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Infectious complications in hospitalized patients with chronic kidney disease on renal replacement therapy: An observational study in a fourth-level health center on the Colombian Caribbean Coast (2019-2024).

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Abstract

Introduction: The second cause of mortality in patients with chronic kidney disease is infections, among which the presence of devices such as catheters is a risk factor. This study examines the factors contributing to catheter-related infections among patients with CKD on the Colombian Caribbean Coast.

Methods: The present observational study was conducted at the Clínica de la Costa (Barranquilla, Colombia) from 2019 to 2024. Records of patients on hemodialysis or peritoneal dialysis hospitalized for infections associated with the renal replacement device, with microbiological confirmation by positive culture, were included. The sample was divided into two groups based on hospital outcome: living and deceased. Sociodemographic, clinical, microbiological, and management variables were collected. Percentages are compared with the Chi-square test and the Odds ratio.

Results: A total of 78 cases were analyzed, of which 38 were from the hemodialysis program and 40 from the peritoneal dialysis program; in-hospital mortality was 25.6% (n=20). No statistically significant differences were found in age, sex, or chronic comorbidities, such as hypertension or diabetes, between the groups of survivors and deaths. A history of previous infection and neurological disease was identified as a critical risk factor, increasing the probability of death almost fourfold (OR: 3.714; 95%CI: 1.037-13.309; P=0.036). The fatal outcome was closely linked to septic shock and admission to the ICU, which were present in 100% of the deceased (P < 0.001). Microbiologically, methicillin-resistant *S. aureus* was the main predictor of mortality, present in 50% of deaths with a significantly higher risk than other pathogens (OR: 117; P=0.0014).

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No significant associations were detected between the type of access device or dialysis modality and patient death.

Conclusion: Survival after renal replacement therapy depends on strict microbiological surveillance and personalization of preventive care in cognitively compromised patients, allowing early intervention before irreversible organ dysfunction occurs.

Keywords:

Chronic kidney disease, renal replacement therapy, hemodialysis, peritoneal dialysis, associated infections.

Chronic kidney disease (CKD) is identified by structural and functional renal abnormalities that last for more than three months, with a decrease in the glomerular filtration rate (GFR) < 60 ml/min/1.73 m², considering specific biomarkers such as increased creatinine, proteinuria, albuminuria, active sediments in urine analysis, structural alterations identified by imaging and histopathological changes [1].

Chronic kidney disease (CKD) places a significant burden on patients, their families, and the healthcare system, particularly in low- and middle-income countries. This is due to the high cost of treating the disease itself and its complications, both advanced renal and cardiovascular, which arise in the intermediate stages of CKD [2]. CKD is projected to be the fifth leading cause of death worldwide by 2040, with a growing impact on morbidity and mortality. CKD also presents a challenge for Latin America, with an average prevalence of 9.9% in the adult population across all stages [3].

CKD is classified according to its severity, on the basis of GFR and albuminuria levels, with stage G5, also called "renal failure", being the worst possible scenario—GFR < 15 ml/min/1.73 m²—which requires renal replacement therapy (RRT) to artificially replace kidney function, promoting renal replacement to restore electrolyte balance by removing water and solutes [4, 5].

There are several modalities for implementing renal replacement therapy (RRT); hemodialysis (HD) involves the periodic extracorporeal removal of excess water and solutes from the blood through a semipermeable membrane powered by the extraction pump of a dialysis machine [4, 5]. Peritoneal dialysis (PD) consists of the exchange of solutes and fluids between the blood in the peritoneal capillaries and a solution administered into the peritoneal cavity, using the peritoneal membrane as the dialysis surface. PD offers a better quality of life due to its portability, allowing patients to perform it independently without having to travel to a specialized center, thus maintaining their mental and socioeconomic capacity for uninterrupted daily life [6, 7].

Both hemodialysis (HD) and peritoneal dialysis (PD) are fundamental renal replacement therapies for the management of advanced chronic kidney disease [8]; however, both present acute and chronic complications that can significantly affect patients' quality of life and prognosis. PD-specific complications include catheter dysfunction, which may fail to infuse or drain; hernias due to increased intra-abdominal pressure, which may require surgical intervention (incidence of 467/1,000,000); and peritonitis, the most common complication [6]. On the other hand, the most frequent HD complications are intradialytic hypotension, muscle cramps, headache, and dialyzer reactions, which are related to sudden hemodynamic changes or adverse immune responses. Furthermore, vascular access-associated infections, especially those involving temporary or tunneled catheters, represent a significant cause of morbidity and mortality [9].

Among these complications, infections associated with hemodialysis (HD) and peritoneal dialysis (PD) are very common. Gram-positive cocci are frequently isolated from HD patients, whereas *Pseudomonas aeruginosa* and fungi are the most common microorganisms in PD patients [10]. Modifiable and nonmodifiable risk factors include prolonged hospital stays, comorbidities affecting the immune system, poor hygiene, nutritional status, type of catheter used, and educational level [11].

The objective of this study was to describe infectious complications in a group of patients from hemodialysis and peritoneal dialysis programs admitted to a reference center on the Colombian Caribbean coast.

Materials and methods

Studio design

This was an observational, cross-sectional study. The source is retrospective.

Scenery

This study was conducted in the statistics department of the "Clínica de la Costa" in Barranquilla, Colombia. The study period was from January 1, 2019, to December 31, 2024.

Participants

Historical records of adult patients who were over 18 years of age, had stage 5-D chronic kidney disease, were undergoing hemodialysis or peritoneal dialysis, were hospitalized with infectious complications associated with the use of renal replacement devices (vascular or peritoneal dialysis catheters), and whose blood or peritoneal fluid cultures were positive were included. No records were excluded. Two

groups were formed according to the outcome during the hospitalization period: alive or deceased.

Variables

The sociodemographic variables included age, sex, educational level, therapy modality, anatomical location of the catheter, microbiological culture reports of peritoneal fluid and blood cultures, with their corresponding resistance, the need for hospitalization or ICU stay, and the subsequent outcome (alive or deceased) and cause of death. Risk and protective factors included personal medical history, comorbidities, adherence to comorbidity treatment, and hygiene habits.

Data sources/measurements

The source was indirect; hospitalization and laboratory records, as well as institutional electronic records, were used for data collection.

Biases

The surveys were administered in a standardized manner by the principal investigator via a preestablished guide approved in the research protocol. The information was independently reviewed by two researchers and recorded in duplicate. Only records with complete agreement were included.

Study size

The sample was not probabilistic and was selected by convenience sampling during the study period, according to the inclusion criteria.

Quantitative variables

The results for ordinal variables are presented as frequencies and percentages. The results for the scale variables are presented as averages. Scale variables were not converted into quantitative variables.

Statistical analysis

Inferential statistics were used. Percentages were compared via the chi-square test. The results of the association analysis are presented as odds ratios and 95% confidence intervals. Statistical analysis was performed via SPSS version 31.0 (IBM Corp., 2024/2025).

Results

Participants

There were 78 cases. A total of 38 patients were included in the hemodialysis program, and 40 were included in the peritoneal dialysis program. A total of 58 patients completed the hospital period alive (Group 1), and 20 died during hospitalization (Group 2).

Characteristics of the study population

In both groups, age was similarly distributed, with a mean age of approximately 51 years, with no statistically significant differences between them. There were no differences in the distribution by sex or education level (Table 1).

Comorbidities

Analysis of the sample revealed that mortality was not significantly influenced by chronic comorbidities such as hypertension or diabetes. However, critical risk factors were identified: patients with a history of prior infection or neurological disease had an almost fourfold-fold greater probability of dying (OR: 3.714; 95% CI: 1.037–13.309; $P = 0.036$). In terms of the clinical course, fatal outcomes were closely linked to severe acute complications, as 100% of those who died presented with septic shock and required admission to the ICU ($P < 0.001$), indicating a statistically significant difference compared with survivors. Conversely, neither the type of access device (vascular or peritoneal) nor the intensity of wound care was significantly associated with mortality in this study group (Table 1).

Etiology associated with mortality

Microbiological analysis revealed a dispersion of pathogens in both groups but highlighted the presence of methicillin-resistant *Staphylococcus aureus* (MRSA) as the main predictor of mortality. This bacterium was identified in 50% of the deceased patients, representing an extremely high risk compared with the survivors (OR: 1.17; 95% CI: 6.36–2152.4; $P = 0.0014$). On the other hand, although microorganisms with complex resistance profiles, such as ESBL-producing *E. coli*, carbapenemase-producing Enterobacter, and *S. aureus-K. oxytoca* coinfection (10% each), were observed in the deceased group, these differences did not reach statistical significance ($P = 0.079$). In contrast, the survivor group presented a greater diversity of pathogens, including more common bacteria such as *S. epidermidis* and Candida species, which were not associated with a fatal outcome in this sample (Table 2).

Discussion

This research demonstrated that mortality in patients with access site infections on renal replacement therapy is closely linked to the severity of systemic involvement and high-resistance microbiological profiles rather than to the patient's demographic characteristics or underlying comorbidities. The most relevant finding is the critical association between septic shock and fatal outcomes present in all deceased patients, along with the determining impact of prior infection and neurological disease, which are conditions that increase the probability of death almost fourfold (OR: 3.714).

From a microbiological perspective, the study revealed that *S. aureus* methicillin-resistant bacteria (MRSA) emerged as the pathogen with the greatest prognostic weight, accounting for 50% of deaths, with a significantly greater risk than other isolates (OR: 117). These results underscore that while the dialysis modality and device type did not significantly affect survival, progression to a critical state and the presence of multidrug-resistant organisms are the cornerstones on which preventive and therapeutic management should focus.

aureus infection The prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in this cohort can be explained by the complex interaction between uremic patients' immune dysfunction and

bacterial virulence. Pathophysiologically, patients receiving renal replacement therapy exhibit functional immunodeficiency affecting both cellular and humoral immunity, facilitating colonization and subsequent invasion by opportunistic pathogens.

Table 1. General description of the sample.

	Group 1 I live n=58	Group 2 Deaths n=20	P	OR	95% CI
Age (Years)	52.9 ± 15.1	50.7 ± 14.5	0.573	--	--
Male sex	28 (48.3%)	6 (20%)	0.155	--	--
Primary schooling	42 (72.4%)	12 (60%)	0.300	--	--
Secondary education	16 (27.6%)	8 (40%)	0.300	--	--
Comorbidities					
High blood pressure	48 (82.8%)	16 (80%)	0.782	--	--
Type 2 Diabetes	24 (41.4%)	4 (20%)	0.086	--	--
Liver disease	2 (3.4%)	0 (0%)	0.400	--	--
Heart disease	18 (31.0%)	2 (10%)	0.063	--	--
Previous infection	6 (10.3%)	6 (30%)	0.036	3,714	1.037-13.309
Neurological disease	6 (10.3%)	6 (30%)	0.036	3,714	1.037-13.309
Type of device and intensity of healing					
Backhoe catheter	4 (6.9%)	0 (0%)	0.228	0.730	0.635-0.838
Subclavian catheter	10 (17.2%)	6 (30%)	0.223	--	--
Jugular catheter	8 (13.8%)	0 (0%)	0.080	0.714	0.616-0.828
Femoral catheter	8 (13.8%)	4 (20%)	0.507		
Peritoneal catheter	28 (48.3%)	10 (50%)	0.894		
Weekly healing	22 (37.9%)	9 (45%)	0.577		
Treatment 3 or more times per week	36 (62.1%)	11 (55%)	0.577		
Type of infection and treatment					
Bacterium	30 (31.7%)	10 (50%)	0.676		
Bacteria + fungus	2 (3.4%)	0 (0%)	0.676		
Admission to intensive care	16 (27.6%)	20 (100%)0	<0.001		
Septic shock	0	20 (100%)	<0.001		
Hemodialysis vs PD	30 (51.7%)	8 (40%)	0.366		

DP: Peritoneal dialysis. OR: Odds ratio. CI: Confidence interval.

Table 2. Description of the germs and fungi in the study sample.

	Group 1 I live n=58	Group 2 Deaths n=20	P	OR	95% CI
Acinetobacter Baumanii	2 (34%)	0	0.379	--	--
E. coli Blee	0	2 (10%)	0.0791	--	--
Enterobacter Carbapenemase Producer Arogenes	0	2 (10%)	0.0791	--	--
K. Penumoniae Esbl	2 (3.4%)	0	0.379	--	--
Morganella Morganii and E. Faecium	2 (3.4%)	0	0.379	--	--
Pseudomonas aeruginosa Mrs	2 (3.4%)	0	0.379	--	--
S. Aureus Methicillin Resistant	8 (13.8%)	2 (10%)	0.6631	--	--
S. Aureus Methicillin- resistant Klebsiella Oxytoca	0	2 (10%)	0.0791	--	--
S. Aureus Methicillin- sensitive	8 (13.8%)	2 (10%)	0.6631	--	--
S. epidermidis	6 (10.3%)	0	0.2757	--	--
S. epidermidis and *Candida albicans*	2 (3.4%)	0	0.379	--	--
Candida Albicans	4 (6.9%)	0	0.4203	--	--
Candida Parapsilosis	2 (3.4%)	0	0.379	--	--
Enterobacter Clocae and Non Blee *E. coli*	2 (3.4%)	0	0.379	--	--
Pseudomine Aeruginosa	4 (6.9%)	0	0.4203	--	--
S. Aureus Methicillin Resistant	0	10 (50%)	*0.0014	117	6.36-2152.4
S. Aureus Methicillin- sensitive	12 (20.7%)	0	0.1017		
S. epidermidis Methicillin Resistant	2 (3.4%)	0	0.379		
Streptococcus Penicillin Sensitive	2 (3.4%)	0	0.379		

The predilection of MRSA for access devices is due to its ability to form biofilms and express virulence factors, such as leukocidins and fibronectin-binding proteins, which allow for persistent bacterial adherence and effective evasion of the immune system. This invasion triggers an uncontrolled systemic inflammatory response; in deceased patients, the massive release of proinflammatory cytokines appears to overwhelm compensatory mechanisms, rapidly leading to microvascular dysfunction, refractory vasodilation, and multiple organ damage—characteristics of septic shock observed in 100% of fatal cases. Furthermore, the increased risk in patients with neurological disease (OR: 3.714) suggests additional vulnerability, possibly linked to greater inadvertent manipulation of the devices, difficulties in access site hygiene, and an altered autonomic response, which accelerates the progression from a local infection to fulminant sepsis before effective therapeutic intervention can be achieved.

The findings of this study have direct implications for optimizing surveillance protocols in dialysis units. *S. aureus* methicillin-resistant *Staphylococcus aureus* (MRSA) was identified as the main predictor of mortality. Therefore, it is imperative to implement active screening programs and nasal/cutaneous decolonization in patients receiving renal replacement therapy, especially those receiving long-term devices. Furthermore, the strong association between neurological disease and the risk of death (OR: 3.714) suggests the need for personalized nursing care. For these patients, the application of reinforced safety dressings and intensive education for the primary caregiver are recommended to minimize inadvertent manipulation of the access site. Given that septic shock is the universal outcome in those who die, clinical practice should be geared toward the use of early detection biomarkers and the empirical initiation of antibiotic regimens covering multidrug-resistant organisms at the slightest suspicion of access site infection, preventing progression to multiorgan failure, which, as our case series demonstrates, is irreversible once established.

The study revealed that *Staphylococcus aureus* was the most common microorganism in catheter-related infections, both in blood cultures and in peritoneal fluid cultures. This finding is consistent with other studies that identified *S. aureus* as the predominant pathogen in catheter-related infections [10]. The observed antimicrobial resistance, at 16% in blood cultures and 30% in peritoneal fluid cultures, highlights a growing challenge in the management of these infections, which aligns with global concerns about the rise of bacterial resistance in nosocomial infections [12-15].

The mortality rate may be influenced by the quality of catheter-related infection management, comorbidity control, and adherence to care practices [16]. The results obtained in this cohort closely correlate with recent international evidence, which ranks access device infections as the second leading cause of death in renal patients, surpassed only by cardiovascular events. The prevalence of *S. aureus* methicillin-resistant staphylococci (MRSA) as a critical predictor of mortality is consistent with findings reported by multicenter studies in Latin America and Europe [17-19], where antimicrobial resistance has been shown to double the likelihood of progression to severe sepsis compared with susceptible strains. However, a distinctive finding of this research is the lack of statistical significance in variables such as as diabetes mellitus and age, factors that, in meta-analyses, often appear to be risk predictors. This discrepancy could be explained by the phenomenon of "selective survival" or by efficient standardization of nursing care at our center, which would neutralize the impact of underlying comorbidities. On the other hand, the observed association between neurological disease and mortality reinforces the theories of the authors, who suggest that cognitive impairment is an independent risk factor for catheter contamination, indicating that access integrity depends on both medical technique and the patient's self-care capacity.

Despite the clinical relevance of the findings, this study has limitations that should be considered when the results are interpreted. First, its retrospective, single-center nature restricts the possibility of establishing a definitive causal relationship and limits the generalizability of the data to populations with different epidemiological contexts. Furthermore, the sample size (N=78), while sufficient to identify critical predictors such as MRSA, may have lacked the statistical power necessary to detect significant differences in less prevalent comorbidities or in the direct comparison between dialysis modalities. These limitations open important avenues for future research; prospective, multicenter studies are suggested to evaluate the impact of preventive interventions, such as the use of antibiotic-impregnated catheter sealing gels or predialysis decolonization protocols. Furthermore, a new line of study is emerging focused on the patient–caregiver dyad, with the aim of quantifying how educational support in patients with neurological impairment can reduce infection rates and, consequently, the progression to septic shock, thus optimizing long-term survival in renal replacement therapy.

Conclusion

This study confirms that mortality in patients with access site infections is primarily determined by progression to septic shock and the presence of methicillin-resistant *S. aureus*. A history of neurological disease is identified as a risk factor that significantly increases the likelihood of death. Therefore, survival following renal replacement therapy depends on strict microbiological monitoring and personalized preventive care in patients with cognitive impairment, allowing for early intervention before irreversible organ dysfunction develops.

Abbreviations

CKD: chronic kidney disease.

Supplementary information

The supplementary materials have not been included.

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Authors' contributions

Gustavo Aroca Martínez: Conceptualization, data curation, research, visualization, original draft writing.
Valentina Pérez Jiménez : Conceptualization, data curation, research, visualization, original draft writing.
Diana Marcela Perea Rojas : Conceptualization, data curation, formal analysis, project management, software, validation, visualization, writing – review and editing.
Andrés Cadena Bonfanti : Conceptualization, formal analysis, methodology, project management, resources, software, supervision, validation, writing – review and editing.
Joanny Judith Sarmiento : Conceptualization, data curation, research, visualization, writing - original draft.
María Raad Sarabia : Conceptualization, formal analysis, methodology, project management, resources, software, supervision, validation, writing – review and editing.
Rodrigo Daza Arnedo: Conceptualization , data curation, research, visualization, original draft writing.
Jorge Rico Fontalvo : Conceptualization, formal analysis, methodology, project management, resources, software, supervision, validation, writing – review and editing.

All the authors read and approved the final version of the manuscript.

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Availability of data or materials
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Statements

Ethics committee approval and consent to participate
The study was approved by the Bioethics Committee of the Clínica de la Costa.

Consent for publication
This does not apply when specific patient images, radiographs, or photographs are not published.

Conflicts of interest
The authors declare that they have no conflicts of interest.

Use of generative AI
The authors declare that they used generative AI responsibly, without replacing their critical thinking, experience, and judgment. The AI was used under supervision and control to develop the discussion section. The use of the AI tool maintains the privacy and confidentiality of data and contributions, including published and unpublished manuscripts, as well as any personally identifiable information. The journal's policies, which permit the use of generative AI only in the introduction and discussion sections, have been followed.
Only limited rights are granted to AI to provide a service.
The accuracy, integrity, and impartiality of all AI-generated results were carefully reviewed and verified to ensure that the manuscript reflects an authentic and original contribution.

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