The American Journal of Medical Sciences and Pharmaceutical Research ISSN 2689-1026 Volume 08 - 2026

Effects of Intradialytic Exercise on Cardiac Biomarkers in Patients Undergoing Maintenance Hemodialysis

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Received: 15 Mar 2026 | Received Revised Version: 03 Apr 2026 | Accepted: 22 Apr 2026 | Published:13 May 2026

Volume 08 Issue 05 2026 | Crossref DOI: 10.37547/tajmspr/Volume08Issue05-07

Abstract

Cardiovascular complications remain the leading cause of morbidity and mortality in patients with Chronic Kidney Disease receiving maintenance hemodialysis. Elevated cardiac biomarkers, including troponin and N-terminal pro–B-type natriuretic peptide (NT-proBNP), are associated with subclinical myocardial injury and poor cardiovascular outcomes. Intradialytic physical exercise has recently gained attention as a potential non-pharmacological strategy for improving cardiovascular health in hemodialysis patients.

Keywords: Maintenance hemodialysis; intradialytic exercise; cardiac biomarkers; troponin; NT-proBNP; cardiovascular risk; chronic kidney disease.

Cite This Article: Kasimova Guzal Botirovna. (2026). Effects of Intradialytic Exercise on Cardiac Biomarkers in Patients Undergoing Maintenance Hemodialysis. The American Journal of Medical Sciences and Pharmaceutical Research, 8(05), 33–36. https://doi.org/10.37547/tajmspr/Volume08Issue05-07

1. Introduction

Cardiovascular disease is the leading cause of morbidity and mortality among patients with Chronic Kidney Disease receiving maintenance hemodialysis. Chronic volume overload, persistent inflammation, oxidative stress, anemia, endothelial dysfunction, and metabolic disturbances contribute significantly to myocardial injury and cardiovascular complications in this population. Patients undergoing long-term hemodialysis are at particularly high risk of left ventricular hypertrophy, heart failure, arrhythmias, and ischemic heart disease. Cardiac biomarkers such as cardiac troponin and N-terminal pro–B-type natriuretic peptide (NT-proBNP) are widely used for the assessment of myocardial injury and cardiovascular risk stratification. Elevated levels of these biomarkers are frequently observed in hemodialysis patients and are associated with adverse cardiovascular outcomes and increased mortality. Monitoring the dynamics of cardiac biomarkers may therefore provide valuable information regarding cardiovascular status and effectiveness of therapeutic interventions. In recent years, intradialytic physical exercise has emerged as a promising non-pharmacological approach aimed at improving functional capacity, muscle strength, cardiovascular health, and quality of life in patients on hemodialysis. Exercise performed during dialysis sessions is considered practical and feasible, as it does not require additional time outside routine treatment schedules. Previous studies have demonstrated that regular physical activity may improve hemodynamic stability, reduce inflammation, and enhance exercise tolerance in dialysis patients. However, despite increasing

interest in intradialytic exercise programs, limited data are available regarding their influence on cardiac biomarkers and subclinical myocardial injury. The effect of intradialytic physical activity on troponin and NT-proBNP levels remains insufficiently studied, particularly in patients undergoing maintenance hemodialysis.Therefore, investigating the impact of intradialytic physical exercise on the dynamics of cardiac biomarkers is of considerable clinical importance and may contribute to the development of effective cardiovascular rehabilitation strategies for hemodialysis patients.

Objective of the Study

To evaluate the effect of intradialytic physical exercise on the dynamics of cardiac biomarkers in patients undergoing maintenance hemodialysis.

2. Methods

A prospective comparative clinical study included 110 patients with end-stage chronic kidney disease undergoing maintenance hemodialysis. The mean age of the patients was 54.6 ± 11.8 years. There were 62 men (56.4%) and 48 women (43.6%). The mean duration of hemodialysis therapy was 4.2 ± 2.1 years. Patients were divided into two groups. The main group included 55 patients who performed intradialytic physical exercise. The control group included 55 patients who received standard hemodialysis without exercise. The intradialytic exercise program was performed 3 times per week during the first 2 hours of hemodialysis. Each session lasted 20–40 minutes. The total duration of the program was 12 weeks. Cardiac biomarkers were measured before and after the intervention. The main laboratory parameters included cardiac troponin I, NT-proBNP, C-reactive protein, hemoglobin, creatinine, urea and electrolytes. Hemodynamic parameters included systolic blood pressure, diastolic blood pressure and heart rate. Statistical analysis was performed using IBM SPSS Statistics. Quantitative data were presented as mean ± standard deviation (M ± SD). Qualitative data were presented as n (%). Differences were considered statistically significant at $p < 0.05$. At baseline, the groups were comparable by age, sex, dialysis duration and main clinical parameters. Mean age was 53.9 ± 10.7 years in the exercise group and 55.2 ± 12.4 years in the control group (p = 0.56). The duration of hemodialysis was 4.1 ± 1.9 years and 4.3 ± 2.3 years, respectively (p = 0.61). After 12 weeks, the exercise group showed more favorable changes in cardiac biomarkers. NT-proBNP decreased from 3850 ± 1240 pg/mL to 3260 ± 1180 pg/mL (p = 0.01), while in the control group it changed from 3920 ± 1310 pg/mL to 3890 ± 1295 pg/mL (p = 0.72). Cardiac troponin I in the exercise group decreased from 0.041 ± 0.018 ng/mL to 0.034 ± 0.015 ng/mL (p = 0.03). In the control group, troponin I changed from 0.040 ± 0.017 ng/mL to 0.042 ± 0.019 ng/mL (p = 0.48). C-reactive protein decreased in the exercise group from 8.6 ± 3.2 mg/L to 6.9 ± 2.8 mg/L (p = 0.02), whereas in the control group no significant change was observed: 8.4 ± 3.5 mg/L to 8.1 ± 3.4 mg/L (p = 0.39). Systolic blood pressure decreased from 148.5 ± 16.2 mmHg to 139.7 ± 14.8 mmHg in the exercise group (p = 0.01). In the control group, it changed from 147.9 ± 15.9 mmHg to 146.8 ± 15.6 mmHg (p = 0.57). Thus, intradialytic physical exercise was associated with a statistically significant reduction in NT-proBNP, cardiac troponin I, C-reactive protein and systolic blood pressure in patients undergoing maintenance hemodialysis.

3. Results

After 12 weeks of observation, patients who participated in the intradialytic physical exercise program demonstrated significant improvement in several cardiovascular and inflammatory parameters compared with the control group. A statistically significant reduction in NT-proBNP levels was observed in the exercise group, decreasing from 3850 ± 1240 pg/mL at baseline to 3260 ± 1180 pg/mL after completion of the intervention (p = 0.01). In contrast, no significant changes were detected in the control group, where NT-proBNP levels changed from 3920 ± 1310 pg/mL to 3890 ± 1295 pg/mL (p = 0.72). Similarly, cardiac troponin I levels significantly decreased in patients performing intradialytic exercise, from 0.041 ± 0.018 ng/mL to 0.034 ± 0.015 ng/mL (p = 0.03), indicating a reduction in subclinical myocardial injury. In the control group, troponin I levels showed no statistically significant changes, increasing slightly from 0.040 ± 0.017 ng/mL to 0.042 ± 0.019 ng/mL (p = 0.48). Inflammatory activity also improved in the exercise group. C-reactive protein levels decreased significantly from 8.6 ± 3.2 mg/L to 6.9 ± 2.8 mg/L (p = 0.02), whereas no significant reduction was observed in the control group (8.4 ± 3.5 mg/L vs 8.1 ± 3.4 mg/L, p = 0.39). Hemodynamic parameters demonstrated favorable changes among physically active patients. Systolic blood pressure significantly decreased from 148.5 ± 16.2 mmHg to 139.7 ± 14.8 mmHg (p = 0.01). In the control group, systolic blood pressure remained relatively unchanged (147.9 ± 15.9 mmHg vs 146.8 ± 15.6 mmHg, p = 0.57). In addition, patients in the exercise group reported better tolerance to hemodialysis procedures, reduced fatigue, and improvement in overall physical activity during the study period. No serious adverse cardiovascular events associated

with intradialytic exercise were recorded. The obtained results suggest that regular intradialytic physical exercise may contribute to improvement of cardiac biomarker profiles, reduction of inflammatory activity, and stabilization of hemodynamic parameters in patients undergoing maintenance hemodialysis.

4. Discussion

Cardiovascular complications remain one of the leading problems in patients receiving maintenance hemodialysis. In patients with end-stage chronic kidney disease, myocardial injury is associated with chronic volume overload, arterial hypertension, inflammation, anemia, endothelial dysfunction and repeated hemodynamic stress during dialysis sessions. According to studies conducted in Uzbekistan, cardiovascular diseases are highly prevalent among dialysis patients, and arterial hypertension, ischemic heart disease and chronic heart failure occupy a leading place in the structure of cardiovascular pathology [1,2]. In the present study, a 12-week program of intradialytic physical exercise was associated with a statistically significant improvement in cardiac biomarker dynamics. NT-proBNP decreased from 3850 ± 1240 pg/mL to 3260 ± 1180 pg/mL in the exercise group ($p = 0.01$), while no significant changes were observed in the control group. This may indicate a reduction in myocardial wall stress and improvement in hemodynamic adaptation during maintenance hemodialysis. Cardiac troponin I also showed a significant decrease in the exercise group, from 0.041 ± 0.018 ng/mL to 0.034 ± 0.015 ng/mL ($p = 0.03$). This finding suggests a possible reduction in subclinical myocardial injury. Elevated troponin levels in hemodialysis patients are considered an important marker of cardiovascular risk, even in the absence of acute coronary syndrome [7]. The decrease in C-reactive protein from 8.6 ± 3.2 mg/L to 6.9 ± 2.8 mg/L ($p = 0.02$) indicates a possible anti-inflammatory effect of regular intradialytic exercise. This is clinically relevant because chronic inflammation contributes to progression of cardiovascular complications in patients with chronic kidney disease. A significant reduction in systolic blood pressure was also observed in the exercise group, from 148.5 ± 16.2 mmHg to 139.7 ± 14.8 mmHg ($p = 0.01$). These results are consistent with international data showing that intradialytic exercise may improve blood pressure control, physical performance, dialysis tolerance and cardiovascular status [6,8,9]. The results of this study support the concept that intradialytic physical exercise is a safe, accessible and clinically useful component of cardiovascular rehabilitation in patients undergoing maintenance hemodialysis. Its routine implementation may help reduce cardiovascular risk, improve functional status and enhance quality of life in this high-risk population.

5. Conclusions

Intradialytic physical exercise was associated with a significant improvement in cardiac biomarker dynamics in patients undergoing maintenance hemodialysis.

After 12 weeks, patients in the exercise group showed a statistically significant decrease in NT-proBNP levels from 3850 ± 1240 pg/mL to 3260 ± 1180 pg/mL ($p = 0.01$).

Cardiac troponin I levels also significantly decreased in the exercise group from 0.041 ± 0.018 ng/mL to 0.034 ± 0.015 ng/mL ($p = 0.03$), suggesting a reduction in subclinical myocardial injury.

Intradialytic exercise contributed to a significant decrease in C-reactive protein levels and systolic blood pressure.

No significant changes in cardiac biomarkers or hemodynamic parameters were observed in the control group.

Intradialytic physical exercise may be considered a safe and effective component of cardiovascular rehabilitation in patients receiving maintenance hemodialysis.

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