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Paper Accepted*

ISSN Online 2406-0895

Original Article / Оригинални рад

Marija Dobričić^{1,*}, Vesna Pakić¹, Vesna Pejović¹, Aleksandra Kuzmanović¹, Miodrag Milić¹,
Jelena Marinković², Višnja Ležaić²

**Factors influencing mortality in prevalent hemodialysis patients with
different types of heart failure – a single-center experience**

Фактори који утичу на смртност код превалентних болесника лечених
хемодијализом са различитим типовима срчане инсуфицијенције –
искуство једног центра

¹Special Hospital for Internal Diseases, Lazarevac, Serbia;

²University of Belgrade, Faculty of Medicine, Belgrade, Serbia

Received: September 21, 2023

Revised: June 27, 2024

Accepted: August 5, 2024

Online First: August 13, 2024

DOI: <https://doi.org/10.2298/SARH230921065D>

* **Accepted papers** are articles in press that have gone through due peer review process and have been accepted for publication by the Editorial Board of the *Serbian Archives of Medicine*. They have not yet been copy-edited and/or formatted in the publication house style, and the text may be changed before the final publication.

Although accepted papers do not yet have all the accompanying bibliographic details available, they can already be cited using the year of online publication and the DOI, as follows: the author's last name and initial of the first name, article title, journal title, online first publication month and year, and the DOI; e.g.: Petrović P, Jovanović J. The title of the article. *Srp Arh Celok Lek*. Online First, February 2017.

When the final article is assigned to volumes/issues of the journal, the Article in Press version will be removed and the final version will appear in the associated published volumes/issues of the journal. The date the article was made available online first will be carried over.

***Correspondence to:**

Marija DOBRIČIĆ

Special Hospital for Internal Diseases, Đorđa Kovačevića 27, 11550 Lazarevac, Serbia

E-mail: marija.dobricic@yahoo.com

Factors influencing mortality in prevalent hemodialysis patients with different types of heart failure – a single-center experience

Фактори који утичу на смртност код превалентних болесника лечених хемодијализом са различитим типовима срчане инсуфицијенције – искуство једног центра

SUMMARY

Introduction/Objective This retrospective longitudinal study aimed to analyze survival factors in prevalent hemodialysis (HD) patients with different heart failure (HF) phenotypes.

Methods Over 36 months, 96 patients were monitored, with 51 deaths recorded. Patients were categorized into HF with reduced ejection fraction (HFrEF), HF with preserved ejection fraction (HFpEF), and non-HF (no HF) groups. Demographic, clinical, and laboratory parameters were analyzed to identify survival predictors within each subgroup.

Results Survival curves did not differ among HF subgroups, and mortality was as follows: 42.9% for HFrEF, 52.4% for HFpEF, and 60.6% for no-HF patients. The main causes of death were COVID-19 infection (70%), followed by *de novo* cardiovascular diseases (myocardial infarction and cerebrovascular insult) (25%). Some demographic (age, male sex, HD vintage) and laboratory differences (anemia, lipids) between the surviving and deceased subgroups of patients have been found. Multivariate analysis identified distinct survival predictors: in HFrEF: pulse rate and interventricular septum thickness, in HFpEF: primary renal disease, cardiac history, and diuretic use; in no-HF: BMI, serum sodium, and HDL/LDL ratios.

Conclusion Our results led us to suspect that COVID-19 infection might have masked the expected impact of HF phenotype on patients' survival. Obtained findings contribute to the evolving understanding of HF in prevalent HD patients in the pandemic era. As HF, dialysis, and COVID-19 intertwine, further investigation is crucial to navigate this intricate finding and optimize patient care.

Keywords: heart failure; hemodialysis; mortality; risk factors

САЖЕТАК

Увод/Циљ Ова ретроспективна студија са дужим праћењем имала је за циљ да анализира факторе преживљавања код превалентних болесника лечених хемодијализом (ХД) са различитим фенотиповима срчане инсуфицијенције (СИ).

Метод Током 36 месеци, праћено је 96 болесника, а забележен је 51 смртни случај. Према типу СИ болесници су подељени у групе: у СИ са смањеном ејекцијом фракцијом (СИрЕФ), СИ са очуваном ејекцијом фракцијом (СИоЕФ) и без-СИ (без СИ). Демографски, клинички и лабораторијски параметри су анализирани да би се идентификовали предиктори преживљавања унутар сваке подгрупе.

Резултати Криве преживљавања нису се значајно разликовале међу испитаним групама, а број умрлих је био следећи: 42,9% за СИрЕФ, 52,4% за СИоЕФ и 60,6% за болеснике без СИ. Главни узроци смрти су били инфекција ковидом 19 у 70% смртних случајева, а затим *de novo* кардиоваскуларне болести (инфаркт миокарда и цереброваскуларни инзулт) у 25% умрлих. Подгрупе преживелих и умрлих болесника разликују се у старости, полу, трајању ХД и анемији и профили липида. Мултиваријантна анализа је идентификовала предикторе преживљавања: код СИрЕФ: брзину пулса и дебљину интервентрикуларног септума, код СИпЕФ примарно обољење бубрега, претходне срчане болести и употреба диуретика; код групе без СИ индекс телесне масе, натријум у серуму и односа *HDL/LDL* липида.

Закључак: Добијени налази доприносе разумевању СИ код превалентних болесника лечених ХД у ери пандемије. Како се СИ, дијализа и ковид 19 преплићу, даље истраживање је кључно за објашњење ове замршене интеракције и оптимизацију бриге о болесницима.

Кључне речи: срчана инсуфицијенција; хемодијализа; морталитет; фактори ризика

INTRODUCTION

Patients with end-stage renal disease undergoing maintenance hemodialysis (HD) frequently encounter an array of cardiovascular complications, further exacerbated by the coexistence of heart failure (HF) [1]. Consequently, the interplay between HD and HF warrants investigation, particularly in the context of mortality outcomes.

Three types of HF in the general population are recognized: HF with preserved ejection fraction (HFpEF), HF with reduced EF (HFrEF), and HF with moderately reduced EF [2]. Their clinical presentation and risk factors are similar, but the approach to treatment and response to treatment is different. Having in mind that HF is a poor predictor of HD patient outcome [3], timely identification of HF risk factors, and clinical presentation would be helpful in prevention and their management [4]. HFrEF is characterized by a compromised left ventricular ejection fraction (EF), often resulting from structural heart damage, myocardial infarction, or dilated cardiomyopathies. On the other hand, HFpEF, characterized by preserved EF, typically involves diastolic dysfunction and is associated with comorbidities such as hypertension, diabetes, and aging [4].

Mortality rates among patients with HF undergoing HD remain a subject of concern. The concomitant presence of both conditions introduces intricate hemodynamic alterations, electrolyte imbalances, and potential medication interactions, all of which contribute to elevated mortality risk [5, 6]. Understanding the differential impact of HFrEF and HFpEF on mortality in the context of maintenance HD is essential for tailoring effective interventions and optimizing patient care.

Existing research has primarily focused on overall mortality in HD patients without distinguishing between HFrEF and HFpEF subgroups, warranting further investigation into the unique contributors to mortality in each subgroup. Thus the present study aimed to identify specific factors that contribute to mortality in prevalent HD population with different types of HF.

METHODS

Patients

This was a single-center retrospective longitudinal analysis of data from a 96 prevalent patient treated with HD. The included patients were older than 18 years, with at least 6 months of HD treatment. Statins, aspirin, angiotensin-converting enzyme inhibitors (or angiotensin-receptor blockers), and beta-blockers were prescribed to all patients in accordance with current guidelines for secondary prevention of CV events independently of clinical evaluation, as well as anti-aggregation treatment and anticoagulants as needed. Parameter of anemia and mineral

metabolism were controlled according to current KDIGO guidelines which are adopted locally [7, 8]. Studied patients were all asymptomatic for chest pain and had no history of acute coronary syndrome in the past three months. Exclusion criteria were the inability of the patients to provide signed written consent for participation in the study. According to the criteria of the American and European Society of Cardiology [2, 4] and based on signs and/or symptoms of HF, and left ventricular function indicators obtained by transthoracic echocardiography, patients were divided into groups: 1. with HF and reduced-EF-rEF (EF < 40%), plus moderately reduced HFmrEF marked as HFrEF (EF = 40–50%)- 21 patients, 2. with HF and preserved EF-HFpEF (EF ≥ 50%)- 42 patients and 3. without overt HF - 33 patients. During the monitoring period (from March 2020 to April 2023), 51 patients died. In order to identify the factors that contributed to the mortality in the study population, we compared all data reported in the methods below between deceased patients and survivors. For easier comparison, the basal groups of patients with HFrEF, HFpEF, and the group without HF were divided into two subgroups each i.e. those who survived and those who died, thus forming six subgroups marked with numbers from 1 to 6.

The approval of the local Ethics committee was obtained (number 110/21.1.2020) and written informed consent was obtained from all the participants.

Data collection

1. Demographic data: age, gender, renal disease, comorbidities (coronary artery disease, hypertension, diabetes mellitus, dyslipidemia, and peripheral obstructive arterial disease), residual diuresis, and body mass index (BMI) including history of coronary artery disease defined as prior revascularization (through angioplasty or coronary artery bypass). Also, each patient was physically examined and questioned for signs and/ or symptoms of HF including edema of the lower extremities, (exertional) dyspnea graded by the New York Heart Association criteria (NYHA I-IV), and paroxysmal nocturnal dyspnea/orthopnea [9].

2. Dialytic data: duration of bicarbonate dialysis session (four hours three times a week), dialysis vintage, dialysis membrane (low and high flow polysulphone membrane, surface between 1.3 and 1.8 m²), without change throughout the study period, single pool Kt/V [10], interdialytic weight gain, dialysis access, and systolic and diastolic blood pressure before HD

session, volume status checked by bioimpedance spectroscopy, using the device Body Composition Monitor (BCM) manufactured by Fresenius Medical Care.

Measurements

All the measured parameters i.e. laboratory data and transthoracic echocardiography characteristics are described in detail in our previous work [11].

Outcomes

The main outcome of this study was all-cause and cardiovascular mortality during the 36 months of follow-up. The date and causes of death were recorded from the patient's medical files. Sudden cardiac death, heart failure, myocardial infarction, severe aortic stenosis, aortic dissection, ischemic stroke, and peripheral vascular ischemia were considered causes of cardiovascular death. Infection-related mortality included COVID-19 cases and sepsis. Also, the number and causes of hospitalizations were recorded from the patient's medical records.

Statistical analyses were performed using the SPSS software (version 25.0) and R software (version 3.6.1). Continuous variates with normal distribution were presented as mean \pm SD and compared using the Student's t-test. Variables without normal distribution were presented as median with interquartile ranges and compared using the Mann-Whitney U test or for multiple comparisons Tukey post-hoc test. Categorical data were presented as the number of cases and percentages and compared using the χ^2 test. Cox multivariate logistic regression model including all significantly different characteristics in the univariate logistic regression models (at $p = 0.05$) as well as those predictors that are known to affect the patient's death, was used to determine the independent association with all-cause mortality. Two-sided p -values < 0.05 were considered significant.

Data availability

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

RESULTS

Study population

Differences in baseline characteristics between surviving and deceased patients at the entry of the study are presented in Table 1. Considering two subgroups with HFpEF, deceased patients were older, and there were more males. They had been on HD for a shorter time before the start of this study compared to patients from other groups, and had more frequent renal anemia compared to deceased persons without HF. In groups of survivors, more women were in the subgroup with HFrEF compared to the subgroup with HFpEF, and zero NYHA score was more common in HFpEF compared to no HF group. In the groups of non-survivors, the patients from the HFrEF group had the lowest mean EF compared to the other two groups of patients. No other difference was found among subgroups regarding demographic, clinical, treatment, and ultrasound heart parameters except for the EF, which was the basis for grouping patients (data are not presented).

Laboratory analyses and lipid profile

Table 2 presents the results of laboratory analyses. When comparing survivors and deceased patients, those with HFrEF had higher platelet counts, while those without HF had lower leukocytes and serum sodium (both within normal limits). Minor differences, not statistically significant in iPTH and CRP were noted in both HFpEF and no HF subgroups. Also, deceased patients with HFrEF had the lowest leukocyte, hemoglobin, and platelet counts in comparison to other subgroups. Among survivors, patients with HFrEF had slightly lower phosphate and PTH compared to group 2 with HFpEF, but this difference was not statistically significant. Looking at lipids, in comparisons between survivors and deceased patients, group 3 had higher HDL-c levels, but a lower HDL/LDL ratio. On the other hand, survivors from group 2 showed a higher HDL/LDL ratio than deceased from the same subgroup.

Clinical outcome and survival analysis

No difference was found in the frequency and cause of hospitalizations between examined groups of patients (Table 3). Throughout the 36 months of follow-up, 51 patients died. The frequency of COVID-19 infection being the cause of death (Table 3) was notably higher in comparison to CVD across all groups of patients studied i.e. 36 vs. 13 patients ($\chi^2 = 35.41$, $p < 0.001$).

No difference in patients' survival curves among the studied groups, as shown by Kaplan-Meier analysis (Figure 1). The medians for survival time—representing the point at which half the patients were anticipated to remain alive—were as follows: 10 months (IQR 4.9–15.1) for HFrEF, 14 months (IQR 12.0–15.9) for HFpEF, and 11 months (IQR 7.39–14.61) for no-HF group.

Mortality predictors were separately analyzed in each group using Cox regression analysis. Univariate Cox logistic regression analysis in patients with HFrEF identified the following mortality predictors: CVI, pulse rate, and IVs thickness. However, multivariate analysis revealed only pulse rate and IVs thickness as independent predictors after adjusting for other variables in the model (Table 4). Each unit increase in pulse rate correlated with a 187.47 times higher risk of mortality, though with considerable uncertainty due to a wide confidence interval. Similarly, IVs thickness showed a substantial risk increase, but with significant uncertainty.

For HFpEF patients, DM2 and nephroangiosclerosis (as an underlying kidney disease), myocardial infarction, coronary artery bypass grafting, the use of diuretics, and the number of hospitalizations were identified by univariate analysis as significant predictors of mortality. Multivariate analysis retained only DM2, nephroangiosclerosis, and diuretic use as independent positive mortality predictors (Table 5). Although the wide confidence interval indicates some uncertainty in the estimate, the point estimate suggests a strong association between DM2, nephroangiosclerosis, and use of diuretics and mortality in patients with HFpEF.

In the case of patients with no HF, univariate Cox logistic regression analysis identified CVI, chronic obstructive pulmonary disease, IVs and posterior wall thickness, BMI, fat tissue, adipose tissue mass, sodium, HDL/LDL ratio, and number of hospitalizations as significant predictors of mortality. Multivariate analysis highlighted independent predictors for mortality to be NYHA class, BMI, posterior wall thickness, and adipose tissue mass after adjusting for other

variables in the model (Table 6). Higher NYHA class correlated with a 2.05 times higher mortality risk, while each unit increase in BMI was associated with a 1.271 times higher risk. Conversely, each unit increase in adipose tissue mass is associated with a 0.882 times lower risk of mortality. Additionally, each unit increase in posterior wall thickness is associated with lower risk of mortality. However, the extremely small hazard ratio and wide CI indicate caution in interpreting this result.

DISCUSSION

In this single-center study, we aimed to examine the factors influencing the survival of prevalent HD patients with different HF phenotypes over a 36-month follow-up period. The key findings can be summarized as follows: 1) mortality rate among prevalent HD patients was high, with 53% of patients dying; 2) the survival rates of patients with two distinct HF phenotypes and those without HF were similar throughout the study; 3) COVID-19 infections emerged as a significantly greater risk factor for mortality compared to CVD; 4) *de novo* cardiovascular events contributed to a quarter of the recorded deaths, reaffirming the enduring significance of CVD as a mortality cause even during the pandemic; 5) analysis of laboratory and clinical parameters revealed noteworthy predictive associations with mortality: elevated pulse rate and specific cardiac structural parameters in patients with HFrEF, while primary kidney diseases, and diuretic usage in patients with HFpEF.

Our findings corroborate the elevated mortality observed in the studied population, aligning with conclusions drawn by other researchers. Comparing survival rates over two years, notable differences emerge when HF is present, with rates of 80% for patients without HF, and 33% for those with HF [12]. Regarding HF phenotypes, survival disparities have been reported. Among patients with HFpEF, a longer survival of 73% was noted, contrasting with HFrEF patients at 55% [12, 13, 14]. In the present study, mortality rates were 42.9% for HFrEF, 52.4% for HFpEF, and 60.6% for no-HF patients. These outcomes, divergent from mortality analyses published so far prompted us to investigate the underlying causes.

We conducted this study during the COVID-19 pandemic, and 70% of patients died due to COVID-19 infection equally distributed in all three groups of patients, compared to 25% who died due to *de novo* CVD (acute myocardial infarction, cerebrovascular insult). It is well known that COVID-19 infection has caused a substantial increase in mortality rates among the general

population, and various patient populations, including those with cardiovascular diseases and patients with chronic kidney disease and on renal replacement therapy [15]. High mortality after the diagnosis of COVID-19 in HD patients was reported: the 28-day probability of death was 25%, but during the 90 days after diagnosis it reached 40.5%, emphasizing the increased vulnerability of HD patients due to a compromised immune system and the presence of numerous comorbidities. [16, 17]. Our results led us to suspect that COVID-19 infection might have masked the impact of HF phenotype on patients' survival.

Our findings emphasize the ongoing significance of CVD in mortality, even beyond the context of the pandemic. Notably, 25% of the studied patients died of new cardiovascular events. Some differences in demographics and laboratory values between surviving and deceased patient subgroups could have influenced mortality. A higher prevalence of anemia was observed among deceased patients with HFpEF. This suggests a potential link between anemia, HF, and unfavorable outcomes, consistent with prior research [7]. Analyzing subgroups within HFrEF and HFpEF, deceased patients were older and with a higher proportion of males. Additionally, deceased patients with HFpEF had a shorter HD vintage. Patient age has consistently emerged as a mortality risk factor across studies, reflecting increasing mortality with age [5, 18]. Our observation of higher mortality among male patients with shorter HD vintage contrasts with findings by Sumida et al. They reported an inverse relationship between patient mortality and prolonged HD duration in a Japanese registry cohort [19]. These disparities underscore the intricate and multifaceted nature of factors contributing to patient outcomes, influenced in part by the size of the analyzed sample.

The observed associations between laboratory and clinical parameters with survival outcomes align with prior research. For instance, regardless of the limitations in interpretation and the uncertainty of the results, elevated pulse rate and cardiac structural parameters in HFrEF patients as positive predictors of mortality highlight the potential significance of both cardiac and hemodynamic factors in this cohort which is well-known from previous studies [14, 20]. The impact of underlying kidney disease (precisely diabetic kidney disease and nephroangiosclerosis), and use of diuretics (which reduce the risk of death) in patients with HFpEF on survival outcomes is consistent with the complex interaction between kidney function, cardiovascular health, and survival observed by other authors [14, 21, 22]. Additionally, the impact of metabolic parameters, serum sodium level, and lipid ratios on survival outcomes among patients with no HF offers further insights into the intricate finding of determinants in this cohort.

It is essential to acknowledge the limitations of our study, including the small sample size and the single-center design, which may limit the generalizability of our findings. Nevertheless, our analysis provides valuable insights into the complex of factors influencing survival outcomes in prevalent HD patients with different HF phenotypes. These findings pave the way for further research, potentially in multicenter studies, to validate and expand upon our observations, ultimately leading to a more comprehensive understanding of the predictors driving survival in this complex clinical scenario.

CONCLUSION

In this study of prevalent hemodialysis patients with diverse HF phenotypes, we analyzed survival dynamics. During the pandemic, COVID-19 emerged as a prominent cause of mortality, potentially obscuring expected differences in HF subtypes. While survival rates between HFrEF, HFpEF, and no-HF subgroups showed no significant disparities, multivariable Cox regression unveiled independent predictors specific to each group that included pulse rate and cardiac parameters in HFrEF, kidney diseases in HFpEF, and metabolic factors in no-HF patients. As we interpret these results in the pandemic context, we emphasize the significance of ongoing research in the interplay of HF, dialysis, COVID-19, and survival, to guide enhanced patient care strategies. By combining personalized treatment plans, multidisciplinary collaboration, patient education, and ongoing research, healthcare providers can strive to improve outcomes and enhance the quality of life for these patients.

Conflict of interest: None declared.

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Table 1. Baseline characteristics of examined patients

Characteristics	Group 1 (HF _r EF + HF _{mr} EF)		Group 2 (HF _p EF)		Group 3 (no HF)		p-value
	Survivors (N = 12 pts)	Deceased (N = 9 pts)	Survivors (N = 20 pts)	Deceased (N = 22 pts)	Survivors (N = 13 pts)	Deceased (N = 20 pts)	
Age, years	70 (61.2–76.5)	67 (52.5–75)	61.6 (52.7–71.2)	71 (61.2–81)	66 (59.2–73)	72 (65–77.5)	0.01
Sex, m/f	10/2	7/2	8/12	17/5	7/6	14/6	0.019
HD vintage, months	51 (30.2–103.2)	57 (35–224)	30.5 (15.2–63.2)	27.5 (17.75–52.5)	51.5 (32.7–82.2)	71 (28.5–130)	0.039
Co-morbidities, HTA/ CVI DM2/tumor COPD/PVD IM/PCI/CABG	2/- -/1 1/- -/-/1	5/1 2/- -/-/1	8/1 1/- 1/- 1/-	9/1 4/2 2/2 8/-/5	6/- -/1 - 1/-	11/2 2/2 3/1 2/2/2	Non-significant
Renal anemia, yes	11	8	18	22	11	16	0.029
NYHA class:							
1	3	1	7	6	1	3	0.021
2	6	5	13	10	10	13	
3	3	3	0	6	2	4	
EF %	46.33 ± 1.50	39.53 ± 5.26	59.0 ± 6.88	55.0 ± 4.53	59.12 ± 6.94	60.37 ± 5.39	0.025
Pre-dialysis BP Systolic, mmHg	155.5 (130–172.7)	155 (141.5–160.5)	148.5 (126.5–158)	146 (136.5–153.7)	145 (131–166.5)	140.5 (132.5–166.5)	Non-significant
Diastolic, mmHg	72.5 (68.5–79.7)	73 (68–95)	77 (64.7–81.7)	66.5 (59.5–77.0)	78 (72–85)	73 (64–88)	Non-significant
kT/V	1.05 (0.96–1.24)	1.41 (0.94–1.57)	1.10 (0.94–1.27)	1.03 (0.88–1.27)	1.18 (1.05–1.38)	0.96 (0.9–1.12)	Non-significant

HF – heart failure; rEF – reduced ejection fraction; pEF – preserved ejection fraction; HD – hemodialysis; HTA – hypertension; CVI – cardiovascular insult; DM2 – diabetes mellitus type 2; PVD – peripheral vascular disease; COPB – chronic obstructive pulmonary disease; IM – myocardial infarction; PCI – percutaneous coronary intervention; CABG – coronary artery bypass grafting; NYHA – New York Heart Association classification of heart failure

Median (IQR), X ± SE, N – patients number;

Statistically significant differences:

age: group 2 survivors vs. deceased; sex: survivors group1 vs. group 2; group 2 survivors vs. deceased; HD vintage: deceased group 1: group 2, group 2 vs. group 3; renal anemia: deceased group 2 vs. group 3; NYHA class 3: group 2 survived vs. deceased; EF: deceased group 1 vs. group 3

Table 2. Laboratory parameters of examined patients

Parameters	Group 1 (HF _r EF + HF _m rEF)		Group 2 (HF _p EF)		Group 3 (no HF)		p-value
	Survivors (N = 12 pts)	Deceased (N = 9 pts)	Survivors (N = 20 pts)	Deceased (N = 22 pts)	Survivors (N = 13 pts)	Deceased (N = 20 pts)	
Leukocytes, × 10 ⁹ /l	6.68 (5.75–8.81)	5.01 (3.62–7.23)	6.72 (5.28–8.16)	5.92 (5.20–7.58)	5.64 (5.28–7.37)	7.37 (5.99–8.73)	< 0.042
Hemoglobin, g/l	98 (93–103)	94 (86–120)	107 (89–121)	98 (84.2–110.5)	107 (94–120)	108 (97–125)	0.047
Platelets, × 10 ⁹ /l	190 (176–203)	122.5 (106.7–182.2)	202 (162–222)	215 (176.7–255.2)	208 (127–229)	189 (156–247)	< 0.036
Sodium, mmol/l	139 (138–141.5)	137 (132–142)	138 (138–140)	138.5 (137–141)	138 (137–139.5)	139 (138–141)	Non-significant
Calcium, mmol/l	2.15 (1.89–2.22)	2 (1.79–2.2)	2.16 (2.10–2.27)	2.13 (2.04–2.25)	2.15 (2–2.32)	2.16 (2.14–2.26)	Non-significant
Phosphate, mmol/l	1.31 (1.11–1.65)	1.17 (0.77–1.61)	1.76 (1.23–2.12)	1.38 (1.17–1.80)	1.31 (1.11–1.79)	1.35 (1.07–1.59)	Non-significant
iPTH, ng/ml	158.4 (51–404.8)	133.4 (21.9–687.5)	418.3 (151.8–774.4)	163.3 (132–294.6)	438.4 (81.9–948.4)	319.2 (148.2–889.7)	Non-significant
CRP, mg/l	3.85 (1.36–7.57)	4.59 (1.72–15.94)	2.86 (1.37–5.40)	4.26 (3.14–16.61)	2.31 (1.11–5.88)	4.17 (2.76–21.63)	Non-significant
Total cholesterol, mmol/l	4.60 (3.85–5.66)	3.8 (3.74–5.62)	4.56 (3.96–5.27)	3.96 (3.52–5.24)	4.51 (3.92–5.009)	3.89 (3.61–5.28)	Non-significant
HDL-c, mmol/l	1.02 (0.84–1.33)	1.17 (0.92–1.47)	1.04 (0.84–1.65)	1.38 (0.94–1.92)	1.56 (1.25–2.01)	1.01 (0.63–1.54)	< 0.012
LDL-c, mmol/l	2.59 (2–2.93)	2.17 (1.96–3.43)	2.41 (2.03–3)	1.89 (1.46–2.70)	2.06 (1.68–2.62)	2.35 (2.05–3.14)	Non-significant
HDL/LDL ratio	2.31 (1.7–3.23)	2.11 (1.6–2.39)	2.16 (1.91–2.75)	1.53 (0.98–2.29)	1.17 (0.65–1.94)	2.38 (2.06–3.55)	< 0.006
TG, mmol/l	1.65 (1.15–3.89)	1.39 (1.12–2.36)	1.96 (1.22–2.48)	1.2 (0.85–2.25)	1.09 (0.87–1.9)	1.72 (1.24–2.76)	Non-significant

PTH – parathyroid hormone, TG – triglyceride, HDL-c – high-density lipoprotein (LDL) cholesterol particles, LDL-c – low-density lipoprotein (LDL) cholesterol particles;

Median (IQR); statistically significant differences: leukocytes: deceased: group 1 vs. group 3, group 3: survived vs. deceased; hemoglobin deceased group 2 vs. group 3; platelets: group 1: survived vs. deceased, deceased: group 1 vs. group 2; group 1 vs. group 3; HDL-c: survived: group 1 vs. group 3; group 2 vs. group 3; group 3 survived vs. deceased; HDL/LDL ratio: survived: group 1 vs. group 3, group 2 vs. group 3, deceased: group 2 vs. group 3; group 3: survived vs. deceased

Table 3. Number and causes of hospitalization and patients' death during the study period

Parameter	Group 1 (HF _r EF + HF _{mr} EF)		Group 2 (HF _p EF)		Group 3 (no HF)		P
	Survivors (N = 12 pts)	Deceased (N = 9 pts)	Survivors (N = 20 pts)	Deceased (N = 22 pts)	Survivors (N = 13 pts)	Deceased (N = 20 pts)	
Hospitalization							Non-sig- nificant
0	4	6	6	10	5	8	
1	4	1	12	6	2	6	
2	3	1	1	4	4	2	
≥3	1	1	1	3	2	6	
Causes							Non-sig- nificant
Infection	6	1	10	5	5	7	
CVD	1	2	3	4	3	5	
others	1	0	1	2	0	0	
Death		9		22		20	
Causes							Non-sig- nificant
COVID-19		4		19		13	
CVD		5		3		5	
Others						2	

CVD – cardiovascular diseases

Table 4. Mortality predictors selected with multivariable Cox regression analysis for patients from group 1 with heart failure with reduced ejection fraction

Parameter	Exp (B)	Sig	95% CI for Exp(B)	
			Lower	Upper
Pulse rate	187.470	0.027	1.839	19110.495
IVs	8864.416	0.023	3.482	22566646.151

IVs – interventricular septum thickness

Paper accepted

Table 5. Mortality predictors selected with multivariable Cox regression analysis for patients from Group 2 with heart failure with preserved ejection fraction

Parameter	Exp (B)	Sig	95.0% CI for Exp(B)	
			Lower	Upper
DM2	15.366	0.007	2.091	112.930
Nscl	5.657	0.049	1.011	31.664
Diuretics, yes	4.043	0.044	1.036	15.777

DM2 – diabetes mellitus type 2; Nscl – nephroangiosclerosis

Paper accepted

Table 6. Mortality predictors selected with multivariable Cox regression analysis for patients from Group 3 with no heart failure

Parameter	Exp (B)	Sig	95% CI for Exp (B)	
			Lower	Upper
NYHA	2.055	0.031	2.055	3.953
Posterior wall	0.002	0.001	0.002	0.080
BMI, kg/m ²	1.271	0.006	1.271	1.511
Adipose tissue mass, kg	0.882	0.011	0.882	0.971

NYHA – New York Heart Association Classification of Heart Failure; BMI – body mass index

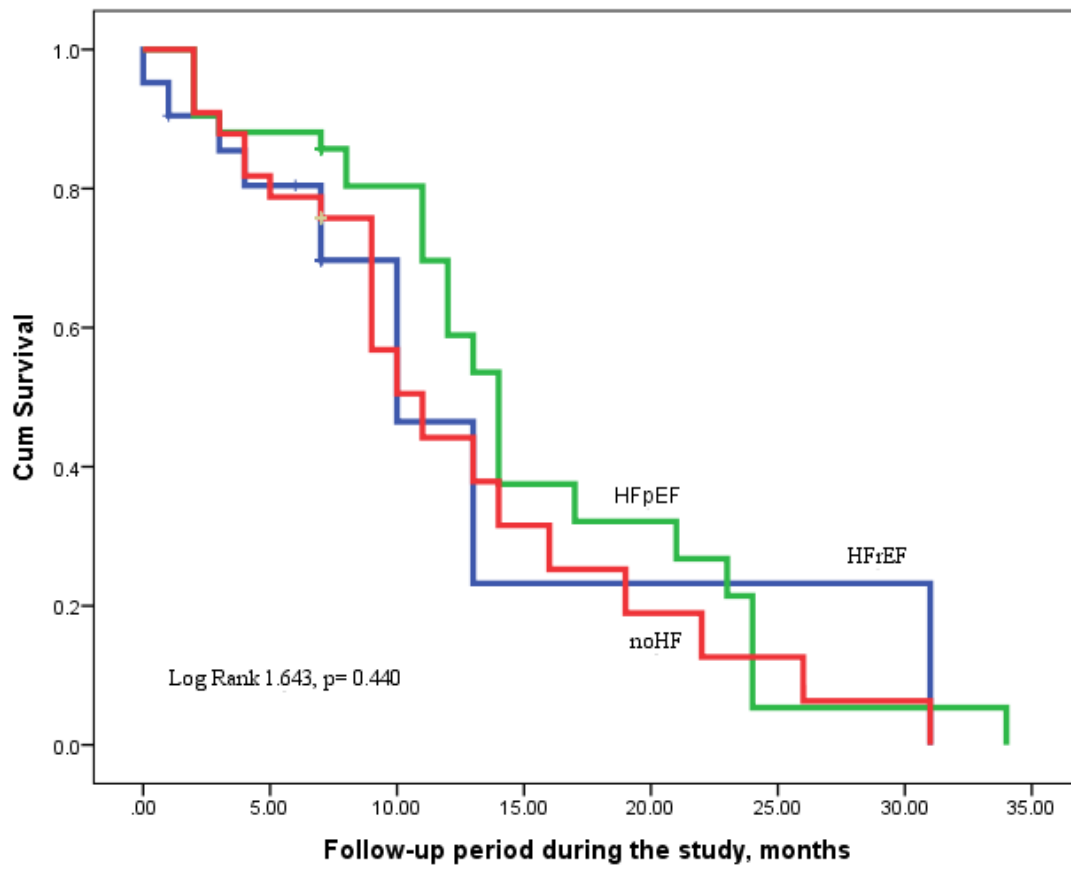


Figure 1. Survival plots for prevalent hemodialysis patients with heart failure (Kaplan–Meier analysis)