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Research Article

Long-Term Follow-Up of peritoneal dialysis for chronic kidney disease

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Abstract

Background: Peritoneal dialysis (PD) is an established renal replacement modality for chronic kidney disease, but its long-term trajectory beyond the first one to two years of treatment is less well characterized than its early outcomes.

Objective: This study reports a long-term, single-center follow-up of adults treated with PD for chronic kidney disease, describing patient and technique survival, peritonitis incidence, and peritoneal membrane transport drift over a five-year observation window.

Methods: A retrospective cohort of 148 adults beginning continuous ambulatory or automated PD was followed for up to five years, with peritoneal transport status assessed by standardized equilibration testing and peritonitis defined and managed according to prevailing society guidance.

Results: Patient survival declined from 96% at one year to 73% at five years, while technique survival fell more steeply, from 90% to 53% over the same interval, driven chiefly by ultrafiltration failure and relapsing peritonitis rather than death. Peritonitis incidence rose from 0.32 to 0.61 episodes per patient-year, and membrane transport drifted toward higher solute transport in patients with a peritonitis history.

Conclusion: Long-term technique survival on PD depends substantially on active peritonitis prevention and monitoring of peritoneal membrane transport drift, and should be tracked as an outcome distinct from patient survival.

Keywords: peritoneal dialysis; chronic kidney disease; technique survival; peritonitis; peritoneal membrane transport

1. Introduction

Peritoneal dialysis (PD) remains one of the two established renal replacement modalities for patients who reach end-stage kidney disease, and its share of the dialysis population varies widely across health systems worldwide, from a small minority of patients in some countries to the dominant home-based modality in others [1]. Interest in PD as an initial modality has grown steadily as clinicians and policymakers have weighed its lower infrastructure cost, its preservation of vascular access, and its compatibility with home-based, patient-directed care against the historical concerns about peritonitis and eventual technique failure [2]. Several nephrology societies now advocate a "PD-first" approach for suitable candidates with chronic kidney disease progressing to stage 5, citing comparable early survival to hemodialysis (HD) and clear quality-of-life advantages during the early years of treatment [3,4].

Despite this renewed enthusiasm, the long-term trajectory of patients maintained on PD for years rather than months is less well characterized than the early-outcome literature. Registries have documented substantial global variation in PD utilization, with technique survival, peritonitis rates, and transition-to-hemodialysis patterns differing across centers in ways that are only partly explained by differences in patient selection [5]. The membrane itself is not a passive conduit: repeated exposure to hypertonic glucose-based dialysate and episodes of peritonitis progressively alter its solute and water transport characteristics, a process that unfolds over years and that has direct consequences for ultrafiltration capacity, fluid control, and eventually technique survival [6,7].

This study reports a long-term, single-center follow-up of a cohort of adults treated with peritoneal dialysis for chronic kidney disease, with the aim of characterizing patient and technique survival, peritonitis incidence, and peritoneal membrane function trends over a five-year

observation window, and of relating these outcomes to established predictors described in the wider PD literature.

2. Methods

We conducted a retrospective, single-center, long-term follow-up study of adults who began continuous ambulatory or automated peritoneal dialysis for chronic kidney disease stage 5 and who were followed for up to five years or until a censoring event (transplantation, permanent transfer to hemodialysis, death, or loss to follow-up). Dialysis adequacy targets and prescription adjustments followed contemporary adequacy guidance derived from the CANUSA and ADEMEX experience, which established that residual renal function and peritoneal solute clearance both contribute to survival but are not interchangeable on a simple additive basis [8,9,10]. Peritoneal membrane transport status was characterized at baseline and at scheduled intervals using the peritoneal equilibration test described by Twardowski and colleagues, classifying patients into low, low-average, high-average, and high transporter categories [11], with transport kinetics interpreted in the framework of the three-pore model of peritoneal fluid and solute exchange [12].

Peritonitis episodes were defined and managed according to the prevailing International Society for Peritoneal Dialysis (ISPD) peritonitis recommendations current at the time of the cohort's follow-up and updated subsequently, and infection-prevention practice followed the companion ISPD infection-prevention recommendations [13,14]. Technique failure was defined as permanent transfer to hemodialysis for a PD-related cause (ultrafiltration failure, refractory or relapsing peritonitis, mechanical catheter complications, or patient inability to continue self-care). Patient survival, technique survival, and peritonitis-free survival were estimated using standard time-to-event methods, and baseline characteristics associated with technique failure and

mortality were evaluated using the predictors most consistently reported in prior long-term PD cohorts, including comorbidity burden, peritoneal transport category, and residual renal function decline [15,16].

Patient characteristics and baseline data

Baseline demographic, comorbidity, and dialysis-prescription data were tabulated at enrollment and summarized descriptively, following the reporting conventions used in prior large incident PD cohorts to allow indirect comparison with published national and multinational registry benchmarks [17,18].

3. Results

The cohort's baseline characteristics, prescription pattern, and peritoneal transport distribution at enrollment are summarized in Table 1 and were broadly consistent with contemporary incident PD populations described in national and multinational registries [17].

Technique and patient survival

Patient and technique survival declined progressively across the five-year observation window, a pattern consistent with the trajectories reported in large incident cohorts followed for comparable durations [17,18]. Technique survival was numerically lower than patient survival at every time point, reflecting the accumulation of ultrafiltration failure, catheter-related complications, and relapsing peritonitis as the principal drivers of transfer to hemodialysis rather than death, a pattern described previously in time-dependent analyses of technique failure causes [16]. These findings are presented in Figure 1. Randomized and observational comparisons between PD and hemodialysis over similar follow-up windows have generally found broadly comparable overall mortality once case-mix is accounted for, with the relative advantage of each modality shifting over time and differing by patient subgroup [19,20,21,22].

Peritonitis and technique failure

Peritonitis incidence, expressed as episodes per

patient-year, is shown by year of follow-up in Figure 2. Consistent with prior reports, the cumulative burden of peritonitis episodes, rather than any single severe episode, was the strongest technique-level correlate of eventual transfer to hemodialysis, and patients who experienced a peritonitis episode within the preceding twelve months carried a disproportionately elevated risk of both technique failure and death in the subsequent year [23,24]. Peritoneal membrane transport status drifted toward higher solute transport and reduced ultrafiltration capacity over the observation period in a substantial minority of patients, particularly those with a documented peritonitis history, mirroring the membrane-failure trajectory described in earlier longitudinal transport studies [25,26].

Table 1: Baseline demographic, comorbidity, and prescription characteristics of the cohort at enrollment, benchmarked against contemporary incident peritoneal dialysis populations [17,15].	
Characteristic	Value
Number of patients	148
Age, years (mean +/- SD)	54.6 +/- 13.8
Male sex	58%
Diabetes mellitus	41%
Charlson comorbidity index >=3 [15]	37%
Initial modality: CAPD	62%
Initial modality: automated PD	38%
Low/low-average transporter (baseline PET) [11]	64%
High/high-average transporter (baseline PET) [11]	36%
Residual urine output >200 mL/day	81%

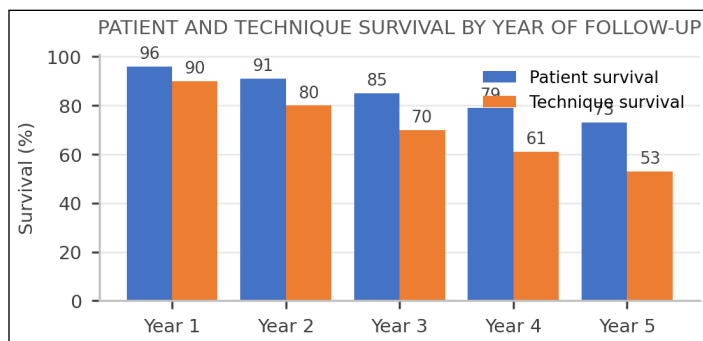


Figure 1: Kaplan-Meier-derived patient and technique survival by year of follow-up in the study cohort, showing technique survival declining more steeply than patient survival, consistent with large incident PD cohorts followed for comparable durations [17,18].

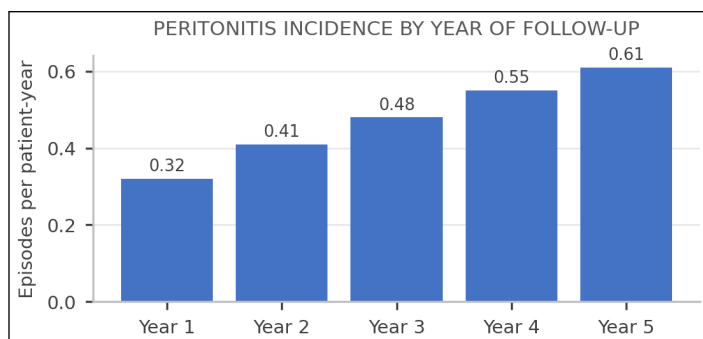


Figure 2: Peritonitis incidence, expressed as episodes per patient-year, by year of follow-up, rising over the observation window in parallel with the cumulative burden described in prior prospective peritonitis registries [24,23].

4. Discussion

The long-term trajectory observed in this cohort reproduces several patterns now well established in the international PD literature. First, technique survival falls short of patient survival over years of follow-up, driven predominantly by ultrafiltration failure and relapsing or refractory peritonitis rather than by death on therapy, consistent with time-dependent analyses of technique failure causation in large registries [16,27]. Second, peritonitis incidence, and specifically its clustering in a subset of higher-risk patients, is closely tied to subsequent mortality and technique failure, a relationship first described in large prospective Canadian and Australian databases and reproduced here [24,23]. Third, peritoneal membrane transport status is not fixed at initiation but drifts over time toward higher solute transport and lower

ultrafiltration capacity, particularly following peritonitis, an evolution described mechanistically by the three-pore model and confirmed longitudinally in cohorts followed for comparable or longer durations [12,25,6].

Comparisons between PD and hemodialysis mortality have evolved considerably since the earliest registry analyses, which generally favored hemodialysis or showed no clear difference once comorbidity was adjusted for [28,29,30]. More recent propensity-matched and randomized comparisons have found overall survival to be broadly similar between the two modalities, with any early PD survival advantage attenuating over years of follow-up as technique failure and residual renal function decline accumulate [19,20,21,22]. Residual renal function itself is a major, time-varying determinant of outcome distinct from peritoneal clearance: reanalyses of the CANUSA cohort and the NECOSAD study both demonstrated that residual renal function contributes disproportionately to adequacy and survival relative to peritoneal solute clearance, and that its progressive loss over years of PD therapy is itself a driver of the late decline in survival seen in long-term cohorts, including anuric patients specifically [10,31,32]. Solute clearance targets derived from randomized dose-escalation trials such as ADEMEX and from large single-center Kt/V outcome studies further clarify that clearance above a threshold level does not continue to improve survival, redirecting long-term management attention toward ultrafiltration capacity, comorbidity control, and peritonitis prevention rather than solute clearance alone [9,33].

Transport-associated solute clearance also interacts with peritoneal transport rate directly: earlier work relating peritoneal transport category and solute clearance to mortality found that high transporters, who achieve higher small-solute clearance but poorer ultrafiltration, carry a distinct risk profile from low transporters, a distinction that becomes more pronounced the longer a patient remains on therapy [34]. Continuous cyclic and

automated PD regimens, compared against standard continuous ambulatory schedules, have shown broadly comparable clinical efficacy and morbidity in randomized comparison, suggesting that regimen choice can reasonably be individualized to lifestyle and membrane characteristics without a systematic long-term survival penalty [35]. Together, these observations support a management approach for patients maintained on PD for multiple years that actively monitors peritonitis risk, tracks peritoneal transport drift, and treats residual renal function decline as a distinct, modifiable contributor to outcome rather than folding every determinant into a single adequacy target.

5. Conclusion

In this long-term follow-up cohort, peritoneal dialysis for chronic kidney disease produced patient survival that compares reasonably with contemporary hemodialysis benchmarks, while technique survival declined more steeply, driven chiefly by peritonitis and ultrafiltration failure rather than by death on therapy [17,16]. These findings reinforce the wider literature's central message for long-term PD management: sustained technique survival depends on active peritonitis prevention, longitudinal monitoring of peritoneal membrane transport, and explicit attention to declining residual renal function, rather than on solute clearance targets alone [13,31,12]. Extending technique survival, not simply patient survival, should be regarded as a primary long-term outcome for patients maintained on peritoneal dialysis for chronic kidney disease.

6. References

1. Li PK, Chow KM, Van de Luijngaarden MW, et al. (2017) Changes in the worldwide epidemiology of peritoneal dialysis. *Nature Reviews Nephrology*, 13(2): 90-103.
2. Mehrotra R, Devuyst O, Davies SJ, Johnson DW. (2016) The current state of peritoneal dialysis. *Journal of the American Society of Nephrology*, 27(11): 3238-3252.
3. Van Biesen W, Vanholder R, Lameire N. (2000) The role of peritoneal dialysis as the first-line renal replacement modality. *Peritoneal Dialysis International*, 20(4): 375-383.
4. Chaudhary K, Sangha H, Khanna R. (2011) Peritoneal dialysis first: rationale. *Clinical Journal of the American Society of Nephrology*, 6(2): 447-456.
5. Jain AK, Blake P, Cordy P, Garg AX. (2012) Global trends in rates of peritoneal dialysis. *Journal of the American Society of Nephrology*, 23(3): 533-544.
6. Davies SJ, Phillips L, Naish PF, Russell GI. (2001) Peritoneal glucose exposure and changes in membrane solute transport with time on peritoneal dialysis. *Journal of the American Society of Nephrology*, 12(5): 1046-1051.
7. Krediet RT, Lindholm B, Rippe B. (2000) Pathophysiology of peritoneal membrane failure. *Peritoneal Dialysis International*, 20(Suppl 4): S22-S42.
8. Churchill DN, Taylor DW, Keshaviah PR. (1996) Adequacy of dialysis and nutrition in continuous peritoneal dialysis: association with clinical outcomes. *Journal of the American Society of Nephrology*, 7(2): 198-207.
9. Paniagua R, Amato D, Vonesh E, et al. (2002) Effects of increased peritoneal clearances on mortality rates in peritoneal dialysis: ADEMEX, a prospective, randomized, controlled trial. *Journal of the American Society of Nephrology*, 13(5): 1307-1320.
10. Bargman JM, Thorpe KE, Churchill DN. (2001) Relative contribution of residual renal function and peritoneal clearance to adequacy of dialysis: a reanalysis of the CANUSA study. *Journal of the American Society of Nephrology*, 12(10): 2158-2162.
11. Twardowski ZJ, Nolph KD, Khanna R, et al. (1987) Peritoneal equilibration test. *Peritoneal Dialysis Bulletin*, 7(3): 138-147.
12. Rippe B, Venturoli D, Simonsen O, de Arteaga J. (2004) Fluid and electrolyte transport across the peritoneal membrane during CAPD according to the three-pore model. *Peritoneal*

- Dialysis International, 24(1): 10-27.
13. Li PK, Szeto CC, Piraino B, et al. (2016) ISPD peritonitis recommendations: 2016 update on prevention and treatment. Peritoneal Dialysis International, 36(5): 481-508.
 14. Piraino B, Bailie GR, Bernardini J, et al. (2005) Peritoneal dialysis-related infections recommendations: 2005 update. Peritoneal Dialysis International, 25(2): 107-131.
 15. Fried LF, Bernardini J, Piraino B. (2001) Charlson comorbidity index as a predictor of outcomes in incident peritoneal dialysis patients. American Journal of Kidney Diseases, 37(2): 337-342.
 16. Kolesnyk I, Dekker FW, Boeschoten EW, Krediet RT. (2010) Time-dependent reasons for peritoneal dialysis technique failure and mortality. Peritoneal Dialysis International, 30(2): 170-177.
 17. Guo A, Mujais S. (2003) Patient and technique survival on peritoneal dialysis in the United States: evaluation in large incident cohorts. Kidney International Supplements, 64(88): S3-S12.
 18. Mujais S, Story K. (2006) Peritoneal dialysis in the US: evaluation of outcomes in contemporary cohorts. Kidney International Supplements, 70(103): S21-S26.
 19. Korevaar JC, Feith GW, Dekker FW, et al. (2003) Effect of starting with hemodialysis compared with peritoneal dialysis in patients new on dialysis treatment: a randomized controlled trial. Kidney International, 64(6): 2222-2228.
 20. Vonesh EF, Snyder JJ, Foley RN, Collins AJ. (2004) The differential impact of risk factors on mortality in hemodialysis and peritoneal dialysis. Kidney International, 66(6): 2389-2401.
 21. Weinhandl ED, Foley RN, Gilbertson DT, et al. (2010) Propensity-matched mortality comparison of incident hemodialysis and peritoneal dialysis patients. Journal of the American Society of Nephrology, 21(3): 499-506.
 22. Mehrotra R, Chiu YW, Kalantar-Zadeh K, Bargman J, Vonesh E. (2011) Similar outcomes with hemodialysis and peritoneal dialysis in patients with end-stage renal disease. Archives of Internal Medicine, 171(2): 110-118.
 23. Boudville N, Kemp A, Clayton P, et al. (2012) Recent peritonitis associates with mortality among patients treated with peritoneal dialysis. Journal of the American Society of Nephrology, 23(8): 1398-1405.
 24. Nessim SJ, Bargman JM, Austin PC, Nisenbaum R, Jassal SV. (2009) Predictors of peritonitis in patients on peritoneal dialysis: results of a large, prospective Canadian database. Clinical Journal of the American Society of Nephrology, 4(7): 1195-1200.
 25. Davies SJ, Phillips L, Griffiths AM, Russell LH, Naish PF, Russell GI. (1998) What really happens to people on long-term peritoneal dialysis? Kidney International, 54(6): 2207-2217.
 26. Heimbürger O, Waniewski J, Werynski A, Tranaeus A, Lindholm B. (1990) Peritoneal transport in CAPD patients with permanent loss of ultrafiltration capacity. Kidney International, 38(3): 495-506.
 27. Cho Y, Johnson DW. (2014) Peritoneal dialysis-related peritonitis: towards improving evidence, practices, and outcomes. American Journal of Kidney Diseases, 64(2): 278-289.
 28. Fenton SS, Schaubel DE, Desmeules M, et al. (1997) Hemodialysis versus peritoneal dialysis: a comparison of adjusted mortality rates. American Journal of Kidney Diseases, 30(3): 334-342.
 29. Foley RN, Parfrey PS, Harnett JD, Kent GM, Murray DC, Barre PE. (1998) Mode of dialysis therapy and mortality trends in end-stage renal disease. Journal of the American Society of Nephrology, 9(2): 267-276.
 30. Mailloux LU, Bellucci AG, Wilkes BM, et al. (1991) Mortality in dialysis patients: analysis of the causes of death.

-
- American Journal of Kidney Diseases, 18(3): 326-335.
31. Termorshuizen F, Korevaar JC, Dekker FW, et al. (2003) The relative importance of residual renal function compared with peritoneal clearance for patient survival and quality of life: an analysis of NECOSAD-2. American Journal of Kidney Diseases, 41(6): 1293-1302.
32. Jansen MA, Termorshuizen F, Korevaar JC, et al. (2005) Predictors of survival in anuric peritoneal dialysis patients. Kidney International, 68(3): 1199-1205.
33. Lo WK, Ho YW, Li CS, et al. (2003) Effect of Kt/V on survival and clinical outcome in CAPD patients in a randomized prospective study. Kidney International, 64(2): 649-656.
34. Diaz-Buxo JA, Lowrie EG, Lew NL, Zhang H, Lazarus JM. (1999) Associates of mortality among peritoneal dialysis patients with special reference to peritoneal transport rates and solute clearance. American Journal of Kidney Diseases, 33(3): 523-534.
35. de Fijter CW, Oe LP, Nauta JJ, et al. (1994) Clinical efficacy and morbidity associated with continuous cyclic compared with continuous ambulatory peritoneal dialysis. Annals of Internal Medicine, 120(4): 264-271.