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The Effect of Rivaroxaban on Tunneled Cuffed Catheter Function in Hemodialysis Patients

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Abstract

Objective: To investigate the effect of oral rivaroxaban on tunneled cuffed catheter function in maintenance hemodialysis patients. **Methods:** A single-center retrospective cohort study design was adopted. Clinical data were collected from 40 patients who underwent maintenance hemodialysis using tunneled cuffed catheters as vascular access in our hospital from February to October 2025. The patients were divided into two groups based on whether they received oral rivaroxaban during dialysis: 20 patients in the observation group (oral rivaroxaban 10 mg/day) and 20 patients in the control group (no anticoagulant or antiplatelet medications). The incidence of catheter dysfunction, dialysis adequacy indicators, coagulation function, and bleeding events were retrospectively analyzed and compared between the two groups. **Results:** The incidence of catheter dysfunction in the observation group was significantly lower than that in the control group（$p < 0.01$）. The Kt/V values in the observation group were higher than those in the control group at all follow-up time points and remained stable($p < 0.05$; $p < 0.01$). The mean blood flow in the observation group was significantly higher than that in the control group at all post-treatment time points($p < 0.05$; $p < 0.01$). No significant differences were observed in coagulation function indicators (PT, APTT, Fib) before and after treatment or between the two groups (all $p > 0.05$). In the observation group, one patient experienced minor gingival bleeding, which resolved spontaneously without discontinuation of medication, while no bleeding events were observed in the control group. No severe bleeding or thromboembolic events occurred in either group. **Conclusion:** Oral rivaroxaban (10 mg/day) effectively reduces the incidence of TCC dysfunction in MHD patients, contributes to maintaining dialysis adequacy, and shows a favorable safety profile without significant coagulation abnormalities or severe bleeding risk.

Keywords: Rivaroxaban; Hemodialysis; Tunneled cuffed catheter; Catheter dysfunction;

Introduction

Arteriovenous fistula is the preferred vascular access for patients undergoing maintenance hemodialysis (MHD). However, for those with poor vascular conditions, difficulty in establishing an arteriovenous fistula, or failure of maturation, tunneled cuffed central venous catheter (TCC) serves as an important alternative vascular access[1]. During usage, TCC often experience functional impairment due to factors such as fibrin sheath formation or intraluminal thrombosis. These issues manifest as an inability to achieve or maintain sufficient hemodialysis blood flow, severely compromising dialysis adequacy[2,3]. Fox et al. conducted a 5-year observation and found that the incidence of TCC dysfunction was as high as 29.2%[4]. Currently, heparin locking is the primary clinical measure for prevention, but its efficacy remains limited. Therefore, exploring more effective

strategies to prevent TCC dysfunction holds significant clinical importance. Rivaroxaban is a highly selective, direct oral Factor Xa inhibitor that exerts its anticoagulant effect by inhibiting a key step in the coagulation cascade. It offers the advantages of convenient oral administration and does not require routine coagulation monitoring[5,6]. Theoretically, it may offer superior efficacy in inhibiting catheter-related thrombosis. However, research on the application of rivaroxaban in the high-risk population of MHD patients, characterized by coexisting bleeding and thrombosis risks, is relatively limited, particularly regarding its use for preventing TCC dysfunction. Therefore, this study, through a retrospective cohort analysis, aimed to evaluate the effect and safety of rivaroxaban on tunneled cuffed catheter (TCC) function in maintenance hemodialysis (MHD) patients, providing a reference for optimizing clinical vascular access management.

Methods

Object of study

A total of 40 patients who underwent maintenance hemodialysis using tunneled cuffed catheters as vascular access at the Blood Purification Center of our hospital from February to October 2025 were selected as the study subjects. Inclusion criteria were as follows: (1) age ≥ 18 years; (2) catheter indwelling time > 1 week, with normal catheter function at enrollment (blood flow rate ≥ 200 mL/min), and catheter tip position confirmed to be correct by imaging. Exclusion criteria were as follows: (1) presence of active bleeding or high risk of bleeding; (2) contraindications to anticoagulation therapy; (3) known allergy to rivaroxaban or its excipients; (4) complicated by severe hepatic insufficiency, severe heart failure, respiratory failure, or active malignancy.

Ethical statement

The study protocol was approved by the Medical Ethics Committee of the China Rongtong Medical & Healthcare Group Tai'an 88 Hospital. As this study was a retrospective case analysis that only collected previous clinical data and did not involve patient identity information, the requirement for informed consent was waived. The study process complied with the ethical guidelines of the Declaration of Helsinki.

Grouping and data collection

A retrospective cohort study design was used. Based on whether patients received rivaroxaban during hemodialysis, the 40 patients were divided into two groups: the observation group (n=20), consisting of patients who received oral rivaroxaban (10 mg/day) in addition to routine heparin locking, and the control group (n=20), consisting of patients who received only routine heparin locking without any anticoagulant or antiplatelet medication. Baseline data, laboratory findings, dialysis records, and follow-up information for all patients were collected through the hospital's electronic medical record system.

Therapeutic regimen

All patients used catheters of the same model and specification, and TCC placement was performed by the same experienced vascular access physician. After each hemodialysis session, all patients received catheter locking with a standard concentration of heparin saline.During the study period, if a patient developed catheter dysfunction (manifested as decreased blood flow), thrombolytic therapy was administered by injecting urokinase (100,000 U/vial) into the catheter lumen. If blood flow returned to the target level (≥200 mL/min) after thrombolysis, follow-up was continued. If repeated thrombolysis was ineffective or failed to achieve the required dialysis flow rate, the catheter was deemed to have "irreversible dysfunction," and it was removed and documented.

Observational indices

1 Incidence of Catheter Dysfunction. Catheter dysfunction was defined as an actual blood flow rate persistently <200 mL/min during a single dialysis session, or an arterial pressure <-250 mmHg and/or a venous pressure >250 mmHg when the blood pump speed was set at 200 mL/min, and was confirmed by a push test to be due to thrombosis[7,8].

2 Dialysis adequacy: The Kt/V values of patients in both groups were recorded at enrollment (baseline) and at 4 weeks, 8 weeks, and 12 weeks of treatment.

3 Hemodynamics: The mean blood flow rate (mL/min) during each dialysis session was recorded.

4 Coagulation function: Collect the patient's prothrombin time (PT), activated partial thromboplastin time (APTT), and fibrinogen (Fib) levels before treatment, at 4 weeks of treatment, and at 12 weeks of treatment.

5 Safety indicators: All bleeding events and other adverse reactions (such as allergies, liver dysfunction, etc.) occurring during the follow-up period were recorded.

Statistical methods

Statistical analysis was performed using SPSS 22.0 software. Measurement data are expressed as mean ± standard deviation ($\bar{x}$ ± s). Independent sample t-tests were used for comparisons between groups, and repeated-measures analysis of variance was employed for comparisons at different time points within groups. Count data are presented as number (percentage), and comparisons between groups were conducted using χ^2 tests. A p-value < 0.05 was considered statistically significant.

Result

1 Baseline data comparison

There were no statistically significant differences in baseline characteristics such as age, gender, composition ratio of primary renal diseases leading to uremia, hemoglobin, albumin, serum creatinine, and blood urea nitrogen between the two groups of patients (P>0.05), indicating comparability (Table 1). During the study period, all patients completed the 12-week follow-up with no dropouts.

Table 1 Comparison of baseline characteristics between the two groups of patients ($\bar{x}$ ± s / n(%))

	Control group (n=20)	Observation group (n=20)	p-value
Age(years)	56.95±8.31	57.8±7.14	0.731
Gender(Male/Female)	9/11	12/8	
The primary disease of uremia,[N (%)]			
Diabetic nephropathy	6(30.0)	8(40.0)	
Chronic glomerulonephritis	3(15.0)	5(25.0)	
Hypertensive renal damage	7(35.0)	6(30.0)	
Unknown cause	4(20.0)	1(5.0)	
Hemoglobin(g/L)	95.94±7.98	94.05±6.15	0.404
Albumin(g/L)	37.7±2.37	35.98±3.03	0.053
Serum creatinine(μmol/L)	696.85±125.56	707.8±134.32	0.791
Urea nitrogen(mmol/L)	21.97±4.75	20.84±3.56	0.477
Site of catheter placement [N (%)]			
Right internal jugular vein	19(95.0)	18(90.0)	
Left internal jugular vein	1(5.0)	2(10.0)	
Dialysis blood flow at enrollment(mL/min)	240.25±17.28	231.75±18.65	0.506

Venous dialysis pressure(mmHg)	138.2±13.96	136.55±16.05	0.731

2 Comparison of catheter function and patency

During the follow-up period, a total of 1,145 catheter-days were observed in the control group, with 137 cases of dysfunction events occurring; in the observation group, a total of 1,252 catheter-days were observed, with 69 cases of dysfunction events occurring. The incidence of catheter dysfunction (calculated per catheter-day) in the observation group was significantly lower than that in the control group (5.51% vs. 11.97%, $p < 0.01$). At the patient level, 16 cases (80.0%) in the control group experienced at least one episode of dysfunction, compared with 9 cases (45.0%) in the observation group, and the difference was statistically significant ($\chi^2=5.014$, $p=0.024$). One patient in the control group required catheter removal due to failure of repeated thrombolysis and loss of catheter function, while no catheter removal occurred in the observation group (Table 2).

Table 2 Comparison of catheter dysfunction incidence between the two groups

项目	Control group **(n=20)**	Observation group **(n=20)**
Follow-up catheter-days (days)	1145	1252
Total number of dysfunction events	137	69
Number of patients with dysfunction [n(%)]	16(80.0)	9(45.0)
Number of patients with catheter removal [n(%)]	1(5.0)	0(80.0)

3 Dialysis adequacy and changes in blood flow

The baseline Kt/V levels were comparable between the two groups before treatment. After 8 and 12 weeks of treatment, the Kt/V values in the observation group were significantly higher than those in the control group, with statistically significant differences($p < 0.05$; $p < 0.01$). Throughout the follow-up period, the Kt/V values in the control group showed a sustained downward trend, while those in the observation group remained relatively stable. This indicates that the regimen in the observation group was more effective in maintaining or improving dialysis adequacy in patients (Table 3). Although there was no significant difference in blood flow between the two groups before treatment, the mean blood flow in the observation group was significantly higher than that in the control group at all post-treatment time points (4, 8, and 12 weeks). Notably, at 12 weeks, the difference between the observation group and the control group was highly significant ($P < 0.01$). This suggests that the intervention in the observation group helped maintain catheter patency and ensure adequate blood flow (Table 3).

Table 3 Comparison of Dialysis Adequacy（Kt/V）and Changes in Average Blood Flow Between the Two Groups($\bar{x} \pm s$)

Group	**指标**	**Pre-treatment**	4 weeks	8 weeks	12 weeks
Control group (n=20)	kt/v	1.326±0.189	1.294±0.185	1.247±0.178	1.192±0.121
	average blood flow(ml/min)	240.75±19.55	231.25±17.98	223.25±18.30	216.5±15.82
Observation group (n=20)	kt/v	1.312±0.198	1.382±0.182	1.306±0.205①	1.324±0.185②
	average blood flow(ml/min)	236.75±18.08	242±13.61①	234.25±15.41①	240.75±17.11②

Note: Compared with the control group, ① $P < 0.05$, ② $P < 0.01$.

4 Evaluation of Coagulation Function and Safety

There was no significant difference in PT, APTT, and Fib levels between the two groups of patients before treatment, at 4 and 12 weeks of treatment (all $p > 0.05$, Table 4). Additionally, there were no

significant differences in PT, APTT, and Fib before and after treatment in the two groups ($p > 0.05$). Regarding safety, one patient in the observation group experienced minor gingival bleeding, which resolved spontaneously without specific intervention and did not lead to discontinuation of anticoagulant therapy. No bleeding events were reported in the control group. During the entire study period, no major bleeding or new thromboembolic events occurred in either group.

Table 4 Comparison of Coagulation Function Indicators Before and After Treatment Between the Two Groups ($\bar{x} \pm s$)

Group	Time points	PT (s)	APTT (s)	Fib (g/L)
Control group (n=20)	**Pre-treatment**	11.04±1.17	28.92±2.86	3.43±1.20
	4 weeks	10.86±1.09	29.07±2.69	3.55±1.14
	12 weeks	11.11±1.08	27.18±3.33	3.62±1.16
Observation group (n=20)	**Pre-treatment**	10.94±1.36	27.66±3.05	3.55±1.03
	4 weeks	11.52±0.96	29.43±2.51	3.71±1.07
	12 weeks	11.39±0.83	28.05±2.8	3.67±1.12

Abbreviations and reference range: PT: prothrombin time, 9.8-12.1s; APTT: activated partial thromboplastin time, 23.3-32.5s; Fib: fibrinogen, 2-4g/L.

Discussion

Tunneled cuffed catheter (TCC) dysfunction is a common complication that adversely affects the dialysis adequacy and quality of life in maintenance hemodialysis (MHD) patients, with its core pathological mechanism being the formation of thrombus and fibrin sheath on the catheter wall and tip[9]. Although the KDOQI guidelines have suggested considering antiplatelet agents such as aspirin to reduce catheter-related thrombosis, the evidence level is limited and the efficacy remains suboptimal[10]. Therefore, exploring more effective anticoagulation prevention strategies is of critical importance.

This study, through a retrospective cohort analysis, found that the incidence of catheter dysfunction in the observation group (5.51%) was significantly lower than that in the control group (11.97%). Additionally, the observation group demonstrated significantly better outcomes in maintaining dialysis adequacy (Kt/V) and mean blood flow rate. These findings suggest that the intervention used in the observation group—rivaroxaban—offers clinical advantages in preventing hemodialysis catheter dysfunction. Rivaroxaban potently inhibits factor Xa in the coagulation cascade, thereby blocking the explosive generation of thrombin upstream and more effectively preventing the formation of microthrombi both inside and outside the catheter[5]. A retrospective cohort study on long-term central venous catheters in cancer patients demonstrated that prophylactic use of rivaroxaban significantly reduced the risk of catheter-related thrombosis by 53%, with even more pronounced benefits observed in high-risk populations, particularly those with peripherally inserted central catheters or active malignancy[11]. Although this study primarily focused on cancer patients, it provides important evidence for the effectiveness of rivaroxaban in preventing catheter-related thrombosis. Another study on pediatric patients with intestinal failure also confirmed that the use of rivaroxaban for the secondary prevention of catheter-related thrombosis achieved an extremely low recurrence rate of thrombosis[12].

The application of rivaroxaban in hemodialysis patients requires special attention to its pharmacokinetic profile. Approximately 66% of rivaroxaban is metabolized via the hepatic CYP450 system, and about one-third is excreted unchanged in the urine[6]. In maintenance hemodialysis patients without residual renal function, a single 10 mg dose of rivaroxaban results in drug exposure comparable to that of a 20 mg dose in healthy volunteers, and no significant accumulation is observed with multiple daily doses. More importantly, due to its over 90% protein binding rate,

hemodialysis has no significant impact on its plasma concentration. Therefore, rivaroxaban can be used in dialysis patients without concerns about clearance via dialysis[13,14].

In terms of safety, rivaroxaban demonstrated good tolerability in this study. Before and after treatment, there were no clinically significant changes in routine coagulation parameters (PT, aPTT), which aligns with the drug's characteristic of not affecting the activity of already-formed thrombin and having minimal impact on the overall coagulation system. Only one case of minor gingival bleeding occurred, which resolved spontaneously, and no major bleeding events were observed. This provides preliminary support for the short-term safety of rivaroxaban use in MHD patients. However, it is crucial to recognize that patients with ESRD inherently have a significantly higher risk of bleeding compared to the general population due to factors such as the accumulation of uremic toxins, platelet dysfunction, and vascular endothelial damage[15]. Therefore, in clinical practice, it is essential to rigorously assess each patient's individual bleeding and thrombotic risks and to enhance monitoring during the period of use. Current authoritative guidelines still recommend the cautious use of rivaroxaban in dialysis patients with eGFR <15 ml/min[14,15]. However, in recent years, a growing number of studies have begun to explore dose optimization strategies for its use in this population[13,14].

This study has the following limitations: (1) The retrospective design inherently carries selection bias and information bias. Although the baseline data were comparable between the two groups, not all confounding factors could be completely controlled. (2) The single-center, small-sample size limits the generalizability of the results. (3) The follow-up period was relatively short (12 weeks), preventing the assessment of long-term efficacy and safety. (4) Rivaroxaban-specific indicators (such as anti-Xa activity) were not monitored, making it impossible to explore the relationship between individual plasma drug concentrations and efficacy or safety.

Future research directions should involve conducting large-scale, multicenter, long-term follow-up randomized controlled trials to provide higher-level evidence. Additionally, exploring rivaroxaban individualized dosing strategies based on anti-Xa activity monitoring holds promise for further optimizing bleeding risk management while ensuring anticoagulation efficacy, achieving "precision anticoagulation," which may be key to optimizing vascular access management in high-risk dialysis patients in the future.

Conclusions

In this retrospective cohort study, oral rivaroxaban (10 mg/day) in maintenance hemodialysis patients helped reduce the incidence of tunneled cuffed catheter dysfunction, maintain stable dialysis adequacy, and did not significantly increase the risk of bleeding or cause coagulation abnormalities during the 12-week observation period. This study provides preliminary clinical evidence for the use of rivaroxaban in preventing dialysis catheter-related thrombosis. However, larger-scale, longer-term prospective studies are still needed to validate its long-term efficacy and safety.

Abbreviations

MHD: maintenance hemodialysis; TCC: tunneled cuffed central venous catheter

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Authors' contributions

XQN and CZ conceived of the study and participated in the design. ML was responsible for collecting samples and statistical analysis. CC helped to perform the statistic analysis, draft the

manuscript and modify the article. All authors read and approved the final manuscript.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no financial or non-financial competing interests.

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