

ASSOCIATION BETWEEN ARTERIOVENOUS FISTULAE AND HEMATOMAS IN A DIALYSIS CENTER IN THE STATE OF RIO GRANDE DO SUL, SOUTHERN BRAZIL

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ABSTRACT

Introduction: Chronic kidney disease (CKD) is characterized by slow, progressive, and irreversible loss of kidney function. CKD has become a serious public health issue because of its increasing morbidity and mortality rates. The present study aimed to investigate factors associated with hematomas caused by arteriovenous fistula (AVF) at a Renal Replacement Therapy Unit in the state of Rio Grande do Sul, southern Brazil.

Methods: In this cross-sectional study, 72 patients with CKD aged 18 years or over, presenting with AVF, and undergoing three hemodialysis sessions per week were evaluated from June 2014 to March 2015. Prevalence ratios (PRs) with 95% confidence intervals (95% CIs) were estimated for identification of risk factors associated with AVF. *P*-values < 0.05 were considered significant.

Results: Sex, age, self-reported skin color, educational level, hypertension, diabetes, nephrotic syndrome, congestive heart failure, and hepatitis C were not associated with hematoma formation (i.e., all estimated PRs had *p*-values > 0.05). The single factor associated with hematomas was AVF time shorter than 60 days (PR = 2.04; 95% CI: 1.28-3.27; *p* < 0.01).

Conclusion: AVF maturation time was associated with higher prevalence of hematomas at the cannulation site. Therefore, AVF time should be given special attention in patients undergoing renal therapy at dialysis centers.

Keywords: *Arteriovenous fistula; hematoma; chronic renal failure*

Chronic kidney disease (CKD) is characterized by slow, progressive, and irreversible loss of kidney function with biochemical and physiological deterioration of the renal system, leading to accumulation of toxins in the body and hydroelectrolytic and hormonal unbalance¹⁻². CKD diagnosis is defined as glomerular filtration rate (GFR) < 60 mL/min/1.73 m or GFR ≥ 60 mL/min/1.73 m in patients with a marker of renal parenchymal damage (e.g., albuminuria) for more than 3 months²⁻⁴. CKD has become a public health issue because of its increasing morbidity and mortality rates as well as high maintenance costs of renal replacement therapies, such as hemodialysis, peritoneal dialysis, and kidney transplantation¹.

According to global health estimates, CKD accounted for 864,226 deaths (i.e., 1.5% of all deaths worldwide) in 2012, being the 14th leading cause of deaths that year⁵. In Brazil, current data show that mortality due to CKD is approximately 15% in renal replacement therapy services⁶. The major contributing cause of mortality in this group of patients is cardiovascular disease, regardless of other classic risk factors such as age, ethnicity, sex, and underlying comorbidities (e.g., diabetes)⁶.

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In patients with CKD, conventional hemodialysis can be performed through different types of vascular access, including central venous catheter and arteriovenous fistula (AVF)⁷. An AVF consists of a subcutaneous anastomosis between an artery and an adjacent vein, with dilation of superficial veins, allowing constant circulation and repeated needle insertion^{8,9}.

A major complication in AVF management is post-cannulation hematoma. Hematomas may present with several forms according to a patient's hemostatic state as well as blood volume and time of blood confinement at the cannulation site^{7,8}. Period of cannulation, use of anticoagulation, and dose and type of anticoagulant are factors which contribute to hematoma formation^{8,9}. Thus, an adequate cannulation technique is essential for preventing AVF hematomas. Hematomas are a major complication because they impair the process of cannulation and, therefore, dialysis, affecting directly the quality of life of a patient with kidney disease. In addition, hematomas contribute to complications such as AVF thrombosis and stenosis^{8,9}.

The present study aimed to investigate factors associated with AVF hematomas at a teaching hospital's Renal Replacement Therapy Unit (RRTU) in the state of Rio Grande do Sul, southern Brazil, in the period of 2014-2015.

METHODS

Design and Location

This retrospective, cross-sectional study was conducted at a teaching hospital's RRTU in a municipality located in the state of Rio Grande do Sul. The hospital is a referral center for 49 nearby municipalities. Users are covered by the Brazilian Unified Health System (*Sistema Único de Saúde*, SUS).

Inclusion Criteria and Data Collection

The following inclusion criteria were used: patients with CKD, aged 18 years or over, presenting with AVF, and undergoing three hemodialysis sessions per week, from June 2014 to March 2015. Data were collected from a RRTU spreadsheet containing indicators measuring the monthly risk of hematoma formation due to AVF. This instrument included the following variables: sex, age, self-reported skin color, educational level, occupation, AVF time, professional in charge of AVF cannulation, and length of experience of this professional. In addition, it informed whether a patient had the following

comorbidities: hypertension, diabetes, nephrotic syndrome, congestive heart failure, and hepatitis C.

AVF Creation and Anticoagulation During Dialysis

In all patients, AVF was created using Nipro Medical Corporation® 17G needles. Anticoagulation was performed at the beginning of dialysis using a bolus of heparin according to each patient's body weight and coagulation state, with doses ranging from 2000 to 5000 UI/mL. The process of dialysis lasted for approximately 4 hours.

Sample Size Calculation

Epi Info™ software was used for estimating the size of the study sample, considering an expected outcome prevalence of 40%¹⁰, a maximum error of $\pm 4\%$, and a confidence level of 95%. Thus, the initial sample size was calculated at 65 patients. To compensate for losses, the sample was increased by 10%, resulting in a total of 72 patients.

Ethical Considerations

This study was conducted in accordance with regulatory standards and guidelines of research involving humans, as defined by resolution no. 466/2012 of the Brazilian National Health Council (protocol no. 37/2014).

Statistical Analysis

Data were analyzed using IBM SPSS® software, version 23.0. For continuous data, normality was assessed using Kolmogorov-Smirnov test, with Lilliefors correction. Student's t-test for independent samples was used for assessing possible differences between mean values in the study groups. Prevalence ratios (PRs) with 95% confidence intervals (95% CIs) were estimated. Categorical data were described as absolute and percentage frequencies, then compared between groups using Pearson's chi-square test or Fisher's exact test, as appropriate. *P*-values < 0.05 were considered significant, and all tests were two-tailed.

RESULTS

Of all participants (*n* = 72), 61.1% were male. Mean age was 59 ± 15.5 years, ranging from 20 to 84 years. Most participants were older than 60 years (54.2%). The sample consisted mainly of self-reported white people (73.6%) with less than 8 years of education (94.4%) and employed in the metallurgical industry (20.8%) (Table 1).

Table 1: Sociodemographic characteristics of patients treated at a Renal Replacement Therapy Unit in southern Brazil between 2014 and 2015.

Variable	n = 72	%
Sex		
Male	44	61.1
Female	28	38.9
Age (years)		
≥ 61	39	54.2
20-60	33	45.8
Self-reported skin color		
White	53	73.6
Non-white	19	26.4
Educational level		
≤ 8 years of education	68	94.4
> 8 years of education	4	5.6
Occupation		
Metalworker	15	20.8
Unemployed	7	9.7
Production assistant	7	9.7
Self-employed	5	6.9
Other	38	52.8

Hemodialysis service staff included four registered nurses with mean length of experience of 10.2 ± 1.25 years and 26 licensed practical nurses with mean length of experience of 2.1 ± 2.19 years, which was a significant difference ($p < 0.01$). Of the 9 hematomas identified in the sample, 1 (11.1%) was cannulated by a registered nurse and 8 (89.9%) were cannulated by licensed practical nurses (PR = 1.03; 95% CI: 0.77-1.38; $p = 0.82$).

A comparison between sociodemographic variables and comorbidities which could be associated with hematoma formation due to AVF is demonstrated in Table 2. No variable was associated with hematoma formation (i.e., all estimated PRs had p -values > 0.05), except for AVF time shorter than 60 days (PR = 2.04; 95% CI: 1.28-3.27; $p = 0.03$), which was more common in the hematoma group (Table 2).

Table 2: Comparison of sociodemographic variables and risk factors in patients with or without hematomas (yes/no) treated at a Renal Replacement Therapy Unit in southern Brazil between 2014 and 2015.

Variable	Yes (n = 31)		No (n = 41)		PR (95% CI)	p-value*
	n	%	n	%		
Sex						
Male	17	54.8	27	65.9	0.77 (0.46-1.31)	0.34
Female	14	45.2	14	34.1	1.00 ref.	
Age (years)						
≥ 61	16	51.6	23	56.1	0.90 (0.53-1.53)	0.71
20-60	15	48.4	18	43.9	1.00 ref.	
Self-reported skin color						
White	25	80.6	28	68.3	1.49 (0.73-3.07)	0.24
Non-white	6	19.4	13	31.7	1.00 ref.	
Educational level						
< 8 years of education	30	96.8	38	92.7	6.6 (0.98-44.79)	0.63
> 8 years of education	1	3.2	3	7.3	1.00 ref.	
Hypertension						
Yes	19	61.3	25	61.0	1.01 (0.58-1.73)	0.98
No	12	38.7	16	39.0	1.00 ref.	
Diabetes						
Yes	7	22.6	14	34.1	0.71 (0.36-1.38)	0.29
No	24	77.4	27	65.9	1.00 ref.	
Nephrotic syndrome						
Yes	5	16.1	4	9.8	1.34 (0.70-2.60)	0.42
No	26	83.9	37	90.2	1.00 ref.	
CHF						
Yes	4	12.9	2	4.9	1.63 (0.86-3.07)	0.22
No	27	87.1	39	95.1	1.00 ref.	
Hepatitis C						
Yes	1	3.2	1	2.4	1.16 (0.28-4.78)	0.84
No	30	96.8	40	97.6	1.00 ref.	
AVF time						
≤ 60 days	7	22.6	2	4.9	2.04 (1.28-3.27)	0.03
> 60 days	24	77.4	39	95.1	1.00 ref.	

AVF: arteriovenous fistula; CHF: congestive heart failure; PR: prevalence ratio. Ref.: reference category. *Statistically significant result in bold.

DISCUSSION

The present study evaluated variables possibly associated with hematomas in patients with AVF undergoing hemodialysis at a teaching hospital's RRTU in Rio Grande do Sul. Sex, age, self-reported skin color, educational level, hypertension, diabetes, nephrotic syndrome, congestive heart failure, and hepatitis C were not statistically associated with hematoma formation. Nonetheless, presence of hematomas was associated with AVF time, suggesting caution in AVF management in patients undergoing hemodialysis.

According to the literature, variables such as age, educational level, diabetes, peripheral vascular disease, hypertension, coagulopathy, obesity, and smoking affect AVF maturation time and hematoma formation^{7,8,11-14}. Consistent with our results, Lee et al. (2006)¹¹ prospectively studied AVF infiltration in the United States and found no association of sex, race, and diabetes with occurrence of hematomas. However, in the same study, age was associated with hematomas¹¹. No statistical association between educational level and presence of hematomas was found in the present study. Conversely, low educational level has already been associated with hematomas in patients with AVF in a study conducted in southern Brazil¹². Furthermore, other studies have described low educational level as a risk factor for AVF complications^{7,13,14}. The finding that most patients undergoing hemodialysis and showing complications have low educational level suggests that those with higher educational levels tend to seek health services earlier and practice self-care^{15,16}. Additionally, age is an important factor for predisposition of hematomas in patients with AVF¹¹, as the older the patient, the higher the likelihood of achieving this outcome, as a result of the aging process affecting the tunica intima of blood vessels¹⁶. This situation suggests that, with aging, vessels become fragile and, therefore, more susceptible to hematomas. However, this association was not found in the present study.

The cannulation method used in the present study for AVF access was the rope ladder technique, which rotates puncture sites in order to prevent formation of aneurysms, hematomas, and stenoses due to repeated damage to the vessel wall^{17,18}. Cannulation care includes vascular access techniques, needle size, level of difficulty, and knowledge of what may cause hematomas, which can be developed through continuing education at health services^{14,18,19}. Of the patients presenting with AVF hematomas, 6 (19.3%)

had their AVF discontinued, requiring the use of a Shiley catheter for hemodialysis. Seven (22.6%) patients had AVF maturation time shorter than 60 days. In several high-income countries, mean time for utilization of a fistula exceeds 60 days (98 days in the United States, 80 days in Spain, and 86 days in France). The few countries which have reported early AVF use are Japan (25 days) and Italy (27 days)²⁰. Data show that insufficient AVF maturation contributes to hematoma formation²⁰. Ideal maturation time would be longer than 60 days, but certain medical situations require early AVF use²¹. As hematomas frequently occur in the early stages of use of a fistula, the first cannulation should be performed by an experienced nurse²². Experienced nurses are capable of successfully predicting AVF maturation in 80% of the cases¹⁷⁻²¹. Thus, technical expertise and length of experience of the nurse in charge of creating an AVF is another relevant variable for reducing complications in hemodialysis access procedures^{13,17-19}. In the present study, despite the lack of statistically significant difference probably because of the small sample size, the difference between number of hematomas in cannulations performed by registered nurses (11.1%) and number of hematomas in cannulations performed by licensed practical nurses (89.1%) was relevant. This finding reinforces that training and length of professional experience are essential for preventing hematomas.

The limitations of this study include its retrospective nature and sample size with low statistical power ($n = 72$). However, the present results may be useful for managing AVF time, with the aim of reducing hematoma formation and thus contributing to improving the quality of life of patients undergoing hemodialysis. Furthermore, future studies such as prospective cohorts with larger samples, more data on patients' hemostatic state, and a wider scope of collected variables should provide greater understanding of AVF complications in patients undergoing hemodialysis.

CONCLUSION

AVF maturation time shorter than 60 days increases substantially the prevalence of hematomas at the cannulation site. Centers providing hemodialysis treatment must be aware of this finding.

Conflicts of Interest

The authors declare no conflicts of interest.

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