inpatients, as a bridge to definitive access, for up to 4 weeks. Besides, there are several restrictions in our health care system for the use of tunneled catheters and AV grafts, resulting in extended use of catheters. To be an adequate dialysis access, the CVC must be functional and allow an effective dialysis session with a blood flow rate greater than 300 mL/min for at least six sessions in 30 days.[4] Catheter dysfunction may have qualitative criteria including failure to maintain flow for an adequate hemodialysis session within the first 60 min despite an attempt to improve flow.[3,9,10] Quantitative criteria include the first occurrence of a peak flow of less than 200 mL/min for 30 min of dialysis or a mean blood flow less than 250 mL/min during two consecutive hemodialysis sessions or inability to start hemodialysis resulting from inadequate blood flow, despite attempts to restore patency.[4]

CKD has a pro-inflammatory phenotype. The chronic inflammatory state is multifactorial and associated with elevated serum levels of acute-phase inflammatory proteins and several immuno-inflammatory mediators.[11,12] Interleukin 6 (IL-6) is a pro-inflammatory cytokine, induces the production of acute phase proteins such as C-reactive protein (CRP) and fibrinogen, and it stimulates the proliferation of mesangial cells, which appears to be the most robust predictor of comorbidity and outcome in CKD.[11,12] Interleukin 10 (IL-10) functions as a general immunosuppressive cytokine, has immunomodulatory properties, and regulates renal function.[13,14] The use of a CVC may contribute to systemic inflammation.[15–17]

The present study aims to evaluate the performance of vascular accesses in patients undergoing hemodialysis at the Dialysis Unit in São Lucas Hospital and to associate it with the infection rate, patency, and systemic inflammatory status.

Methods

This is an observational, cross-sectional, and descriptive study including 91 patients in a chronic hemodialysis program at São Lucas Hospital. Patients on hemodialysis for less than 90 days, with acute systemic inflammatory disease, and those with acute cardiovascular illness were excluded.

Clinical and demographic data, dialysis access information, effectiveness of the dialysis session, assessment of AVF by echo-Doppler, and measurement of inflammatory markers (leukocytes, interleukin-6, and interleukin-10) were evaluated. The sample size calculation was based on a subjective pre-analysis by the dialysis nurses regarding the adequacy rate and functionality of all access. Their impression was that the rate of adequacy was 89% for AVF and 59% for CVC. Considering a statistical power of the test of 80% ($b = 20\%$) and α of 5%, a sample size of 47 patients with AVF and 31 with catheter was calculated. The study initiated after approval by the ethics and research committee.

A SonoSite M-turbo echograph, linear transducer, was employed. A mature fistula was defined as an access allowing cannulation using two needles for a period of at least six sessions during 30 days, with a palpable thrill and audible murmur. Maturation was further defined with a vein diameter >6 mm; fistula flow >600 mL/min, and vein depth <6 mm. AVF thrombosis was diagnosed by the absence of flow in color Doppler and spectral mode. Hemodynamically significant stenosis was defined by luminal narrowing equal to or greater than 50% in B mode, compared to the normal vascular segment (artery or vein) located upstream of the AVF stenosis. In addition to that, we also considered flow turbulence in color Doppler mode (aliasing) and spectral criteria such as increased velocities (VPS and VDF) associated with a VPS ratio (VPS stenosis/VPS 2 cm proximal artery) greater than 3 for arterial stenosis and VPS ratio (VPS stenosis/VPS 2 cm caudal vein) greater than 2 for venous stenosis. Pseudoaneurysms were defined as blood surrounded by tissue, which communicates with the fistula or prosthetic graft through a neck. Hematomas were defined as a well-delimited, non-color-stained echogenic collection in the topography of the fistula puncture site. Steal syndrome was defined by reversed flow direction in the radial artery distal to the AVF, considered a complete steal, or spectral wave distal to the biphasic AVF, considered a partial steal, and was corroborated by normalization of the distal arterial flow direction when compressing the AVF. Catheter dysfunction was defined by first occurrence of a peak flow of less than 200 mL/min for 30 min during hemodialysis, mean blood flow of less than 250 mL/min during two consecutive dialysis sessions, or by failure to maintain an adequate flow in the first 60 min of the session according to the subjective opinion of the care team. Vascular access infection

was characterized by bacteremia (positive blood culture from the catheter, fistula, or peripheral access, in a patient with no other source of infection) and/or inflammatory signs at the catheter insertion, subcutaneous tunnel, or in the fistula, regardless of a positive blood culture test.

Blood was collected during the monthly routine lab analysis. Blood was centrifuged, plasma was frozen, and interleukin-10 and interleukin-6 levels were measured. Samples were retrieved, thawed, and used for measurements using ELISA (Sigma-Aldrich dosing kit).

The AVF was considered adequate when the pump blood flow and effective blood flow was >300 mL/min. It should be mature and have a puncturable extension >10 cm, absence of stenosis, steal syndrome, pseudoaneurysm, infection, flow-restrictive hematoma, or complications. The adequate CVC should have a pump and effective flow >300 mL/min, no infection, nor require thrombolytics. The catheter should have no sign of dysfunction.

SPSS software was used to analyze data. Normal distribution was verified with the Kolmogorov-Smirnov test, according to their symmetry described as mean (standard deviation) or median (interquartile range). Categorical data were described by absolute and relative values. Means were compared using *Student's T*-test and the median with Mann-Whitney test. Chi-square and Fisher's exact tests were used for categorical variables. Prevalence ratio was used for measures of association that aimed to measure the relationship between binary outcome and exposure variable. The evaluation of the outcome variable, vascular access performance, was evaluated using the Chi-square test, logistic regression, and odds ratio as a measure of association. Correlations between quantitative variables were evaluated using the Spearman correlation coefficient (r_s) and comparisons of the access adequacy time employed Kaplan Meier curves.

Results

The total sample included 91 patients, with 59 patients (65%) undergoing dialysis via autogenous upper limb AVF and 32 patients (35%) undergoing dialysis via CVC (5 via a short-term non-tunneled catheter, and 27 patients via a long-term tunneled catheter). There were no patients with AVG. Men were predominant in the total sample ($n=57$; 62.6%) and the AVF group ($n=44$; 74.6%), while in the CVC group women were predominant ($n=19$; 59.4%), with a statistically significant difference between the groups ($p=0.001$).

Figure 1 shows adequacy rates. Parameters associated with AVF performance are shown in Table 1. All hematomas diagnosed by echo-Doppler were small in diameter, were restricted to puncture sites and did not show any flow restriction or pseudoaneurysm degeneration. After multivariate analysis, the variables that remained associated with inadequacy of AVF performance were non-mature

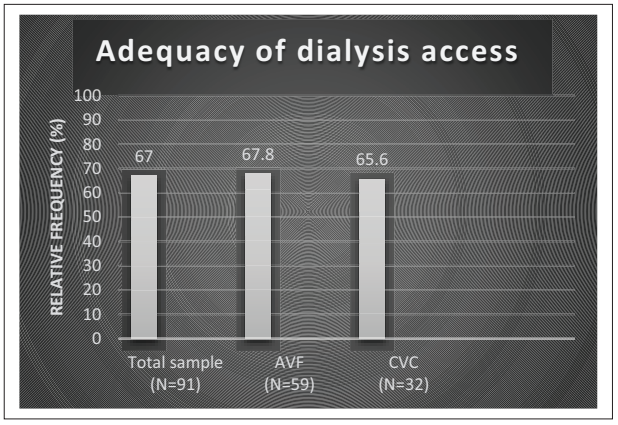

Figure 1. Frequency of adequacy of vascular access performance in patients on a chronic hemodialysis program at the dialysis unit in São Lucas Hospital.
AVF: arteriovenous fistula; CVC: central venous catheter.

AVF, pseudoaneurysm, and presence of hematoma. Among the causes of fistula inadequacy, with the highest prevalence ratio, were non-mature AVF (PR: 4.055; 95% CI: 2.017–8.151), pseudoaneurysm (PR: 6.580; 95% CI: 3.723–11.629), and presence of hematoma (PR: 4.360; 95% CI: 2.125–8.946), all with $p<0.001$.

The parameters associated with CVC performance are shown in Table 2. After multivariate analysis, the variables that remained associated with inadequate catheter performance were the use of alteplase, current access infection, and effective flow in mL/min. Among the causes of catheter inadequacy with the highest prevalence ratio, the present study points access thrombosis, indicating the use of thrombolytics (PR: 11.103; 95% CI: 4.746–25.977; $p<0.001$) and infection (PR: 2.984; 95% CI: 1.293–6.889; $p=0.010$). The increase in the effective flow decreased the prevalence of inadequate access by 2.5% (PR: 0.975; 95% CI: 0.967–0.983; $p<0.001$).

Table 3 disclosed the time for AVF maturation.

Figure 2 shows the comparative Kaplan-Meier curve regarding primary and functional patency of accesses. Median primary AVF patency was 72 months (II: 24–96 months) and median catheter patency was 7 months (II: 4–24 months), with $p<0.001$.

No significant difference between inflammatory markers was disclosed (Table 4).

Discussion

The main type of vascular access in the Dialysis Unit of São Lucas Hospital is an AVF, which was used in 65% of patients. Moreover, there was a high prevalence (35%) of CVCs, with long-term catheters accounting for 30% of all accesses. The adequacy rates of vascular access in patients undergoing hemodialysis in São Lucas Hospital did not differ between arteriovenous fistulas and catheters. The

Table 1. Parameters associated with the performance of arteriovenous fistula for hemodialysis in patients in a chronic hemodialysis program at the dialysis unit of São Lucas Hospital (*N* = 59).

Variables	Arteriovenous fistula performance		*p*
	Adequate *N* = 40	Inadequate *N* = 19	
Mean blood flow in mL/min	330.6 ± 37.1	298.4 ± 45.2	0.005[a]
Effective flow in mL/min	314.5 ± 22.3	286.8 ± 43.4	0.015[a]
Systolic blood pressure in mmHg*	144.4 ± 25.3	138.8 ± 28.6	0.455[a]
Diastolic blood pressure in mmHg*	75.7 ± 17.9	77.3 ± 14.9	0.735[a]
Venous pressure in mmHg	184.8 ± 43.6	179.0 ± 49.5	0.649[a]
Kt/V in the evaluation day	1.2 ± 0.2	1.2 ± 0.3	0.880[a]
Kt/V in a monthly average	1.3 ± 0.3	1.3 ± 0.3	0.419[a]
Mature arteriovenous fistula, *N* (%)			<0.001[b]
Yes	40 (100.0)	11 (57.9)	
No	0 (0.0)	8 (42.1)	
Thrill, *N* (%)			0.100[b]
Yes	40 (100.0)	17 (89.5)	
No	0 (0.0)	2 (10.5)	
Bruit, *N* (%)			0.322[b]
Yes	40 (100.0)	18 (94.7)	
No	0 (0.0)	1 (5.3)	
Vein diameter in mm	9.3 ± 3.2	8.3 ± 3.6	0.291[a]
Vein diameter classification, *N* (%)			0.074[c]
Normal (>6 mm)	32 (80.0)	11 (57.9)	
Small (<6 mm)	8 (20.0)	8 (42.1)	
AVF flow in mL/min (median-II)	2806.5 (1526.0–3980.0)	1997.0 (1456.0–3666.0)	0.284[d]
AVF flow classification, *N* (%)			0.100[b]
Normal (more than 600 mL/min)	40 (100.0)	17 (89.5)	
Low (600 mL/min or less)	0 (0.0)	2 (10.5)	
Depth in mm (median-II)	2.0 (1.0–2.0)	2.0 (1.0–3.0)	0.797[d]
Depth rating, *N* (%)			0.999[b]
Normal (less than 6 mm)	38 (95.0)	18 (94.7)	
Deep (6 mm or more)	2 (5.0)	1 (5.3)	
AVF length, *N* (%)			0.078[b]
Normal (more than 10 cm)	38 (95.0)	15 (78.9)	
Short (10 cm or less)	2 (5.0)	4 (21.1)	
Stenosis, *N* (%)			0.322[b]
No	40 (100.0)	18 (94.7)	
Yes	0 (0.0)	1 (5.3)	
Steal syndrome, *N* (%)			0.322[b]
No	40 (100.0)	18 (94.7)	
Yes	0 (0.0)	1 (5.3)	
Pseudoaneurysm, *N* (%)			0.100[b]
No	40 (100.0)	17 (89.5)	
Yes	0 (0.0)	2 (10.5)	
Hematoma, *N* (%)			0.001[b]
No	40 (100.0)	13 (68.4)	
Yes	0 (0.0)	24 (31.6)	
Abscess, *N* (%)			¥
No	22 (100.0)	37 (100.0)	
Yes	0 (0.0)	0 (0.0)	

AVF: arteriovenous fistula; II: interquartile range.
Quantitative variables with normal distribution are presented as mean and standard deviation, asymmetric variables as median and interquartile range and categorical variables as absolute and relative values.
p: [a]*Student's T* test; [b]Fischer's Exact Test; [c]Pearson's Chi-square test; [d]Mann-Whitney test.
¥: data collected does not allow proper analysis.
*Blood pressure measured at the end of the dialysis session.

Table 2. Parameters associated with the performance of the hemodialysis catheter in patients in a chronic hemodialysis program at the dialysis unit of São Lucas Hospital ($N = 32$).

Variables	Catheter performance		*p*
	Adequate *N* (%) *N* = 21	Inadequate *N* (%) *N* = 11	
Mean blood flow in mL/min	308.6 ± 24.3	309.1 ± 20.2	0.952[a]
Effective flow in mL/min	308.6 ± 14.4	260.4 ± 39.7	0.002[a]
Systolic blood pressure in mmHg*	136.7 ± 28.9	139.4 ± 25.8	0.797[a]
Diastolic blood pressure in mmHg*	77.8 ± 20.0	73.7 ± 22.0	0.600[a]
Venous pressure in mmHg	138.5 ± 35.9	140.0 ± 41.0	0.916[a]
Kt/V in the evaluation day	1.3 ± 0.3	1.3 ± 0.3	0.872[a]
Kt/V in a monthly average	1.4 ± 0.2	1.3 ± 0.1	0.430[a]
Catheter dysfunction			<0.001[b]
No	21 (100.0)	2 (18.2)	
Yes	0 (0.0)	9 (81.8)	
Catheter dysfunction parameters			<0.001[b]
Peak flow <200 mL/min for 30 min	0 (0.0)	2 (18.2)	
Medium flow <250 mL/min 2 sessões	0 (0.0)	4 (36.4)	
Inability to dialyze	0 (0.0)	3 (27.3)	
No dysfunction	21 (100.0)	2 (18.2)	
Use of alteplase			0.033[b]
No	21 (100.0)	8 (72.7)	
Yes	0 (0.0)	3 (27.3)	
Current access infection			0.033[b]
No	21 (100.0)	8 (72.7)	
Yes	0 (0.0)	3 (27.3)	

Quantitative variables with normal distribution are presented as mean and standard deviation, asymmetric variables as median and interquartile range and categorical variables as absolute and relative values.
The missing data was an specific one for venous pressure in mmHg.
p: [a]*Student's T* test; [b]Fischer's Exact Test.
*Blood pressure was measured at the end of the dialysis session.

occurrence of infection in dialysis catheters is associated with decreased access performance. The present study has not found an association between increased systemic inflammatory activity and access performance or with the access route in use. The primary and functional patency of arteriovenous fistulas is longer lasting than that of catheters. The variables associated with inadequate CVC performance were thrombolytic drug use (alteplase), current access infection, and low effective flow. The prevalence of AVF inadequacy increased in patients with unmatured AVFs, pseudoaneurysm, and presence of a hematoma. The median time for fistula maturation in patients with a clinical history of previous CVC use was shorter in comparison to the maturation time of patients who had not previously used CVCs. The median of primary AVF patency is higher in non-diabetics compared to diabetic patients.

The prevalence of catheter use in our study is considerably higher compared to the national average of 14.4%, according to the last Brazilian dialysis census.[2] The latest UK Renal Association guidelines recommend that at least 60% of incident patients have a functioning AVF and that at least 80% of all prevalent patients undergo dialysis via definitive access: Autogenous AVF, prosthetic AVG, or Tenckhoff catheter. The *UK Renal Registry Vascular Access Audit* (2012) describes a 70% prevalence of AVFs in patients who underwent a surgical evaluation at least 3 months before starting dialysis.[18,19]

We believe that the high prevalence of catheters in our study is explained by several factors. Our service is a tertiary care service, where there is a greater number of patients with greater clinical complexity. These patients have spent more time on dialysis, with a greater possibility of superficial venous exhaustion. Another major associated factor is the late referral of patients for access, causing the initiation of dialysis therapy using temporary CVC.[7] We had no patients with AVG. Unfortunately, there are many restrictions in our health care system for using tunneled catheters and AV grafts that results in the extended use of a catheter. However, this specific analysis was not performed in our study.

The median time of fistula and catheter patency showed a significant statistical difference (72 and 7 months, respectively). The only variable statistically associated with patency was the absence of a diagnosis of diabetes mellitus ($p = 0.006$). Arterial calcification and increased parietal thickness, common in diabetic patients, have been associated with a significant increase in the loss of primary AVF patency, in addition to being a marker of poor prognosis

Table 3. Comparison of maturation times and functioning access (patency) via arteriovenous fistula, according to clinical parameters of patients in a chronic hemodialysis program at the dialysis unit of São Lucas Hospital ($N = 59$).

Variables	Maturation (months)	*p*	Patency (months)	*p*
	Median and II		Median and II	
Prior use of central venous catheter		0.001		0.081
No ($n = 15$)	2.0 (1.0–7.0)		24.0 (18.0–60.0)	
Yes ($n = 44$)	1.0 (1.0–1.0)		13.0 (8.3–48.0)	
Fistula in more than one blood vessel		0.559		0.387
No ($n = 29$)	1.0 (1.0–1.5)		17.0 (9.5–54.0)	
Yes ($n = 15$)	1.0 (1.0–1.0)		12.0 (6.0–48.0)	
Comorbidities				
Diabetes mellitus		0.135		0.006
No ($n = 36$)	1.0 (1.0–2.0)		24.0 (12.0–72.0)	
Yes ($n = 23$)	1.0 (1.0–1.0)		12.0 (6.0–24.0)	
Inflammatory diseases		0.966		0.522
No ($n = 56$)	1.0 (1.0–2.0)		22.5 (9.0–48.0)	
Yes ($n = 3$)	1.0 (1.0–¥)		24.0 (12.0–¥)	
Use of medicines				
Antiplatelet drugs		0.756		0.477
No ($n = 26$)	1.0 (1.0–2.0)		24.0 (11.8–63.0)	
Yes ($n = 33$)	1.0 (1.0–2.0)		18.0 (9.0–36.0)	
Anticoagulant		0.757		0.763
No ($n = 53$)	1.0 (1.0–2.0)		24.0 (10.0–48.0)	
Yes ($n = 6$)	1.0 (1.0–6.0)		17.0 (8.0–63.0)	
Post-op exercises		0.736		0.141
No ($n = 47$)	1.0 (1.0–2.0)		18.0 (9.0–36.0)	
Yes ($n = 12$)	1.0 (1.0–1.8)		42.0 (12.0–81.0)	
Upper limbs preservation		0.086		0.265
No ($n = 36$)	1.0 (1.0–1.0)		20.5 (7.3–48.0)	
Yes ($n = 23$)	1.0 (1.0–2.0)		24.0 (12.0–78.0)	

There was missing data for 15 patients for fistula in more than one vessel; and 40 patients for current catheter use in more than one vessel.
p: Mann-Whitney Test.
¥: data does not enable analysis; II: interquartile range.

for access.[4] Additionally, there are several factors associated with the choice of type of access that is directly associated with its patency, such as clinical, surgical, social, bureaucratic, and educational factors.[19] There is an imperative need for education of the multidisciplinary team, to help preemptively create an access prior to dialysis initiation. In their 2021 annual report, *the United States Renal Data System* (USRDS) describes that patients who received nephrologist care for more than 12 months before starting renal replacement therapy showed a higher percentage of fistula use (28.6%) whereas the use of fistula was only 5.4% among patients without previous assistance from a nephrologist.[20]

The presence of vascular access infection was the defining criterion of access adequacy. There was no active infection in the patients in the AVF group and the CVC group with adequate access. In addition, 27% of CVC patients who performed poorly had active catheter infections. The prevalence of inadequate access was 198.4% higher in patients with catheter infection (PR: 2.984; 95% CI: 1.293–6.889; $p = 0.010$).

In the present study, we did not observe an association between the use of CVC and the increase in systemic inflammatory activity. Serum inflammatory markers were not different between the groups with adequate and inadequate access. The group of patients were very small and the estimated sample size calculation was not calculated for this comparison only. Laboratory results were very different, except for leukocytes, which generated unreliable frequency analyzes (median and interquartile range). Different studies demonstrate that the use of biocompatible membranes and ultrapure dialysate reduces inflammatory parameters, as well as the use of ACE inhibitors—which have renal protective effects and anti-inflammatory properties in end-stage renal disease. However, the patients in our study were not evaluated for these variables.[21] Patients with uremia have an increased cardiovascular risk compared to the general population. For instance, the MIA syndrome (malnutrition, inflammation, and atherosclerosis) shows that inflammation and malnutrition play an important role in endothelial dysfunction. In addition, it contributes to atherosclerosis and has a considerable increase in

cardiovascular morbidity and mortality in patients with end-stage renal disease.[21]

We did not identify a negative impact on the performance of an AVF in patients who had previously used a CVC, nor in a newly implanted CVC. The use of CVCs had a statistically significant association with shorter AVF maturation time. We believe that these differences may be due to the small group of patients and their recall bias, as these variables were questioned to the patient. Additionally, there is a possibility (not measured) that patients without a history of previous catheter did not present the need or urgency for start dialysis. Despite not reaching statistical significance, it is possible that the longer AVF patency time in patients without previous catheter use could be clinically relevant. A supervised postoperative exercise program should be encouraged to increase the diameter of the drainage vein and increase AVF flow.[4] The AVF maturation rate was lowest in the group that used non-tunneled CVCs, followed by the tunneled CVCs and no history of CVC groups: 54.7%, 65.2%, and 74.7%, respectively ($p < 0.001$). The use of non-tunneled CVC was an independent negative predictor of AVF maturation and based on univariate and multivariate analysis, only the non-tunneled CVC group had a lower chance of AVF maturation compared to the group without CVC (adjusted odds ratio: 0.43; 95% CI: 0.29–0.62).[16]

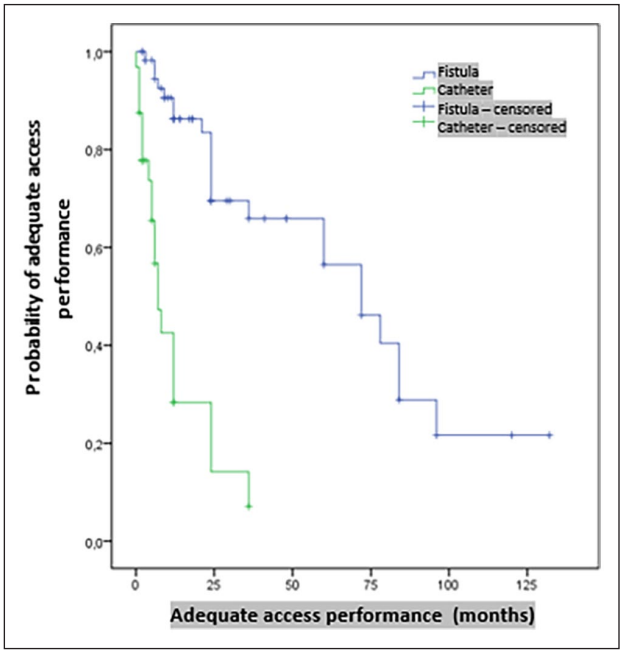

Figure 2. Comparative Kaplan-Meier curve between the adequacy time of the arteriovenous fistula and the adequacy time of the catheter access, concerning patients of chronic hemodialysis program of the dialysis unit in São Lucas Hospital.

The present study presents limitations given that it is observational, single-center, with a small sample size of prevalent patients on hemodialysis, and subject to some biases. The question about the AVF maturation time, previous accesses, and medications were asked to the patient and searched for in the medical record, which can lead to recall bias or inadequate filling of data in the medical record. We asked about the maturation time in months, but the theoretical references determine the maturation period in weeks. We did not evaluate C-reactive protein and erythrocyte sedimentation rate because they are not routine monthly tests at the Unit and because they are requested based on a specific indication, which would be useful for further evaluation of the inflammatory profile. Vascular echo-Doppler assessment and adequacy classification was performed by only one examiner, which may be associated with measurement bias. The present study did not evaluate recirculation rate, type of puncture performed, the distance between needles, and the direction of needles, which are factors that are determinants of Kt/V.

In his editorial, Dirk M. Hentschel describes that, with the creation of AVF, the patient acquires "chronic vascular access disease." Professional training in adequate puncture techniques is vital to maintaining access and its survival in the face of the reality of care team rotation, learning curve, hygiene care, and manual dexterity at the time of cannulation.[22]

The present study highlights the necessity to evaluate incident patients and follow them up regarding the patency, functionality, and intercurrence of accesses. Additionally, it is necessary to characterize the sample regarding the chronic or emergency dialysis program and the pre-existence of pre-established renal disease. In addition to that, it is vital to conduct a periodic evaluation of the accesses in use for

Table 4. Comparison between inflammatory markers according to the performance of arteriovenous fistula and catheter in patients in a chronic hemodialysis program at the dialysis unit in São Lucas Hospital.

Markers	Performance					
	Fistula			Catheter		
	Adequate $N = 22$	Inadequate $N = 37$	p	Adequate $N = 21$	Inadequate $N = 11$	p
Interleukin-6 in pg/mL	1.0 (1.0–1.0)	1.0 (1.0–1.00)	0.349	1.0 (1.0–1.0)	1.0 (1.0–39.0)	0.612
Interleukin-10 in pg/mL	2.0 (2.0–6.9)	3.5 (2.0–36.7)	0.191	2.7 (2.0–12.2)	3.1 (2.0–6.4)	0.895
Leukocytes em/uL	6479.1 ± 1695.6	6357.3 ± 1908.1	0.806	7378.6 ± 3555.6	7224.5 ± 1768.7	0.894

p: Mann-Whitney test for the comparison of measurements of Interleukins, which are presented as median and interquartile range; *Student's T* Test for Leukocytes, which are presented as mean and standard deviation.

dialysis, through pre-established protocols, aiming to detect early functional abnormalities that can reduce the time of primary access patency and indicate early surgical and/or endovascular intervention to restore patency.

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Contributorship

All the authors worked at conception, planning, writing the paper, and final version revising.

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Ethical approval

We have approval by the ethics and research committee. Participants provided informed consent written. The project was approved by the Clinical Research Center of São Lucas Hospital (according to number 10792/01/2020), approved by PUCRS Scientific Committee (SIPESQ Code: 10017), and approved by CEP (according to number 4.271.518 and CAAE: 37125420.9.0000.5336).

Guarantor

The authors did not have any guarantor.

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