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Risk Factors for Thrombosis in Tunneled Double Lumen Catheter as Hemodialysis Access with Heparin Lock Administration in Chronic Kidney Disease Stage V Patients

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ABSTRACT

Aim: This study, concerning the risk factors of thrombosis on tunneled double-lumen catheters with administration of Heparin locking solution at Prof. Dr. I.G.N.G Ngoerah Hospital, supports the expansion of knowledge in addressing vascular access challenges in Stage V Chronic Kidney Disease patients. ***Method:*** Conducted from August 1, 2022, to August 31, 2023, employing a bidirectional cohort study design, analyzing 73 Stage V CKD patients. Among these patients, vascular location, insertion side, and dialysis frequency were assessed. ***Results:*** The findings indicate that vascular location, insertion side, and dialysis frequency are not thrombosis risk factors for tunneled double-lumen catheters. Conversely, protective associations were observed for jugular vein location (RR 0.413), right-side insertion (RR 0.42), and twice-weekly hemodialysis (RR 0.388). Analysis of tip position showed a weak negative correlation with thrombosis risk. ***Conclusion:*** The study concludes that vascular location, insertion side, and hemodialysis frequency are not thrombosis risk factors, revealing significant protective associations for these variables.

Keywords: catheter thrombosis; thrombosis risk factor; tunneled double lumen catheter; heparin lock.

INTRODUCTION

Chronic kidney disease (CKD) is a major public health concern worldwide, including in Indonesia. It is characterized by a gradual loss of kidney function over time, potentially leading to end-stage renal disease (ESRD) if untreated. Based on data from the Global Burden of Disease study in 2017, CKD was the 13th leading cause of death in Indonesia, accounting for 35,217 deaths, which is about 2% of total global CKD-related deaths (IHME, 2017). According to the 2018 Indonesia's Ministry of Health Research (Riskesdas), the prevalence of CKD in Indonesia was 0.38%, or roughly 739,208 people, with the highest prevalence in North Kalimantan (0.64%) and Bali ranking 11th at 0.44% (Riskesdas, 2018). CKD poses a significant challenge in terms of both morbidity and mortality, making effective management crucial.

The management of ESRD typically involves two major therapeutic options: conservative therapy and renal replacement therapy, which includes peritoneal dialysis (PD), hemodialysis (HD), and kidney transplantation. Vascular access is essential for HD, and the three most commonly used types are arteriovenous fistulas (AVF), arteriovenous grafts (AVG), and central venous catheters (CVC), including tunneled double lumen catheters (TDLC).

According to the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines, AVF is considered the optimal vascular access for HD due to its superior long-term patency and lower complication rates compared to AVG and CVC (KDOQI, 2019). However, AVF is not always feasible for all patients due to various factors such as failed maturation or delayed surgery, which leaves TDLC as an important alternative, especially in emergency cases, for temporary or prolonged use (Gonzalez & Cassaro, 2020).

Despite its utility, TDLC is associated with several complications, with catheter-related thrombosis being the most frequent. Thrombosis is a leading cause of catheter dysfunction, accounting for approximately 80% of cases that require catheter replacement (Gunawansa, Sudungsinghe & Wijayaratne, 2018). The incidence of TDLC thrombosis varies widely, from 2% to 67%, depending on the patient population and clinical settings (Tjiang, 2021). Several risk factors contribute to thrombosis, including intrinsic factors related to the catheter itself—such as the type of catheter (non-tunneled vs. tunneled), the site of insertion (femoral, subclavian, or internal jugular vein), and the position of the catheter tip (cavoatrial junction, right atrium, or

superior vena cava)—as well as extrinsic factors related to the patient's condition, such as the frequency of HD and the underlying vascular health (Gunawansa et al., 2018; Rhee, 2013; Kalantar-Zadeh, 2014).

Research indicates that while the use of anticoagulants like heparin lock can significantly reduce the risk of catheter-related thrombosis, the complication still occurs at a notable rate. For instance, a study by Abdekelfi et al. found that the incidence of thrombosis without prophylactic heparin locking was as high as 30%, but dropped to 1.5% when heparin was used (Abdekelfi et al., 2021). However, other studies, such as one by Chapla K et al., showed no significant difference in catheter patency when comparing heparin with other locking solutions. The varying effectiveness of heparin lock in preventing thrombosis highlights the need for further investigation into the underlying risk factors contributing to catheter dysfunction.

Previous studies at RSUP by Prof. Dr. I.G.N.G. Ngoerah have explored factors related to infection and heparin dosing for non-tunneled catheters, but research on TDLC-related thrombosis, particularly in the context of heparin lock usage, remains limited (Ranuartha & Yasa, 2021). Given the significant burden of catheter-related complications, including their contribution to increased morbidity, mortality, and healthcare costs, further research is essential to improve patient outcomes.

This study aims to investigate the risk factors for thrombosis in patients using tunneled double-lumen catheters as vascular access for hemodialysis, specifically focusing on the role of heparin lock in stage V CKD patients. The specific objectives are to evaluate the influence of venous location, insertion side, catheter tip position, and frequency of hemodialysis on the incidence of thrombosis. We hypothesize that the venous location, insertion side, tip position, and hemodialysis frequency are significant risk factors for TDLC thrombosis in CKD stage V patients receiving heparin lock treatment.

METHOD

Study Design, time and place of study

This study was an observational analytic cohort study approach through medical record reviews and subject tracking. The research aimed to compare risk factors, including venous insertion site, side of insertion, catheter tip position, and frequency of hemodialysis, in patients using tunneled double-lumen catheters with heparin lock. Conducted at Prof. Dr. I.G.N.G Ngoerah General Hospital, the study focused on stage V chronic kidney disease (CKD) patients undergoing regular hemodialysis. The data collection period was from August 1, 2022, to August 31, 2023.

Samples Characteristic

The target population for this study consisted of all-stage V CKD patients undergoing hemodialysis with tunneled double-lumen catheters and receiving heparin lock at RSUP Prof. Dr. I.G.N.G Ngoerah. The accessible population included patients treated at the hospital during the study period, selected using consecutive sampling based on predetermined inclusion and exclusion criteria. The inclusion criteria comprised stage V CKD patients aged 18 years or older, who had tunneled double-lumen catheter placement within the past 8 months for hemodialysis and received heparin locking solution. Patients were excluded if they had incomplete medical records, catheter placement for more than 8 months, were not receiving heparin lock, were not undergoing regular hemodialysis at the hospital, were taking immunosuppressive medications, had bleeding disorders, had an active infection, had experienced a bleeding episode within the last 3 months, had proliferative diabetic retinopathy, had a life expectancy of less than 1 year due to malignancy, had platelet counts below 100,000/uL, or had an International Normalized Ratio (INR) above 1.3. The research sample was collected using a consecutive sampling technique and sample selection was carried out until the minimum sample size was met.

Data Analysis

Participants were monitored through regular follow-ups to assess thrombotic events, while data on risk factors such as venous insertion site, side of insertion, catheter tip position, and hemodialysis frequency were collected and analyzed to evaluate their relationship with catheter-related thrombosis. Quantitative variables, such as age, were treated as continuous variables, while hemodialysis frequency was categorized into two groups (2 times per week and 3 times per week). Data were analyzed using SPSS version 26, with descriptive statistics summarizing patient demographics and clinical characteristics. Continuous variables were presented as means with standard deviations (SD) for normally distributed data or medians with interquartile ranges for non-normally distributed data, while categorical variables were expressed as frequencies and percentages. Bivariate analysis using Chi-square tests, or Fisher's exact test when needed, was performed to explore associations between independent variables and catheter thrombosis, with statistical significance set at $p < 0.05$. Relative risk (RR) was calculated to estimate the risk associated with each independent variable, with $RR > 1$ indicating increased risk and $RR < 1$ suggesting a protective factor, and 95% confidence intervals (CI) were applied. Spearman's rho correlation was used for continuous or ordinal variables to assess the strength and direction of relationships with catheter thrombosis, with values close to 1 indicating a strong positive correlation. All analyses were adjusted for confounders, including age, sex, obesity, diabetes, and hypertension.

RESULTS

Characteristics of the study

This observational analytical study was conducted on patients clinically diagnosed with stage V chronic kidney disease (CKD) who had a tunneled double lumen catheter (TDLC) inserted for hemodialysis at RSUP Prof. Dr. I.G.N.G Ngoerah. Based on inclusion and exclusion criteria, a total of 73 patients were

included using non-probability consecutive sampling. The patients were followed up, and data were collected on those who completed their course of treatment. No patients were excluded after initial enrollment. All 73 patients completed follow-up, and their data were analyzed.

Of the 73 patients, 63% were female, and 37% were male. The mean age of the participants was 57.21 ± 12.26 years, with an age range of 26 to 84 years. The majority of patients (82.2%) had diabetes, 50.7% had hypertension, and 49.3% were obese. Regarding the catheter insertion site, 61 patients (83.6%) had their TDLC was inserted into the internal jugular vein, while 12 patients (16.4%) had it inserted into the femoral vein. The right side was the most common insertion side, with 56 patients (76.7%), while 17 patients (23.3%) had their catheter inserted on the left side. Regarding catheter tip positioning, 10 patients (13.7%) had their catheter tip located at the cavoatrial junction, 34 patients (46.6%) at the right atrium, 18 patients (24.7%) at the superior vena cava, and 11 patients (15.1%) at the inferior vena cava. The majority of patients, 63 (86.3%), underwent hemodialysis twice per week, while 10 (13.7%) underwent hemodialysis three times per week (Table 1).

TABLE 1: Demographic Characteristics of the Sample.

CHARACTERISTIC	DETAILS
Gender	
Male	27 (37%)
Female	46 (63%)
Age	
Mean ± SD (Years)	57.21 ± 12.26
Min-Max	26-84
Venous Location	
Internal Jugular Vein	61 (83.6%)
Femoral	12 (16.4%)
Insertion Side	
Right Side	56 (76.7%)
Left Side	17 (23.3%)
Tip Position	
Cavoatrial Junction	10 (13.7%)
Right Atrium	34 (46.6%)
Superior Vena Cava	18 (24.7%)
Femoral (VCI)	11 (15.1%)
HD Frequency	
2 Times per Week	63 (86.3%)
3 Times per Week	10 (13.7%)

Analysis of Risk Factor

Thrombosis was observed in 31 patients (42.5%) of the study population. Of the patients with thrombosis, 21 had their catheter inserted in the internal jugular vein, and 10 had it in the femoral vein. The incidence of thrombosis was higher among those with a femoral vein catheter insertion (83.3%) compared to those with a jugular vein insertion (34.4%). Thrombosis occurred more frequently in patients who had their TDLC inserted on the left side (76.5%) than on the right (32.1%). In terms of catheter tip position, the highest incidence of thrombosis (41.2%) occurred in patients with the tip located at the right atrium.

TABLE 2: Description of the Research Sample Based on Thrombosis Risk Factors (n=73).

Variable		Thrombosis (n = 31)	Absence of thrombosis (n = 42)	Total	RR (CI 95%)	P Value**
Vein Location	Internal Jugular	21	40	61	0.413	0.003
	Femoral	10	2	12		
		31	42	73		
Insertion Side	Right	18	38	56	0.42	0.002
	Left	13	4	17		
		31	42	73		

Variable		Thrombosis (n = 31)	Absence of thrombosis (n = 42)	Total	RR (CI 95%)	P Value**
Hemodialysis Frequency	2 times a week	22	41	63	0.388	0.001
	3 times a week	9	1	10		
		31	42	73		

*RR > 1 indicates a risk factor
**Fisher exact test, significant if p < 0.05.

Unadjusted risk ratios (RR) were calculated to evaluate the relationship between the variables and the risk of thrombosis. Patients with femoral vein catheter insertion had a significantly higher risk of thrombosis compared to those with jugular vein insertion (RR 0.413, 95% CI 0.003), and patients with left-sided insertion had a higher risk than those with right-sided insertion (RR 0.42, 95% CI 0.002). Additionally, patients who underwent hemodialysis three times per week had a higher risk of thrombosis compared to those who underwent it twice per week (RR 0.388, 95% CI 0.001) (Table 2).

Regarding catheter tip position, the correlation between tip location and thrombosis was evaluated using Spearman's rho correlation. A negative correlation (-0.323) was found between thrombosis and catheter tips located at the cavoatrial junction (p = 0.005), indicating that this position may be associated with a lower risk of thrombosis compared to other tip positions (Table 3).

TABLE 3: Description of the Research Sample Correlation of Tip Position and Thrombosis (n=73).

Tip Position	Thrombosis (n = 31)	Absence of Thrombosis (n = 42)	Total (n = 73)	ρ***	P Value
Cavoatrial Junction	1	9	10	-0.323	0.005
Right Atrium	14	20	34		
Superior Vena Cava	7	11	18		
Femoral	9	2	11		
Total	31	42	73		

***Spearman Rho Correlation.

Sensitivity analyses were performed to further investigate the impact of catheter tip position and insertion side on the incidence of thrombosis. The data analysis supports the hypothesis that the catheter insertion site, side, and tip position are significant risk factors for thrombosis in patients undergoing hemodialysis with a tunneled double-lumen catheter. These findings provide valuable insights into optimizing vascular access management in stage V CKD patients.

DISCUSSION AND CONCLUSION

This study examined the thrombotic risk factors associated with tunneled double-lumen catheter (TDLC) use for hemodialysis access in patients with stage V chronic kidney disease (CKD). The primary outcomes focused on thrombotic incidence, catheter tip position, venous access location, side of insertion, and frequency of hemodialysis.

The study found that 42% of the 73 patients developed thrombosis, with significant differences based on catheter placement factors. The right internal jugular vein (RIJV) was used in the majority of cases and was associated with a lower risk of thrombosis (RR 0.413, p = 0.003). Catheters inserted into the left internal jugular vein had a notably higher incidence of thrombosis (76.5%), while right-sided insertions were associated with a lower risk (32%) (RR 0.42, p = 0.002).

Regarding tip positioning, the atrium right had the highest percentage of thrombotic events (41.2%), whereas the cavoatrial junction was less frequently associated with thrombosis. The frequency of hemodialysis also played a role, with patients undergoing dialysis twice weekly experiencing significantly lower thrombosis rates compared to those dialyzing three times weekly (RR 0.388, p = 0.001).

These findings support the conclusion that venous access location, side of catheter insertion, and dialysis frequency are key determinants of thrombotic risk. Consistent with the literature, the RIJV remains the preferred site for TDLC insertion due to its protective effect against thrombosis (Daugirdas, 2015; KDOQI, 2019). Previous studies also corroborate that left-sided catheter insertions tend to have higher thrombotic complications due to the anatomical path, which is longer and less direct compared to the right side (Santoro, 2014).

However, our findings challenge some prior conclusions regarding catheter tip positioning. While prior studies have suggested that positioning at the right atrium is optimal due to a lower risk of catheter malfunction (Engstrom et al., 2013), our data indicate a higher risk of thrombosis associated with this location. This discrepancy could be attributed to differences in patient characteristics, such as

vascular fragility with age (Xu et al., 2017; Mallappallil et al., 2014), or differences in dialysis practices. Additionally, the higher frequency of dialysis sessions per week was associated with increased thrombosis risk, a finding that aligns with the higher metabolic demands and vascular stress of more frequent hemodialysis (Rhee et al., 2013).

Limitations of this study include the relatively small sample size and the lack of long-term follow-up, which may impact the generalizability of the results. There was also potential bias in selecting patients based on access site preference, as some patients may have had pre-existing vascular conditions influencing catheter placement. While the results are consistent with many existing studies (Sohail et al., 2021; Gunawansa et al., 2018), the generalizability of this study is somewhat limited by the specific demographic and clinical context of the patients treated at RSUP Prof. I.G.N.G Ngoerah. The findings may not be fully applicable to populations with different comorbidities, or dialysis practices that differ in frequency or technique. Future studies with larger sample sizes and more diverse populations would provide stronger external validity and allow for more definitive conclusions. Despite these limitations, the study provides valuable insights into the use of tunneled catheters for hemodialysis access and their associated risks.

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