REV SEN
rev-sen.ec

Risk factors for hemodialysis catheter-associated infection in patients on hemodialysis programs: A multicenter observational study.

Guido Andrés Mayorga Velastegui [1], Jorge Fabián Chonata Quinteros [1], Jorge Washington Vélez [1].

1. Postgraduate Department of Nephrology, Faculty of Medical Sciences, Universidad Central del Ecuador, Quito, Ecuador.

Received: February 12, 2025.
Accepted: April 5, 2025.
Published: April 5, 2025.
Editor: Dr. Salvador Magaña.

How to cite:
Mayorga G, Chonata J, Velez J. Risk factors for hemodialysis catheter-associated infection in patients in hemodialysis programs: A multicenter observational study. REV SEN 2025; 13(2):98-106.

DOI: http://doi.org/10.56867/119
Sociedad Ecuatoriana de Nefrología, Diálisis y Trasplantes.

ISSN-L: 2953-6448

Abstract

Introduction: The hemodialysis catheter is a vascular access that allows immediate dialysis therapy. However, it triggers a significant percentage of infections, affecting patients' quality of life, increasing morbidity and mortality, and increasing healthcare costs. Objective: To identify risk factors associated with catheter infection in chronic hemodialysis patients during the one year from January 2018 to January 2019 in dialysis centers in Quito.

Methodology: A multicenter, analytical, observational, case–control study was conducted in 304 patients receiving catheter-based hemodialysis in four dialysis units in Quito.

Results: Risk factors for catheter infection were: history of smoking (OR 4.6), previous catheter infection (OR 3.2), temporary catheter use (OR 7.7), albumin levels less than 3.5 g/dL (OR 25.5), hemoglobin levels less than 11 g/dL (OR 3.2), and lymphocyte counts less than 1500 mm ^{3} (OR 9.4).

Conclusions: Patients with catheter infection were temporary catheter users with a history of smoking, previous catheter infection, and lower albumin, hemoglobin, and lymphocyte counts. The risk factors associated with catheter infection in this study did not differ from those described in the literature, and it is worth mentioning that these infections are preventable.

Keywords:

Chronic kidney disease, hemodialysis, catheter, catheter-associated infection.

* Corresponding author

Email: Guido Andrés Mayorga Velastegui < andymayorga@gmail.com >/Address: Postgraduate Department, Faculty of Medical Sciences, Central University of Ecuador. Galápagos Street and "La Guaragua" Street, Quito, Ecuador. Telephone [593] 2-252-8810.

Hemodialysis catheter infection is a preventable cause of death in patients with chronic kidney disease on dialysis, and the use of a temporary catheter is widely used in incident patients with chronic kidney disease stage 5d. After obstruction, infectious complications occur after the 7th day of catheter positioning [1].

Catheter-related infections include local and systemic infections, significantly increasing healthcare costs, morbidity, and mortality [2]. In patients with advanced kidney disease, sepsis is the second most common cause of death, following cardiovascular disease [3]. The incidence of catheter-associated infections ranges from 0.6 to 6.5 episodes per 1000 catheter days, with *Staphylococcus aureus* being the most common etiologic agent [4]. Given this issue, identifying risk factors is crucial for establishing prevention policies; these risk factors generally differ from one study to another. These factors include catheter duration, diabetes mellitus, age, and low hemoglobin and serum albumin levels [5-7].

Catheter infections pose a high-risk condition for multiple complications in hemodialysis patients and for public health system costs. Therefore, any information contributing to reducing catheter infections can represent significant progress in improving the prognosis of hemodialysis patients and lowering healthcare costs in Ecuador, which are exceptionally high for chronic kidney disease patients. The hemodialysis centers in Quito, Ecuador, serve as national referral centers for patients in high demand. It is essential to gather information to establish a database to identify the risk factors contributing to catheter infections.

This study aimed to identify the risk factors associated with hemodialysis catheter infections in patients undergoing chronic hemodialysis during the one year from January 2018 to January 2019 in dialysis centers in the city of Quito, Ecuador.

Materials and methods

Study design

This was an observational, case–control study. The source is prospective.

Scenery

The study was conducted in four hemodialysis clinics in Quito, Ecuador. The participating units were as follows:

1. CLINEF North,
2. Nephrology,
3. Nephromedic
4. Contigo-Dialicon.

The study period was from January 1, 2018, to January 31, 2019.

Participants

Patients aged 18 years and older who had been undergoing conventional hemodialysis for less than 3 months and who had used a hemodialysis catheter for vascular access were included in the study. Cases with a confirmed diagnosis of access site infection were documented. Controls were established with patients who had catheters but no infections. The case–control ratio was 1:3 because of the natural incidence of infection. The following were excluded from the study:

- Patients with neoplasms
- Patients with autoimmune disorders
- Patients with HIV, HBV, or HCV infections.
- Patients receiving immunosuppressive therapy.

Variables

The variables included sex, age, ethnicity, smoking history, nutritional status, etiology of chronic kidney disease, catheter type, duration of catheter use, vascular anatomical location, history of prior catheter infections, albumin levels, hemoglobin levels, lymphocyte concentrations, transferrin saturation index, and safety measures implemented for catheter asepsis.

Data sources/measurements

The source of the information was indirect. Data were collected physically via a predesigned table that included all the variables relevant to the study. Each patient's electronic file from the institution was consulted. The data were then entered into the educational version of SPSS statistical software from Central University of Ecuador for analysis. Finally, the report was completed and presented in physical and digital formats.

Biases

Biases related to observation and selection were mitigated by implementing participant selection criteria. A medical representative from each coordinating center was tasked with gathering data recorded on a single online form. The principal investigator consistently managed the data via a guide and records approved in the research protocol to avert potential interviewer, information, and recall bias. If any doubts emerged regarding the standard deviation of the data, corrections were made through onsite reviews of anomalous data. Two investigators independently analyzed each record in duplicate, and variables were entered into the database after verification of concordance.

Study size

The sample was probabilistic. Ecuador has a population of 17,980,083 inhabitants (2023), with an incidence rate of CKD totaling 21,394 cases for 2022 [8 -9]. According to EPI Info TM (Stat Calc, Epi Info, CDC, Atlanta. Version 7.2.6 [October 2023]), with a catheter use frequency of 18%, a confidence limit of 5%, and a confidence level of 97.00%, the sample size was 274 cases.

Quantitative variables

The results are presented as frequencies and percentages. Categorical variables were not converted to scale variables.

Statistical analysis

The variables were analyzed using frequencies and percentages. The 95% confidence interval for a proportion is presented.

Results

Participants

A total of 304 patients were included, achieving the expected sample size. Of these, 40.1% developed catheter-related infections, whereas 59.9% did not.

Description of the groups

The mean age of the patients was 60 ± 15 years, and a higher frequency of mixed-race patients was observed (82.6%). Table 1 summarizes the demographic characteristics of the study population, showing that the characteristics found in both cases and controls are comparable, except for a history of smoking, which was more common in the case group.

Concerning catheters, 65.5% of patients had temporary catheters, with a mean duration of catheterization of 60.9 ± 44.4 days, whereas those with permanent catheters had a mean duration of catheterization of 664.2 ± 336.4 days. A history of catheter infection was present in 49.7% of the patients. Most patients (58.2%) were from a hemodialysis center categorized as 0. Table 2 summarizes the factors associated with the catheter and the hemodialysis center.

Regarding laboratory parameters, the mean albumin level was 3.5 ± 0.4 g/dl, the mean hemoglobin level was 10.4 ± 1.6 g/dl, and the lymphocyte count was 1457.6 ± 471.2 mm³.

Table 1. Descriptive variables .

Variable	Cases n=122	Controls n=182	*P*
Age (Years)	57±15	58±14	0.392
Sex Woman	57 (46.7%)	93 (51.1%)	0.454
Body mass index (kg/m ²)	24±4	25±4	0.289
Hispanic, n(%)	97 (79.5%)	154 (84.6%)	0.486
Mulatto, n(%)	2 (1.6%)	3 (1.6%)	
African American, n(%)	23 (18.9%)	25 (13.7%)	
Smoking	82 (67.2%)	56 (30.8%)	<0.001 *
Etiology of kidney disease			
Unaffiliated , n(%)	16 (13.1%)	29 (15.9%)	0.079
Diabetes, n(%)	60 (49.2%)	67 (36.8%)	
Hypertension , n(%)	28 (23.0%)	64 (35.2%)	
Glomerular, n(%)	10 (8.2%)	16 (8.8%)	
Polycystic disease , n(%)	8 (6.6%)	6 (3.3%)	
Diabetes mellitus	60 (49.2%)	67 (36.8%)	0.032

Table 2. Data related to the catheter .

Variable	Cases n=122	Controls n=182	*P*
Previous catheter infection	83 (68.0%)	68 (37.4%)	<0.001 *
Catheter indwelling time			
Permanent, days	872±198	606±344	<0.001 *
Temporary, days	76.6±26.6	45.5±52.8	<0.001 *
Type of catheter			
Permanent, n(%)	23 (18.9%)	82 (45.1%)	<0.001 *
Temporary, n(%)	99 (81.1%)	100 (54.9%)	
Catheter location			
Jugular , n(%)	64 (52.5%)	127 (69.8%)	0.007 *
Jugular Left , n(%)	33 (27.0%)	36 (19.8%)	
Left Femoral , n(%)	9 (7.4%)	2 (1.1%)	
Femoral , n(%)	14 (11.5%)	15 (8.2%)	
Subclavian , n(%)	2 (1.6)	2 (1,1)	
Hemodialysis center			
0, n(%)	69 (56.6%)	108 (59.3%)	0.127
1, n(%)	12 (9.8%)	14 (7.7%)	
2, n(%)	21 (17.2%)	44 (24.2%)	
3, n(%)	20 (16.4%)	16 (8.8%)	

On the other hand, 43.1% of the patients had albumin levels less than 3.5 g/dl. In addition, patients with hemoglobin levels less than 11 g/dl (62.5%) and lymphocyte counts less than 1500 mm³ (60.2%) were more common. Table 3 summarizes the characteristics of the laboratory parameters.

Table 3. Laboratory parameters prior to infection:

	Cases n=122	Controls n=182	*P*
Albumin (<3.5 g/dl)	108 (88.5%)	23 (12.6%)	<0.001 *
Hemoglobin (<11 g/dl)	109 (89.3%)	81 (44.5%)	<0.001 *
Lymphocytes (<1500 mm ³)	113 (92.6%)	70 (38.5%)	<0.001 *
Transferrin saturation (<20%)	3 (2.5%)	104 (57.1%)	<0.001 *

Risk factor analysis for catheter infection

When the study variables were compared between the case and control groups, it was evident that having a history of diabetes mellitus and a history of smoking were associated with catheter infection (Table 1). Additionally, having a temporary catheter, a longer time with a temporary catheter, and a history of previous catheter infection were associated with a greater risk of infection. Among the catheter

locations, the left jugular, right femoral, and left femoral areas presented a greater risk of infection, since approximately half of the patients with catheters at that level presented infection (Table 2).

Laboratory parameters obtained the month before catheter infection revealed that the patients had lower albumin and lymphocyte levels. Furthermore, hemoglobin levels were lower in the case group than in the control group.

A logistic regression model was used to analyze all significant variables relevant to the univariate analysis. An albumin level less than 3.5 g/dL and a lymphocyte count less than 1500 mm^3 are the most critical risk factors for catheter-associated infection, increasing the risk 25- and 9-fold, respectively. Similarly, having a temporary catheter increases the risk of catheter-associated infection sevenfold. Furthermore, having a history of smoking increases the risk of catheter-associated infection nearly fivefold. A hemoglobin level under 11 g/dL and a history of previous catheter-associated infection triple the risk.

Notably, diabetes mellitus achieved significant value in the univariate analysis. Nevertheless, in the final adjustment of the multivariate analysis, it was not a relevant variable for catheter infection because there were stronger factors that determined catheter infection (Table 4).

Table 4. Logistic regression analysis .

	Univariate					**Multivariate** R^2: 0.85 **P value:** <0.05				
				IC-OR 95%					**IC-OR 95%**	
Variables	**P value**	**B**	**OR**	**Lower**	**Superior**	**P value**	**B**	**OR**	**Lower**	**Superior**
Age	0.391	-0.007	0.993	0.979	1.008	0.436	-0.014	0.986	0.952	1.021
Female sex	0.454	-0.175	0.839	0.530	1.328	0.774	0.211	1.235	0.292	5.228
Type 2 diabetes	0.033*	0.507	1,661	1,043	2.646	0.145	0.784	2.19	0.764	6.275
Smoking	<0.001*	1,529	4.612	2.820	7.543	0.047*	1,547	4.698	1,024	21,555
Previous Catheter Infection	<0.001*	1.272	3.568	2.197	5.793	0.044*	1.192	3.295	1.035	10.494
Temporary Catheter	<0.001*	1.261	3.530	2.058	6.054	0.002*	2.042	7.703	2.053	28,896
Albumin < 3.5 g/dl	<0.001*	3.976	53.33	26.274	108.25	<0.001*	3.241	25.558	8.06	81.05
Hemoglobin < 11 g/dl	<0.001*	2.347	10.46	5.485	19,930	0.048*	1.168	3.216	1.013	10.212
Lymphocytes < 1500 mm3	<0.001*	3,000	20.09	9.569	42.173	<0.001*	2.245	9.44	2.889	30,842

Discussion

This study investigated the risk factors associated with catheter-related infections in hemodialysis patients across four dialysis centers in Quito. The risk factors included having a temporary catheter, a history of smoking, a history of catheter-related infections, an albumin level less than 3.5 g/dL, a hemoglobin level less than 11 g/dL, and a lymphocyte count less than 1500 mm^3.

Our study revealed that a history of smoking increased the risk of catheter infection by 4.6-fold. This finding is consistent with a study conducted in a Chinese population that reported a 2. A 3-fold increased risk of developing catheter infection with a history of smoking [10]. No studies have assessed this finding in the Latin American population. Another study reported that a history of smoking or current smoking increases the risk of catheter infection by 2-fold, specifically, the associated mortality [11]. This may be explained by smoking's effects on both innate and adaptive immunity, leading to decreased levels of immunoglobulins, impaired macrophage interleukin-1 production, reduced tumor necrosis factor activity, and less effective T-cell responses, thereby enhancing bacterial adhesion and proliferation [11]. Other smoking-related factors, such as vasoconstriction and various comorbidities, especially cardiovascular conditions, may further increase the risk of developing catheter infections and warrant further investigation.

Another significant risk factor is the presence of a temporary catheter. In this study, this factor was associated with a 7.7-fold increase in the risk of developing catheter-related infections. This finding is supported by several studies, including a retrospective cohort study in Denmark that examined the relationship between the use of temporary versus permanent catheters and infection rates, new infection episodes, and mortality; these studies reported that patients with temporary catheters face a 6. 9-fold greater risk of infection and a 5.1-fold increase in mortality from any cause following an infection. Furthermore, the risk of infection and mortality after experiencing an episode of infection with a permanent catheter is 2.2-fold and 1.4-fold, respectively [12]. Overall, the risk of subsequent catheter-associated infection events was significantly greater in hemodialysis patients with previous infection episodes associated with temporary catheters than in those with permanent catheters, with risks ranging from 1.6-3 times greater and a 30% increased risk of hospitalization for this reason [12, 13].

Furthermore, the present findings are consistent with the "Choices for Healthy Outcomes in Caring for ESRD" (CHOICE), which shows a worse prognosis for patients with temporary catheters, with a 40% rate of catheter infection, thus increasing the risk of

mortality [14]. The risk of infection arises because, after catheter insertion, the patient generates a biofilm of fibrin, fibrinogen, and fibronectin that covers both the external and internal surfaces of the catheter. This alters the material, promoting adhesion and subsequently bacterial proliferation.

Additionally, this biofilm facilitates platelet adherence, enhancing thrombogenesis and forming fibrin clots [15-16]. These clots serve as nutrients for bacterial growth and may also lead to partial catheter obstruction, resulting in increased manipulation and a greater risk of infection [17]. Notably, a tunneled catheter has a lower risk of infection due to the presence of a cuff [18], which elicits a fibrotic reaction in the surrounding subcutaneous tissue, preventing catheter movement. Thus, it acts as a barrier to the exoluminal displacement of pathogens toward the distal and endoluminal ends of the catheter, inhibiting bacterial colonization.

In contrast to the current study, a previous report indicated that a history of infection was not statistically significant [19]. This discrepancy may stem from the small sample size (100 patients) or the fact that most catheters were placed for the first time.

Moreover, a study conducted in southern California concluded that patients with temporary or permanent catheters experience chronic inflammation, regardless of the presence of an infectious process [20]. Consequently, the inflammatory state present in patients with advanced chronic kidney disease, exacerbated by catheter presence, can weaken immunity, particularly T lymphocytes, thereby increasing the likelihood of infection [18].

Patients with chronic kidney disease receiving dialysis maintain an inflammatory state that is further intensified by catheters. This significantly impacts catheter infections; however, additional factors, such as hypoalbuminemia, anemia, and lymphopenia, also play crucial roles.

In this study, hypoalbuminemia, defined as a level less than 3.5 g/dl, was noted in patients before infection and identified as the most significant risk factor for catheter infection, increasing the risk by up to 25 times. Albumin serves as both a nutritional marker and an indicator of inflammation and a predictor of mortality. A Texas study involving only permanent catheters reported a 3.7-fold increase in the risk of catheter infection with albumin levels less than 3.5 g/dl [6]. Hypoalbuminemia has been linked to impaired immune activity; at the cellular immunity level, it causes phagocytic and complement dysfunction, whereas in adaptive immunity, it leads to a decrease in immunoglobulins, particularly IgA and cytokines. As such, chronic kidney disease patients on hemodialysis with catheters, who are in a state of chronic inflammation, become susceptible to infections. A retrospective study in China involving 366 hemodialysis patients with catheters revealed that having albumin levels exceeding 3.5 g/dl serves as a protective factor against catheter infection and reported a 24.5% mortality rate among hemodialysis patients hospitalized for various reasons, indicating that low albumin levels (below 3.5 g/dl) significantly increase the risk of mortality [21].

Another finding in the present study is that hemoglobin levels less than 11 g/dl before infection resulted in a 3.2-fold increase in risk. A multicenter retrospective study involving 400 patients in Malaysia reported that anemia increases the risk of catheter infection by 3.4 times [22]. The type of anemia encountered in chronic kidney disease patients is often inflammatory or anemia of chronic disease, which correlates with infection in the following way: the inflammatory state present in hemodialysis patients with catheters triggers the release of cytokines such as IL-6, stimulating the production and release of hepcidin. This inhibits iron absorption, sequesters iron at storage sites (within tissues or reticuloendothelial reserves), limits iron availability for hemoglobin synthesis, and suppresses erythropoiesis. The outcomes are functional iron deficiency (hypoferremia), decreased transferrin, hyperferritinemia, and restricted erythropoiesis [23]. Hyperferritinemia can adversely affect adaptive immunity by disrupting antibody production in B lymphocytes and inhibiting T-cell activation, increasing patient susceptibility to infections [24].

Additionally, this study revealed that lymphocyte counts less than 1500 mm^3 before infection resulted in a 9.4-fold increase in the risk of catheter infection. This observation contradicts some studies that utilized a lymphocyte cutoff of less than 1000 mm^3 (lymphopenia). For example, a Mexican study involving 282 patients revealed that the presence of lymphopenia (lymphocytes <1000 mm^3) increased the risk of catheter infection by 4.5 times [25]. This risk can be explained by the reduction in lymphocytes, which weakens immune responses due to decreased antibody production, thus increasing infection vulnerability [26].

Finally, factors such as diabetes mellitus and advanced age were not found to be significantly relevant in this study because, in the final adjustment, much stronger risk factors influenced catheter infection.

Although our study has limitations, as it is retrospective, the sample size is acceptable, and our findings align well with most of the compared results. One strength of our research is the multicenter evaluation and its novelty in examining laboratory parameters, such as albumin and lymphocytes, which other studies in Ecuador have overlooked. Additionally, we present epidemiological data on this significant complication in hemodialysis. Our findings highlight modifiable factors to consider in this population to reduce morbidity and mortality and improve the quality of life of our patients. Future studies should explore additional infection prevention strategies in scheduled hemodiafiltration for diabetic patients [27-29].

Conclusion

In the present study, the infection rate associated with temporary hemodialysis catheters was 1.3/1,000, whereas the infection rate associated with permanent catheters was 0.03/1,000. Most patients with catheter infections have diabetes mellitus and hypertension as their main comorbidities. Patients with catheter infections were mainly patients with temporary catheters, had a history of smoking, and had a previous history of catheter infections. Regarding laboratory parameters, hypoalbuminemia, low hemoglobin levels, low lymphocyte counts, and having a temporary catheter were the most significant risk factors in the present study. Regarding the location of the

hemodialysis catheter, most patients had temporary catheters, predominantly located in the right internal jugular vein. Patients with catheters in the left jugular, right, and left femoral veins were at greater risk of infection.

Abbreviations
CKD: Chronic kidney disease.

Additional information
No supplementary materials have been declared.

Acknowledgments
Not applicable.

Authors' contributions
Guido Andrés Mayorga Velastegui: Conceptualization, methodology, research, writing – original draft, project management, supervision, validation, visualization, writing – review and editing.
Jorge Fabián Chonata Quinteros: Conceptualization, Project management, Supervision, validation, visualization, Writing – review and editing.
Jorge Washington Vélez: Conceptualization, methodology, research, writing – Original draft.
All the authors read and approved the final version of the manuscript.

Financing
The study was self-funded by the authors.

Availability of data or materials
Not applicable.

Statements

Ethics committee approval and consent to participate
The CEISH committee of the Faculty of Medical Sciences of the Central University of Ecuador approved the study.

Consent for publication
Does not apply when specific patient images, X-rays, or photographs are not published.

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

Authors' information
Not declared.
Josser Jiménez Escobar : General Practitioner. La Nuestra Clinic. Cartagena, Bolívar.

References

1. Ethier J, Mendelssohn DC, Elder SJ, Hasegawa T, Akizawa T, Akiba T, Canaud BJ, Pisoni RL. Vascular access use and outcomes: an international perspective from the Dialysis Outcomes and Practice Patterns Study. Nephrol Dial Transplant. 2008 Oct;23(10):3219-26. doi: 10.1093/ndt/gfn261. Epub 2008 May 29. Erratum in: Nephrol Dial Transplant. 2008 Dec;23(12):4088. PMID: 18511606; PMCID: PMC2542410.

2. Muñoz P, Guembe M, Pérez-Granda MJ, Del Pozo JL, López-Cortés LE, Pittiruti M, Martín-Delgado MC, Bouza E. Vascular catheter-related infections: an endemic disease in healthcare institutions. An opinion paper of the Spanish Society of Cardiovascular Infections (SEICAV). Rev Esp Quimioter. 2024 Oct;37(5):387-400. doi: 10.37201/req/051.2024. Epub 2024 Jun 26. PMID: 38916720; PMCID: PMC11462325.

3. Sarnak MJ, Jaber BL. Mortality caused by sepsis in patients with end-stage renal disease compared with the general population. Kidney Int. 2000 Oct;58(4):1758-64. doi: 10.1111/j.1523-1755.2000.00337.x. PMID: 11012910.

4. Pasilan RM, Tomacruz-Amante ID, Dimacali CT. The epidemiology and microbiology of central venous catheter related bloodstream infections among hemodialysis patients in the Philippines: a retrospective cohort study. BMC Nephrol. 2024 Oct 2;25(1):331. doi: 10.1186/s12882-024-03776-8. PMID: 39358687; PMCID: PMC11447977.

5. Martin K, Lorenzo YSP, Leung PYM, Chung S, O'flaherty E, Barker N, Ierino F. Clinical Outcomes and Risk Factors for Tunneled Hemodialysis Catheter-Related Bloodstream Infections. Open Forum Infect Dis. 2020 Apr 11;7(6):ofaa117. doi: 10.1093/ofid/ofaa117. PMID: 32550235; PMCID: PMC7291682.

6. Wang K, Wang P, Liang X, Lu X, Liu Z. Epidemiology of hemodialysis catheter complications: a survey of 865 dialysis patients from 14 hemodialysis centers in Henan province in China. BMJ Open. 2015 Nov 20;5(11):e007136. doi: 10.1136/bmjopen-2014-007136. PMID: 26589425; PMCID: PMC4663418.

7. Delistefani F, Wallbach M, Müller GA, Koziolek MJ, Grupp C. Risk factors for catheter-related infections in patients receiving permanent dialysis catheter. BMC Nephrol. 2019 May 31;20(1):199. doi: 10.1186/s12882-019-1392-0. PMID: 31151433; PMCID: PMC6544915.

8. Abril J, Sánchez J. Características de la enfermedad renal crónica en el Ecuador desde el año 2009 hasta el año 2012.

[Tesis de grado]. Universidad de Cuenca 2014. Dspace.ec/0f483bd8

9. Santacruz Mancheno J, Santacruz AC. Global Dialysis Perspectives: Ecuador. Kidney360. 2022 Oct 16;3(12):2131-2135. doi: 10.34067/KID.0003762022. PMID: 36591349; PMCID: PMC9802541.

10. Tal MG, Yevzlin AS. Catheter-related blood stream infection in hemodialysis patients with symmetric tunneled non-side-hole hemodialysis catheters. J Vasc Access. 2023 Jul;24(4):614-619. doi: 10.1177/11297298211027058. Epub 2021 Jul 21. PMID: 34289732; PMCID: PMC10566221.

11. Mc Causland FR, Brunelli SM, Waikar SS. Association of smoking with cardiovascular and infection-related morbidity and mortality in chronic hemodialysis. Clin J Am Soc Nephrol. 2012 Nov;7(11):1827-35. doi: 10.2215/CJN.03880412. Epub 2012 Aug 23. PMID: 22917700; PMCID: PMC3488948.

12. Nelveg-Kristensen KE, Laier GH, Heaf JG. Risk of death after first-time blood stream infection in incident dialysis patients with specific consideration on vascular access and comorbidity. BMC Infect Dis. 2018 Dec 20;18(1):688. doi: 10.1186/s12879-018-3594-7. PMID: 30572826; PMCID: PMC6302499.

13. Ng LJ, Chen F, Pisoni RL, Krishnan M, Mapes D, Keen M, Bradbury BD. Hospitalization risks related to vascular access type among incident US hemodialysis patients. Nephrol Dial Transplant. 2011 Nov;26(11):3659-66. doi: 10.1093/ndt/gfr063. Epub 2011 Mar 3. PMID: 21372255.

14. Wystrychowski G, Kitzler TM, Thijssen S, Usvyat L, Kotanko P, Levin NW. Impact of switch of vascular access type on key clinical and laboratory parameters in chronic hemodialysis patients. Nephrol Dial Transplant. 2009 Jul;24(7):2194-200. doi: 10.1093/ndt/gfp052. Epub 2009 Feb 19. PMID: 19228757.

15. Bonilla A, Andrade N, Pérez S, Aveiga J, Espín L. Blood cultures in pediatric oncology, epidemiology 2023 of the National Oncology Institute - Solca Guayaquil. Actas Médicas (Ecuador) 2025;35(1):42-48. https://doi.org/10.61284/228.

16. Bonilla A, Aveiga F, Gonzalez A, Espín L. Epidemiology of bacteremia in the pediatric oncology service, report 2022, Hospital de Solca-Guayaquil. Actas Médicas (Ecuador) 2023;33(2):77-84. https://doi.org/10.61284/139.

17. Richardson IP, Sturtevant R, Heung M, Solomon MJ, Younger JG, VanEpps JS. Hemodialysis Catheter Heat Transfer for Biofilm Prevention and Treatment. ASAIO J. 2016 Jan-Feb;62(1):92-9. doi: 10.1097/MAT.0000000000000300. PMID: 26501916; PMCID: PMC4714858.

18. Fariñas MC, García-Palomo JD, Gutiérrez-Cuadra M. Infecciones asociadas a los catéteres utilizados para la hemodiálisis y la diálisis peritoneal [Infection associated with hemodialysis and peritoneal dialysis catheters]. Enferm Infecc Microbiol Clin. 2008 Oct;26(8):518-26. Spanish. PMID: 19094867.

19. Hajji M, Neji M, Agrebi S, Nessira SB, Hamida FB, Barbouch S, Harzallah A, Abderrahim E. Incidence and challenges in management of hemodialysis catheter-related infections. Sci Rep. 2022 Nov 29;12(1):20536. doi: 10.1038/s41598-022-23787-5. PMID: 36446808; PMCID: PMC9709051.

20. Dukkipati R, Molnar MZ, Park J, Jing J, Kovesdy CP, Kajani R, Kalantar-Zadeh K. Association of vascular access type with inflammatory marker levels in maintenance hemodialysis patients. Semin Dial. 2014 Jul-Aug;27(4):415-23. doi: 10.1111/sdi.12146. Epub 2013 Oct 9. PMID: 24118625.

21. Kim MJ, Hwang Y, Jeon JW, Kim HR, Han S, Park H, Lee EJ, Ham YR, Na KR, Park H, Choi DE. Relationship between Permanent Catheter Patency and Nutrient Score in Patients Aged >75 Years Requiring Renal Replacement Therapy. J Clin Med. 2024 Mar 8;13(6):1562. doi: 10.3390/jcm13061562. PMID: 38541789; PMCID: PMC10970778.

22. Wang IK, Chang YC, Liang CC, Chuang FR, Chang CT, Lin HH, Lin CC, Yen TH, Lin PC, Chou CY, Huang CC, Tsai WC, Chen JH. Bacteremia in hemodialysis and peritoneal dialysis patients. Intern Med. 2012;51(9):1015-21. doi: 10.2169/internalmedicine.51.7111. Epub 2012 Apr 29. PMID: 22576379.

23. Abbasi SH, Aftab RA, Lai PSM, Lim SK, Zainol Abidin RN. Impact of Healthcare Associated Infections on Survival and Treatment Outcomes Among End Stage Renal Disease Patients on Renal Replacement Therapy. Front Pharmacol. 2021 Aug 10;12:707511. doi: 10.3389/fphar.2021.707511. PMID: 34447309; PMCID: PMC8383202.

24. Abshire TC. The anemia of inflammation. A common cause of childhood anemia. Pediatr Clin North Am. 1996 Jun;43(3):623-37. doi: 10.1016/s0031-3955(05)70425-9. PMID: 8649902.

25. Lachmann G, Knaak C, Vorderwülbecke G, La Rosée P, Balzer F, Schenk T, Schuster FS, Nyvlt P, Janka G, Brunkhorst FM, Keh D, Spies C. Hyperferritinemia in Critically Ill Patients. Crit Care Med. 2020 Apr;48(4):459-465. doi: 10.1097/CCM.0000000000004131. PMID: 32205591.

26. Yamaguchi M, Sugiyama H, Nobata H, Kinashi H, Asai A, Kitamura F, Katsuno T, Ando M, Kubo Y, Banno S, Ito Y, Ishimoto T. Lymphopenia is a risk factor for severe infections in older patients with microscopic polyangiitis: a retrospective cohort study in Japan. Rheumatol Adv Pract. 2023 Aug 30;7(3):rkad073. doi: 10.1093/rap/rkad073. PMID: 37692053; PMCID: PMC10483030.

27. Mora-Bravo FG, Torres PTM, Campoverde NR, Carcelen GLB, Mancheno JCS, Tipanta ÁCS, Perez-Grovas H, Abarca WPR. Blood pressure control with active ultrafiltration measures and without antihypertensives is essential for survival in hemodiafiltration and hemodialysis programs for patients with CKD: a prospective observational study. BMC Nephrol. 2025 Jan 17;26(1):30. doi: 10.1186/s12882-025-03948-0. PMID: 39825259; PMCID: PMC11742504.

28. Alemán-Iñiguez J, Alemán-Iñiguez V, Alemán-Iñiguez P. Higher prevalence of diabetic peripheral neuropathy associated with secondary hyperparathyroidism. Revista Portuguesa de Endocrinologia, Diabetes e Metabolismo 2023;18(3-4):143-148. Doi: 10.26497/AO210011.

29. Mariscal A, Herrera-Felix JP, Magaña S, Flores N, Rosales L, Franco M, Pérez-Grovas H. Arterial line pressure control enhanced extracorporeal blood flow prescription in hemodialysis patients. BMC Nephrol. 2008 Nov 24;9:15. doi: 10.1186/1471-2369-9-15. PMID: 19025625; PMCID: PMC2613872. https://bmcnephrol.biomedcentral.com/articles/10.1186/1471-2369-9-15

DOI: Digital Object Identifier. **PMID**: PubMed Identifier.

Editor's Note

REV SEN remains neutral concerning jurisdictional claims regarding published maps and institutional affiliations.