ACTAS MÉDICAS (ECUADOR)
actasmedicas.ec

ORIGINAL ARTICLE

Multicentric observational analysis of mortality in patients on hemodialysis programs.

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Abstract

Introduction: In patients with chronic kidney disease (CKD), cardiovascular disease is considered the leading cause of mortality. This study seeks to analyze mortality and its associated factors in patients undergoing hemodialysis (HD) and hemodiafiltration (HDF) in 14 private centers in Ecuador.

Methods: This observational study was conducted between 2018 and 2022. Patients who received three weeks of conventional therapy were included. Patients who died at the end of the observation period (Group 1–G1) were compared with those who were alive (Group 2–G2). The variables evaluated included demographic data, comorbidities, clinical indicators, laboratory results and descriptions of impedance. Logistic regression was performed to estimate the odds ratio (OR).

Results: A total of 821 patients were analyzed in G1, and 3,586 were analyzed in G2, with a mortality of 22.89% at 42 months (6.54% per year). There were 182 deaths from cardiovascular causes (22.17%), 162 from infections (19.73%) and 477 from other causes (58.09%). Patients with HDF in G1 represented 167 cases (20.3%), while in G2, there were 1,078 cases (30.5%) ($p < 0.0001$). The risk factors for mortality included the development of cerebrovascular disease (OR: 1.81), vascular disease with hypertension (OR: > 1.49) and type 2 diabetes mellitus (OR: > 1.33). The protective factors identified were the serum albumin concentration (OR: 0.61), hemoglobin level (OR: 0.83) and lean tissue index (OR: 0.95).

Conclusion: The main causes of death were noncardiovascular, cardiovascular and infectious. A higher concentration of albumin, elevated levels of hemoglobin, a higher index of lean tissue and a longer duration of effective weekly treatment were identified as protective factors against mortality.

Keywords:

Mortality, hemodiafiltration, hemodialysis, risk factors, chronic renal failure.

Abbreviations

HDF-OL: high-volume in-line hemodiafiltration.
HD: hemodialysis.
CKD: chronic kidney disease.
Qd: dialysate flow
Qb: blood flow.

Supplementary information

No supplementary materials are declared.

Acknowledgments

We thank the staff and patients of the Davita-Ecuador clinics where the study was conducted.

Authors' contributions

Gabriela Tamayo, conceptualization, research, original writing draft, resources, software, supervision.

Jorge Quinchuela, Methodology, Data curation, Formal analysis, Fundraising, Project management, Validation, Visualization, Writing – review and editing.

Natalia Benavides, conceptualization, research, original writing draft, resources, software, supervision.

Franklin Mora-Bravo, Methodology, Data curation, Formal analysis, Validation, Visualization, Writing – review and editing.

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

Financing

The authors financed the costs of this research.

Availability of data and materials

The datasets used and analyzed during this study are available to the corresponding author upon reasonable request.

Introduction

Since 2009, the incidence of stage 5 chronic kidney disease (CKD) in Ecuador has increased from 3,524 to 21,394 cases in 2022, resulting in a prevalence rate of 1,183 cases per million inhabitants [1 ,2]. The survival rate reported for patients in hemodialysis programs in Ecuador is 3.8 years [2].

Among patients with advanced CKD, cardiovascular disease is the main cause of mortality and is aggravated by risk factors such as hypertension, diabetes, dyslipidemia, smoking and advanced age. These traditional cardiovascular risk factors are highly prevalent in the population with CKD and are associated with the severity of renal dysfunction, which increases the risk of mortality in these patients [3 ,4]. The contributing factors include underdialysis, uncontrolled anemia and alterations in bone and mineral metabolism derived from secondary hyperparathyroidism. In addition, many dialysis patients present with proinflammatory states and malnutrition. The combination of these uncontrolled factors increases the risk of cardiovascular events and, consequently, mortality from any cause. Online high-volume hemodiafiltration (HDF-OL) has been developed as an alternative to improve the treatment of patients with CKD, allowing more significant elimination of medium- and high-molecular-weight molecules through a convective process. This treatment has been associated with a reduction in the accumulation of uremic toxins and benefits the hemodynamic stability of patients, which could decrease the incidence of hypotension and other adverse effects common in conventional hemodialysis [5 -8].

Several studies have suggested that compared with high-flux hemodialysis (HD), OL-HDF may have a positive effect on survival. A detailed analysis revealed that patients with OL-HDF have lower mortality from all causes, lower cardiovascular mortality and better control of anemia. In addition, studies have reported a decrease in the use of erythropoiesis-stimulating agents (EEA), better phosphorus levels and a lower incidence of beta-2-microglobulin-related amyloidosis [9,10]. OL-HDF has also been associated with better nutritional parameters and a reduction in morbidity and hospitalizations, which entails additional benefits for the quality of life of dialysis patients. Given that mortality rates in dialysis patients remain high, between 15% and 20% per year, and that the increase in urea elimination has not shown significant direct effects on survival, clinical interest has shifted toward convective therapies such as OL-HDF. In recent years, randomized controlled trials comparing conventional hemodialysis with online postdilution hemodiafiltration have yielded mixed results, although generally positive, regarding the benefits of OL-HDF on mortality and morbidity.

Hemodiafiltration is not widely accepted in medical practice; thus, reports on its use are scarce in Latin America. This study evaluated mortality and associated factors in patients receiving hemodialysis and hemodiafiltration in multiple private centers in Ecuador.

Materials and methods

Study design

The present study is observational. The source is prospective.

Scenario

The study was conducted in 14 hemodialysis clinics in Ecuador, which belong to the Davita-Ecuador group. The participating units were the following: 1. Manadialisis Manta, 2. Sermens Quito, 3. Dialcentro, 4. Cener SA, 5. Manadialysis Portoviejo, 6. Sermens Guayaquil, 7. Medicopharma Machala, 8. Dialibarra, 9. Manadialisis Calle Quito, 10. Jipijapa Manadialysis, 11. Chone Manadialysis, 12. Famardial Guayaquil, 13. Farmadial Daule, 14. Nefrosalud, 15. Manadialisis Bahia. The study period was from September 3, 2018, to March 30, 2022.

Participants

Adult patients who underwent bariatric surgery in the 2 years prior to entry into the study were included. Patients older than 65 years were excluded. The sample was divided into 2 groups: the first group included patients who received nutritional controls, and the second group included patients who did not receive nutritional controls.

Variables

Independent variables included age, sex, dry weight, body mass index, Charlson comorbidity index and probability of survival (AACCIS + albumin). The presence of comorbidities included coronary artery disease, heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic lung disease, connective tissue disorders, gastrointestinal bleeding, liver disease and neurological disease. The etiology of chronic kidney disease includes glomerulonephritis, diabetic nephropathy, polycystic kidney disease, interstitial nephritis, vascular disease with arterial hypertension and diuresis of 100 ml/24 hours. Hemodialysis modalities included HDF-OL and HD, along with Qb (blood flow), Qd (dialysate flow), the effective duration of weekly treatment, Kt/V, the convective volume and ultrafiltration. Pre- and postdialysis blood pressure was measured. Laboratory parameters included potassium, hemoglobin, ferritin, C-reactive protein, albumin, nCRP (normalized protein catabolism rate), phosphorus, calcium and PTH (parathyroid hormone). The medications administered included erythropoietin and calcitriol. Predialysis relative overhydration was evaluated by bioimpedance and lean tissue and adipose tissue indices. The dependent variable was mortality.

Data sources/measurements

The source was direct. The data were collected using the EuCliD computer system following the protocols of privacy and patient consent. The data collected are presented as individual averages. The treatments were performed with supplies from Fresenius Medical Care; the hemodiafiltration machines included 83 volumetric units of Fresenius Medical Care 5008/S and 528 Fresenius Medical Care 4008/S hemodialysis machines. Classix FX 60, 80 and 100 dialyzer filters were used for hemodialysis, and CorDiax and CorAL 600, 800 and 1000 filters were used for HDF.

Assignment to hemodiafiltration

The policy of assigning patients to the Renal Units of Ecuador for the hemodiafiltration program is based on the presence of cardiovascular complications, such as congestive heart failure, recurrent intradialytic hypotension, difficult-to-control hyperphosphatemia, complex arterial hypertension and borderline low-flow access. The indications are reviewed in each center, and the admission of each patient to the program is proposed.

Bias

Observation and selection bias were avoided by applying participant selection criteria. A medical representative of each coordinating center was assigned to collect the data, which were recorded in a single online form. The principal investigator always kept the data using a guide and records approved in the research protocol to avoid possible biases of the interviewer, information and recall. In case of doubt about the standard deviation of the data, corrections were made by in situ reviews of anomalous data. Two researchers independently analyzed each record in duplicate, and the variables were entered into the database after verifying their agreement.

Study size

The sample was probabilistic. Ecuador has a population of 17,980,083 inhabitants (2023) and an incidence rate of CKD of 21,394 cases in 2022. EPI info TM (Stat Calc, Epi Info, CDC, Atlanta. Version 7.2.6 [October 2023]), with an expected mortality frequency of 15.7%, a confidence limit of 5% and a confidence level of 99.99%, the sample size was 773 cases of deceased patients. The controls were represented in a ratio of 4 to 1.

Quantitative variables

The results are presented as frequencies and percentages. A scale variable was converted into a categorical variable. A new variable, “KT/V*Convective volume *QB”, was created to standardize the HDF and HD treatments for different degrees of extracorporeal flow prescription; the units of convective volume were liters per session, and the Qb was measured in milliliters per minute. The variables were categorized as follows: Category 1: 0 to 5.9 L*L/min* kt/V; Category 2: 6–9.9 L*L/min* kt/V; Category 3: 10–13.9 L*L/min* kt/V; Category 4: 14–17.9 L*L/min* kt/V; and Category 5: 18 or more L*L/min* kt/V.

Statistical analysis

The qualitative variables were analyzed using frequencies and percentages. The proportions were compared using the chi-square test, and the means were compared using Student’s t test. Logistic regression was performed to estimate the odds ratio. As a secondary objective, survival was analyzed in specific groups of patients, including diabetic patients and those who had cerebrovascular events. The statistical package used was IBM Corp. (published in 2018). IBM SPSS Statistics for Windows, version 26.0. Armonk, NY: IBM Corp.

Results

Participants

A total of 821 deceased patients and 3586 survivors were analyzed. This overall mortality rate represents 22.89% of the population observed for 42 months (95% confidence interval: 21.53–24.31%). The annual mortality rate was 6.54%. There were 182 deaths from cardiovascular causes (22.17%), 162 from infections (19.73%) and 477 from other causes (58.09%).

Characteristics of the study groups

In the group of deceased patients, 693 patients (84.4%) had one or more comorbidities, compared to 2,580 patients (71.9%) in the living group (P <0.001). The prevalence of patients in the hemodiafiltration programs in Group 1 was 167 cases (20.3%), while in Group 2, it was 1,078 cases (30.5%) (P <0.0001). The mean age was greater in Group 1 (64.4 years) than in Group 2 (61.1 years) (P <0.001). There were no significant differences between the means of weight, body mass index, Charlson comorbidity index or probability of survival (aCIS + albumin) at the first year of observation. A difference in the probability of survival between “aaCCIs + albumin” was observed at the second year of observation, with 63.6 points in Group 1 versus 71.2 points in Group 2 (P <0.001). In Group 1, 128 patients had no comorbidities (15.59%), whereas in Group 2, 1006 patients did (28.05%) (P < 0.001). The variables of the scale are presented in Table 1 .

Etiology of kidney disease and comorbidities

Diabetic nephropathy was prevalent in 63.2% of deceased patients and in 47% of living patients (P <0.001). Arterial hypertension was less common in the group of deceased patients (20.3% vs. 33.8%, P <0.001). There were no significant differences in the other etiologies between the two groups (Table 2). Among the comorbidities, the absence of comorbidities was less frequent in Group 1, with 15.6% compared with 28% in the living group (P <0.001). Cerebrovascular disease and dementia were more common in the deceased group (13.6%) than in the living group (7.4%) (P <0.001) (Table 2).

Survival adjusted for convection, kt/V and extracorporeal flow in diabetic patients

The Kt/V*Convective Volume*Qb index was lower in Group 1 (5.05 ± 7.3) than in Group 2 (7.22 ± 9.19 L*L/min*Kt/V), P < 0.001. This index had a greater impact in the group of patients with diabetes mellitus, who showed greater survival with greater convective volume, greater extracorporeal flow and, in general, a greater Kt/V in category 5 (Table 3; Figure 1). The Cox proportional hazards model for diabetic patients is presented in Table 4.

Survival adjusted for convection, kt/V and extracorporeal flow in patients with cerebrovascular events

The index has a significant impact on the group of patients diagnosed with cerebrovascular events, where greater survival is observed with greater convective volume, greater extracorporeal flow and higher Kt/V, in general, in categories 4 and 5 (Table 5). The Cox proportional hazards model for diabetic patients is presented in Table 5.

Factors associated with mortality

The logistic regression model to predict mortality in patients is presented in Table 6, where the statistically significant factors are highlighted. The risk factors include the development of cerebrovascular disease, vascular disease associated with hypertension and type 2 diabetes mellitus. In contrast, the protective factors, listed in order of importance, are the concentration of albumin, serum hemoglobin, lean tissue, postdialysis systolic blood pressure and the effective duration of weekly treatment.

Discussion

A total of 821 deceased patients and 3586 survivors were analyzed. This overall mortality rate represents 22.89% of the observed population, with notable contributing factors such as cardiovascular problems (22.17%) and infections (19.73%). However, most deaths are attributed to various causes, which together represent more than half of all deaths (57.13%). Since more patients had one or more comorbidities, these data strongly suggest that the presence of comorbidities is associated with an increased risk of death in this group.

Age was 3.3 years greater in the group of deceased patients. The simple Charlson comorbidity index and the indices adjusted for age and albumin at one year did not differ between deceased patients and survivors; however, the Charlson odds ratio adjusted for albumin at 2 years was 7.6 points higher in surviving patients. With respect to the hemodialysis treatment data, there were no differences in the number of treatments per month, Qb, Qd, convective volume, ultrafiltration or pre- and postdialysis blood pressure. The effective duration of weekly treatment was 61 minutes longer for patients in Group 2. The number of patients who received hemodiafiltration was 10% greater in the surviving group.

Table 1. Scale variables of the study groups.

	Group 1: Deceased N=821	Group 2: Alive N=3586	*P*
Survival time (months)	42.1 ± 35.6	45.6 ± 30.1	0.996
Age (years)	64.4 ± 12.1	61.1 ± 13.9	**<0.001***
Dry weight (kg)	62.8 ± 31.1	64.0 ± 21.1	0.848
Body mass index (kg/m ^{2})	25.3 ± 4.9	25.6 ± 4.8	0.082
Value of the Charlson comorbidity index	5.7 ± 5.4	7.5 ± 8.2	1
Age-adjusted Charlson (aCCI)	6.0 ± 1.8	5.23 ± 2.0	0.404
Survival probability: Charlson + Albumin: 1 year	75.6 ± 16.9	75.5 ± 23.5	0.807
Charlson + Albumin: 2 years	63.6 ± 13.7	71.2 ± 13.6	**<.001***
Number of comorbidities	1.6 ± 0.7	1.5 ± 0.7	0.996
Hemodialysis treatment data			
Hemodialysis treatments/month	10.7 ± 3.2	11.3 ± 3.2	1
Qb (ml/min)	348 ± 37	365 ± 34	1
Qd (ml/min)	466 ± 61	490 ± 34	1
Effective duration of weekly treatment (min)	619 ± 133	680 ± 100	**<0.001***
Effective infusion volume (liters) (HDF patients)	21.4 ± 4.0 (n=167[20.3%])	22.1 ± 4.9 (n=1078[30%])	0.983/X^2 = **P<0.001**
K/TV* Convective volume* Qb (L*L/min* Kt/V).	5.05 ± 7.3	7.22 ± 9.19	**<0.001***
Effective convective volume (liters)	6.4 ± 8.7	8.89 ± 10.6	1
Ultrafiltration (ml)	2186 ± 672	2282 ± 647	1
Predialysis systolic blood pressure (mmHg)	145 ± 16	146 ± 15	1
Predialysis diastolic blood pressure (mmHg)	73 ± 8	74 ± 8	1
Postdialysis systolic blood pressure (mmHg)	141 ± 14	142 ± 14	1
Postdiastolic blood pressure (mmHg)	73 ± 6	74 ± 6	1
Laboratories			
Kt/Vsp	1.82 ± 0.46	1.95 ±0.37	1
Predialysis potassium * (meq/L)	5.0 ± 0.62	5.05 ±0.56	0.988
Hemoglobin* (g/dl)	10.5 ± 1.4	11.01 ±1.2	1
Ferritin*(ng/ml)	811 ± 437	808 ±423	1
C-reactive protein	40.4 ± 66.3	22,5 ±38.7	**<0.001***
Albumin (g/dL)	3.77 ± 0.49	4.02 ±0.38	**<0.001***
nCRP gr/kg/day	0.97 ± 0.21	1 ±0.2	1
Phosphorus (mg/dl)	4.24 ± 1.42	4.21 ±1.44	1
Calcium corrected (mg/dl)	8.74 ± 0.59	8.74 ±0.51	1
iPTH (pg/ml)	264 ± 262	335 ±349	1
Medications			
Erythropoietin (Units/kg/week)	92.1 ± 54.2 (n=760)	83.8. ±45.9 (n=3417)	1
Iron (mg/month)	219 ± 64 (n=720)	212 ±63 (n=3316)	0.997
Calcium carbonate (mg/day)	886 ±1087 (n=533)	819 ± 1054 (n=2851)	1
Oral calcitriol (μg/week)	0.50 ± 0.83 (n=556)	0.35 ± 1.20 (n=2303)	1
Bioimpedance			
Predialysis relative overhydration (%)	15.2 ±9.3	12.3 ±7.9	**<0.001***
Lean tissue index	11.0 ±2.6	11.94 ±2.9	1
Adipose tissue index	14.0 ±5.9	13.7 ±6.7	1

Table 2. Etiology and comorbidities.

	Group 1: Deceased N=821	Group 2: Alive N=3586	*P*
Etiology			
Diabetic nephropathy	519 (63.2%)	1685 (47.0%)	**<0.001***
Vascular disease/hypertension	167 (20.3%)	1212 (33.8%)	**<0.001***
Interstitial nephritis	28 (3.4%)	166 (4.6%)	0.125
cystic kidney disease	17 (2.1%)	76 (2.1%)	0.931
Glomerulonephritis	14 (1.7%)	104 (2.9%)	0.056
Comorbidities			
Congestive heart failure	136 (16.6%)	612 (17.1%)	0.732
Coronary artery disease	130 (15.8%)	475 (13.2%)	0.052
Without comorbidities	128 (15.6%)	1006 (28.0%)	**<0.001***
Cerebrovascular disease	114 (13.9%)	264 (7.4%)	**<0.001***
Peripheral vascular disease	74 (9.0%)	346 (9.6%)	0.578
Chronic lung disease	47 (5.5%)	190 (5.3%)	0.624
digestive bleeding	41 (5.0%)	154 (4.3%)	0.378
Liver disease	29 (3.5%)	95 (2.6%)	0.167
Dementia or other psychiatric illness	21 (2.6%)	46 (1.3%)	**0.007***
Connective tissue disorder	10 (1.2%)	70 (2.0%)	0.156
HIV	2 (0.3%)	26 (1.0%)	0.091
Other characteristics			
Residual diuresis >100 ml/day	8 (1.4%)	116 (4.0%)	**0.002***

Table 3. Survival in diabetic patients according to categories of convective volume, Kt/v and Qb.

	Mean estimate (months)	Median estimate (months)	95% CI Lower limit of the median	95% CI Upper limit of the median
Category 1	41.32	39 (32-43)	32	43
Category 2	55.46	55 (48-59)	48	59
Category 3	64.58	67 (48-80)	48	80
Category 4	55.46	56 (47-63)	47	63
Category 5	65.12	62 (56-69)	56	69

Categoría 1: 0 a 5.9 L*L/min* Kt/V; Categoría 2: 6-9.9 L*L/min* Kt/V; Categoría 3: 10-13.9 L*L/min* Kt/V; Categoría 4: 14-17.9 L*L/min* Kt/V; Categoría 5: mayor o igual an 18 L/L/min* Kt/V. Rango logarítmico $x^2 = 35.1$ $P < 0.001$.

Table 4. Cox proportional hazards model for diabetic patients with convective volume, Kt/v and Qb **.**

	Coeffi-cients	Lower 95% CI	Upper 95% CI	Standard error	z	*P*	Exp (B)	Lower 95% CI	Upper 95% CI
Category 4	-0.61	-0.93	-0.3	0,16	3.8	<0.001	0.54	0.4	0.74
Category 5	-0.9	-1.13	-0,68	0.12	7.81	<0.001	0.41	0.32	0.51
Category 3	-0.36	-0.77	0.05	0.21	1.73	0.083	0.7	0.46	1.05
Category 2	-0.11	-0.66	0.44	0.28	0.4	0.693	0.9	0.52	1.55
Diabetes mellitus type 2	0.62	0,48	0.76	0.07	8.63	<0.001	1.86	1.62	2.15

Categoría 1: 0 a 5,9 L*L/min* Kt/V; categoría 2: 6-9,9 L*L/min* Kt/V; categoría 3: 10-13,9 L*L/min* Kt/V; categoría 4: 14-17,9 L*L/min* Kt/V; categoría 5: mayor o igual an 18 L/L/min* Kt/V. DMT2: Diabetes mellitus tipo 2.

Table 5. Cox proportional hazards model for patients with cerebrovascular events with different categories of convective volume, Kt/v and Qb.

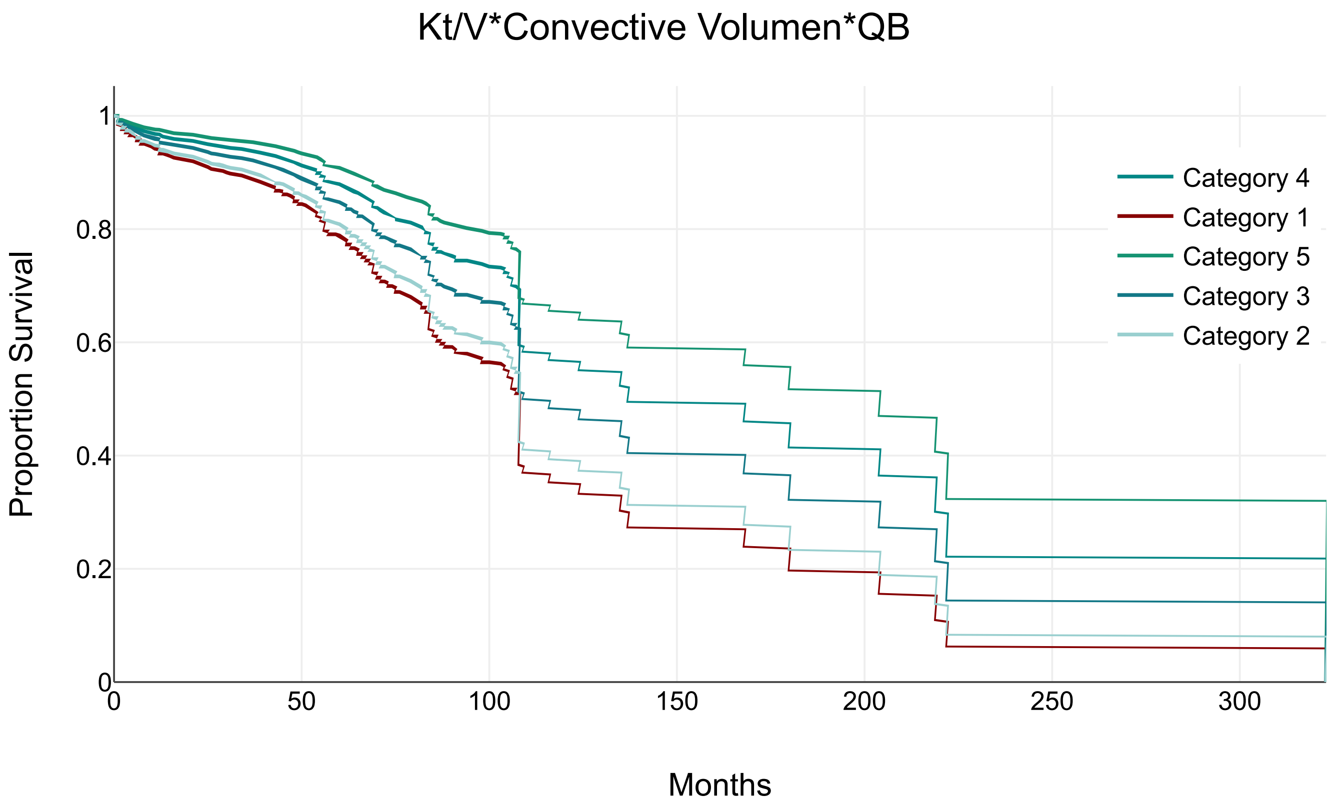
	Coef-ficient B	Lower 95% CI	Upper 95% CI	Stand-ard error	z	*P*	Exp (B)	Lower 95% CI	Upper 95% CI
Cerebrovascular disease.	0.41	0.21	0.61	0.1	4.04	<.001	1.51	1.24	1.84
Kt/V*Convective volume*Category QB 4	-0.61	-0,93	-0.3	0,16	3.8	<.001	0,54	0.4	0.74
Kt/V*Convective volume*Category QB 5	-0.98	-1.21	-0.76	0.12	8.54	<.001	0.37	0.3	0.47
Kt/V*Convective volume*Category QB 3	-0.37	-0.78	0.04	0.21	1.77	.077	0.69	0.46	1.04
Kt/V*Convective volume*Category QB 2	-0.13	-0.68	0.42	0.28	0.46	.647	0.88	0.51	1.52

Categoría 1: 0 a 5,9 L*L/min*Kt/V; categoría 2: 6-9,9 L*L/min*Kt/V; categoría 3: 10-13,9 L*L/min*Kt/V; categoría 4: 14-17,9 L*L/min*Kt/V; categoría 5: mayor o igual an 18 L/L/min*Kt/V.

Table 6. Logistic regression of risk factors and protection of death in hemodialysis patients.

	Coefficient B	Standard error	Z	*P*	Odds ratio	Confidence interval of 95%
Constant	5.82	0.82	7.08	<0.001	337.47	67.31-1692.06
Cerebrovascular disease	0.59	0,13	4.49	<0.001	1.81	1.4-2.34
Vascular disease/hypertension	0.4	0.11	3.53	<0.001	1.49	1,19-1,86
Diabetes mellitus type 2	0.29	0.1	2.88	0.004	1.33	1.1-1.62
Age (years)	0.01	0	3.85	<0.001	1.01	1.01-1.02
Predialysis relative overhydration	0.01	0.01	2.5	0.013	1.01	1-1.03
Ultrafiltration (ml)	0	0	2.8	0.005	1	1-1
Effective duration of weekly treatment (min)	-0.01	0	9.86	<0.001	0.99	0.99-1
Postdialysis systolic blood pressure (mmHg)	-0.01	0	3.14	0.002	0.99	0.98-1
Lean tissue index	-0.05	0.02	2.58	0.01	0.95	0.92–0.99
Hemoglobin (g/dL)	-0.18	0.04	4.35	<0.001	0.83	0.77–0.91
Albumin (g/dL)	-0.49	0.13	3.87	<0.001	0.61	0.48–0.78

Figure 1. Graph of the Kaplan–Meier survival function for patients with type 2 diabetes mellitus with different doses of convective volume.



Categoría 1: 0-5.9 L*L/min* Kt/V; Categoría 2: 6-9.9 L*L/min* Kt/V; Categoría 3: 10-13.9 L*L/min* Kt/V; Categoría 4: 14-17.9 L*L/min* Kt/V; Categoría 5: mayor o igual an 18 L/L/min* Kt/V.

The Kt/V * Convective volume * Qb ratio was greater in the survivor group at 2.17 L * kt/v * L/min. With respect to laboratory tests, no differences were observed in Kt/V, predialysis potassium, hemoglobin, ferritin, phosphorus, calcium or PTH. Albumin levels were higher in living patients (4.02 g/dl) than in those who had died (3.77 g/dl) (*P* <0.001). The C-reactive protein concentration was 17.9 mg/l higher in deceased patients. No differences were observed in the use of medications such as erythropoietin, iron, calcium carbonate, oral aluminum or oral calcitriol. In bioimpedance evaluations, relative overhydration was 2.9% greater in deceased patients.

Diabetic nephropathy was 16.2% more prevalent among deceased patients, with 6.17% of whom needed harm. In contrast, hypertension was more prevalent among living patients (13.5% higher) than among deceased patients (P < 0.001). Cerebrovascular disease occurred in 6.5% of deceased patients. Dementia or other psychiatric illnesses were 1.3% more common among deceased patients (*P* = 0.007). A residual diuresis greater than 100 ml per day was recorded in 4% of living patients and 1.4% of deceased patients (*P* <0.002).

In the subanalysis, the survival of diabetic patients was greater in the category 5 convective therapy group (> 18 L * L/min * Kt/V), with a proportional and progressive decrease in each lower category of convective therapy. The worst survival was observed in categories 1 (0 to 5.9 L * L/min * Kt/V), 2 (6 to 9.9 L * L/min * Kt/V) and 3 (10 to 13.9 L * L/min * Kt/V).

In the logistic regression, the main risk factors for death included cerebrovascular disease (OR: 1.81), vascular disease/hypertension (OR: 1.49) and type 2 diabetes mellitus (OR: 1.33). Protective factors included elevated levels of albumin and hemoglobin, a lean tissue index, predialysis systolic and diastolic blood pressures (negative) and the effective duration of weekly treatment.

Interpretations

Current findings support the established notion that diabetic patients with hypertension have a high mortality rate during hemodialysis programs. However, this situation could be alleviated by achieving an optimal nutritional status, indicated by an albumin concentration above 4.02 g/dL, along with a significant improvement in the dose of dialysis administered during each session. The relevant factors include effective treatment time, convective volume, Kt/V and extracorporeal flow (Qb), as well as control of overhydration during each treatment. Cerebrovascular disease is particularly devastating for this group of patients, accelerating the onset of death. Nonmodifiable factors, such as age and residual urine loss, also contribute to an increased risk of mortality.

Practical application

Practical applications in hemodialysis programs are focused on optimizing treatment and managing risk factors to increase the survival of patients, especially those with diabetes and hypertension.

Prioritize nutritional status: Ensuring an optimal nutritional status in patients is crucial and involves monitoring and maintaining albumin levels close to 5 g/dL through nutritional interventions, such as a protein-rich diet and muscle strengthening exercises, to improve muscle mass in the extremities.

Optimization of dialysis dose: Programs should seek to increase the dose administered in each treatment. This implies that factors such as an effective treatment time of at least 680 minutes per week, a convective volume, Kt/V and an extracorporeal flow (Qb) greater than 18 liters per treatment should be considered.

Strict control of overhydration: In the coming years, it will be essential to implement strategies for monitoring and managing overhydration during each session of hemodialysis using bioimpedance because of its detrimental effects on survival.

Surveillance and management of cerebrovascular disease: Given the high incidence and devastating impact of this disease in these patients, it is vital to adopt early surveillance strategies and aggressively control associated risk factors. These methods may include the detection of atrial fibrillation, atrial dilation by echocardiography and carotid ultrasound, or simple cranial computed tomography upon admission to hemodialysis programs.

Customization of convective therapy: The results of the subanalysis indicate that a higher dose of convective therapy (>18 L*K/min*Kt/V) is associated with better survival in diabetic patients. Hemodialysis programs should consider implementing hemodiafiltration strategies to reach these doses in patients who need them as candidates.

Related studies

The optimal accepted convective volume is 23 liters [11 -25]. However, some studies do not report differences in mortality associated with these volumes. In the opinion of the authors, these differences could be attributed to the variation in extracorporeal volumes between the interdialysis and interpatient studies. Therefore, we propose to standardize the convective volume by multiplying it by Kt/V and the extracorporeal flow, expressed in liters. This study supports the idea that controlling hypervolemia in hemodialysis patients is crucial for survival [7,12 15, 19–] and that nutrition and increased muscle mass contribute to better survival [13].

Limitations

Owing to the observational nature of the study, the ability to establish causal relationships is limited. Additional unmeasured or confounding factors could explain these associations. In some cases, reverse causality may occur. Specifically, overhydration could be a consequence of the deterioration of nutritional status, muscle mass and general health in patients near death rather than being a direct cause of mortality.

Lines of research

Future studies should explore the relationships between hypervolemia, arterial hypertension, loss of muscle mass and mortality in patients undergoing hemodialysis (hemodifiltration).

Generalizability

The study included a diverse ethnic group of Ecuadorian adult patients: 60% mestizos and 40% indigenous people from the Ecuadorian highlands, Afro-Ecuadorians and montubios. It includes patients with diabetes mellitus and hypertension, which are prevalent causes of renal failure worldwide. Patients with disabilities and lower limb amputations were also included.

Conclusions

The overall mortality rate in the study population of hemodialysis patients was 22.89% during an observation period of 42 months. The main causes of death were noncardiovascular (58.09%), cardiovascular (22.17%) and infection (19.73%). Patients who died had significantly more comorbidities and were older than those who survived. Compared with survivors, deceased patients also had significantly lower levels of albumin and higher levels of C-reactive protein. Relative overhydration was notably higher in deceased patients. High convection hemodiafiltration was associated with better survival rates in diabetic patients. Patients who experienced cerebrovascular events had a very low survival rate. High albumin concentrations, elevated hemoglobin levels, a high lean tissue index, adequate postdialysis systolic blood pressure and a long duration of effective weekly treatment are recognized as protective factors against mortality.

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Multicenter observational analysis of mortality among patients in hemodialysis programs.

Abstract

Introduction: In patients with chronic kidney disease (CKD), cardiovascular disease is considered the leading cause of mortality. In this study, mortality and its associated factors among patients undergoing hemodialysis (HD) and hemodiafiltration (HDF) at 14 private centers in Ecuador were analyzed.

Methods: This observational study was conducted between 2018 and 2022. Patients who received conventional therapy 3 days per week were included. Patients who died at the end of the observation period (Group 1–G1) were compared with those who were alive (Group 2–G2). The evaluated variables included demographic data, comorbidities, clinical indicators, laboratory results, and impedance descriptions. Logistic regression was performed to estimate the odds ratio (OR).

Results: A total of 821 patients were analyzed in G1, and 3,586 were analyzed in G2, with a mortality rate of 22.89% at 42 months (6.54% per year). There were 182 deaths due to cardiovascular causes (22.17%), 162 due to infections (19.73%), and 477 due to other causes (58.09%). A total of 167 patients (20.3%) had HDF in G1, whereas 1,078 patients (30.5%) had HDF in G2 ($p < 0.0001$). Risk factors for mortality included the development of cerebrovascular disease (OR: 1.81), vascular disease with hypertension (OR: > 1.49), and type 2 diabetes mellitus (OR: > 1.33). The protective factors identified were the serum albumin concentration (OR: 0.61), hemoglobin level (OR: 0.83), and lean tissue index (OR: 0.95).

Conclusion: The present study revealed that the leading causes of death were noncardiovascular, cardiovascular, and infectious disease. High albumin concentrations, elevated hemoglobin levels, a high lean tissue index, and a long duration of effective weekly treatment were identified as protective factors against mortality.

Keywords: Mortality, hemodiafiltration, hemodialysis, risk factors, chronic renal failure.

Statements

Ethics committee approval and consent to participate

The Bioethics Committee of the Ecuadorian Society of Nephrology, in Quito, Ecuador, approved the study. This study was performed in accordance with the Declaration of Helsinki.

Consent for publication

This information was not needed, since the present study did not publish images, radiographs or specific studies of patients.

Conflicts of interest

This research has no financial interests or conflicts of interest. The authors Gabriela Tamayo, Jorge Quinchuela and Natalia Benavides are attending physicians of the hemodialysis units of the DaVita Ecuador group.

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Editor's Note

The Journal Actas Médicas (Ecuador) remains neutral with respect to jurisdictional claims regarding published maps and institutional affiliations.

Received: September 3, 2025.
Accepted: November 12, 2025.
Published: November 17, 2025.
Editor: Dr. Mayra Ordoñez Martínez.

How to cite:

Tamayo G, Quinchuela J, Benavides N, Mora F. Multicentric observational analysis of mortality in patients on hemodialysis programs. Actas Médicas (Ecuador) 2025; 35 (2): 175-189.

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