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Risk Factors Associated with All-Cause Death Among Dialysis Patients with Diabetes

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Background: Patients receiving dialysis who also have diabetes mellitus have high mortality. This study aimed to investigate the risk factors associated with all-cause death among Polish patients with diabetes receiving dialysis.

Material/Methods: This prospective observational study included 100 patients with type 1 or type 2 diabetes who were treated with peritoneal dialysis or hemodialysis. Blood laboratory tests, the occurrence of diabetes complications, and comorbidity, using the Charlson Comorbidity Index, were estimated. Survival analysis was performed using the multivariate Cox proportional hazard model, and Kaplan-Meyer survival analyses with log-rank tests were performed to show differences between groups.

Results: During 16.0±5.0 months, 23 patients died. The deceased group had significantly higher levels of HbA1c (P=0.046) and fructosamine (P=0.011) than the surviving group. The deceased patients also had higher comorbidity scores (P=0.013). In the stepwise multivariate Cox proportional hazard regression model, history of stroke or transient ischemic attack was an independent risk factor of all-cause death (hazard ratio [HR] 3.15, 95% CI 1.34-7.39; P=0.009), while regular physical activity significantly reduced the risk of all-cause death (HR 0.26, 95% CI 0.08-0.87; P=0.029).

Conclusions: Deceased patients had higher HbA1c and fructosamine levels and higher comorbidity. However, history of stroke or transient ischemic attack was an independent risk factor of all-cause death, while regular physical activity was associated with the reduction of the risk of all-cause death in patients with type 1 and type 2 diabetes treated with peritoneal dialysis or hemodialysis. Regular physical activity should be recommended to improve survival in this population.

Keywords: Diabetes Mellitus • Mortality • Motor Activity • Stroke • Renal Dialysis

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Background

Diabetes mellitus is a primary cause of end-stage renal disease (ESRD) [1,2]. According to the European Renal Association-European Dialysis and Transplant Association (ERA-EDTA) Registry from 2016, which included 36 countries, the incidence of renal replacement therapy (RRT) was 121 per million people. Almost two-thirds of patients were men, over one-half were ≥65 years old, and in nearly one-fourth of cases, diabetes was the main cause of kidney failure. At the end of 2016, the RRT prevalence in these countries was 823 per million people. For all patients initiating RRT from 2007 to 2011, the 5-year survival probability was 50.5% [3]. Among the dialysis population, patients with diabetes represent the group where the highest mortality rates are observed [4], with the 5-year mortality rate in this population exceeding 70% [5]. Cardiovascular diseases are the main cause of death in patients receiving dialysis, and they occur twice as often in patients with diabetes [4]. The second most frequent cause of death are infectious complications, which are more than twice as common in this same population [5]. A recent systematic review and meta-analysis assessing risk factors of mortality among patients undergoing hemodialysis (HD) revealed that increased age, previous cardiovascular disease, and higher C-reactive protein (CRP), HbA1c, adiponectin, ferritin, troponin T, and brain natriuretic peptide levels were associated with increased risk of all-cause mortality, while a higher body mass index (BMI) and higher hemoglobin, albumin, total iron-binding capacity, serum iron, and apolipoprotein A2 and A3 levels were associated with a reduced risk of all-cause mortality [6]. Independent predictors of mortality among patients receiving peritoneal dialysis (PD) with diabetes were older age, female sex, previous cardiovascular disease, protein-energy wasting, and low renal residual function [7]. In a small Polish study, independent risk factors of all-cause mortality among patients with diabetes on PD were hypoalbuminemia and older age, while low serum albumin level and low cholesterol concentration were independent risk factors of all-cause mortality in patients with diabetes on HD [8]. According to the meta-analysis of 17 cohort studies, including 441 842 patients on HD and 62 462 patients on PD, patients with diabetes and ESRD in the HD group had a significantly lower mortality risk than did patients with diabetes and ESRD in the PD group [9]. Transient ischemic attack (TIA) and stroke are serious vascular events. Chinese patients with diabetes and a history of stroke who were treated with PD had shorter survival than did those treated with HD, while the mortality rate was similar between patients receiving PD and HD treatment with a history of stroke but not diabetes [10].

In the general population, regular physical activity is an important element of a healthy lifestyle, reducing the risk of cardiovascular disease and thus contributing to improved survival. However, there is little data on the effect of physical activity on mortality in the dialysis population. One study demonstrated that low physical activity was associated with higher mortality in patients on dialysis [11]. In another study that included patients on HD, very active aerobic exercise significantly reduced the risk of death [12]. There are no studies including the impact of lifestyle on mortality among patients who are on dialysis treatment and have diabetes.

The study aimed to investigate the risk factors, including lifestyle, associated with all-cause death in patients with type 1 and type 2 diabetes and ESRD who were on HD or PD.

Material and Methods

Ethics Approval and Consent to Participate

This work was conducted according to the principles of the Declaration of Helsinki. The study is a part of the project that was approved by the Bioethics Committee at the Military Institute of Medicine (resolution No. 29/WIM/2017). All patients gave their written informed consent to participate in the study.

Eligibility Criteria

Inclusion criteria were age ≥18 years, ESRD during HD or PD, duration of RRT ≥3 months, and type 1 or type 2 diabetes for ≥3 months. Three months of RRT or diabetes before inclusion to the study was used arbitrarily to eliminate bias from increased mortality in patients initiating HD and to allow for the stabilization of laboratory test results after initiation of RRT or diabetes treatment. This time also allowed patients to adjust their lifestyle to the limitations related to the diseases and their treatment.

Exclusion criteria were a patient's lack of consent to participate in the study, other types of diabetes, severe verbal or cognitive disorders that did not allow for the collection of a medical interview.

Study Population

We initially intended to assess mortality in a group consisting of 4 equally sized subgroups of patients (all n ≥20) with type 1 or type 2 diabetes and different types of RRT (PD or HD). Thus, we qualified all patients with diabetes treated in the 2 largest dialysis centers in central Poland who met the inclusion and exclusion criteria. Because of a significant disproportion of patients in the groups, we searched for patients with type 1 diabetes in other minor dialysis centers. However, up until the recruitment deadline, only 7 patients with type 1 diabetes and HD were eligible for inclusion in the study (**Figure 1**).

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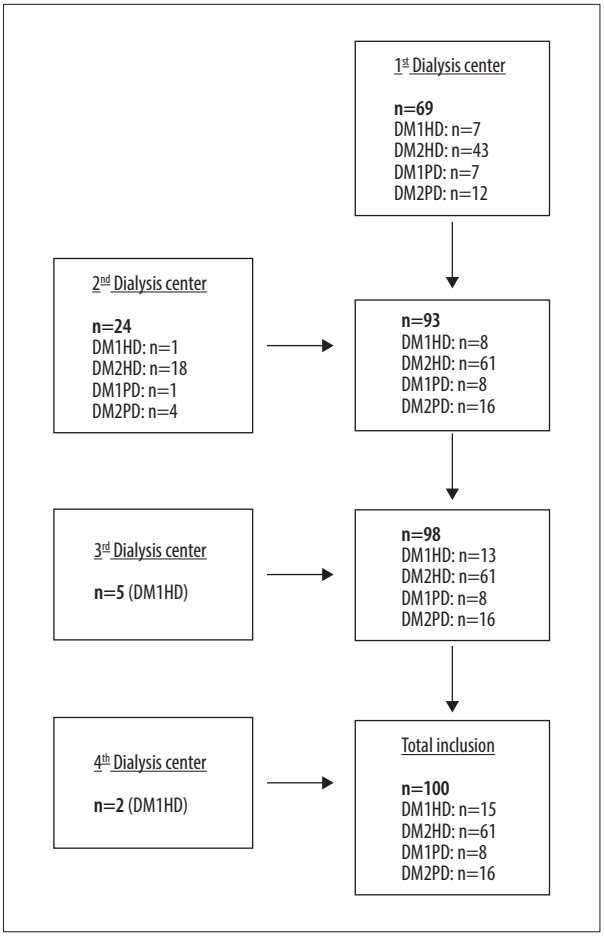

Figure 1. Patients' inclusion data. DM1 – type 1 diabetes mellitus; DM2 – type 2 diabetes mellitus; HD – hemodialysis; PD – peritoneal dialysis.

Patients with diabetes were identified based on the analysis of the medical records from the dialysis centers. The presence of diabetes micro- and macroangiopathic complications and all comorbidities were assessed by medical record analysis and an interview. Patients were asked about their duration of diabetes, residual diuresis, and lifestyle factors including regular physical activity and cardiovascular risk factors like smoking.

Study Measurements

Comorbidity was assessed using the Charlson Comorbidity Index (CCI) [13], and cognitive condition was tested with Mini-Mental State Examination [14].

Patients' weight and height were obtained on scales with a height measuring device. Waist and hip circumference were measured according to the World Health Organization recommendations, using a stretch-resistant tape. The waist was measured at the midpoint between the lower margin of the last rib and the top of the iliac crest in the mid axillary line. Hip circumference was measured around the widest part of the buttocks [15]. These measurements were obtained before HD or at the control visit for patients receiving PD. The waist-to-hip ratio (WHR) was calculated according to the following formula: WHR=waist circumference/hip circumference. The BMI was calculated according to the following formula: BMI=body weight (kg)/height^2 (m).

Systolic and diastolic blood pressure, as well as pulse rate, were measured with an oscillometric blood pressure device on the arm at the beginning of HD or at the control visit for patients receiving PD. Heart rate was estimated from the measured pulse rate.

Laboratory tests were performed in the Department of Laboratory Diagnostics at the Military Institute of Medicine. Blood samples were drawn at the beginning of HD or at the control visit for patients receiving PD. Blood HbA1c levels were obtained by the turbidimetric inhibition immunoassay; serum fructosamine, total protein, and albumin were assessed by the colorimetric method; total cholesterol, high-density lipoprotein, low-density lipoprotein, and triglycerides were obtained with enzymatic colorimetric reactions; and serum CRP was determined using the immunoturbidimetric method; all tests were performed using a Cobas c 501 analyzer (Roche Diagnostics). Blood hemoglobin concentration was assessed by an automated hematology analyzer SYSMEX XN-1000.

The duration of the study was limited by the framework of the project. Patients were recruited from June 1, 2018 to April 30, 2019. From the first evaluation, patients were followed for hospitalizations and mortality to the end of May 2020. The causes of death were collected from hospital discharge summary reports along with diagnoses and data from dialysis center archive records.

Statistical Analysis

Statistical tests were performed using Statistica 12 software (StatSoft, Cracow, Poland). The normal distribution of the variables was checked by the Shapiro-Wilk test. In assessing the differences between the study groups, the *t* test was used if the normal distribution criterion was met. Otherwise, the Mann-Whitney U test for quantitative non-parametric variables or chi-squared test for qualitative data was performed. For qualitative observations with sample sizes <5, the Fisher's exact test was used. Survival analysis included factors that differed between study groups (trend or significant difference), and was performed using the stepwise multivariable Cox proportional hazard model. A P level <0.05 was set for adding a variable to the model, and $P \geq 0.15$ for removing a variable from the model. Kaplan-Meyer survival analyses with log-rank tests were performed to show differences between groups. The level of

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statistical significance was 2-sided $P<0.05$. The results were presented as mean values with standard deviation in parametric variables, median with interquartile range (IQR) in non-parametric variables, and percentages.

Results

One hundred patients were included in this prospective observational study. The homogeneity of the study participants resulted from the homogeneity of the local Polish population. Patients were recruited from June 1, 2018 to April 30, 2019, and observation for mortality continued until May 31, 2020, for a total of 16.0±5.0 months.

Study participants' mean age was 64.0±13.3 years, the mean diabetes duration was 22.4±11.3 years, and patients were undergoing RRT for median (IQR) 24.5 (36.0) months. During the observation period, 23 patients died (23%) in the following groups: diabetes type 1 5/23 (21.74%), diabetes type 2 18/77 (23.38%), HD 17/59 (22.37%), and PD 6/24 (25%), with no statistically significant differences between groups. After dividing into subgroups and taking into account the modality of RRT and type of diabetes, the mortality also did not differ significantly: diabetes type 1 and HD in 3/15 (20%) patients, diabetes type 2 and HD in 14/61 (23%) patients, diabetes type 1 and PD in 2/8 (25%) patients, and diabetes type 2 and PD in 4/16 (25%) patients.

In the studied cohort, the leading causes of death in 9/23 patients (39.13%) were concomitant cardiovascular and infectious complications. In 7/23 patients (30.43%), cardiovascular diseases were the only cause of death, and in 6/23 patients (26.09%), infectious complications were the main cause of death. One person (4.35%) died due to respiratory failure. The characteristics of the study participants divided into deceased and surviving groups are shown in **Table 1**.

The deceased group had significantly higher HbA1c and fructosamine levels than did the surviving group. The deceased patients also had significantly higher comorbidity, as determined by the CCI score, with a substantially lower estimated 10-year survival rate and more hospitalizations during observation. Further, significantly more patients from the deceased group had a history of stroke or TIA.

In the stepwise multivariate Cox proportional hazard regression model, which included duration of chronic kidney disease, duration of tobacco smoking, number of hospitalizations, HbA1c, fructosamine, stroke or TIA, and physical activity, only stroke or TIA and regular physical activity were independent factors significantly affecting survival. Although CCI scores differed significantly between groups, they were excluded from the Cox regression model because of significant collinearity with other included variables. History of stroke or TIA was a statistically significant predictor of all-cause death (hazard ratio [HR] 3.15, 95% confidence interval [CI] 1.34-7.39; $P=0.009$), while regular physical activity reduced risk of all-cause death (HR 0.26, 95% CI 0.08-0.87; $P=0.029$). Survival probability data, dependent on the history of stroke or TIA (**Table 2**) and regular physical activity (**Table 3**), are presented in the form of Kaplan-Meier curves in **Figures 2 and 3**, respectively. The log-rank test showed significantly worse survival of patients with a history of stroke or TIA compared with those without this diagnosis ($P=0.016$) and better survival of patients undertaking regular physical activity compared with those with no physical activity ($P=0.029$).

Discussion

In our study, the history of stroke or TIA was an independent risk factor of all-cause death (HR 3.15, 95% CI 1.34-7.39; $P=0.009$). Wang et al also evaluated the impact of prior stroke on survival in patients on a long-term PD or HD program. They found that, in patients with diabetes and stroke history, those on PD had worse survival than those on HD (adjusted HR 1.22, 95% CI 1.05-1.43), particularly women (adjusted HR 1.55, 95% CI 1.25-1.91) [10].

Regular physical activity as a part of a healthy lifestyle contributes to improving prognosis by reducing cardiovascular risk [16]. Lack of physical activity leads to sarcopenia, which increases the risk of death [17]. In our present study, undertaking regular physical activity significantly reduced the risk of death (HR 0.26, 95% CI 0.08-0.87; $P=0.029$). Persons who exercise regularly may also have a better general condition. Lopes et al, in their study involving 5763 patients undergoing HD, demonstrated that aerobic activity is inversely associated with mortality (adjusted HR of death for very active vs never/rarely active was 0.60, 95% CI 0.47-0.77). Similar associations were observed, regardless of diabetes status [12].

In a US study including 1554 patients beginning HD or PD, of which 56% had diabetes, the association between physical activity scores and mortality was linear. Patients with the lowest physical activity level had a higher risk of death than those with average physical activity or physical activity above an average HR of 3.5 (95% CI 2.54-4.89) [11].

HbA1c is the recommended marker of long-term glycemic control. Although a higher level of HbA1c is associated with poor outcome, its optimal level in diabetic patients with ESRD is unknown [18]. Serum fructosamine is also a good indicator of glycemic control in patients on HD and PD [19,20], as well as a significant predictor of hospitalization and infection in

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Table 1. Characteristics of study participants.

	Deceased (n=23)	Surviving (n =77)	P value
Sex (Male/Female)	15 (65.3%)/8 (34.7%)	59 (76.6%)/18 (23.4%)	0.980**
Age (years)	66.8±10.3	65.0 (15.0)	0.320*
Type of RRT (HD/PD)	17 (73.9%)/6 (26.1%)	59 (76.6%)/18 (23.4%)	0.789**
Type of diabetes (type1/type2)	5 (21.7%)/18 (78.3%)	12 (15.6%)/6 (84.4%)	0.870**
Number of hospitalizations	1.0 (2.0)	0.0 (1.0)	**<0.001***
Insulin therapy	22 (95.7%)	90 (90.9%)	0.462**
Duration of diabetes (years)	25.9±12.9	20.0±15.0	0.136*
Duration of CKD (years)	8.0 (5.0)	5.0 (7.0)	0.078*
Duration of RRT (months)	34.0±21.5	22.0 (38.5)	0.282*
Body mass index (kg/m^2)	29.0 (7.0)	29.3 (8.1)	0.928*
Waist circumference (cm)	107.5±14.7	106.0 (21.0)	0.844*
Hip circumference (cm)	101.0 (16.0)	102.0 (11.0)	0.491*
Waist/hip ratio	1.02±0.09	1.03±0.11	0.485
Systolic blood pressure (mmHg)	142.3±22.3	142.3±18.3	0.990
Diastolic blood pressure (mmHg)	74.8±13.4	75.7±15.2	0.775
Heart rate (beats/min)	70.3±13.0	73.2±9.2	0.229
Residual diuresis (mL/24h)	807.0±600.0	800.0 (1000.0)	0.597*
Serum albumin (g/dL)	3.80±0.38	3.80 (0.50)	0.870*
Serum total protein (g/dL)	6.60±0.70	6.60 (0.60)	0.830*
HbA1c (%)	7.38±1.53	6.50 (1.40)	**0.046***
Hgb (g/dL)	10.98±1.50	10.98±1.27	0.995
Fructosamine (µmol/L)	373.3±79.6	321.0 (89.0)	**0.011***
C-reactive protein (mg/dL)	0.6 (1.4)	0.4 (0.8)	0.951*
Total cholesterol (mg/dL)	166.3±55.2	144.0 (49.0)	0.237*
Triglycerides (mg/dL)	145.0 (110.0)	134.0 (105.0)	0.664*
HDL (mg/dL)	39.0 (14.0)	43.0 (15.0)	0.285*
LDL (mg/dL)	102.9±49.1	83.0 (37.0)	0.312*
Diabetic retinopathy	16 (69.57%)	49 (63.64%)	0.600**
Diabetic nephrtopathy	21 (91.30%)	65 (84.45%)	0.403**
Diabetic neuropathy	16 (69.56%)	48 (62.34%)	0.526**
Coronary artery disease or MI	14 (60.87%)	42 (54.55%)	0.592**
Stroke or TIA	9 (39.13%)	13 (16.88%)	**0.024****
Diabetic foot syndrome	8 (34.78%)	23 (29.87%)	0.655**
Amputation	3 (13.04%)	12 (15.58%)	1.000#

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Table 1 continued. Characteristics of study participants.

	Deceased (n=23)	Surviving (n =77)	P value
Regular physical activity	4 (17.39%)	30 (39.47%)	**0.078#**
Tobacco smoking currently	4 (17.39%)	7 (9.09%)	0.271#
Tobacco smoking in the past	17 (73.91%)	48 (62.33%)	0.369**
Duration of tobacco smoking (years)	26.0 (33.0)	10.0 (30.0)	**0.088***
Charlson Comorbidity Index (points)	9.0±1.8	8.0 (3.0)	**0.013***
Charlson Comorbidity Index (%)	0.0 (0.0)	0.0 (2.0)	**0.011***
Mini-Mental State Examination (points)	28.0 (3.0)	27.0 (3.0)	0.862*

CKD – chronic kidney disease; HD – hemodialysis; Hgb – hemoglobin; HDL – high-density lipoprotein; LDL – low-density lipoprotein; MI – myocardial infarction; PD – peritoneal dialysis; TIA – transient ischemic attack; RRT – renal replacement therapy. * Mann-Witney U test; ** Chi-squared test; # Fisher's exact test. The results were presented as mean values with standard deviation (±SD) in parametric variables, median with interquartile range (IQR) in non-parametric variables, and percentages.

Table 2. Cumulative survival of patients without and with stroke/TIA.

Time (months)	Number of patients at risk		Cumulative survival (%)	
	Without stroke/TIA	With stroke/TIA	Without stroke/TIA	With stroke/TIA
0.8	78	22	100.0	100.0
3.3	78	20	100.0	90.9
5.8	77	19	98.7	86.4
8.3	76	18	97.4	81.8
10.8	73	17	93.6	77.3
13.3	51	10	90.6	71.8
15.8	43	9	83.2	71.8
18.3	35	7	79.1	55.8
20.8	10	2	75.6	44.6
23.3	1	0	75.6	44.6

TIA – transient ischemic attack.

patients with diabetes on HD [19]. Fructosamine is also connected with an increased risk of cardiovascular and all-cause mortality, first cardiovascular disease event, and first sepsis hospitalization in HD [5].

According to the results of our study, worse diabetes control, expressed by higher levels of HbA1c (7.38±1.53% vs 6.72±1.47%; *P*=0.046) and fructosamine (373.3±79.6 µmol/L vs 333.1±86.5 µmol/L; *P*=0.011), occurred in the deceased group. HbA1c values in groups with a worse and better outcome in our study were similar to those described in a US cohort study involving 16 387 diabetic patients who started HD treatment from 2006 to 2008 and survived for > 90 days. In that study, higher HbA1c level (7.5-8.5% and >8.5%) was significantly (*P*=0.01) associated with higher rates of cardiovascular mortality (16%, 95% CI 2-32% and 18%, 95% CI 1-37%, respectively) and nonfatal myocardial infarction (MI) (16%, 95% CI 1-33% and 15%, 95% CI 1-32%, respectively), but not with stroke, peripheral arterial disease, or all-cause mortality, compared with the reference group (HbA1c <6.5%) [21]. In a large 6-year US study, which included 54 757 patients on HD, HbA1c levels <6% and >8% were associated with increased mortality [22]. In a Japanese study including 114 HD patients with diabetes, according to the results of multivariate Cox analysis, there was a higher risk of death in patients with HbA1c ≥8.0% (HR 2.89, 95% CI 1.54-5.43; *P*=0.010) and those with HbA1c 6.5% to 8.0% (HR 1.26, 95% CI 1.08-1.47; *P*=0.003) than in patients with HbA1c levels <6.5% [23]. In a large group of 2798 diabetic patients on PD, increased levels of HbA1c were associated with significantly higher mortality. Compared with the reference group

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Table 3. Cumulative survival of patients with and without physical activity.

Time (months)	Number of patients at risk		Cumulative survival (%)	
	Active PA	Absent PA	Active PA	Absent PA
0.8	34	65	100.0	100.0
3.3	34	63	100.0	96.9
5.8	33	62	97.1	95.4
8.3	33	60	97.1	92.3
10.8	31	58	91.2	89.2
13.3	23	38	91.2	83.8
15.8	22	30	91.2	74.5
18.3	20	22	86.9	66.4
20.8	4	8	86.9	58.1
23.3	0	1	86.9	58.1

PA – physical activity.

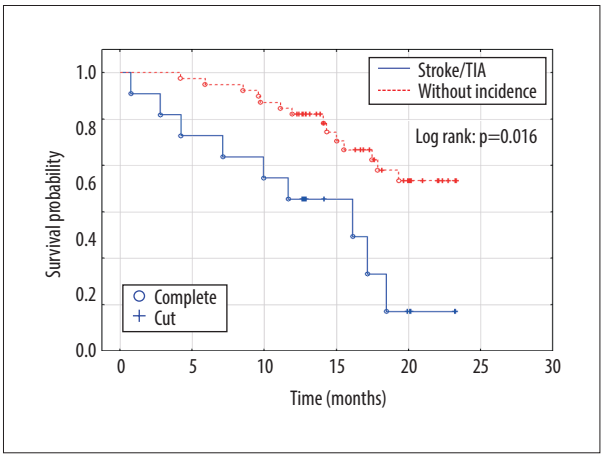

Figure 2. Kaplan-Meier survival function. The difference in mortality between patients with diabetes and end-stage renal disease according to history of stroke or transient ischemic attack.

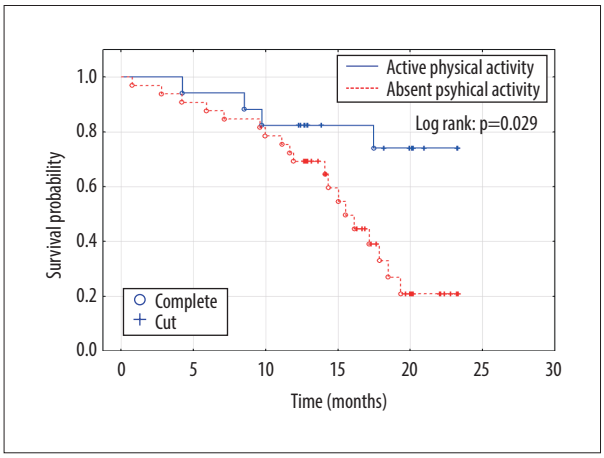

Figure 3. Kaplan-Meier survival function. The difference in mortality between patients with diabetes and end-stage renal disease according to regular physical activity.

(HbA1c 6.0-6.9%), patients with HbA1c >10% had an adjusted risk ratio of all-cause death of 1.48 (95% CI 1.18-1.86; *P*<0.05).

Patients from our study with diabetes and ESRD had a very high cardiovascular risk due only to having these diseases, based on the SCORE scale, which was developed for the Polish population [24]. In the present study, deceased patients had a trend of longer tobacco smoking history (26 (33) vs 10 (30) years; *P*=0.088). They were also older and had higher total cholesterol and low-density lipoprotein levels, but with no statistically significant difference between the groups. The systolic and diastolic blood pressure were almost the same in both groups, with systolic blood pressure above recommended values. Although coronary artery disease and MI are known risk factors of all-cause death in the dialysis population, as well as the type of RRT (according to some studies), in the present research, the deceased and surviving groups did not differ in these parameters. For this reason, they were not included in the survival analysis. However, other variables, which are more important in survival analysis, could have partially represented or even masked the influence of these common risk factors of all-cause death in the present study. We found significantly more hospitalizations in the PD group than in the HD group (2.0 (2.0) vs 0.0 (1.0); *P*<0.001), and the number of hospitalizations was higher in the deceased group (**Table 1**). Moreover, patients with coronary artery disease and MI had significantly lower HbA1c concentrations than those without (6.52±1.28 vs 7.32±1.66%, respectively; *P*=0.008), and HbA1c concentration was higher in the deceased group than in the surviving group (**Table 1**).

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Patients with cardiovascular diseases, ESRD, and diabetes have higher mortality rates. However, the coexistence of diabetes and ESRD increases the risk of cardiovascular disease. Chang et al investigated the influence of ESRD and diabetes on the risk of cardiovascular events, including congestive heart failure, acute MI, and stroke. Their study included 648 851 patients without ESRD and 71 397 patients with ESRD, of which 53 342 and 34 754, respectively, had diabetes. Participants were followed up from 1998 to 2009, and the study demonstrated that in comparison with people without ESRD or diabetes, concomitant diabetes and ESRD had a synergistic effect for acute MI and stroke (HR 5.24, 95% CI 4.83-5.68; *P*<0.0001 and HR 2.43, 95% CI 2.32-2.55; *P*<0.0001, respectively). Diabetes de novo after beginning RRT had a similar influence (HR 4.12, 95% CI 3.49-4.87; *P*<0.0001 and HR 1.75, 95% CI 1.57-1.95; *P*<0.0001, respectively) [25].

In the present study, mortality in subgroups regarding the type of diabetes and dialysis modality was similar: type 1 diabetes 21.74%, type 2 diabetes 23.38%, HD 22.37%, and PD 25% (P>0.05). In the literature, data on the influence of type of dialysis modality on mortality differ. There are studies reporting higher overall mortality in patients on HD [26,27], in patients on PD [28,29], or showing no difference between them [8,30-33]. In some works, during the first months of RRT, survival is better in patients on PD [30,34-36]. In many studies, diabetes [25,33,35,36] and, as expected, older age [32,33,35,36] are associated with the higher mortality of patients on dialysis.

Patients with type 1 diabetes or type 2 diabetes on prevalent HD or PD treatment have complex health problems. This is also reflected by the fact that in our research, concomitant cardiovascular and infectious complications were the cause of death in the majority of analyzed cases (39.13%). Combining the above number with cases of only cardiovascular deaths (30.43%) or with only infectious deaths (26.09%), cardiovascular complications were responsible for 69.56% of deaths and infection led to 65.22% of deaths.

In patients with ESRD and diabetes, other chronic concomitant diseases also affect prognosis. The CCI was created to investigate the influence of comorbid conditions on the risk of mortality in prospective studies and estimates a 10-year survival due to this additional burden [13]. The CCI is widely used as a valid and reliable method [37]. It was also validated in assessing comorbidity and predicting survival in patients with ESRD [38]. In our study, comorbidity assessed by the CCI in both groups was high, but it was statistically significantly higher in the deceased patients (9.0±1.8 vs 8.0 (3.0) points; *P*=0.013), with a significantly lower estimated 10-year survival (median 0.0 (0.0) vs median 0.0 (2.0)%; *P*=0.011) in this group.

In spite of the limitations of the study, which included a rather small number of participants and a relatively short observation time, we hope that our work demonstrated a broader view of Polish patients undergoing dialysis who also have diabetes. We believe that the presented work will contribute to a better understanding of the complex health problems of these patients. More research is needed in the ESRD population with diabetes owing to the increased mortality rates in these patients. We plan further observation of this study group.

Conclusions

Based on the conducted research, deceased diabetic patients with ESRD on HD or PD had worse control of diabetes, expressed as higher HbA1c and fructosamine levels. Higher comorbidity was found among patients with worse outcomes. A history of stroke or TIA was an independent risk factor of all-cause death, while regular physical activity was associated with the reduced risk of all-cause death in patients with type 1 or 2 diabetes mellitus treated with PD or HD. Undertaking regular physical activity should be recommended to improve survival in the evaluated population as a modifiable factor. New solutions in education and medical care should be introduced to improve outcomes in this population.

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Conflicts of Interest

None.

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