



RESEARCH ARTICLE



Beyond the Five-Year survival threshold in Peritoneal Dialysis: Public Health insights from the Moroccan experience in a Low- and Middle-Income country context: Five-Year outcomes in Moroccan peritoneal dialysis

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ABSTRACT

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Background: Long-term survival on peritoneal dialysis (PD) remains uncommon globally and is even more challenging in low- and middle-income countries (LMICs), where resource constraints and health system factors influence dialysis outcomes. This study compared clinical, biological, and outcome differences between Moroccan patients who achieved ≥ 5 years of PD survival and those who did not. **Methods:** We conducted a retrospective descriptive and analytical study from June 2006 to January 2024 including 175 PD patients. Participants were categorized into long-term survivors (≥ 5 years, n=61) and non-survivors (< 5 years, n=114). Demographic characteristics, comorbidities, laboratory parameters, and technique-related complications were assessed. Survival and mortality determinants were analyzed using linear and logistic regression models.

Results: Female sex was significantly associated with longer PD survival ($p=0.019$). Non-survivors presented higher baseline urea, creatinine, and vitamin D levels, and lower bicarbonate, albumin, residual kidney function (RKF), and weekly creatinine clearance (WCC). Infectious complications—including peritonitis and catheter infections—were more frequent among non-survivors. Among long-term survivors, RKF, Kt/V, and albumin decreased over time, while hemoglobin and vitamin D improved. Cardiovascular events were the leading cause of death across both groups. Low ultrafiltration, hypoalbuminemia, and recurrent peritonitis were major predictors of mortality.

Conclusion: Although uncommon, long-term PD survival is achievable in Morocco. Better preservation of RKF, higher serum albumin, and fewer infectious complications contribute to prolonged survival. Strengthening early identification and management of these modifiable factors may improve outcomes in PD programs. Enhancing PD management strategies, infection control practices, and nutritional support could significantly reduce mortality and ease the burden on health systems in LMICs where access to renal replacement therapies remains limited.



Introduction

Chronic kidney disease (CKD) represents a growing public health challenge worldwide, with

increasing incidence and prevalence in low- and middle-income countries (LMICs), including those in

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the Middle East and North Africa (MENA) region. In many LMIC settings, limited access to renal replacement therapies (RRT), resource constraints, and inequities in healthcare infrastructure amplify the burden of end-stage renal disease (ESRD) (1).

The clinical outcomes of patients on peritoneal dialysis (PD) depend on many factors, including age, presence of comorbidities, nutritional status, and the transport properties of the peritoneal membrane (2–4).

In Morocco, despite a rising number of patients reaching ESRD, access to hemodialysis (HD) remains unevenly distributed geographically and socioeconomically, especially in rural and underserved areas. In that context, peritoneal dialysis stands out as a potentially cost-effective, patient-centered alternative that can improve access to RRT, reduce travel burden, and alleviate pressure on HD centers. However, the sustainability and long-term viability of PD in such resource-limited settings remain uncertain (5).

Few patients globally, and particularly in LMICs, remain on PD for five years or more. Existing data suggest that median PD survival hovers around five years, and long-term continuation of PD is relatively uncommon. In Morocco, and more broadly in the MENA region, robust data on long-term PD survival are scarce, and the few studies conducted tend to be limited in size or scope.

Understanding the determinants of long-term PD survival in a Moroccan cohort is particularly relevant for health policy and planning. Demonstrating that substantial proportions of patients can achieve ≥ 5 years of PD, and identifying modifiable factors associated with better survival provides evidence to support the expansion of PD programs. Such evidence is critical for resource allocation, capacity-building, and designing strategies to improve equity of access to RRT in Morocco. It may guide national nephrology authorities and healthcare planners in optimizing dialysis services, reducing reliance on hospital-based HD centers, and better distributing care according to patients' needs and geographic constraints.

Therefore, this retrospective cohort study aims to compare and analyze the demographic, clinical, biological, and outcome characteristics of Moroccan patients on PD, distinguishing between those who survived five years or more and those whose PD survival duration was less than five years. By doing so, we intend to provide data-driven insights to inform policy-makers, enhance PD program sustainability, and ultimately improve equitable access to long-term dialysis care in resource-limited settings.

Materials and methods

This retrospective cohort study was conducted in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for observational studies.

A total of 235 patients were included, for whom peritoneal dialysis was initiated due to end-stage chronic kidney disease in our PD unit between June 2006 and January 2024.

Excluded were patients with less than 90 days of follow-up after the start of PD, patients who are still on PD but for less than 5 years, and those who were on PD for less than 5 years and received a kidney transplant.

Data from the remaining 175 patients were collected from paper records and analyzed, including 61 patients who survived 5 years or more (Survivor group), and 114 patients considered to have survived less than 5 years (Non-survivor group) (Figure 1).

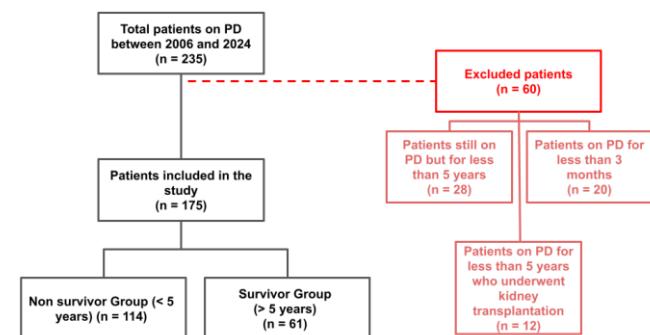


Figure 1. Flowchart of the study population

Data Collection

Demographic and clinical data were extracted from patient medical records, including: age, sex, body

mass index (BMI, defined as weight in kilograms divided by height in meters squared), and socioeconomic status (SES). SES was categorized based on income, education level, and occupation into low, medium, and high groups. Additional sociodemographic variables included the presence of a helper for PD exchanges and the patient's choice regarding PD modality (personal preference, self-decision, or imposed option).

Follow-up duration on PD therapy, presence of prior hemodialysis (HD) before PD, and its duration, if applicable, were also recorded. Initial estimated glomerular filtration rate (eGFR) as well as comorbidities such as cardiovascular disease, hypertension, and diabetes were reported.

Measurements of systolic and diastolic blood pressure, daily urine volumes, and average daily ultrafiltration amounts for all patients were recorded at initiation and at the last consultation. Serum levels of urea, creatinine, calcium, phosphorus, albumin, intact parathyroid hormone (iPTH), hemoglobin, and ferritin were recorded at the beginning of treatment and at the last follow-up.

Dialysis Protocol

The start of treatment for continuous ambulatory peritoneal dialysis (CAPD) was defined as the time after catheter placement and patient training, when they began the standard CAPD regimen of 2L four times daily.

The start of treatment for automated peritoneal dialysis (APD) was defined as the time when patients began PD with the required exchange volume, usually 2 to 3 weeks after catheter placement.

A standard solution was used containing: 132 meq/L of sodium, 3.5 meq/L of calcium, 1.5 meq/L of magnesium, 5 meq/L of lactate, 102 meq/L of chloride. Glucose concentrations were adjusted according to the patient's volume status and intraperitoneal pressure (IPP).

Daily total clearance (peritoneal plus residual kidney) of peritoneal urea (Kt/V) and weekly creatinine clearance (WCC) were measured, along with a

peritoneal equilibration test (PET) during PD treatment.

Complications

Infections were classified as follows:

- Exit site infections (defined by drainage, erythema, or pain at the exit site),
- Tunnel infections (defined by swelling, pain, or tenderness with or without erythema over the catheter tunnel).
- Peritonitis was defined by the presence of cloudy effluent with 100 white blood cells/L, of which 50% were neutrophils according to the ISPD guidelines (6).

Mechanical complications were classified as follows : Catheter migration, catheter dysfunction, catheter perforation and peritoneal leaks.

Factors associated with mortality were analyzed for all patients. The patient survival rate was calculated from the start date of PD to the end of PD therapy or until the end of follow-up (January 1, 2024).

Statistical Analysis

Factors associated with mortality were analyzed using linear and logistic regression models. Quantitative variables were expressed as mean \pm SD or median (IQR), and qualitative variables as counts (%). Student's t-test or ANOVA and chi-square or binomial tests were used as appropriate. Missing data were handled using complete-case analysis, as the proportion of missing values for key variables was <5%. A p-value <0.05 was considered statistically significant. Analyses were performed using Jamovi version 2.3.21.

Ethical Considerations

This study was conducted in accordance with institutional policies. Written informed consent was not required under Moroccan law for retrospective analysis of anonymized medical records routinely collected for clinical care. Oral consent was obtained for use of medical data for research purposes.

Results

Patient Characteristics

Among the data of 175 patients analyzed, 61 survived 5 years or more, while 114 survived less than 5 years.

At the initiation of peritoneal dialysis (PD), the mean age of the study population was 47.7 ± 17.4 years, the average follow-up duration was 42.1 ± 32.9 months, males accounted for 61.4% of patients, and the mean body mass index (BMI) was $24.8 \pm 5 \text{ kg/m}^2$.

Diabetes was the most common cause of end-stage kidney disease (25%), followed by chronic glomerulonephritis (18.7%) and tubulointerstitial nephropathy (13.5%).

Demographic data for the two groups are summarized in Table I. Comorbidities were present in both groups and were not associated with technique failure. However, female sex appeared to be associated with better survival on PD ($p = 0.019$).

Table 1. Baseline clinical and demographic characteristics of the patients

Variable Survival	All patients (n = 175)	Non survivor Group (< 5 years) (n = 114)	Survivor Group (> 5 years) (n = 61)	p
Male/Female	95 / 80	70 (61.4%) / 44 (38.5%)	25 (41%) / 36 (59%)	0.019
Mean age (years)	47.7 ± 17.4	50 ± 17.8	46.5 ± 17.8	0.272
Diabetes	48	35 (30.5%)	13 (21.7%)	0.207
Hypertension	131	87 (76.3%)	44 (72%)	0.483
Low Socio-Economic Status	65	43 (37.8%)	22 (36.8%)	0.865
Hemodialysis before PD	45	29 (25.2%)	16 (26.7%)	0.761
Indication of PD: Choice/Vascular access problem	162/13	105 (92.5%) / 9 (7.5%)	57 (93.3%) / 4 (6.7%)	0.489
Autonomy: Autonomous/Assisted PD	140/35	89 (78.3%) / 75 (21.7%)	51 (83.3%) / 10 (16.7%)	0.833

Clinical parameters of the patients

At the start of PD, total plasma urea levels ($p = 0.024$), plasma creatinine levels ($p = 0.039$), and vitamin D levels ($p = 0.025$) were significantly higher in the group that survived less than 5 years on PD. In contrast, the weekly total creatinine clearance (WCC) ($p = 0.010$), bicarbonate levels ($p = 0.042$), serum albumin levels ($p = 0.04$), and residual kidney function (RKF) ($p < 0.001$) were all significantly lower. There was no statistically significant difference between the groups regarding other clinical parameters ($p > 0.05$). (Table II)

The incidence of peritonitis episodes and catheter exit-site infections was 14.2 vs. 34.14 and 22.91 vs. 36.67 patient-months, respectively in the Non-survivor group versus the survivor group. ($p = 0.200$ and $p = 0.013$, respectively).

Table 2. Clinical and biological data of the two groups at the initiation of PD

	Non-Survivor Group (n = 114)	Survivor Group (n = 61)	p
BMI (Kg/m ²)	24.2 +/- 4.65	24.6 +/- 5.26	0.540
Systolic blood pressure (mmHg)	135 +/- 17	133 +/- 18.0	0.750
Diastolic blood pressure (mmHg)	77.5 +/- 11.5	76.2 +/- 12.0	0.656
Urine output (mL/day)	1500 [1000 - 2000]	1500 [1350 - 2000]	0.143
Kt/V (mL/mn)	1.63 +/- 0.67	1.82 +/- 0.67	0.108
nPCR (g/kg/day)	0.835 +/- 0.24	0.816 +/- 0.216	0.575
WCC (mL/mn)	63 [47 - 102]	80.5 [50.5 - 109]	0.010
RKF (mL/mn)	3 [2 - 10.7]	5 [2.51 - 7.20]	< 0.001
Ultrafiltration (mL/day)	900 [425 - 1200]	500 [300 - 875]	0.021
Blood urea (g/L)	2.26 +/- 0.938	1.9 +/- 0.677	0.024
Blood creatinine (mg/L)	111 +/- 52.3	94.6 +/- 39	0.039
Bicarbonates (mmol/L)	19.2 +/- 4.52	20.7 +/- 5	0.042
Vitamin D (ng/mL)	21.6 +/- 13.6	17.2 +/- 8.23	0.025
Albumin (g/L)	36.9 +/- 6.49	39 +/- 5.6	0.048
Triglycerides (g/L)	1.42 +/- 0.655	1.74 +/- 0.8	0.078
High PET	27 (79.5%)	12 (66%)	0.310
eGFR (ml/mn)	6.69 +/- 3.03	6.88 +/- 2.83	0.60

Evolution of the final paraclinical parameters compared to the initiation of PD in the survivor group

Statistical analysis showed a significant decrease in clearance parameters, particularly in Kt/V ($p = 0.006$), normalized protein catabolic rate (nPCR) ($p = 0.005$), WCC ($p < 0.001$), as well as in urine output ($p < 0.001$) and residual kidney function ($p < 0.001$). In parallel, there was also a significant decrease in urea levels ($p < 0.001$), potassium levels ($p < 0.001$), uric acid ($p < 0.001$), and serum albumin ($p = 0.004$). Conversely, there was a significant increase in bicarbonate levels ($p < 0.001$), vitamin D ($p < 0.001$), Protein C Reactive (CRP) ($p = 0.04$), and hemoglobin ($p = 0.035$). (Table III). By January 2024, four of these patients had been transferred to hemodialysis.

Table 3. Comparison of initial and final parameters of the survivor group

	Initial Parameters	Final Parameters	p
BMI (kg/m ²)	24.6 +/- 5.26	24.7 +/- 6	0.657
Systolic blood pressure (mmHg)	133 +/- 18	129 +/- 17.9	0.090
Diastolic blood pressure (mmHg)	76.2 +/- 12	76.6 +/- 11.9	0.877
Urine output (mL/day)	1500 [1350 - 2000]	500 [0 - 1200]	< 0.001
Kt/V (mL/mn)	1.82 +/- 0.67	1.51 +/- 0.865	0.006
nPCR (g/kg/day)	0.816 +/- 0.216	0.73 +/- 0.26	0.005
WCC (mL/mn)	80.5 [50.5 - 109]	45 [37 - 60]	< 0.001
RKF (mL/min)	5 [2.51 - 7.20]	0.6 [0 - 2.19]	< 0.001
Ultrafiltration (mL/day)	500 [300 - 875]	1000 [440 - 1100]	0.104
Blood urea (g/l)	1.9 +/- 0.677	1.28 +/- 0.432	< 0.001
Blood Creatinine (mg/L)	94.6 +/- 39	113 +/- 36	0.009
Potassium (mmol/L)	5.1 +/- 0.7	4.42 +/- 0.45	< 0.001
Bicarbonates (mmol/L)	20.7 +/- 5	26.4 +/- 3.59	< 0.001
Uric Acid (mg/L)	82.2 +/- 45	63.4 +/- 11.7	< 0.001
Vitamine D (ng/ml)	17.2 +/- 8.23	26.3 +/- 8.91	< 0.001
Hemoglobin (g/dl)	10.5 +/- 2.26	11.2 +/- 1.87	0.035
Albumin (g/l)	39 +/- 5.6	36.3 +/- 5.61	0.004
CRP (mg/l)	4 [2 - 5]	5 [2 - 7]	0.04

Mortality and technique withdrawal

Technique withdrawal is defined as either the death of the patient or permanent transfer to hemodialysis.

According to the Kaplan-Meier curve, the median overall survival on PD for the patients included in the study is 6 years (Figure 2), while it is 8 years for patients who survived more than 5 years on PD. Twelve patients survived more than 10 years on PD (Figure 3).

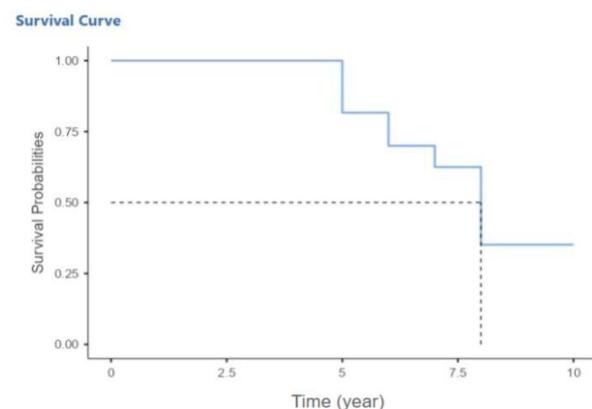


Figure 2. Kaplan-Meier survival curve for peritoneal dialysis technique in the study population

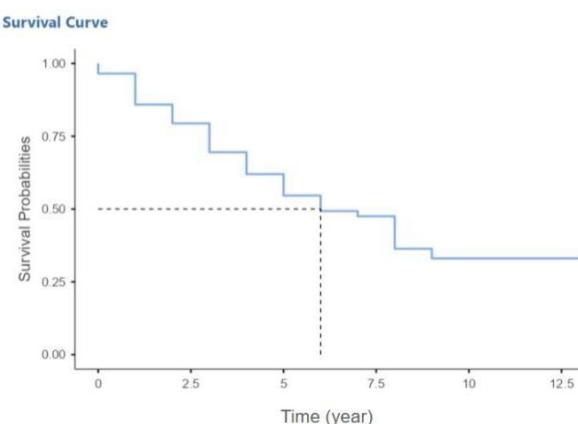


Figure 3. Kaplan-Meier survival curve for peritoneal dialysis technique in patients who survived more than 5 Years on PD

In the non-survivor group the average follow-up time was 22.1 ± 14.9 months. Cardiovascular events (41.8%) represented the most important cause of death followed by infectious causes and are distributed as follows: peritonitis ($n = 4$), COVID infection ($n = 3$), or infection from other causes ($n = 9$).

In the linear regression model, the following factors were significantly associated with an increased risk of death : low ultrafiltration (RR = 0.28, 95% CI, $p = 0.015$) low serum albumin level (RR = 0.347, 95% CI, $p = 0.002$), high number of peritonitis episodes (RR = 0.194, 95% CI, $p = 0.03$), whereas in the logistic regression model, assistance during exchanges (OR = 3.67, 95% CI [1.45 - 9.31], $p = 0.006$) and a history of tumor (OR = 9.2, 95% CI [1 - 83], $p = 0.04$) were significantly associated with death.

In the survivor group the average follow-up time was 46.5 ± 17.6 months. The most frequent cause of death was cardiovascular events ($n = 13$). Two patients died as a result of peritonitis , and three patients died due to septic shock.

In the linear regression model, the following factors were significantly associated with an increased risk of death : advanced age at the start of PD (RR = 0.37, 95% CI, $p = 0.004$) and low albumin level (RR = 0.282, 95% CI, $p = 0.045$), whereas in the logistic regression model, age over 60 years (OR = 4, 95% CI [1 - 12], $p = 0.021$) and albumin level less than 35 g/l (OR = 3.4, 95% CI [0.9 - 12], $p = 0.05$) after 5 years were significantly associated with mortality.

There was no statistically significant relationship when comparing the causes of death in the two groups ($p > 0.05$)

Discussion

The prevalence of 34.8% of patients surviving more than five years on peritoneal dialysis (PD) in our cohort is consistent with international data, where 5-year survival rarely exceeds 50%. Reported 5-year survival varies substantially across regions; studies from Europe, Oceania, South America, and North America typically describe survival rates ranging from 48% to 64% (7-13). Data from North Africa and the Middle East generally demonstrate similar or lower long-term survival, largely influenced by limited access to transplantation, higher infection rates, and resource constraints.

In Tunisia, a 27-year single-center PD experience reported long-term patient and technique survival comparable to global cohorts (14). A Moroccan series from our center also documented modest technique survival and identified infectious complications as a key determinant of outcomes (15). Likewise, Egyptian CAPD studies and evaluations from other North African and Sudanese programs have reported elevated peritonitis rates and heterogeneous 5-year survival in resource-limited settings (16,17).

Taken together, these MENA and African data position our 34.8% 5-year survival within the lower to mid-range of published outcomes and underscore the need to reinforce infection control, enhance patient training, and improve access to kidney transplantation to optimize long-term results (18). The exceptionally high uptake of PD in our center (>92% in both groups) further reflects the strong impact of our structured therapeutic education program on modality selection.

Our study highlights several factors that can influence the survival of PD patients, emphasizing the interaction between modifiable and non-modifiable factors. Patients surviving more than 5 years had slightly fewer comorbidities and fewer technique-related infectious episodes. These results corroborate studies showing that reducing comorbidities and infections contributes to improved survival on PD (19,20). Moreover, these patients had better initial

residual kidney function (RKF) and higher serum albumin levels, factors often associated with better survival in the literature (21,22).

Also, the increasing prevalence of the elderly population on dialysis worldwide underscores the importance of age and comorbidities as key determinants of survival (23–26), particularly the cardiovascular condition of patients, regardless of the duration of dialysis.

On the other hand, hypoalbuminemia is shown to be a predictor of mortality and chronic inflammation (27,28). Each 1 g/dL decrease in serum albumin is associated with a 38% increase in mortality risk (29). In our study, higher albumin levels at the start of PD were strongly associated with better outcomes.

Furthermore, initially high residual kidney function is associated with better survival in PD patients (30). Each 1 mL/min increase in RKF is correlated with about a 50% reduction in mortality rate (31). An initially high RRF is associated with better survival in PD patients (32), as demonstrated by our cohort, emphasizing the importance of preserving this function over the long term.

It is also important to note that technique-related infectious complications, such as peritonitis, affect both the technical survival and mortality of patients (33,34). In a recent meta-analysis, Tse et al. demonstrated that high rates of peritonitis are associated with increased mortality and faster failure of the technique (35). In our study, non-surviving patients had a significantly higher incidence of peritonitis, confirming its determining role.

International studies show that cardiovascular diseases are the leading cause of death in patients with end-stage kidney failure, especially when they have high rates of comorbidities, such as diabetes, hypertension, and hyperlipidemia, all of which are risk factors for cardiovascular diseases. Additionally, there are non-traditional risk factors in dialysis patients, such as chronic volume overload, anemia, endothelial dysfunction, hyperparathyroidism, inflammation, malnutrition, and uremic toxins (36). All these factors

contribute to the high cardiovascular mortality rate in dialysis patients (37).

Health-system and resource-related constraints

Beyond individual patient factors, several health-system challenges likely influence PD outcomes in Morocco. Limited availability of nephrology services, particularly outside major urban centers, constrains early referral, patient education, and timely management of complications. Cost and access barriers also persist, as many low-income households cannot afford optimal nutritional support, home supplies, or transportation for follow-up visits. Access to automated peritoneal dialysis remains restricted, making continuous ambulatory PD the predominant and often the only feasible modality in low-resource settings. In addition, infection-control measures may be difficult to sustain in facilities with limited staffing, inadequate space, or insufficient sterilization and storage capacity.

Socioeconomic determinants of PD outcomes

Socioeconomic status appears to play a substantial role in technique survival in our population. Patients with lower education levels may face challenges in mastering PD procedures and adhering to aseptic technique, increasing infection risk. The need for assisted PD, commonly observed in elderly, frail, or low-literacy patients, may further limit autonomy, increase caregiver burden, and predispose to early complications. Consistent with findings from other low- and middle-income countries, lower SES in our cohort was likely associated with earlier technique failure, lower RKF preservation, and greater risk of malnutrition and peritonitis.

Comparison with other LMIC settings

When compared to PD cohorts in Tunisia, Algeria, Egypt, and Sub-Saharan Africa, our 5-year survival remains within the reported range but appears slightly lower than some North African middle-income settings where technique survival benefits from stronger home-based support and broader APD use (14,16,38). Studies from several Sub-Saharan programs also report high early technique failure driven by similar barriers: limited training, inadequate supply chains, and high infection burden (39). These comparisons underline the importance of health-

infrastructure differences in shaping long-term PD outcomes across LMICs.

Policy implications

The findings of our study underscore the need for targeted policy interventions to strengthen PD programs in Morocco. Priority actions include the expansion of standardized PD training programs for both patients and healthcare teams, reinforcement of home-based dialysis support systems, and structured infection-prevention strategies. Improving nutritional support, addressing economic barriers, and ensuring systematic monitoring of RKF may also contribute to better long-term outcomes. Furthermore, establishing a national registry for chronic kidney disease and dialysis would provide essential surveillance data to support resource planning and assess program performance over time.

Overall, our study highlights the importance of addressing modifiable factors, particularly nutrition, infection prevention, and preservation of residual kidney function, in order to extend the survival of the technique and the dialysis patient. Retraining both patients and medical staff remains essential to prevent the occurrence of technique-related complications.

Conclusion

In conclusion, our study demonstrates that patients surviving five years or more on peritoneal dialysis exhibited fewer comorbidities, better nutritional status, higher initial residual kidney function, and experienced fewer episodes of peritonitis. In contrast, patients surviving less than five years were characterized by lower serum albumin, higher rates of infectious complications, and a more rapid decline in residual kidney function, with infections representing a major cause of mortality. Cardiovascular deaths remained substantial among long-term survivors, reflecting the ongoing burden of chronic comorbidities.

These findings highlight the need for multidisciplinary management to optimize nutrition, prevent cardiovascular complications, preserve residual kidney function, and reinforce infection-prevention strategies, including regular retraining of both patients and healthcare staff. At the health-

system level, national policy interventions are warranted, including standardized PD training programs, enhanced nutritional and home-based support, reinforced infection-control protocols, and systematic monitoring of residual kidney function and dialysis outcomes.

These findings provide evidence for strengthening PD programs in Morocco and other resource-limited settings.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author.

Source of support

None.

Authorship

All authors listed have made substantial contributions to the conception and design of the study, the analysis and interpretation of data, and the drafting or critical revision of the manuscript. All authors have approved the final version and agree to take public responsibility for the content. The order of authorship is a joint decision. No assistance requiring acknowledgment outside authorship criteria was received. No conflict of interest to declare

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