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Examination of Factors Influencing the Risk of Falls in Hemodialysis Patients: A Cross-sectional Study

Damla Anar, Mehmet Göktuğ Kılınçarslan, Erkan Melih Şahin

Department of Family Medicine, Canakkale Onsekiz Mart University, Faculty of Medicine, Canakkale, Türkiye

ABSTRACT

Objectives: This study aimed to investigate the factors influencing the risk of falls in hemodialysis patients within the community.

Methods: This cross-sectional study was conducted on all patients receiving maintenance hemodialysis treatment in the central district of Çanakkale between July 2020 and August 2020. A total of 133 (74.7%) of 178 hemodialysis patients were included in the study. The risk of falls was assessed by the Hendrich II Scale. Sociodemographic variables, anthropometric variables, presence of diabetes mellitus, and biomarker values from the past 3 months were used as independent variables.

Results: Of the 133 participants who had been receiving hemodialysis for a median of 5.0 (2.0–8.0) years, 86 (64.7%) were male and the median age was 63.0 (53.0–69.0) years. Participants had a mean score of 2.1±0.1 on the Hendrich II Scale and 9 (6.8%) were at high risk of falling. There was no association identified between age, gender, educational attainment, marital status, height, weight, presence of diabetes mellitus, smoking status, hemoglobin levels, albumin levels, calcium levels, parathormone levels, grip strength in the dominant hand, triceps skinfold thickness, mid-upper arm circumference, mean arterial blood pressure, and the duration of hemodialysis with the risk of falls in individuals undergoing maintenance hemodialysis (Likelihood ratio test=12.532, p=0.767).

Conclusion: Physicians will not be able to simply determine the fall risk in hemodialysis patients by looking at certain values within the community. Larger and more comprehensive studies are needed to identify the fall risk in hemodialysis patients within the community.

Keywords: Anthropometry, falls, hemodialysis, muscle strength

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Address for correspondence:
Dr. Mehmet Göktuğ Kılınçarslan. Department of Family Medicine, Canakkale Onsekiz Mart University, Faculty of Medicine, Canakkale, Türkiye

Phone: +90 506 610 85 40

E-mail: goktugmk@gmail.com

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INTRODUCTION

Chronic kidney disease is characterized by the National Kidney Foundation –Kidney Disease Outcomes Quality Initiative as abnormalities in kidney structure or function that persist for a duration of at least 3 months and have implications for one's health.[1] It has been determined that chronic kidney diseases affect a portion of the global population ranging from 11% to 13%.[2] As its prevalence continues to increase and its effects on hemostasis in the body become clearer, chronic kidney disease is observed to transform into a global health problem.[3] Chronic kidney disease is defined as Stage G5 renal failure based on glomerular filtration rate classification.[4] The majority of patients at this stage require hemodialysis. Specifically, 0.041% of the entire population needs hemodialysis.

The bone abnormalities resulting from reduced kidney function contribute to a higher prevalence of fractures in hemodialysis patients compared to the general population.[5] These

fractures are associated with elevated mortality rates.[6] While falling is a crucial risk factor for fractures, the risk is higher in hemodialysis patients compared to the general population.[7,8]

In hemodialysis patients, factors such as decreased serum albumin levels, reliance on walking aids, sarcopenia, depression, advanced age, shorter stature, orthopedic and cerebrovascular diseases, reduced calf circumference, diminished quadriceps muscle thickness, increased body weight, presence of diabetes mellitus, inappropriate environmental conditions, frailty, and worse postural balance have been linked to an elevated risk of falls.[9-17] These risk factors are typically identified using multivariate statistical tests. It is not uncommon to encounter conflicting results, where variables identified in one study as increasing the risk of falls in hemodialysis patients are found to be ineffective in another study. Although there is only one study assessing the factors influencing the risk of falls in hemodialysis patients in the Turkish community, the study solely evaluated the risk of falls before and after hemodialysis sessions.[18]

There is a limited number of studies in the literature on factors influencing the risk of falls in hemodialysis patients, and some of these studies present conflicting results. There is a need to reconcile these contradictions and demonstrate the validity of identified risk factors in different populations. In addition, falls are preventable and avoidable circumstances. Early detection of increased fall risk in hemodialysis patients within primary health-care services will be highly beneficial in preventing many comorbidities, such as fractures, and reducing mortality in these patients.[19] Therefore, identifying the factors associated with fall risk in hemodialysis patients in the Turkish population will empower primary care physicians to prevent adverse health outcomes. This study aimed to investigate the factors influencing the risk of falls in hemodialysis patients within the community.

METHOD

This cross-sectional study was conducted on all patients receiving maintenance hemodialysis treatment in the central district of Çanakkale with a population of approximately 200000, located in the northwest of Turkey. Between July 2020 and August 2020, a total of 178 hemodialysis patients were reached as all patients who are under maintenance hemodialysis in the city center.

In our study, where 17 independent variables were used, the minimum required sample size for the smallest group was determined to be 17×10=170. Finding 170 high-fall-risk hemodialysis patients would require 1000 participants, which is excessively higher than the number of hemodialysis patients in the city. Forty-five (25.3%) individuals were excluded from the study, consisting of 23 (12.9%) who declined to participate, 20 (11.2%) who had not received hemodialysis treatment in the past 3 months, and 2 (1.1%) who had sensory organ impairment directly associated with falls (loss of visual acuity). Thus, the final study was conducted on 133 (74.7%) patients receiving maintenance hemodialysis treatment.

At the hemodialysis center, patients underwent a face-to-face interview before receiving hemodialysis, during which the Hendrich II Scale and a questionnaire comprising sociodemographic variables were administered, and anthropometric measurements were taken. In addition, the results of laboratory tests performed in the past 3 months were accessed and recorded through electronic medical records.

The participants' risk of falling was assessed using the Hendrich II Fall Risk Scale before each hemodialysis session. This scale is not specific to a particular field and is designed to evaluate the risk of falls in patients across all domains. The model, which is based on a comprehensive literature review of risk factors for falls, was initially developed by Hendrich and colleagues in 1995. It was later revisited in 2003, leading to the creation of its second version.[20] The highest possible score on the scale is 16, and a score of 5 or higher indicates the presence of a high risk of falling.

Sociodemographic characteristics of the participants such as age, gender, marital status, and educational status, as well as anthropometric measurements such as height, weight, grip strength in the dominant hand, upper middle arm circumference, and triceps skinfold thickness measurements were used as independent variables. Marital status was recorded as "Married" and "Other (single/widowed/divorced)." Educational status was recorded on a scale ranging from "Illiterate" to "University and above," with six options.

Grip strength in the dominant hand was measured using a hand dynamometer in our study, and it is generally associated with overall muscle health and performance in the body.[21] The upper mid-arm circumference is utilized as an indicator of malnutrition.[22] Triceps skinfold thickness, measured with a skinfold caliper in our study, serves as a reliable indicator of body fat percentage.[23] The inclusion of body anthropometric measurements in the predictive model for fall risk is justified by the fact that the muscle system and its health can directly impact the occurrence of falls.

Cigarette smoking (pack/year for quit, current smokers vs. zero for never smokers) and the time elapsed after starting hemodialysis treatment were also used as independent variables.

It is well-established that diabetes mellitus is an independent risk factor for falls in hemodialysis patients.[24] Therefore, in this study, the presence of diabetes mellitus was utilized as an independent variable. The existence of diabetes mellitus was self-reported by the patients.

Hemoglobin, albumin, calcium, and parathormone values measured within the past 3 months were used as independent variables. Laboratory test results were obtained from the electronic medical records of the patients. In addition, both systolic and diastolic blood pressure values were measured before the hemodialysis session, and mean arterial blood pressure ([2xdiastolic blood pressure+systolic blood pressure]/3) was added to the model as an independent variable.

Statistical analyses were conducted using the "logistf" version 1.26.0 package in the R software, version 4.3.1. The normal distribution of continuous independent variables was assessed using the Shapiro–Wilk test. The data that followed a normal distribution were presented as mean±standard deviation, whereas non-normally distributed data were presented as median (1st quartile-3rd quartile). Categorical data are described as frequency and percentage. As all variables did not exhibit a normal distribution, univariate tests, specifically the Chi-Square and Mann–Whitney U tests were employed. Due to the dichotomous nature of the dependent variable, logistic regression was chosen as the primary statistical method. For logistic regression, it is necessary to have a minimum of 10 cases per independent variable (for the smaller group). In this study, considering 17 independent variables, it was calculated that there should be at least 170 individuals in the smaller group for logistic regression analysis. However, despite efforts to reach all possible dialysis patients, only nine cases at risk of falls were identified. The "Firth's logistic regression with added covariate" method was employed in our study. A significance level of $p<0.05$ was considered the threshold for statistical significance.

RESULTS

A total of 133 participants, of whom 86 (64.7%) were male, with a median age of 63.0 (53.0–69.0) years. Of the participants, 96 (72.2%) were married, and 73 (54.9%) had completed primary school. The participants had been receiving hemodialysis treatment for a median duration of 5.0 (2.0–8.0) years. A diagnosis of diabetes mellitus was present in 44 (33.1%) participants. Sociodemographic and laboratory characteristics of hemodialysis patients according to fall risk are summarized in Table 1.

Participants obtained a mean score of 2.1±0.1 on the Hendrich II Scale. A score of 5 or higher on the Hendrich II Scale was observed in 9 (6.8%) participants, indicating a high risk of falls.

Firth's logistic regression with an added covariate model created to predict the dependent variable, the risk of falls, was not statistically significant (Likelihood ratio test=12.532, p=0.767). The prediction of fall risk in hemodialysis patients is summarized in Table 2.

DISCUSSION

This study aimed to investigate the factors influencing the risk of falls in hemodialysis patients within the community. No relationship was found between age, gender, education level, marital status, height, weight, diabetes mellitus, smoking status, hemoglobin, albumin, calcium, parathormone, grip strength in the dominant hand, triceps skinfold thickness, mid-upper arm circumference, mean arterial blood pressure, and duration of hemodialysis with the risk of falls in patients undergoing maintenance hemodialysis. Although significant associations were observed between albumin levels and Hendrich II scores in pairwise comparison tests, this significance disappeared in Firth's logistic regression model.

In our study, none of the dependent variables that we considered to be related to the risk of falls in hemodialysis patients were found to be significant in the multiple models. However, in studies conducted in the literature, increased risk of falls in hemodialysis patients has been associated with various factors such as serum albumin levels, use of assistive devices for walking, sarcopenia, depression, advanced age, short stature, orthopedic and cerebrovascular diseases, decreased calf circumference, decreased quadriceps muscle thickness, increased weight, presence of diabetes mellitus, inappropriate environmental factors, frailty, and worse postural balance.[9–17] However, in the literature, while some studies have found a statistically significant relationship between the presence of diabetes mellitus, albumin levels, female gender, parathormone levels, increased body weight, number of medications used, and systolic blood pressure levels with an increased risk of falls in hemodialysis patients, there are also studies stating no relationship between the same variables – the presence of diabetes mellitus, albumin levels, female gender, parathormone levels, increased body weight, number of medications used, and systolic blood pressure levels – and the risk of falls.[12,13,16,17,25-28] As evident, there is no clarity in

Table 1. Sociodemographic and laboratory characteristics of hemodialysis patients according to fall risk

	Fall Risk		p
	Absent (n=124)	Present (n=9)	
Age (years)	63.0 (53.2–69.0)	58.0 (49.0–68.5)	0.482*
Gender			
Female	44 (35.5)	3 (33.3)	1.000†
Male	80 (64.5)	6 (66.7)	
Marital status			
Single/divorced/widowed	36 (29.0)	1 (11.1)	0.444†
Married	88 (71.0)	8 (88.9)	
Education level			
Illiterate	7 (5.6)	0 (0.0)	0.362†
Literate	2 (1.6)	0 (0.0)	
Primary school	68 (54.8)	5 (55.6)	
Middle school	8 (6.5)	1 (11.1)	
High school	24 (19.4)	0 (0.0)	
University and above	15 (12.1)	3 (33.3)	
Diabetes mellitus			
Absent	82 (66.1)	7 (77.8)	0.717†
Present	42 (33.9)	2 (22.2)	
Smoking status (pack/year)	0.0 (0.0–20.0)	30.0 (0.0–38.0)	0.188*
Weight (kg)	69.2 (61.0–80.0)	66.0 (58.0–83.7)	0.989*
Height (cm)	166.5 (160.0–172.0)	173.0 (159.0–176.5)	0.272*
Hemoglobin (g/dL)	11.2 (10.2–12.0)	11.4 (9.3–12.6)	0.982*
Albumin (g/dL)	4.1 (3.9–4.4)	3.9 (3.6–4.1)	0.039*
Calcium (mg/dL)	9.0 (8.6–9.5)	9.2 (8.6–9.9)	0.507*
Parathormone (pg/mL)	178.1 (334.4–555.0)	280.0 (193.4–562.4)	0.771*
Grip strength in dominant hand (kg)	20.0 (13.0–25.0)	15.0 (9.5–26.0)	0.308*
Triceps skinfold thickness (mm)	9.0 (8.0–14.0)	11.0 (8.5–15.0)	0.278*
Mid-upper arm circumference (cm)	27.0 (25.0–29.0)	28.0 (24.0–30.5)	0.958*
Mean arterial blood pressure (mm/Hg)	88.3 (83.3–96.7)	93.3 (85.0–100.0)	0.282*
Duration of hemodialysis	5.0 (2.0–8.0)	6.0 (1.5–10.5)	0.666*

Data are presented as median (25-75. percentiles) and n (%).
*Mann-Whitney U test, †Chi-square test.

the literature regarding risk factors for falls in hemodialysis patients. One possible primary reason for this could be errors made in model selection during multiple analyses. The results in these studies generally rely on the outcomes obtained from regression analyses. Many studies did not specify the method followed for variable selection for regression.[11,12,14,25-27] Even worse, articles that mention about variable selection, have used the most incorrect method of deciding independent variables of the model just by significance in univariate statistics.[29,30] Furthermore, considering that regression models are highly sensitive to the included independent variables, the heterogeneity in the results of studies investigating risk factors for falls in hemodialysis patients is an expected outcome.[31] Although the small numbers of hemodialysis patients and the limited inclusion of hemodialysis patients in the investigated cases may necessitate the use of different regression types, it is observed that this aspect is not often emphasized in studies examining the relationship between hemodialysis and the risk of falls.[13,14,16,26,27,32] In this context, it is observed that the factors affecting the risk of falls in hemodialysis patients are not sufficiently clear in the literature. In our study, despite reaching all dialysis centers in the city and including all patients from these centers, only 133 participants could be

Table 2. Prediction of fall risk in hemodialysis patients

	β	SE	p	Exp (β)	95%CI
Age	–0.052	0.035	0.121	0.949	0.882–1.014
Gender (Ref:male)	0.651	1.402	0.633	1.917	0.140–35.709
Education level*	0.608	0.338	0.081	1.836	0.937–3.741
Marital status (Ref:married)	0.926	0.973	0.294	2.524	0.491–25.382
Height	0.113	0.085	0.204	1.120	0.944–1.361
Weight	0.014	0.051	0.782	1.014	0.918–1.121
Diabetes mellitus (Ref:absent)	–1.499	1.209	0.190	0.223	0.004–1.934
Smoking status	0.011	0.016	0.472	1.011	0.974–1.041
Hemoglobin	0.125	0.261	0.624	1.133	0.693–2.173
Albumin	–0.029	0.631	0.960	0.972	0.038–2.349
Calcium	0.229	0.405	0.553	1.256	0.597–2.912
Parathormone	–0.001	0.001	0.455	0.999	0.998–1.001
Grip strength in the dominant hand	–0.167	0.080	0.044	0.846	0.689–0.997
Triceps skinfold thickness	0.242	0.200	0.364	1.274	0.954–1.815
Mid-upper arm circumference	–0.179	0.146	0.102	0.836	0.556–1.224
Mean arterial blood pressure	0.055	0.036	0.091	1.056	0.992–1.142
Duration of hemodialysis	0.014	0.065	0.833	1.014	0.893–1.166

SE: Standard error.
*Education level coded as continuous.
Firth's logistic regression with added covariate method.

reached. Therefore, in our study, the Firth's logistic regression method was chosen appropriately for this small number of participants, and decisions regarding the variables to be included in the model were made before the study, using a proper method for creating an accurate model. As a result, in our study, no relationship was found between age, gender, education level, marital status, height, weight, diabetes mellitus, smoking status, hemoglobin, albumin, calcium, parathormone, grip strength in the dominant hand, triceps skinfold thickness, mid-upper arm circumference, mean arterial blood pressure, and duration of hemodialysis with the risk of falls in hemodialysis patients.

In the literature, despite the identification of some risk factors for falls in hemodialysis patients, another reason for not detecting them in our study may be the inadequacy of the Hendrich II Scale used to calculate the risk of falls in hemodialysis patients. Most studies in the literature generally take the number of falls within a specific period as the dependent variable, with rare cases where scales are used. However, to the best of our knowledge, the Hendrich II scale has not been used in any study to measure the risk of falls in hemodialysis patients. In this context, it may raise doubts about the suitability of the Hendrich II Scale as a good tool for measuring the risk of falls in hemodialysis patients.

Although all patients in dialysis units in the provincial center were reached in our study, an insufficient sample size could be reached for logistic regression. As a strength of our study, this problem was overcome using a very new statistical correction method. The limitation of our study is the lack of a study showing the validity and reliability of the Hendirch II Scale in hemodialysis patients, but there is no other valid and reliable scale that can be selected for this situation. In addition, since this study is a single-center study, caution should be exercised when generalizing its results. Another strength of our study is that the variables to be included in the model were decided in the study design and a model selection method criticized in the literature was avoided.

CONCLUSION

Maintenance hemodialysis patients were evaluated for the relationship between age, gender, education level, marital status, height, weight, diabetes mellitus, smoking status, hemoglobin, albumin, calcium, parathormone, grip strength in the dominant hand, triceps skinfold thickness, mid-upper arm circumference, mean arterial blood pressure, and duration of hemodialysis with the risk of falls, but no significant relationship was found. In the literature, while some variables in this study were shown to have a

relationship with the risk of falls in hemodialysis patients, there are noticeable methodological and statistical errors in these studies. In addition, there is currently no scale with sufficient discriminative power to measure the risk of falls in hemodialysis patients. In this context, more comprehensive and multi-center studies are needed to evaluate the risk of falls in hemodialysis patients due to the limitations in the number of patients.

Disclosures

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Conflict of Interest: All authors do not have any disclosure of conflict of interest to declare.

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Ethics Committee Approval: Approval for our study was obtained from the Çanakkale Onsekiz Mart University Clinical Research Ethics Committee (Approval date: November 11, 2020 and approval number: 2020-05). Informed consent forms were obtained from all participants involved in our study.

Authorship Contributions: Concept – D.A., E.M.Ş.; Design – D.A., E.M.Ş.; Supervision – E.M.Ş., M.G.K.; Materials – D.A.; Data collection and/or processing – D.A., E.M.Ş., M.G.K.; Analysis and/or interpretation – M.G.K.; Literature search – M.G.K.; Writing – D.A., E.M.Ş., M.G.K.; Critical review – E.M.Ş., M.G.K.

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