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The relationship between body mass index changes and mortality in geriatric peritoneal dialysis patients: a case-control study

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Abstract

Background The prevalence of chronic kidney disease (CKD) is increasing, reflecting the rising incidence of chronic diseases. With the continuous growth of the global geriatric population, a significant portion of individuals with CKD consists of those aged over 65. Regardless of the chosen treatment method, protein-energy loss in patients undergoing renal replacement therapy (RRT) has been associated with elevated morbidity and mortality rates.

Methods This is a retrospective, single-center study of incident adult PD patients on peritoneal dialysis (PD) from 1998 to 2022. We aimed to compare the survival outcomes of geriatric patients on PD with changing BMI measurements.

Results In the geriatric patient group exhibiting a reduced BMI after dialysis initiation, BMI significantly and negatively influenced survival ($p=0.01$). The negative effect of BMI on survival was independent of known risk factors such as diabetes mellitus, a history of cardiovascular disease, gender, residual renal function, and history of hemodialysis before peritoneal dialysis (HD before PD) ($p=0.04$).

Conclusion Although BMI is easy and extensively measured, it is not considered the perfect monitoring parameter for dialysis patients. However, regular follow-up of BMI, especially in geriatric cases, can be a guiding tool for estimating patients' prognoses.

Keywords Peritoneal dialysis, Chronic kidney disease, Body mass index, Malnutrition

Background

The increasing prevalence of chronic kidney disease (CKD), along with the technical improvement in renal replacement therapies (RRT), led to the prolonged survival of patients with end-stage renal disease [1–3]. A substantial proportion of CKD patients comprises those over 65, termed the geriatric population [4]. Almost 50% of the patients who undergo RRTs are geriatric [5–7]. The drawbacks of hemodialysis (HD) in geriatric patients include the necessity for frequent interventions due to hemodynamic instability, which leads to ischemic changes in the brain and heart, and recurrent dialysis vascular access issues [8, 9]. Conversely, peritoneal dialysis (PD) offers advantages, including performing the treatment at home, avoiding frequent hospital visits, less hemodynamic instability, and preserving residual renal function (RRF) in the long term [10–12].

Increased morbidity and mortality rates are linked to protein-energy wasting (PEW) in RRT patients, irrespective of the treatment modality [13]. Age-related muscle

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loss, commonly termed sarcopenia, is more frequent than anticipated in the dialysis population [14].

Various methods reflect the nutritional status of patients, including body mass index (BMI), serum albumin levels, geriatric nutritional risk index (GNRI), and dietary scales [15, 16]. Although the value of BMI is under debate as a marker of PEW, some studies establish a clear association between low BMI and increased mortality in PD, particularly within the older age [17–19]. Hence, in this study, we aimed to examine the mortality rates among incident PD patients by analyzing the changes in BMI, a simple, cheap, and easily achievable marker, from the baseline, specifically in the geriatric population.

Methods

Patient population

This retrospective study included 220 incident PD patients under follow-up at Dokuz Eylul University outpatient PD clinic between 1998 and 2022. Patients aged 18 years or older and undergoing PD were included in the study. The exclusion criteria for the study include a history of malignancy or chronic infections requiring more than six weeks of treatment, such as osteomyelitis or tuberculosis. Patient demographic and clinical information, age, gender, primary renal disease, dry weight, body mass index, PD treatment modality, systolic and diastolic blood pressure, previous RRT, Kt/V, and residual daily urine were obtained. Laboratory data, including hemoglobin, serum sodium, calcium, phosphorus levels, parathormone (PTH), and serum ferritin levels, were recorded from the initial and last visits. Continuous Ambulatory Peritoneal Dialysis (CAPD) and Automated Peritoneal Dialysis (APD) were utilized. Various PD solutions were used throughout the study period, including non-biocompatible solutions until 2016. After that, biocompatible PD solutions were used. In our center, PD patients are treated with fluids containing different glucose concentrations to achieve a weekly Kt/V>2 and maintain euvolemia.

Individuals aged≥65 years were categorized as geriatric, whereas those aged<65 were classified as non-geriatric. The study's primary endpoint is the analysis of factors influencing all-cause and cardiovascular mortality. BMI is calculated by dividing weight in kilograms by the square of height in meters. Dry weight is defined as the weight at which the patient is noted as normovolemic by their nephrologist. The BMI values from the patients' last visits were subtracted from their BMI values at their initial visits after excluding hypervolemia, resulting in ΔBMI. Those with a positive ΔBMI were defined as increased, while those with a negative ΔBMI were defined as decreased.". BMI values were recorded for PD patients at each visit. GNRI values were calculated using the patients' serum albumin levels and body weight as previously published [16].

$$\begin{aligned}\mathrm{GNRI} = {} & [1,489 \mathrm{X} \mathrm{albumin}\,(\mathrm{g/L})] \\ & + [41,7 \times (\mathrm{bodyweight/idealbodyweight})]\end{aligned}$$

Δ BMI was calculated as the last BMI measurement minus the first BMI measurement, albumin as the last albumin level minus the initial albumin level, and GNRI as the last GNRI minus the initial GNRI.

Statistical analysis

Statistical analyses were performed using SPSS version 24 (IBM Corp., Armonk, NY, USA). A two-sided p-value<0.05 was deemed statistically significant. Continuous variables were reported as mean±SD or median with interquartile range (IQR), depending on their distribution. Categorical variables were presented as frequencies and proportions. ANOVA, Kruskal-Wallis, survival analyses, multinomial logistic regression, and chi-square tests were performed as appropriate.

Results

The demographic and laboratory characteristics of study groups are depicted in Table 1. There was a significant difference between study groups regarding age due to the study design ($p<0.01$). However, no difference was found in gender frequencies ($p=0.88$). The rate of diabetes mellitus was highest in the geriatric decreased BMI group. ($p=0.03$). The baseline Kt/V, hemodialysis history, and baseline residual urine analyses were all similar between the study groups ($p=0.66$, $p=0.58$, and $p=0.45$, respectively).

Regarding the nutritional parameters, there were no significant differences in initial BMI ($p=0.07$), baseline serum albumin ($p=0.25$), and baseline GNRI levels ($p=0.29$) in group comparisons (Table 1). However, significant differences were observed in the last BMI, albumin, and GNRI values among the groups ($p<0.01$) (Table 2).

In the univariate analysis, age significantly increased the risk of mortality, with a hazard ratio (HR) of 1.04 (95% CI: 1.01–1.07, $p<0.05$). Additionally, residual renal function (RRF) was associated with a slightly decreased risk of mortality, with an HR of 0.99 (95% CI: 0.90–1.00, $p<0.05$). Among the groups, the "geriatric decreased BMI" group demonstrated the highest mortality hazards (HR 3.11, 95% CI: 1.27–7.60, $p=0.01$).

In the multivariate analysis, which evaluated age, DM, HT, CVD, ΔGNRI, RRF, and study groups, the protective effect of RRF was observed to persist. Among the groups, the "geriatric decreased BMI" group again demonstrated significantly highest mortality hazard (HR 3.72, 95% CI: 1.02–13.36, $p=0.04$).

Table 1 Comparison of patients' initial demographic and Laboratory Study-Related Data

	Non-geriatric Increased BMI ***N*** **= 123**	**Non-geriatric Decreased BMI** ***N*** **= 44**	**Geriatric Increased BMI** ***N*** **= 33**	**Geriatric Decreased BMI** ***N*** **= 20**	***p***
Age (years)	46.02 (± 9.90)	43.93 (± 11.18)	67.61 (± 4.71)	68.20 (± 6.01)	< 0.01
Gender (Female)	63 (51%)	21 (48%)	17 (52%)	12 (60%)	0.84
Primary Disease					
• Hypertension	34 (27%)	9 (20%)	16 (48%)	5 (25%)	0.03
• DM	23 (19%)	5 (12%)	8 (24%)	7 (35%)	
• Chronic GN	18 (15%)	8 (18%)	0 (0%)	1 (5%)	
• Others	48 (39%)	22 (50%)	9 (28%	7 (35%)	
CVD	45 (36.6%)	44 (38,6%)	22 (66.7%)	9 (45%)	0.02
BMI (kg/m^2)	24.11 (± 3.70)	24.07 (± 4.82)	24.88 (± 4.97)	26.6 (± 4.83)	0.07
ΔBMI (kg/m^2)	2.30 (± 1.73)	-1.41 (± 1.26)	2.24 (± 1.58)	-1.39 (± 1.68)	0.00
Modality (CAPD)	95 (77%)	31 (70%)	26 (79%)	13 (65%)	0.54
Kt/V	2.43 (± 0.63)	2.33 (± 0.85)	2.32 (± 0.79)	2.24 (± 0.54)	0.66
Creatinine clearance	55.49 (± 15.66)	52.48 (± 15.89)	55.19 (± 15.90)	54.02(± 10.7)	0.82
Systolic BP (mmHg)	136.81 (± 24.83)	137.40 (± 27.51)	144.94 (± 28.76)	132.80 (± 16.01)	0.31
Diastolic BP (mmHg)	85.52 (± 16.20)	83.64 (± 15.77)	84.67 (± 12.41)	75.70 (± 11.03)	0.07
Kt/V residue urine(ml)	0.81 (0, 3.3)	0.70 (0, 3.6)	0.64 (0, 2.2)	0.55 (0, 2.6)	0.45
HD before PD	43 (35%)	17 (39%)	9 (27%)	9 (45%)	0.58
Initial UF (ml)	450 (82, 950)	620 (36, 850)	500 (185, 875)	300 (0, 642)	0.89
Last UF (ml)	790 (440,1050)	750 (400,1025)	750 (500,1093)	55 (90, 800)	0.73
Initial GNRI	103.86 (± 12.51)	101.94 (± 18.61)	108.72 (± 11.34)	111.35 (± 15.80)	0.29
Last GNRI	106.40 (± 12.08)	92.71 (± 16.90)	103.70 (± 12.94)	96.53 (± 12.87)	< 0.01
ΔGNRI	2.5 (± 10.7)	-9.2 (± 13)	-5.0 (± 13)	-14.8 (± 10)	< 0.01
Follow-up years	3 (0,23)	2.5 (0,19)	4 (0,15)	1.5 (0,10)	0.09
Hemoglobin (gr/dl)	10.36 (± 1.69)	9.94 (± 1.44)	10.63 (± 1.62)	10.49 (± 1.45)	0.27
Initial albumin (gr/dl)	3.81 (± 0.61)	3.70 (± 0.81)	3.99 (± 0.45)	3.90 (± 0.62)	0.25
Last albumin (gr/dl)	3.66 (± 0.50)	3.26 (± 0.72)	3.39 (± 0.67)	3.06 (± 0.60)	< 0.01
Δ Albumin (gr/dl)	-0.14 (± 0.6)	-0.43 (± 0.8)	-0.6 (± 0.8)	-0.8 (± 0.7)	< 0.01
CaXP	50.8 ± 13.8	49.7 ± 15.2	45.8 ± 15.8	47.2 ± 12.4	0.29
Initial PTH (pg/ml)	131 (4.7, 2287)	158 (19.3, 1389)	151.5 (17, 685)	219 (21, 1117)	0.10
Last PTH (pg/ml)	314 (79, 523)	227 (78, 481)	218 (105, 329)	216 (75, 400)	0.12
Sodium (mEq/l)	138.70 (± 4.01)	139.25 (± 4.68)	137.84 (± 4.83)	139.25 (± 4.17)	0.51
Initial HbA1c (%)	7.25 (± 1.27)	8.85 (± 3.04)	7.13 (± 1.60)	6.82 (± 1.22)	0.39
Last HbA1c (%)	7.87 (± 1.79)	7.38 (± 0.42)	8.13 (± 0.90)	8.18 (± 1.40)	0.87
Mortality					
Cardiovascular	53 (43.1%)	17 (38.6%)	21(63.6%)	13 (65%)	0.01
All-cause	12(9.7%)	8(18.2%)	8 (24.2%)	7 (35%)	0.03

*Values are shown as means with standard deviation, medians with interquartile ranges, or numbers with percentages

Abbreviations: (BMI:body-mass index, GN: glomerulonephritis, CAPD: continuous ambulatory peritoneal dialysis, CVS: Cardiovascular Disease PD: peritoneal dialysis, HD: hemodialysis, UF: ultrafiltration, GNRI: Geriatric nutrition index, CaxP: calcium-phosphorus product, PTH: parathormone, Hba1c: hemoglobin A1c

Table 2 Post hoc analysis of final BMI, albumin, and GNRI

Groups			***p***
Final BMI	Non-geriatric Increased BMI	Non-geriatric decreased BMI	< 0.001
		Geriatric Increased BMI	1.00
		Geriatric Decreased BMI	0.03
Final albumin	Non-geriatric Increased BMI	Non-geriatric decreased BMI	0.03
		Geriatric Increased BMI	0.16
		Geriatric Decreased BMI	0.01
GNRI final	Non-geriatric Increased BMI	Non-geriatric decreased BMI	< 0.01
		Geriatric Increased BMI	1.00
		Geriatric Decreased BMI	< 0.01

Abbreviation: BMI: body mass index

Table 3 Univariate analysis for determining the effects of various factors on mortality

	95% CI	*p*
Age	1.04 (1.01–1.07)	< 0.05
Gender	1.41 (0.79–2.53)	0.25
DM	0.75 (0.40–1.40)	0.36
HT	1.16 (0.59–2.29)	0.66
RRF	0.99 (0.99-1.00)	< 0.05
ΔBMI	0.90 (0.80-1.00)	0.05
ΔGNRI	0.99 (0.97–1.02)	0.58
ΔAlbumin	1.05 (0.73–1.48)	0.85
CVD	1.26 (0.70–2.27)	0.44
Non-geriatric increased BMI		
Non-geriatric decreased BMI	1.53 (0.69–3.39)	0.30
Geriatric increased BMI	2.00 (0.96–4.16)	0.06
Geriatric decreased BMI	3.11 (1.27–7.60)	0.01

Abbreviation: (DM: Diabetes Mellitus, HT: Hypertension, RRF: residual renal function, ΔBMI: delta body-mass index, HD: hemodialysis, GNRI: Geriatric nutrition index, CVD: cardiovascular disease, BMI: delta body-mass index

Table 4 Multivariate analysis for determining the effects of various factors on mortality

	95% CI	*p*
Age	1.03 (0.99–1.08)	0.12
DM	1.05 (0.56–1.99)	0.87
HT	1.16 (0.55–2.45)	0.68
CVD	1.77 (0.93–3.36)	0.81
ΔGNRI	1.01 (0.99–1.1.04)	0.17
RRF	0.58 (0.38–0.95)	0.03
Non-geriatric increased BMI		
Non-geriatric decreased BMI	1.68 (0.69–4.06)	0.25
Geriatric increased BMI	0.97 (0.32–2.94)	0.96
Geriatric decreased BMI	3.72 (1.02–13.36)	0.04

Abbreviation: (DM: Diabetes Mellitus, HT: Hypertension, RRF: residual renal function, HD: hemodialysis, GNRI: Geriatric nutrition index, CVD: cardiovascular disease, BMI: delta body-mass index

Figures 1 and 2 present the Kaplan-Meier survival analysis of the four study groups. The analysis revealed distinct survival outcomes of the groups based on age and BMI changes. Patients in the "geriatric decreased BMI" group exhibited the lowest survival rates, while the "non-geriatric increased BMI" group demonstrated the highest survival rates. Survival probabilities at various time points for all groups were compared using the log-rank test, which indicated statistically significant differences ($p=0.04$ for all-cause mortality and $p=0.02$ for cardiovascular mortality).

Discussion

Our study identified a decline in BMI over time is associated with increased mortality, particularly in the geriatric patient group. All PD patients, as in the geriatric population, encounter an elevated risk of frailty, sarcopenia, and protein-energy malnutrition. All three factors have been linked to heightened mortality risk in both PD patients and the geriatric age group. BMI serves as a straightforward clinical assessment that can signal protein-energy malnutrition.

Some studies suggest that geriatric individuals undergoing PD with lower body mass may experience increased mortality rates, aligning with the findings of our research. Hence, closely monitoring nutritional and metabolic parameters in this demographic is recommended [19, 20]. However, Hung et al. reported contrasting findings in their study involving the Asian population. They observed no significant difference in technical survival among PD patients aged 65 and above despite these patients having a lower BMI compared to Western populations [18]. Similarly, an Italian study comparing clinical outcomes between younger and geriatric PD patients over a 24-month period found no significant differences in survival. Based on these findings, the authors recommended using PD as a suitable intervention for the geriatric age group [20]. The data also supports our findings, indicating that the decline in BMI might be the primary factor influencing the variability in survival rates among patients in the geriatric age group, aside from age itself.

In univariate analysis age was linked to a higher risk of mortality, while RRF had a slight protective effect. When we performed multivariate analyses, the negative effect of age was no longer observed. In the multivariable analysis, a higher mortality risk was noted in the 'geriatric decreased BMI' group compared to the 'non-geriatric increased BMI' group. However, the lack of a significant rise in mortality risk within the 'geriatric increased BMI' group indicates that BMI's effect on mortality is statistically significant and independent of age.

In their meta-analysis, Liu et al. linked both low and high BMI to mortality among PD patients in the Asian population. Another study by Ramkumar et al. revealed that among overweight PD patients, those with higher muscle mass exhibited lower mortality compared to those with lower muscle mass. This implies that, in this context, muscle mass may carry greater significance than numerical weight [21, 22]. In our research, although no significant difference was noted in the initial albumin values, a significant difference emerged, particularly in the groups experiencing a decrease in BMI, when examining the last albumin values. Furthermore, a significant difference in the GNRI, another nutritional parameter, was observed in the BMI-decreased groups. Based on these observations, we deduced that the BMI-decreased groups are likely underwent a reduction in muscle mass. Aligning with existing literature, it was observed that the group facing malnutrition-induced muscle loss also exhibited higher mortality rates. Although muscle loss in PD patients has been associated with mortality, there are conflicting results regarding the increase or decrease in adipose tissue [23–26]. Therefore, we believe that the

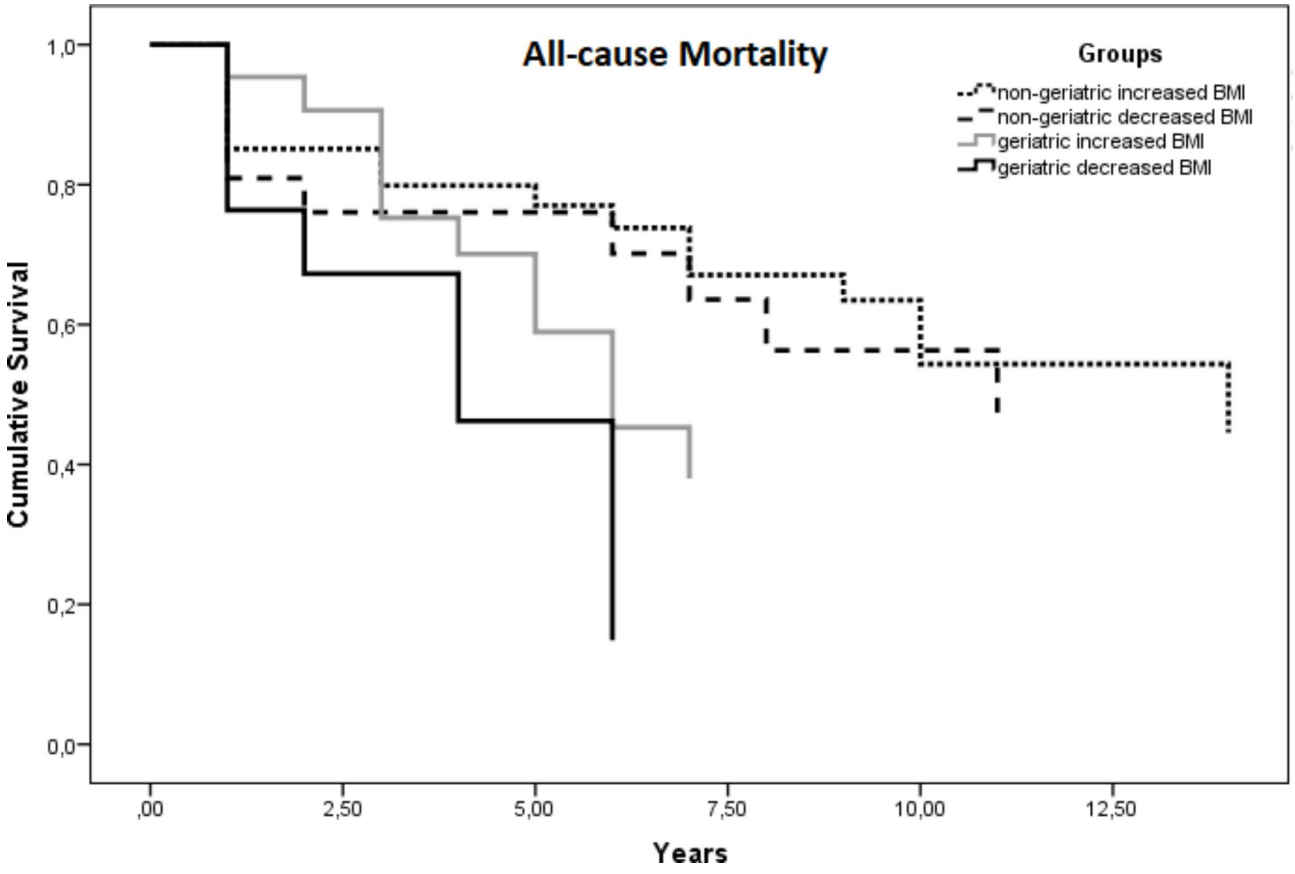

Fig. 1 Kaplan-Meier curves for all-cause mortality of the study groups

association of BMI reduction over time with mortality, regardless of the type of tissue lost, is a valuable finding and an inspiring basis for future studies.

Even though it is acknowledged that mortality tends to be elevated in patients with particular underlying renal pathologies, such as those with diabetes mellitus, our regression analysis did not reveal any substantial impact on survival for patients in the geriatric and BMI-decreased groups.

Changes in BMI among PD patients can stem from various factors. In individuals with end-stage renal disease (ESRD), irrespective of the type of RRT, a reduction in BMI may be noticeable due to managing hypervolemia, particularly in the initial stages of RRT [27]. Evaluating our patients as euvolemic, considering recorded weights, maintaining normal serum sodium levels, and the absence of differences in ultrafiltration amounts between groups help eliminate confounding factors such as hypervolemia. Furthermore, the resolution of uremia-induced cachexia and potential weight gain resulting from an increased protein content in the CKD-specific diet after initiating RRT may contribute to the observed changes in weight [28].

Reduced hemoglobin levels in patients undergoing PD have been linked to increased mortality [29, 30]. On the other hand, in the study conducted by Methora et al., it was determined that having a serum albumin level below 3 g/dL resulted in a cardiovascular mortality risk of more than three times higher [31]. In another study conducted by Na Hoa et al., it was discovered that PD patients with higher albumin levels exhibited lower five-year mortality rates [32]. Since the initial hemoglobin values were not different among the groups and albumin values consistently remained above 3 g/dL throughout the study period, we believe these confounding factors have minimal impact on the observed results regarding the survival of the groups.

In the study conducted by Georginos et al., it was observed that increased systolic blood pressure was positively correlated with both morbidity and mortality. In contrast, no association was identified with diastolic blood pressure [33]. Another study determined that mortality rates rise when systolic blood pressure falls below 110 mmHg. The International Society for Peritoneal Dialysis (ISPD) recommends maintaining blood pressure below 140/90 for PD patients, with the safe lower limit for systolic blood pressure defined as 120 mmHg [34]. Diastolic blood pressure has not consistently been associated with mortality in the existing literature. Our study showed no significant difference among the groups

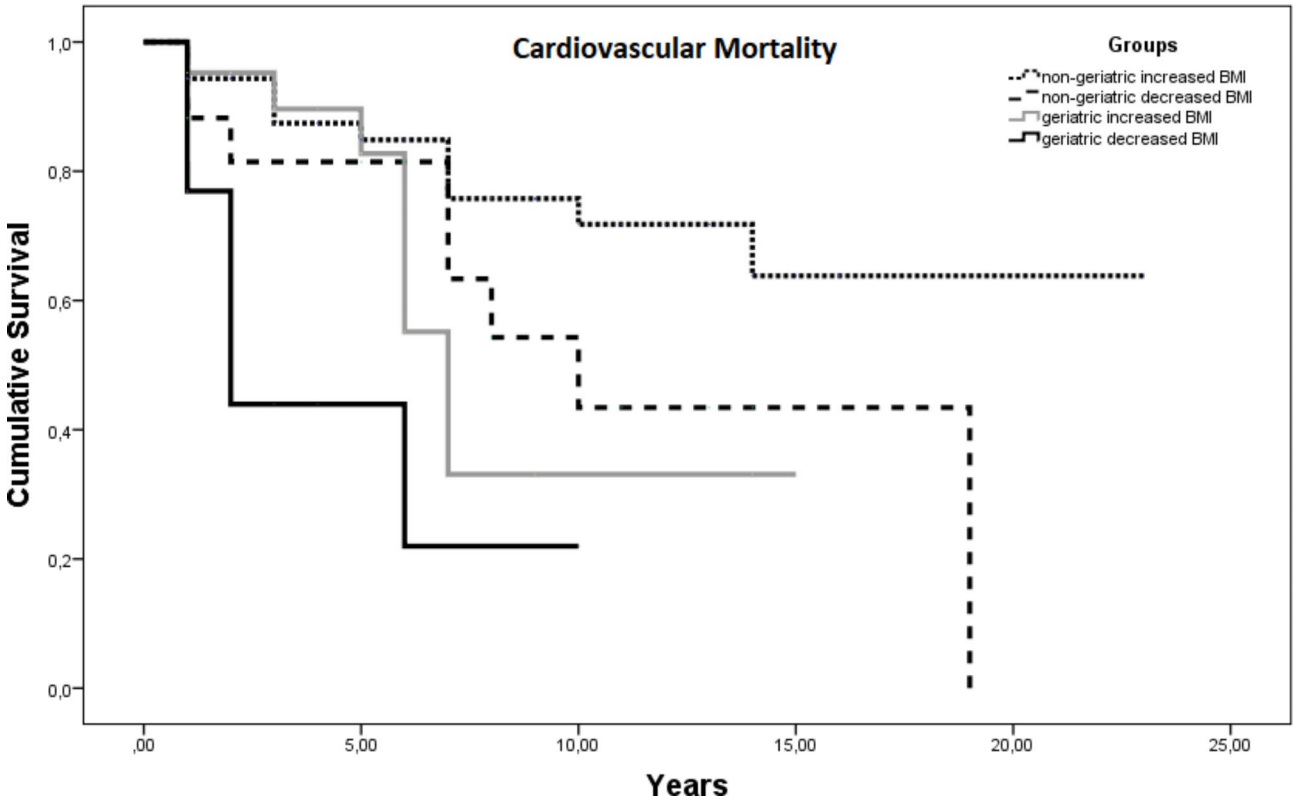

Fig. 2 Kaplan-Meier curves for cardiovascular mortality of the study groups

regarding blood pressure measurements, suggesting that blood pressure may not significantly influence the outcomes observed.

Our survival analysis highlights the interplay between age and BMI changes, with decreased BMI, particularly in geriatric patients, associated with higher mortality risk. These findings align with the broader regression analyses, emphasizing the importance of monitoring BMI as a dynamic and clinically significant parameter in PD patients and the need for careful nutritional and metabolic monitoring, especially among geriatric individuals.

Our study stands as the first in the literature to demonstrate elevated mortality, specifically in the geriatric population and among patients experiencing a decrease in BMI after PD initiation, in contrast to the other study groups. The strengths of our study are the large study cohort and groups comperable basline values, such as baseline BMI, albümin, or GNRI. The absence of anthropometric measurements and body fat-water ratios poses limitations inherent in its retrospective design. Consequently, there is a pressing need for further randomized controlled trials to delve deeper into this specific topic.

Conclusion

Although BMI is easy and extensively measured, it is not considered the perfect monitoring parameter for dialysis patients. However, regular follow-up of BMI, especially in geriatric cases, can be a guiding tool for estimating patients' mortality risks. Despite the study's retrospective design, the results are consistent with existing literature, affirming the correlation between malnutrition and mortality. Additionally, for the geriatric population, PD seems to be a viable treatment option; however, the observed decrease in BMI over time emphasizes the importance of vigilant monitoring and observation in clinical practice.

Abbreviations

(BMI	Body-mass index
GN	Glomerulonephritis
CAPD	Continuous ambulatory peritoneal dialysis
CVS	Cardiovascular Disease PD: peritoneal dialysis
HD	Hemodialysis
UF	Ultrafiltration
GNRI	Geriatric nutrition index
CaxP	Calcium-phosphorus product
PTH	Parathormone
Hba1c	Hemoglobin A1c

Author contributions

YDB and BK collected and analyzed the data. MAO helped drafting manuscript and data collection. CC and SMD made literature research and reviewed the final manuscript. All authors approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The Dokuz Eylul University Institutional Review Board approved the study protocol. Due to its retrospective nature, participant consent was not required.

Consent for publication
Not Applicable.

Competing interests
The authors declare no competing interests.

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References

1. Zhang QL, Rothenbacher D. Prevalence of chronic kidney disease in population-based studies: systematic review. BMC Public Health. 2008;8:117.
2. Chung SH, Han DC, Noh H, Jeon JS, Kwon SH, Lindholm B, et al. Risk factors for mortality in diabetic peritoneal dialysis patients. Nephrol Dial Transpl. 2010;25(11):3742–8.
3. Foley RN, Murray AM, Li S, Herzog CA, McBean AM, Eggers PW, et al. Chronic kidney disease and the risk for cardiovascular disease, renal replacement, and death in the United States Medicare population, 1998 to 1999. J Am Soc Nephrol. 2005;16(2):489–95.
4. U.S. Renal Data System. Researcher's guide to the USRDS database. Bethesda M. National Institutes of Health, National Institute of diabetes and digestive and kidney diseases; 2015.
5. Brown EA, Johansson L. Epidemiology and management of end-stage renal disease in the elderly. Nat Rev Nephrol. 2011;7(10):591–8.
6. Amaral TLM, Amaral CA, Vasconcellos MTL, Monteiro GTR. Prevalence and factors associated to chronic kidney disease in older adults. Rev Saude Publica. 2019;53:44.
7. Fenton SS, Desmeules M, Jeffery JR, Corman JL. Dialysis therapy among elderly patients; data from the Canadian organ replacement Register, 1981–1991. Adv Perit Dial. 1993;9:124–9.
8. Harris SA, Lamping DL, Brown EA, Constantinovici N, North Thames Dialysis Study G. Clinical outcomes and quality of life in elderly patients on peritoneal dialysis versus hemodialysis. Perit Dial Int. 2002;22(4):463–70.
9. Griva K, Kang AW, Yu ZL, Mooppil NK, Foo M, Chan CM, et al. Quality of life and emotional distress between patients on peritoneal dialysis versus community-based hemodialysis. Qual Life Res. 2014;23(1):57–66.
10. Otowa T, Sakurada T, Nagasawa M, Shimizu S, Yokoyama T, Kaneshiro N, et al. Clinical outcomes in elderly (more than 80 years of age) peritoneal dialysis patients: five years' experience at two centers. Adv Perit Dial. 2013;29:43–5.
11. Brown EA. Should older patients be offered peritoneal dialysis? Perit Dial Int. 2008;28(5):444–8.
12. Brown EA, Finkelstein FO, Iyasere OU, Kliger AS. Peritoneal or hemodialysis for the frail elderly patient, the choice of 2 evils? Kidney Int. 2017;91(2):294–303.
13. Ikizler TA, Cano NJ, Franch H, Fouque D, Himmelfarb J, Kalantar-Zadeh K, et al. Prevention and treatment of protein energy wasting in chronic kidney disease patients: a consensus statement by the International Society of Renal Nutrition and Metabolism. Kidney Int. 2013;84(6):1096–107.
14. Larsson L, Degens H, Li M, Salviati L, Lee YI, Thompson W, et al. Sarcopenia: aging-related loss of muscle Mass and function. Physiol Rev. 2019;99(1):427–511.
15. Yamada K, Furuya R, Takita T, Maruyama Y, Yamaguchi Y, Ohkawa S, et al. Simplified nutritional screening tools for patients on maintenance hemodialysis. Am J Clin Nutr. 2008;87(1):106–13.
16. Bouillanne O, Morineau G, Dupont C, Coulombel I, Vincent JP, Nicolis I, et al. Geriatric nutritional risk index: a new index for evaluating at-risk elderly medical patients. Am J Clin Nutr. 2005;82(4):777–83.
17. Genestier S, Meyer N, Chantrel F, Alenabi F, Brignon P, Maaz M, et al. Prognostic survival factors in elderly renal failure patients treated with peritoneal dialysis: a nine-year retrospective study. Perit Dial Int. 2010;30(2):218–26.
18. Hung CC, Chang CT, Lee CC, Chen KH, Yu CC, Wu CH, et al. Prognostic predictors of technique and patient survival in elderly southeast Asian patients undergoing continuous ambulatory peritoneal dialysis. Int J Clin Pract. 2009;63(2):254–60.
19. Wu H, Ye H, Huang R, Yi C, Wu J, Yu X, et al. Incidence and risk factors of peritoneal dialysis-related peritonitis in elderly patients: a retrospective clinical study. Perit Dial Int. 2020;40(1):26–33.
20. Lai S, Amabile MI, Bargagli MB, Musto TG, Martinez A, Testorio M, et al. Peritoneal dialysis in older adults: evaluation of clinical, nutritional, metabolic outcomes, and quality of life. Med (Baltim). 2018;97(35):e11953.
21. Ramkumar N, Pappas LM, Beddhu S. Effect of body size and body composition on survival in peritoneal dialysis patients. Perit Dial Int. 2005;25(5):461–9.
22. Liu J, Zeng X, Hong HG, Li Y, Fu P. The association between body mass index and mortality among Asian peritoneal dialysis patients: a meta-analysis. PLoS ONE. 2017;12(2):e0172369.
23. Beaudart C, Zaaria M, Pasleau F, Reginster JY, Bruyere O. Health outcomes of Sarcopenia: a systematic review and Meta-analysis. PLoS ONE. 2017;12(1):e0169548.
24. Jager KJ, Merkus MP, Huisman RM, Boeschoten EW, Dekker FW, Korevaar JC, et al. Nutritional status over time in hemodialysis and peritoneal dialysis. J Am Soc Nephrol. 2001;12(6):1272–9.
25. Fernandes NM, Bastos MG, Franco MR, Chaoubah A, Lima Mda G, Divino-Filho JC, et al. Body size and longitudinal body weight changes do not increase mortality in incident peritoneal dialysis patients of the Brazilian peritoneal dialysis multicenter study. Clin (Sao Paulo). 2013;68(1):51–8.
26. Castro ACM, Bazanelli AP, Nerbass FB, Cuppari L, Kamimura MA. Waist circumference as a predictor of mortality in peritoneal dialysis patients: a follow-up study of 48 months. Br J Nutr. 2017;117(9):1299–303.
27. Tangvoraphonkchai K, Davenport A. Changes in body composition following haemodialysis as assessed by bioimpedance spectroscopy. Eur J Clin Nutr. 2017;71(2):169–72.
28. Davenport A. Weight loss and weight gains in patients starting peritoneal dialysis; the effect of peritonitis. Nephrol (Carlton). 2023;28(7):372–8.
29. Foley RN, Parfrey PS, Harnett JD, Kent GM, Murray DC, Barre PE. The impact of anemia on cardiomyopathy, morbidity, and and mortality in end-stage renal disease. Am J Kidney Dis. 1996;28(1):53–61.
30. Molnar MZ, Mehrotra R, Duong U, Kovesdy CP, Kalantar-Zadeh K. Association of hemoglobin and survival in peritoneal dialysis patients. Clin J Am Soc Nephrol. 2011;6(8):1973–81.
31. Mehrotra R, Duong U, Jiwakanon S, Kovesdy CP, Moran J, Kopple JD, et al. Serum albumin as a predictor of mortality in peritoneal dialysis: comparisons with hemodialysis. Am J Kidney Dis. 2011;58(3):418–28.
32. Hao N, Cheng BC, Yang HT, Wu CH, Lei YY, Chao MC, et al. Time-varying serum albumin levels and all-cause mortality in prevalent peritoneal dialysis patients: a 5-year observational study. BMC Nephrol. 2019;20(1):254.
33. Georgianos PI, Vaios V, Zebekakis PE, Liakopoulos V. The relation of Clinic and ambulatory BP with the risk of Cardiovascular events and all-cause mortality among patients on peritoneal Dialysis. J Clin Med. 2021;10(11).
34. Wang AY, Brimble KS, Brunier G, Holt SG, Jha V, Johnson DW, et al. ISPD Cardiovascular and Metabolic guidelines in Adult Peritoneal Dialysis patients Part I - Assessment and Management of various Cardiovascular Risk factors. Perit Dial Int. 2015;35(4):379–87.

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