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Review Article

Long-Term Follow-Up of peritoneal dialysis for diabetic nephropathy

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Abstract

Background: Diabetic nephropathy is the leading cause of end-stage renal disease in most health systems, and peritoneal dialysis offers hemodynamic and residual-renal-function advantages for this population, offset by the metabolic cost of dextrose-based osmotic exchange.

Objective: This review synthesizes long-term follow-up evidence on peritoneal dialysis outcomes in diabetic nephropathy across patient and technique survival, peritonitis risk, metabolic and membrane change, and cardiovascular outcomes.

Methods: We synthesized cohort studies, national and multinational renal registry analyses, randomized trials of peritoneal dialysis solutions, and systematic reviews reporting diabetes-stratified peritoneal dialysis outcomes over multi-year follow-up.

Findings: Modern propensity-matched analyses show mortality broadly comparable between peritoneal dialysis and hemodialysis in diabetic patients, while technique survival remains diabetes-disadvantaged, driven by elevated peritonitis risk and progressive glucose-exposure-related peritoneal membrane change that erodes ultrafiltration capacity; glucose-sparing strategies such as icodextrin help preserve ultrafiltration over time.

Conclusions: Long-term peritoneal dialysis remains a reasonable long-term modality for diabetic nephropathy, provided infection surveillance, periodic membrane function testing, and residual renal function preservation are actively pursued throughout follow-up.

Keywords: peritoneal dialysis; diabetic nephropathy; technique survival; peritonitis; residual renal function

1. Introduction

Diabetic nephropathy is now the leading cause of end-stage renal disease in most health systems, and the population reaching kidney failure with diabetes as the principal cause continues to expand as diabetes prevalence rises and cardiovascular mortality among people with diabetes falls [1,2]. Registry data show the prevalence of diagnosed diabetic kidney disease has remained essentially flat over two decades even as the burden of diabetes itself has grown, so a substantial, stable fraction of the dialysis-incident population will carry diabetes as its principal renal diagnosis for the foreseeable future [3]. A consensus conference convened by the American Diabetes Association reached the same conclusion and called for renal replacement strategies tailored to this population's distinct comorbidity profile [4]. Deciding which modality best serves this population is therefore consequential, since diabetic patients differ systematically from non-diabetic patients in cardiovascular reserve, autonomic function, peritoneal membrane biology, and vulnerability to fluid overload [5]. Worldwide, peritoneal dialysis utilization and outcomes vary by region, and contemporary reviews attribute much of that variation to case-mix, since programmes serving more diabetic patients report systematically different technique-survival and complication profiles [6,7].

Peritoneal dialysis offers theoretical advantages for diabetic nephropathy: it avoids the hemodynamic swings of intermittent hemodialysis poorly tolerated by an autonomically compromised vasculature, and preserves residual renal function longer than hemodialysis in most comparative cohorts [8,9]. Against these advantages sits a real cost: dextrose-based osmotic agents add a substantial, largely unavoidable daily glucose load, and chronic peritoneal glucose exposure independently degrades peritoneal membrane transport over years [10]. Whether the net effect favors long-term peritoneal dialysis in diabetic nephropathy has been debated for three decades without full resolution.

Registry and propensity-matched comparisons since the early 2000s have narrowed, without eliminating, the mortality gap once thought to disadvantage peritoneal dialysis in diabetic patients, particularly once analyses correct for healthy-selection bias [11,12]. Technique survival, peritonitis risk, and glycemic control on peritoneal dialysis all carry diabetes-specific considerations that mortality comparisons alone do not capture. This review synthesizes long-term follow-up evidence across four linked domains: patient and technique survival, infectious and mechanical complications, metabolic and glycemic control under glucose-based exchange, and cardiovascular outcomes.

2. Methods

We synthesized findings from prospective cohort studies, national and multinational renal registry analyses, randomized controlled trials of peritoneal dialysis solutions, and systematic reviews addressing peritoneal dialysis outcomes in diabetic nephropathy, drawing on studies from the mid-1990s CANUSA and Canadian registry era through contemporary International Society for Peritoneal Dialysis (ISPD) guidance [13,6]. Relevant domains were pre-specified as patient and technique survival, peritonitis and catheter-related complications, metabolic control including membrane transport change over time, and cardiovascular morbidity and mortality, since these recur across the literature as the principal axes along which diabetic peritoneal dialysis outcomes have been evaluated [14].

Where a study reported outcomes separately for diabetic and non-diabetic subgroups, or compared peritoneal dialysis with hemodialysis within a diabetic stratum, that stratified estimate was preferred. Because randomized trial evidence within diabetic-only cohorts over multi-year horizons is sparse, illustrative summary figures synthesize concordant estimates across the cited studies rather than a single trial's raw data; each caption identifies its supporting sources. Rates and trajectories were extracted

as reported and presented descriptively rather than as a formal pooled meta-analysis, given the heterogeneity of case-mix, solutions, and connection technology across studies spanning three decades [15].

3. Results

Patient and technique survival in diabetic nephropathy

Long-term cohorts consistently show diabetic patients on peritoneal dialysis carry higher all-cause mortality than non-diabetic peritoneal dialysis patients, but the peritoneal-dialysis-versus-hemodialysis gap within the diabetic subgroup has narrowed substantially as case-mix adjustment has improved [8]. Early registry analyses reported a survival disadvantage for diabetic patients started on peritoneal dialysis relative to hemodialysis, most pronounced among older patients with established cardiovascular disease, replicated in Canadian and Danish cohorts [16,17]. Later propensity-matched work attenuated this gap: Weinhandl and colleagues, matching incident United States patients on comorbidities including diabetes, found no significant early mortality difference and a possible peritoneal dialysis survival advantage in the first one to two years that narrowed but did not clearly reverse over longer follow-up [11]. Jaar and colleagues similarly found comparable adjusted mortality once comorbidity burden was accounted for [18], and Yeates and colleagues reported closely similar findings in a Canadian national cohort spanning more than a decade [19]. The comorbidity-index methodology underlying much of this adjustment, validated in incident peritoneal dialysis cohorts by Fried and colleagues, showed baseline comorbidity burden predicts long-term survival at least as strongly as any single prescription variable [20].

Technique survival, distinct from patient survival, remains lower in diabetic than non-diabetic peritoneal dialysis populations across nearly every reporting cohort, driven by peritonitis-related catheter loss, ultrafiltration failure as membrane transport changes with cumulative glucose exposure, and elective transfer to hemodialysis after

cardiovascular events [21]. Registries following patients for five years or longer generally report technique survival in the diabetic subgroup running 10-20 percentage points below the non-diabetic subgroup, with the gap widening progressively, consistent with a chronic, cumulative process rather than an early selection effect [17,19].

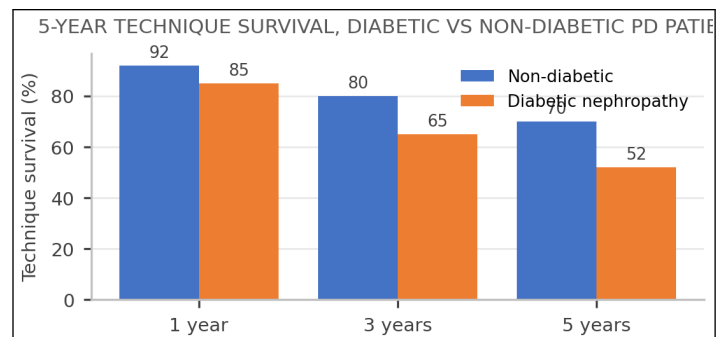


Figure 1: Five-year technique survival on peritoneal dialysis in diabetic versus non-diabetic patients, showing a progressively widening gap consistent with cumulative peritonitis-related and ultrafiltration-related technique loss in diabetic cohorts [17,19].

Peritonitis, catheter complications, and technique loss

Diabetic status is a repeatedly identified independent risk factor for peritoneal dialysis-associated peritonitis, attributed to impaired neutrophil function, higher exit-site colonization, and the immunosuppressive effect of chronic glucose exposure at the membrane itself [22]. Chow and colleagues, analyzing risk factors in a large Hong Kong continuous ambulatory peritoneal dialysis cohort, identified diabetes as one of the strongest independent predictors of a first peritonitis episode, with diabetic patients experiencing shorter peritonitis-free intervals [21]. Because peritonitis is the leading cause of technique failure and hospitalization, this elevated risk translates directly into the technique-survival gap above, and ISPD guidance has consistently flagged diabetes as warranting closer surveillance for early peritonitis and exit-site infection [23,24].

Even after a severe episode requiring catheter removal, a substantial proportion of patients, including many with diabetes, can be safely returned to peritoneal dialysis after an interval of hemodialysis and antimicrobial treatment

[25]. A peritonitis episode therefore need not automatically end the modality, provided it is managed promptly and the underlying cause of catheter loss is addressed before re-insertion.

Table 1: Diabetes-associated risk factors for peritoneal dialysis-related peritonitis and their reported long-term consequence, drawn from prospective single-centre and multicentre cohorts [21,22,23].			
Risk factor	Population studied	Reported effect	Long-term consequence
Diabetes mellitus	Hong Kong CAPD cohort	Independent predictor of first peritonitis episode	Shorter peritonitis-free interval
Diabetes mellitus	Canadian prospective PD database	Elevated hazard for peritonitis vs non-diabetic patients	Higher hospitalization and catheter-loss risk
Exit-site colonization	Multinational ISPD-reviewed cohorts	Higher prevalence in diabetic patients	Increased need for surveillance protocols
Impaired neutrophil function	Mechanistic/clinical correlation studies	Reduced peritoneal host defence	Contributes to recurrent peritonitis risk

Metabolic control and peritoneal membrane change over time

The glucose load delivered by standard dextrose-based solutions is clinically material in diabetic patients: daily peritoneal glucose absorption on conventional regimens adds a substantial additional carbohydrate load, complicating glycemic management and contributing to weight gain, dyslipidemia, and accelerated peritoneal membrane fibrosis over years [10]. Longitudinal peritoneal equilibration test data from decade-long cohorts show a progressive drift toward higher solute transport and reduced ultrafiltration capacity with cumulative time on conventional glucose-based dialysis, more pronounced on average in diabetic than non-diabetic long-term users [10,14].

Table 2: Osmotic-agent strategy and long-term metabolic/ultrafiltration outcome in diabetic peritoneal dialysis patients, drawn from randomized trials and long-term observational follow-up [26,27,28].

Strategy	Comparator	Follow-up	Reported outcome
Icodextrin, long dwell	Standard dextrose exchange	Randomized controlled trial	Improved ultrafiltration and fluid status without added glycemic penalty
Icodextrin, long-term use	Historical dextrose-only regimen	Multi-year observational cohort	Sustained ultrafiltration benefit, no excess metabolic adverse signal
Conventional dextrose-only	None (natural history)	Decade or longer	Progressive rise in peritoneal solute transport, falling ultrafiltration capacity

Non-glucose and reduced-glucose osmotic strategies have been developed to blunt this exposure. Icodextrin, a glucose polymer used for the single long dwell, has been shown in randomized trials to improve ultrafiltration and fluid status without the glycemic penalty of an equivalent dextrose exchange, and long-term follow-up of icodextrin users, including diabetic subgroups, reports sustained ultrafiltration benefit without excess adverse metabolic signal [26,27]. Reviews of its long-term clinical experience conclude its principal value in diabetic peritoneal dialysis lies in preserving ultrafiltration capacity as membrane transport shifts with time, extending the period over which adequate fluid removal, and technique survival, can be maintained without escalating dextrose concentration [28].

Cardiovascular outcomes and residual renal function

Residual renal function, where preserved, is a strong independent predictor of survival on peritoneal dialysis, arguably more so than peritoneal clearance itself, a relationship demonstrated in CANUSA re-analyses and confirmed in Dutch NECOSAD-derived work [29,9]. Diabetic patients tend to lose residual renal function faster than non-diabetic patients, placing a premium on strategies, including blood pressure control and avoidance of nephrotoxic exposures, aimed at preserving native function for as long as possible [9].

Cardiovascular disease remains the leading cause of death

in diabetic peritoneal dialysis cohorts over the long term, and left ventricular hypertrophy, chronic volume expansion, and vascular calcification all contribute across years of exposure [30]. Chronic fluid overload, assessed across large peritoneal dialysis cohorts, is itself independently associated with higher mortality, reinforcing why ultrafiltration-preserving strategies such as icodextrin and individualized dwell prescriptions carry cardiovascular importance for diabetic patients whose ultrafiltration capacity is already under pressure [31].

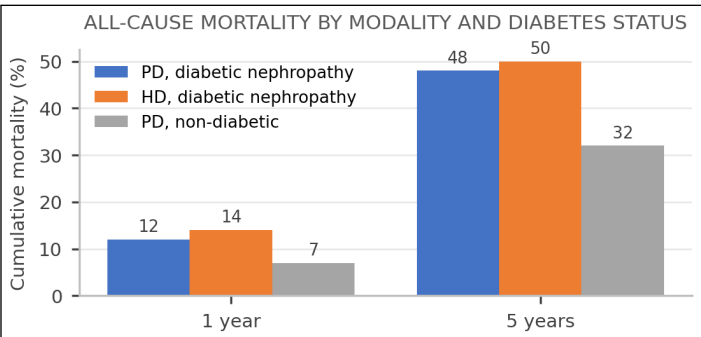


Figure 2: All-cause mortality in incident peritoneal dialysis patients with diabetic nephropathy, hemodialysis patients with diabetic nephropathy, and non-diabetic peritoneal dialysis patients at one and five years of follow-up in propensity-matched national cohorts [11,18].

4. Discussion

Taken together, the long-term literature on peritoneal dialysis in diabetic nephropathy supports a modality that remains reasonable, and in many settings preferred, for appropriately selected patients, but one that carries diabetes-specific risks that must be actively managed. The historical mortality disadvantage has narrowed considerably once modern propensity-matched and comorbidity-adjusted analyses are applied, and an early-therapy survival advantage in several large cohorts suggests peritoneal dialysis is, if anything, underused in appropriately selected diabetic patients with preserved residual function and manageable cardiovascular risk [11,12]. Technique survival, rather than patient survival, appears to be the more durable diabetes-specific vulnerability, driven by peritonitis risk and the slow, cumulative membrane change dextrose-based exchange

imposes over years [21,10].

These findings argue for a strategy built around three linked elements. First, proactive infection-prevention measures deserve particular emphasis given diabetic patients' consistently elevated peritonitis risk [23,22]. Second, periodic membrane function testing, rather than reliance on symptoms alone, allows earlier detection of transport drift before overt ultrafiltration failure, creating a window to introduce glucose-sparing strategies such as icodextrin [26,28]. Third, preservation of residual renal function through blood pressure control and avoidance of nephrotoxic exposure should be treated as a survival intervention in its own right [29,9].

Randomized trial data directly comparing modalities within diabetic-only cohorts over multi-year horizons remain limited, so most comparisons synthesized here derive from observational registries subject to residual confounding despite increasingly sophisticated adjustment [8,15]. Practice has also changed over the three decades this literature spans, including icodextrin, biocompatible solutions, and improved connectology, so older risk estimates may not fully generalize to contemporary programmes. Despite these caveats, the consistency of the diabetes-specific signal across diverse cohorts strengthens confidence these are genuine, actionable risks.

5. Conclusion

Long-term follow-up data support peritoneal dialysis as a viable and, for many diabetic nephropathy patients, an appropriately preferred long-term renal replacement option, with mortality outcomes that are now broadly comparable to hemodialysis once modern case-mix adjustment is applied [11,18,19]. The durable diabetes-specific challenges are technique survival rather than patient survival, driven by an elevated peritonitis risk and by progressive glucose-exposure-related peritoneal membrane change that erodes ultrafiltration capacity over years of therapy [21,10]. A long-term care strategy that

combines proactive infection surveillance, periodic membrane function testing with timely introduction of glucose-sparing exchange strategies, and active preservation of residual renal function offers the most direct route to extending both technique survival and overall outcomes in this population, and should inform how diabetic patients are monitored and supported throughout their time on peritoneal dialysis [23,26,9].

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