Research Square

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Divergent Predictors of Mortality and Technique Failure in Peritoneal Dialysis: A Competing-Risks Analysis

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Abstract

Background

In peritoneal dialysis (PD), PD discontinuation is commonly used to benchmark program performance. However, death may account for a larger share of treatment attrition. We examined predictors of PD discontinuation and mortality and evaluated a simplified cardio–kidney–metabolic (CKM) composite score for mortality risk stratification.

Methods

We performed a retrospective cohort study of 134 incident PD patients at a Malaysian tertiary center (2023–2025). Cause-specific Cox models and Fine–Gray subdistribution models were used to assess predictors of PD discontinuation and all-cause mortality. A simplified cardiometabolic composite score incorporating diabetes mellitus, hypertension, atherosclerotic cardiovascular disease (ASCVD), dyslipidaemia, and hypoalbuminaemia was evaluated against a conventional multivariable model for mortality discrimination using receiver operating characteristic (ROC) analysis and time-dependent area under the curve (AUC).

Results

Over 166 person-years (median follow-up 14 months), 34 attrition events occurred: 25 deaths and 9 PD discontinuation. PD discontinuation was associated with peritonitis burden (HR 2.20, p = 0.001) and PD-related hospitalizations (HR 2.00, p = 0.001). In competing-risk analyses, these associations were attenuated. Mortality was associated with baseline CKM burden (HR 1.77 per point, p = 0.003; sHR 1.79, p = 0.017). Discrimination was broadly comparable between the composite score and the traditional multivariable model (AUC 0.745 vs 0.747).

Conclusions

Mortality was the dominant contributor to PD attrition in this cohort and appeared to arise through pathways distinct from technique failure. Acute PD-related complications were more strongly associated with PD discontinuation, whereas baseline cardiometabolic burden was more closely associated with mortality. A simplified cardiometabolic composite score demonstrated mortality discrimination comparable to conventional multivariable modelling, although external validation is required.

Background

Peritoneal dialysis (PD) is an established kidney replacement therapy that offers advantages in patient autonomy, home-based care, and preservation of residual kidney function [1, 2]. Clinical success in PD has

traditionally been assessed through technique survival and prevention of PD-related complications, particularly peritonitis and membrane failure [3, 4]. However, mortality in PD remains substantial and is frequently driven by cardiovascular and metabolic comorbidity rather than by technique-related events alone [5, 6]. This broader risk landscape is increasingly reflected in the cardiovascular-kidney-metabolic (CKM) framework, which emphasizes the interdependence of metabolic disease, kidney dysfunction, and cardiovascular risk [12, 30]. Despite this, PD outcomes are still often framed primarily around technique survival, even though death may account for a greater share of overall treatment attrition in contemporary PD cohorts [7, 20, 21]. In Malaysia, where PD uptake has been supported by a national "PD First" strategy and the active PD population exceeded 8,400 patients in 2023, understanding these competing outcome pathways is especially relevant to long-term programme evaluation and patient care [1, 14].

Emerging evidence suggests that the determinants of PD outcomes may differ fundamentally. PD discontinuation is often precipitated by acute clinical complications, particularly peritonitis and hospitalization [3, 8], whereas mortality appears to be more closely linked to baseline patient factors, including comorbidity burden, nutritional status, and systemic inflammation [5, 9]. Conventional risk stratification approaches typically rely on individual variables such as diabetes, cardiovascular disease, or serum albumin [10, 11], which may not adequately capture the combined burden of cardiovascular, metabolic, and kidney-related risk. As a result, current models may underestimate the complexity of risk in PD populations.

Against this background, there is a need to characterise how cardiometabolic burden and acute PD-related events differentially shape the risks of mortality and technique failure, and to evaluate whether a simple CKM-based construct can provide clinically useful risk stratification beyond traditional models.

We therefore conducted a single-centre cohort study of incident PD patients to (i) quantify the relative frequency and determinants of PD discontinuation and all-cause mortality using competing-risks methods, and (ii) assess whether a simplified CKM composite score offers mortality discrimination comparable to a conventional multivariable model. Our aim was to inform a more patient-centred approach to outcome assessment in PD, in which prevention of cardiometabolic death is considered alongside preservation of technique.

Methods

Study design and setting

This was a retrospective, observational single-center cohort study conducted at the Peritoneal Dialysis Unit of University Malaya Medical Centre (UMMC). The study utilized existing longitudinal data from the UMMC PD registry and electronic medical records (EMR) to evaluate treatment outcomes over the study period.

Study Population and Inclusion Criteria

We included all adult patients (≥ 18 years) who initiated chronic peritoneal dialysis at UMMC between 1 January 2023 and 31 December 2025. To ensure a focus on long-term maintenance PD, patients with incomplete initiation data or those whose therapy was only intended for acute kidney injury support were excluded.

Follow-up and Outcome Definitions

Patients were followed from the date of PD initiation until the occurrence of a primary endpoint, kidney transplantation, or the end of the study period (31 December 2025). We defined two distinct primary outcomes:

- *Peritoneal Dialysis (PD) Discontinuation*: Permanent cessation of PD and transfer to hemodialysis (HD) due to PD-related complications, including refractory peritonitis, catheter-related mechanical failure, or membrane dysfunction.
- *All-Cause Mortality*: Death from any cause occurring while the patient was active on PD or within 30 days of transfer to HD.

Patients who received a kidney transplant or transferred to other centers were censored at the time of the event. Mortality was analyzed separately from PD discontinuation to evaluate divergent predictors of each outcome.

Patients who did not experience an event by the end of the study period were right-censored. While the cohort included incident patients throughout the study period, the use of Cox proportional hazards models accounted for varying follow-up durations, ensuring that each patient's contribution to the risk pool was proportional to their time on therapy.

Data Collection and CKM Composite Score Construction

Baseline demographic and clinical data were collected at PD initiation, including age, sex, primary kidney disease, and comorbidities such as diabetes mellitus, hypertension, dyslipidemia, and atherosclerotic cardiovascular disease (ASCVD). ASCVD was defined as a history of ischemic heart disease, heart failure, ischemic stroke, or peripheral vascular disease.

PD-related hospitalizations were defined as any inpatient admission directly attributable to PD complications, including refractory peritonitis, catheter-associated infection or malfunction, and symptomatic volume overload due to ultrafiltration failure. Peritonitis burden was defined as the total number of peritonitis episodes per patient during the study period.

A simplified Cardiovascular-Kidney-Metabolic (CKM) composite score was constructed using five baseline variables: diabetes mellitus, hypertension, ASCVD, dyslipidemia, and hypoalbuminemia, defined as serum albumin < 35 g/L. One point was assigned for each variable present, yielding a total score ranging from 0 to 5, with higher scores indicating greater cardiometabolic burden. For analysis, the CKM score was treated as both a continuous variable and a categorical variable. Patients were further grouped into low-risk (0–1), moderate-risk (2–3), and high-risk (4–5) strata for descriptive and survival analyses.

This simplified composite was adapted to reflect key domains of the CKM framework using variables routinely available in clinical practice.

Statistical Analysis

Continuous variables were assessed for normality using the Shapiro–Wilk test. Normally distributed data were expressed as mean ± standard deviation (SD), while non-normally distributed data were presented as median and interquartile range (IQR). Categorical variables were summarized as frequencies and percentages.

Technique survival and patient survival were estimated using the Kaplan-Meier method, and differences between groups were assessed using the log-rank test. Survival curves were stratified according to CKM risk categories (low, moderate, and high risk).

Primary analysis for treatment attrition was performed using Fine and Gray subdistribution hazard models to account for the competing risks between mortality and PD discontinuation. As a sensitivity analysis, standard Cox proportional hazards models were also utilized to estimate cause-specific hazards. The PD discontinuation model included clinical burden variables such as peritonitis episodes and PD-related hospitalizations. The mortality model included the CKM composite score as a continuous variable.

A separate model was also constructed to compare the CKM score with a traditional model incorporating individual components, including diabetes, ASCVD, and albumin. Hazard ratios (HRs) and 95% confidence intervals (CIs) were calculated. Proportional hazards assumptions were verified using log-log plots.

The discriminatory performance of the CKM composite score for time-dependent mortality was evaluated using receiver operating characteristic (ROC) curve analysis. The area under the curve (AUC) of the CKM-based model was compared with that of the traditional multivariable risk model to assess predictive accuracy. To account for the variable follow-up inherent in this cohort, time-dependent ROC analysis was additionally performed using Uno's inverse probability of censoring weighting (IPCW) estimator under the cumulative/dynamic definition to account for censoring. Discrimination was evaluated at 0.5, 1.0, 1.5, 2.0, and 2.5 years. All time-dependent analyses were performed in Python using the scikit-survival library (version 0.27).

All statistical analyses were performed using SPSS version 29.0 (IBM Corp, Armonk, NY). A two-sided $p < 0.05$ was considered statistically significant.

Results

Study Population

A total of 134 incident peritoneal dialysis patients were enrolled between 1 January 2023 and 31 December 2025. The cohort had a mean age of 56.4 ± 17.4 years (median 60.0, IQR 42.0–69.0), and males comprised the majority (n = 76, 56.7%). By ethnicity, patients were predominantly Malay (41.0%), followed by Chinese (38.8%), Indian (16.4%), and others (3.7%). The leading cause of end-stage kidney disease was diabetic nephropathy (53.7%), followed by hypertensive nephropathy (21.6%) and glomerulonephritis (14.2%).

Baseline Comorbidities and CKM Risk Staging

Hypertension was the most prevalent comorbidity (n = 108, 80.6%), followed by dyslipidaemia (74.6%), diabetes mellitus (60.4%), and ASCVD (41.0%). Hypoalbuminaemia (serum albumin < 35 g/L) was present in 66.4% of patients at PD initiation, with a mean baseline albumin of 32.1 ± 5.1 g/L. Using the CKM composite score, the majority of patients were classified as high-risk (CKM score 4–5: 51.5%), with 34.3% moderate-risk (score 2–3) and 14.2% low-risk (score 0–1); the median CKM score was 4.0 (mean 3.2 ± 1.4).

[Insert Table 1 here]

Table 1
Baseline Characteristics and Clinical Outcomes of the Study Cohort (N = 134)

Variable	Value (N = 134)
DEMOGRAPHICS	
Age, years — median (IQR)	60.0 (42.0–69.0)
Male sex — n (%)	76 (56.7%)
ETHNICITY — n (%)	
Malay	55 (41.0%)
Chinese	52 (38.8%)
Indian	22 (16.4%)
Others	5 (3.7%)
PRIMARY RENAL DISEASE — n (%)	
Diabetic nephropathy	72 (53.7%)
Hypertensive nephropathy	29 (21.6%)
Glomerulonephritis	19 (14.2%)
Unknown/Others	14 (10.4%)
COMORBIDITIES — n (%)	
Hypertension	108 (80.6%)
Dyslipidaemia	100 (74.6%)
Diabetes mellitus	81 (60.4%)
ASCVD (any)	55 (41.0%)
— Ischaemic heart disease	33 (24.6%)
— Heart failure	24 (17.9%)
— Stroke	15 (11.2%)
— Peripheral vascular disease	11 (8.2%)
BASELINE SERUM ALBUMIN	
Mean ± SD (g/L)	32.1 ± 5.1
Hypoalbuminaemia (< 35 g/L) — n (%)	89 (66.4%)

ASCVD = atherosclerotic cardiovascular disease; APD = automated peritoneal dialysis; CAPD = continuous ambulatory peritoneal dialysis; CKM = cardiovascular-kidney-metabolic; IQR = interquartile range; PD = peritoneal dialysis; SD = standard deviation; TF = technique failure.

Variable	Value (N = 134)
DEMOGRAPHICS	
PD CHARACTERISTICS — n (%)	
CAPD	96 (71.6%)
APD	38 (28.4%)
Preemptive PD	73 (54.5%)
Obligatory PD	11 (8.2%)
CKM COMPOSITE SCORE	
Mean ± SD	3.2 ± 1.4
Median (IQR)	4.0 (3.0–5.0)
Low risk (score 0–1) — n (%)	19 (14.2%)
Moderate risk (score 2–3) — n (%)	46 (34.3%)
High risk (score 4–5) — n (%)	69 (51.5%)
CLINICAL OUTCOMES	
Median follow-up, months (IQR)	14.0 (7.0–21.8)
Total person-years of observation	166.0
Ongoing PD at study end — n (%)	87 (64.9%)
All-cause mortality — n (%)	25 (18.7%)
— Mortality rate per 100 patient-years	15.1
— Median time to death, days (IQR)	340 (188–443)
Technique failure (PD discontinuation) — n (%)	9 (6.7%)
— TF rate per 100 patient-years	5.4
— Median time to TF, days (IQR)	249 (171–337)
Kidney transplantation — n (%)	5 (3.7%)
Transfer out — n (%)	8 (6.0%)
Total attrition events (death + TF) — n (%)	34 (25.4%)
— Death as proportion of attrition	73.5%

ASCVD = atherosclerotic cardiovascular disease; APD = automated peritoneal dialysis; CAPD = continuous ambulatory peritoneal dialysis; CKM = cardiovascular-kidney-metabolic; IQR = interquartile range; PD = peritoneal dialysis; SD = standard deviation; TF = technique failure.

Variable	Value (N = 134)
DEMOGRAPHICS	
— TF as proportion of attrition	26.5%

ASCVD = atherosclerotic cardiovascular disease; APD = automated peritoneal dialysis; CAPD = continuous ambulatory peritoneal dialysis; CKM = cardiovascular-kidney-metabolic; IQR = interquartile range; PD = peritoneal dialysis; SD = standard deviation; TF = technique failure.

Follow-Up and Outcomes

The median follow-up duration was 14.0 months (IQR 7.0–21.8), representing 166.0 total person-years of observation. At the end of the study period, 87 patients (64.9%) remained on active PD, while 25 (18.7%) had died and 9 (6.7%) experienced PD discontinuation. Among all 34 attrition events (deaths and PD discontinuation combined), all-cause mortality accounted for 73.5% versus 26.5% for PD discontinuation, confirming that death was the dominant mode of treatment attrition in this cohort. The overall mortality rate was 15.1 per 100 patient-years, compared with a PD discontinuation rate of 5.4 per 100 patient-years.

Kaplan-Meier survival analysis

Kaplan-Meier analysis demonstrated a significant difference in technique survival according to history of peritonitis. Patients without prior peritonitis had longer estimated technique survival on PD than those with a history of peritonitis, with estimated survival times of 1034 days and 825 days, respectively (log-rank $p < 0.001$). For patient survival, Kaplan-Meier curves showed significant separation across CKM risk groups (log-rank $p = 0.002$). Estimated survival was longest in the moderate-risk group (956 days), followed by the low-risk group (906 days), and shortest in the high-risk group (741 days), indicating worse survival with increasing CKM burden.

[insert Fig. 1 here]

Predictors of PD discontinuation

Nine patients experienced permanent transfer to haemodialysis, with a median time to PD discontinuation of 249 days (IQR 171–337 days). On multivariable Cox proportional hazards regression, total peritonitis episodes (HR 2.203, $p = 0.001$) and PD-related hospitalisation frequency (HR 2.003, $p = 0.001$) were the only independent predictors of PD discontinuation. Baseline comorbidities, including diabetes mellitus and hypertension, were not significantly associated with PD discontinuation, highlighting the critical role of acute clinical events — rather than chronic metabolic burden — in driving this outcome.

In the competing risk analysis for PD discontinuation (with mortality as the competing event), the impact of acute clinical events was attenuated compared to standard models. Total peritonitis episodes showed a strong trend toward increased PD discontinuation (sHR 1.862; 95% CI 0.911–3.805; $p = 0.085$), while

hospitalization frequency was no longer a significant predictor (sHR 1.251; p = 0.550). This shift suggests that the strong associations seen in initial models were partially confounded by the high background mortality rate.

[Insert Table 2 here]

Table 2
Multivariable Predictors of PD Discontinuation

Variable	Cause-Specific HR (Cox Regression)	Subdistribution sHR (Fine–Gray Model)
Total peritonitis episodes	HR 2.203 95% CI 1.393–3.483 p = 0.001	sHR 1.862 95% CI 0.911–3.805 p = 0.085
PD-related hospitalisation frequency	HR 2.003 95% CI 1.362–2.946 p = 0.001	sHR 1.251 95% CI 0.595–2.629 p = 0.550
Diabetes mellitus	HR 0.87 (NS)	sHR — (NS)
Hypertension	HR 0.92 (NS)	sHR — (NS)

Both Cox and Fine–Gray models adjusted for age, sex, diabetes, hypertension, peritonitis episodes, and hospitalisation frequency. Fine–Gray model treats all-cause mortality as the competing event. HR = hazard ratio; sHR = subdistribution hazard ratio; CI = confidence interval; NS = not significant.

Predictors of All-Cause Mortality

Twenty-five patients died during follow-up at a median of 340 days (IQR 188–443 days) from PD initiation. Mortality was markedly concentrated in the high CKM risk group, with 30.4% of high-risk patients (score 4–5) dying during follow-up, compared with 10.5% in the low-risk group (score 0–1) and 4.3% in the moderate-risk group (score 2–3).

Traditional multivariable model (diabetes, ASCVD, albumin): In the first Cox regression model incorporating individual conventional risk factors, ASCVD was the only statistically significant independent predictor of mortality (HR 3.094, 95% CI 1.242–7.707, p = 0.015). Diabetes mellitus (HR 1.851, 95% CI 0.573–5.975, p = 0.303) and serum albumin (HR 0.949, p = 0.223) did not reach statistical significance as independent predictors when evaluated simultaneously, likely reflecting multicollinearity between overlapping risk domains.

CKM composite score model: In the second Cox regression model, the CKM composite score was a robust independent predictor of all-cause mortality (HR 1.771 per unit increase, 95% CI 1.218–2.575, p = 0.003), with overall model significance of p < 0.001. The CKM composite score remained independently

associated with mortality even after accounting for PD discontinuation as a competing risk. Each unit increase in the CKM score (0–5) was associated with a 78.6% increase in mortality risk (sHR 1.786; 95% CI 1.111–2.871; p = 0.017). The cumulative incidence function clearly demonstrated a risk gradient, with the highest mortality observed in patients with CKM scores ≥ 4.

[Insert Table 3 here]

Table 3
Multivariable Predictors of All-Cause Mortality: Traditional Model vs. CKM Composite Score

Variable	Model	HR	95% CI	p-value
Model 1: Traditional Multivariable Model				
ASCVD	Traditional (Cox)	3.094	1.242–7.707	0.015
Diabetes mellitus	Traditional (Cox)	1.851	0.573–5.975	0.303
Serum albumin	Traditional (Cox)	0.949	0.872–1.033	0.223
Model 2: CKM Composite Score Model				
CKM composite score	CKM (Cox)	1.771	1.218–2.575	0.003
CKM composite score	CKM (Fine–Gray)	1.786	1.111–2.871	0.017
Discriminatory Performance (ROC Analysis)				
AUC comparison	Traditional vs CKM	0.747 vs 0.745	*Difference = 0.002*	NS

Both models constructed as separate multivariable Cox regression analyses. CKM composite score entered as a continuous variable (range 0–5). Fine–Gray model treats PD discontinuation as competing event. ASCVD = atherosclerotic cardiovascular disease; CKM = cardiovascular-kidney-metabolic; HR = hazard ratio; sHR = subdistribution hazard ratio; AUC = area under the ROC curve; NS = not significant.

ROC Analysis: Discriminatory Performance

Receiver operating characteristic (ROC) curve analysis was performed to compare the discriminatory performance of both models for 3-year all-cause mortality. The traditional multivariable model achieved an AUC of 0.747, while the CKM composite score model achieved a comparable AUC of 0.745 — a difference of only 0.002. Both models demonstrated acceptable-to-good discrimination, correctly identifying the higher-risk patient approximately 75% of the time when comparing a random survivor–non-survivor pair. Although the CKM model did not exceed the traditional model in raw discriminatory accuracy, it achieved equivalent predictive performance using a single composite variable, compared with three independent predictors in the traditional approach. This suggests that simplified baseline risk assessment may be feasible using routinely available clinical variables. Given variable follow-up, ROC estimates should be interpreted as approximate measures of discrimination.

Time-Dependent ROC Analysis

Time-dependent AUC estimates using Uno's IPCW estimator are presented in Table 6, with trends illustrated in Fig. 6. Across all evaluated horizons (0.5 to 2.5 years), the traditional model achieved a mean AUC of 0.682 and the CKM composite score model achieved a mean AUC of 0.684 — a difference of 0.002 — confirming the near-equivalence of the two models observed under static ROC analysis. Harrell's C-statistic was 0.670 for the traditional model and 0.661 for the CKM model, consistent with this overall finding. Time-dependent discrimination appeared broadly similar between models across follow-up.

[Insert Fig. 2 here]

Discussion

This study suggests that mortality and PD discontinuation represent related but distinct outcome pathways in incident PD patients. In this cohort, mortality accounted for nearly three-quarters of all attrition events, indicating that death, rather than technique failure, was the dominant mode of treatment loss during follow-up. This finding supports a broader view of PD outcomes in which programme performance should not be assessed solely by technique survival, particularly in cohorts with substantial cardiometabolic comorbidity [5, 14]. Unlike broader comorbidity indices, the simplified CKM construct was intended to focus specifically on overlapping cardiovascular, metabolic, and nutritional domains relevant to PD populations.

Acute PD-related events appeared to be more important for technique outcomes than baseline comorbidity burden. Peritonitis episodes and PD-related hospitalisation frequency were associated with PD discontinuation in cause-specific models, consistent with prior studies showing that infection and other acute complications are major drivers of transfer to haemodialysis [3, 15, 16]. Baseline comorbidities such as diabetes and hypertension were not independently associated with PD discontinuation, which is in keeping with previous cohort studies suggesting that technique preservation depends more on prevention of acute complications than on chronic baseline risk [17, 18]. However, these associations were attenuated in the competing-risk analysis once death was treated as a competing event, reinforcing the point that standard Cox models may overestimate technique-failure risk when mortality is frequent [20, 21, 23].

In contrast, mortality was more closely linked to baseline cardiometabolic burden. The CKM composite score remained independently associated with death in both cause-specific and subdistribution models, suggesting that cumulative risk across metabolic, cardiovascular, and kidney-related domains may be more informative than isolated covariates when evaluating survival in PD populations [10, 11, 26]. This is biologically plausible given the increasing recognition of CKM syndrome as an integrated construct that captures overlapping pathways of cardiovascular, metabolic, and renal risk [12, 24, 25, 30]. In the traditional model, only ASCVD remained significant, likely reflecting overlap between risk variables and limited statistical power.

The CKM composite also achieved mortality discrimination comparable to the traditional multivariable model despite its simpler structure. Although the absolute difference in AUC was minimal, this degree of parsimony may support the feasibility of simplified baseline risk assessment using routinely available clinical variables.

The apparent survival advantage observed in the moderate-risk group compared with the low-risk group likely reflects instability arising from small subgroup sizes and limited event numbers, particularly within the low-risk category. This finding should therefore be interpreted cautiously.

Limitations

This study has several limitations. First, it was a retrospective single-centre analysis, which introduces the possibility of selection bias and limits generalisability to PD populations with different case mix, practice patterns, and healthcare systems. Second, the modest number of events limited model complexity. Third, although competing-risk methods improve interpretation when death and technique failure coexist, residual confounding remains possible because the study relied on routinely collected clinical data and did not include all potentially relevant biological and treatment-related covariates. Fourth, the simplified CKM score used here was adapted from routinely available baseline variables rather than a formally validated CKM staging system, so its transportability to other dialysis cohorts remains uncertain. Finally, the median follow-up was relatively short, which may have limited detection of longer-term divergence in mortality and technique-failure trajectories.

Conclusion

In summary, mortality was the dominant contributor to PD attrition in this cohort and was more closely linked to cardiometabolic burden than to individual traditional risk factors. PD discontinuation, in contrast, remained largely driven by acute complications. These findings suggest that mortality and technique failure may represent partially distinct outcome domains in PD populations. The CKM composite score offers a pragmatic approach to capturing this risk, although further validation is warranted.

Declarations

Conflict of Interest:

The authors declare no conflict of interest.

Ethics Approval:

Approved by the University Malaya Medical Centre Medical Research Ethics Committee, MREC ID NO: 2026130-16289.

Disclosure

The authors declare no conflict of interest.

Consent to Participate

As this was a retrospective study involving review of existing medical records, individual patient consent to participate was waived by the Medical Research Ethics Committee, Universiti Malaya Medical Centre (MREC No. 2026130-16289). All data were anonymised prior to analysis, and patient confidentiality was maintained throughout.

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Author Contribution

KVP: Conceptualization, methodology, data curation, formal analysis, writing the original draft, manuscript review & editing, prepared figures 1-2. LXEN: Data curation, data collection & data analysis. WJB: Data curation, data collection & data analysis. SSB: Conceptualization, editing and review of original draft and manuscript. WAH: Supervision, review and editing of manuscript. SFC: Supervision, review and editing of manuscript. CKT: Supervision, review and editing of manuscript. All authors reviewed the manuscript.

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Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to institutional ethical guidelines.

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Figures

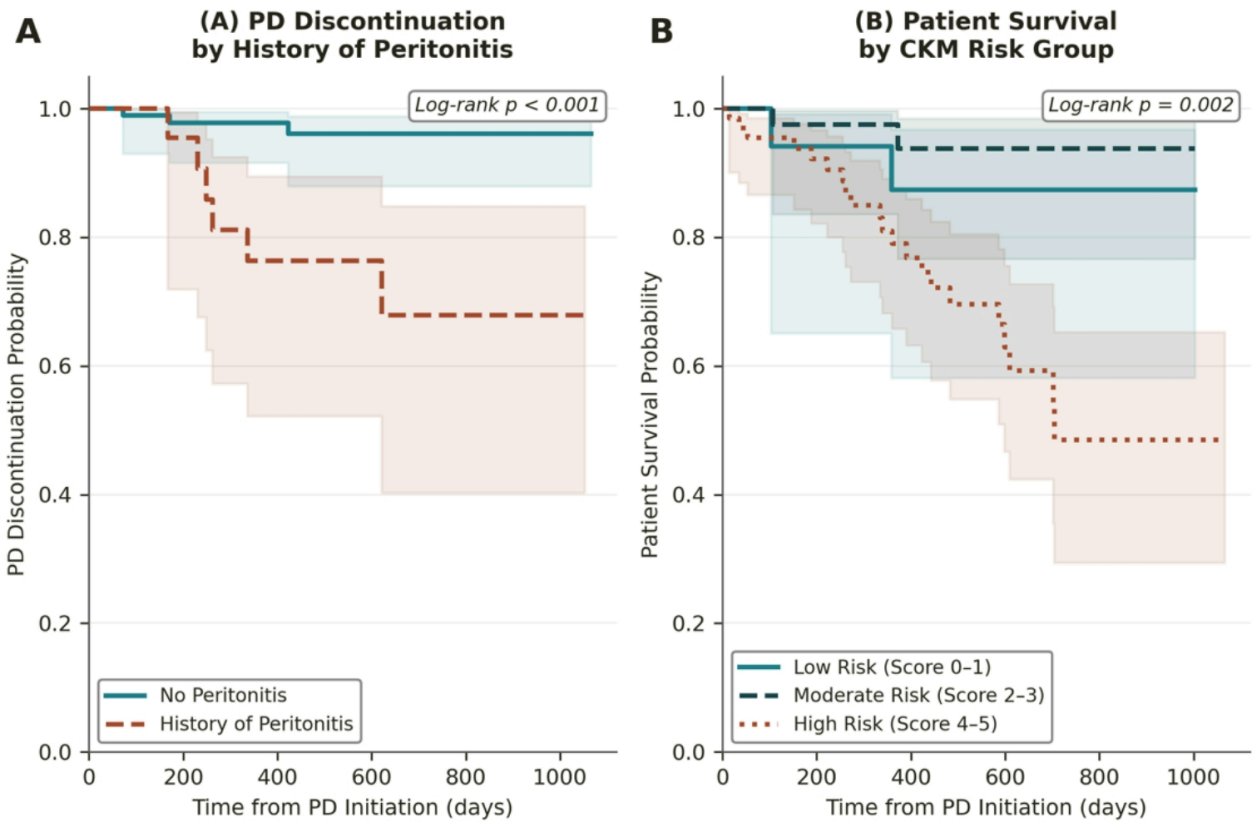


Figure 1

Kaplan-Meier survival analysis: PD discontinuation by peritonitis history and patient survival by CKM risk group.
Panel A demonstrates a significant reduction in PD technique survival among patients with a history of peritonitis compared to those without (log-rank p < 0.001). Panel B illustrates a clear survival gradient

across CKM risk groups, with significantly lower patient survival probability in the high-risk group (score 4–5) compared to low- and moderate-risk groups (log-rank p = 0.002). Shaded areas represent 95% confidence intervals.

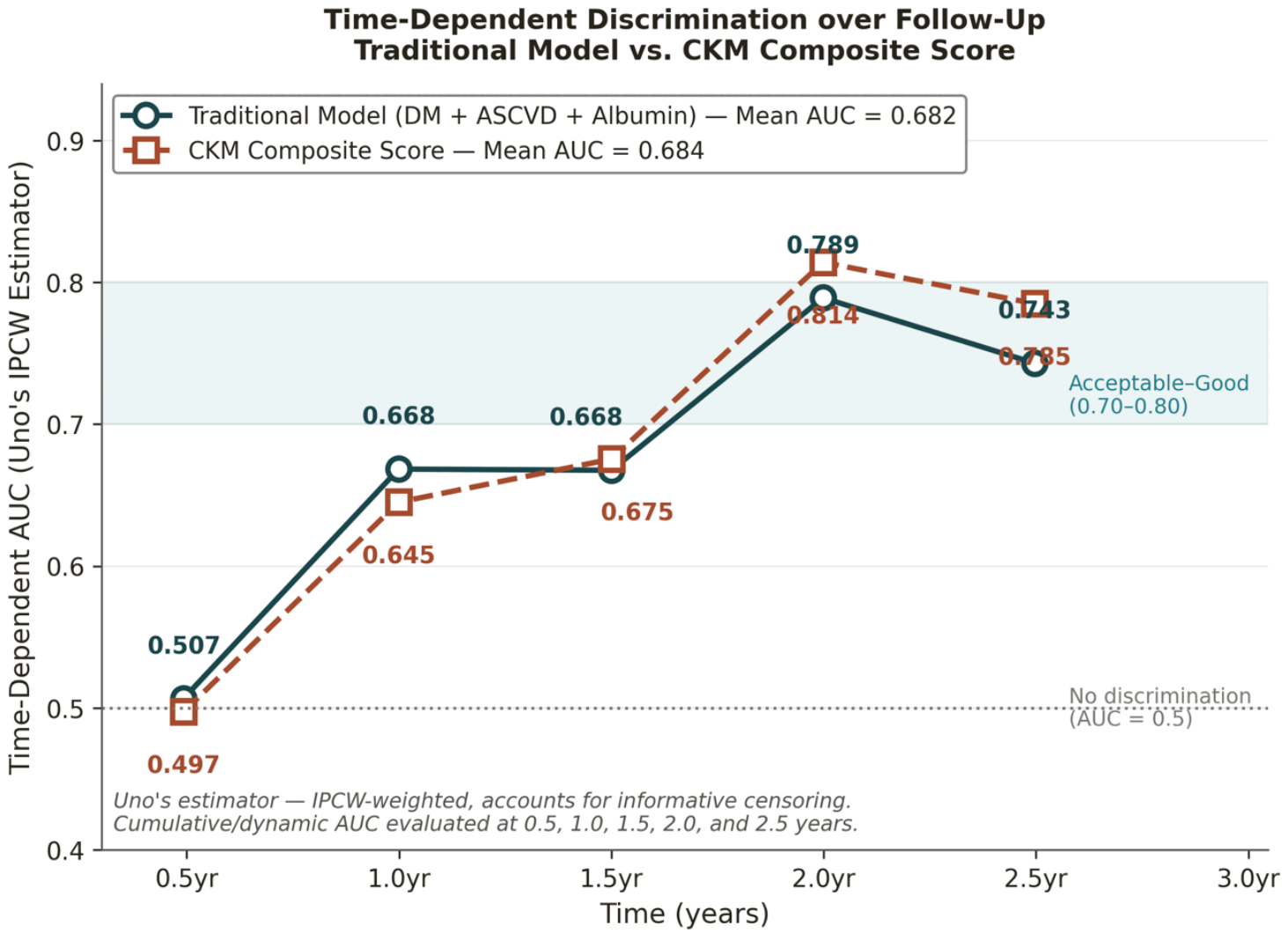


Figure 2

Time-dependent discriminatory performance of the Traditional Model and CKM Composite Score for all-cause mortality prediction.

Time-dependent AUC values were estimated using Uno's inverse probability of censoring weighted (IPCW) estimator across five horizons from 0.5 to 2.5 years. Both models demonstrated near-equivalent mean AUC over the follow-up period (Traditional: 0.682; CKM: 0.684). At shorter horizons (≤1.0 year), discrimination was modest for both models, consistent with early mortality being driven by acute events not captured by baseline cardiometabolic variables. At longer horizons (2.0–2.5 years), the CKM composite score demonstrated a progressive advantage over the traditional model (ΔAUC +0.025 at 2.0 years; +0.042 at 2.5 years), reflecting the increasing prognostic relevance of cumulative cardiometabolic burden over time.