Hunjul et al. BMC Nephrology (2025) 26:510
https://doi.org/10.1186/s12882-025-04436-1

BMC Nephrology

RESEARCH

Open Access

Exploring the relationship between intravenous iron therapy and troponin T levels in hemodialysis patients: a cross-sectional study

Marah Hunjul[1†], Diana Owda[1†], Bayan Sawaid[1†], Heba Saadeh[1], Ahmad Enaya[2], Zakaria Hamdan[1*] and Zaher Nazzal[1*]

Abstract

Background Cardiac troponin T is often elevated in hemodialysis patients, even without apparent heart disease. Cardiac troponin T has been used to predict mortality and morbidity among asymptomatic dialysis patients. However, only a single retrospective study has reported that higher IV iron use was associated with higher troponin levels; therefore, it remains unclear whether IV iron therapy could influence troponin levels and thus affect patients' outcomes.

Methods A cross-sectional study was conducted from February 2023 to October 2024 at the dialysis unit. We included 244 patients who had been on hemodialysis for more than 3 months, were on IV iron therapy, and were aged 18 years or older. High-sensitivity troponin T level (h-cTnT) was measured before the start of the dialysis session, and patients were stratified into two groups based on h-cTnT (≤ 60 ng/L and > 60 ng/L).

Results Among 224 hemodialysis patients (137 male, 87 female; mean age of 59.96 ± 13.02 years). The average IV iron dose was 255.5 ± 143.0 mg/month. hs-TnT levels averaged 90.5 ± 89.4 ng/L, with 58.5% (131 patients) have h-cTnT level > 60 ng/L. No significant relationship between IV iron and h-cTnT was found. However, higher h-cTnT levels were significantly associated with male gender, age, ischemic heart disease, cerebrovascular accidents, statin use, and doxazosin. The > 60 ng/L group had a significantly lower processed blood volume ($p = 0.038$), shorter effective treatment time ($p = 0.021$), and lower KT/V urea ($p = 0.008$). Albumin levels were also lower in this group ($p = 0.018$).

Conclusion There is no statistically significant relationship between h-cTnT and IV iron. However, these results don't eliminate the importance of IV iron therapy in hemodialysis patients.

†Marah Hunjul, Diana Owda and Bayan Sawaid contributed equally to this work.

*Correspondence:
Zakaria Hamdan
z.hamdan@najah.edu
Zaher Nazzal
znazzal@najah.edu

Full list of author information is available at the end of the article

Clinical trial number Not applicable.

Keywords High-sensitivity troponin, Hemodialysis, Iron, Ischemic heart disease

Introduction

The prevalence of End-stage renal disease (ESRD) is increasing rapidly worldwide [1]. Patients with ESRD are dependent on peritoneal dialysis or hemodialysis (HD) to get rid of body wastes [2]. The leading cause of death in ESRD patients is cardiovascular disease, which is the most common complication in this vulnerable population [3, 4]. Furthermore, anemia, which occurs as a result of reduced erythropoietin production and loss of iron, is one of the most common problems in ESRD patients, especially those treated with HD [5]. According to the PIVOTAL trial, Patients on HD need an average of 2400 mg/year to maintain a stable level of ferritin around 650 ng/ml [6], due to iron loss from HD procedure and blood sampling [7]. Adequate iron stores are essential for achieving optimal hemoglobin (HGB) levels and maximum benefit from erythropoiesis-stimulating agents (ESAs) [8].

Intravenous (IV) iron therapy has been a mainstay of anemia management in HD patients for years [9]. It enhances the response to ESAs, as shown by several clinical studies [6, 10]. However, there's an ongoing discussion about the potential unintended effects of IV iron therapy, particularly on heart health. A previous study shows that IV iron supplements for ESRD patients with heart failure with reduced ejection fraction (HFrEF) decrease heart failure symptoms and improve physical activity [9]. Earlier studies in HD patients found that high-dose IV iron is better than low-dose in lowering the risk of death, reducing the dose of ESAs, blood transfusions, and major nonfatal cardiovascular events [6].

Cardiac troponin T is often elevated in HD patients, even without any apparent heart attack [11, 12], and has been used to predict mortality and morbidity among asymptomatic HD patients [13, 14]. High levels have been linked to worse prognosis and were found to increase mortality risk by two [11, 13, 15–17]. Despite this, it remains unclear whether certain treatments, like IV iron therapy, may influence these troponin levels and what this might mean for patient outcomes. Additionally, IV iron therapy has been linked to reduced mortality in this population [18]. However, despite an extensive literature review, only one study has explored the relationship between these two variables. This study reported higher cardiac troponin T (h-cTnT) levels were associated with increased IV iron treatment and elevated ferritin levels [19].

In Palestine, considerable research has been conducted on various aspects of HD patient care, including the impact of patient education and counseling on therapeutic outcomes and the influence of nutritional status on quality of life [20–23]. However, no studies have specifically examined the relationship between IV iron therapy and cardiac troponin T levels in this population. Given the clinical significance of both parameters in patients with HD and the limited available data, this study aims to investigate the association between IV iron therapy and h-cTnT levels in patients with HD.

Methodology

Study design and population

This cross-sectional study was conducted between February 2023 and October 2024 at the An-Najah National University Hospital (NNUH) Dialysis Unit. As a referral center for ESRD patients across the West Bank, it serves a diverse patient population, making it an ideal setting for conducting this study and ensuring the generalizability of the findings.

In the HD unit, there are 269 long-term HD patients; only 224 patients met the inclusion criteria and were enrolled. Patients in the dialysis unit took IV Iron according to KDIGO guidelines [24], and adjusted according to monthly blood test results for ferritin and transferrin saturation. We give IV iron with a ferritin level up to 700 mg and transferrin saturation of 25–30%. Eligible participants were adults aged 18 years or older with ESRD, undergoing HD for a minimum of three months, receiving dialysis three times per week, and administered intravenous iron during the study period. All dialysis sessions were conducted at a single hospital-based HD unit. A total of 45 patients were excluded from the study: 30 patients did not receive IV iron during the study period, 11 patients were on HD for less than three months, and four patients were under 18 years of age. The remaining 224 patients were stratified into two groups based on their h-cTnT (≤ 60 and > 60 ng/L), as this threshold has the highest sensitivity and specificity in patients on HD, 0.70 and 0.83 consecutively [25]. The two groups were: 93 patients (41.5%) had h-cTnT levels ≤ 60, while 131 patients (58.5%) had levels > 60.

Variables and measurement tools

Demographic and clinical characteristics were collected from the patient's medical records and HD charts, Gender, age, weight, Body mass index (BMI), smoking status, HD vintage (duration in months between HD initiation and research data entry), vascular access for HD, medications, and history of diabetes mellitus, hypertension, ischemic heart disease (IHD), and cerebrovascular accident (CVA).

Whereas HGB (g/dl), iron level (mcg/dl), transferrin saturation (%), ferritin (ng/dl), albumin (pg/ml), phosphate (mg/dl), Parathyroid hormone (PTH) (pg/ml), were taken from medical records as an average value of 21 months from February 2023 to October 2024. IV sucrose supplement dose(mg/month), darbepoetin dose (mcg/month), systolic blood pressure SBP (mmHg), systolic difference (pre-SBP -post-SBP) (mmHg), mean arterial pressure (MAP) (mmHg), Blood volume processed (L), effective treatment time (hours), Ultrafiltration volume (L), ultrafiltration rate(ml/H/kg) and clearance*time/volume (KT/V), were also taken from medical records as an average value for the same duration.

Patients in the dialysis unit follow one of these schedules for receiving dialysis three sessions per week: Sunday, Tuesday, and Thursday, or Saturday, Monday, and Wednesday. Before initiating the dialysis session on Wednesday and Thursday in October 2024, a blood sample was collected from each of the 224 participants to measure h-cTnT (ng/L) and C-reactive protein (CRP, mg/L). h-cTnT levels were analyzed using an immunochemistry analyzer (Cobas e 402, Roche Diagnostics), while CRP levels were determined through a combination of photometric and ion-selective electrode (ISE) testing using the Cobas c 303 system (Roche Diagnostics).

Table 1 Socio-demographics and clinical characteristics of hemodialysis patients on IV iron

Characteristics	Frequency (%)	Mean ± SD
Gender:		
Male	137 (61.2%)	
Female	87 (38.8%)	
Age:		59.96 ± 13.61
BMI		28.68 ± 6.66
Smoking		
Current smoker	49 (21.9%)	
Previous smoker	19 (8.5%)	
Non-smoker	156 (69.6%)	
Dialysis vintage in months		64.01 ± 49.11
HD Access		
Arteriovenous fistula	203 (90.6%)	
Central venous catheter	21 (9.4%)	
Comorbidities		
Diabetes Mellitus	129 (57.6%)	
Hypertension	158 (70.5%)	
IHD	71 (31.7%)	
CVA	14 (6.3%)	
Medication		
RAAS	32(14.3%)	
Beta-blockers	130 (58.0%)	
Calcium channel blocker	135 (60.3%)	
Statin	103 (46.0%)	
Doxazosin	51 (22.8%)	
Anti-Platelet (Aspirin or Clopidogrel)	110 (49.1%)	

BMI: Body mass index, HD: Hemodialysis, IHD: Ischemic heart disease, CVA: Cerebrovascular accident, RAAS: The renin-angiotensin-aldosterone system

Statistical analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS), version 25. Descriptive statistics were applied to summarize patient characteristics, with categorical variables presented as frequencies and percentages and continuous variables expressed as means and standard deviations. h-cTnT levels were categorized using a cut-off value of 60 ng/L, based on prior research indicating this threshold provides the highest sensitivity (0.70) and specificity (0.83) [25]. Comparisons between the two groups (h-cTnT levels ≤ 60 ng/L and > 60 ng/L) were performed using Crosstab and Chi-square tests for categorical variables and Independent Sample T-tests for continuous variables. Furthermore, variables that showed a significant association with h-cTnT level in the univariate analysis and those considered important in the literature were included in the multivariate analysis to control for confounders and identify independent factors. Statistical significance was defined as a P-value ≤ 0.05.

Ethical consideration

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was granted by the Institutional Review Board (IRB) at NNUH (Ref: Med. Dec. 2023/34) in Palestine, and official permission was obtained from the hospital to proceed with the research. All participants were informed about the study's objectives and the voluntary nature of their participation. Those who agreed to take part provided written informed consent. Patient privacy and data confidentiality were strictly maintained, with all collected information accessible only to the research team. Participants retained the right to withdraw from the study at any time.

Results

The study included 224 patients whose demographic and clinical characteristics are detailed in Table 1. Of the participants, 137 (61.2%) were male, and 87 (38.8%) were female, with a mean age of 59.96 ± 13.02 years and a BMI of 28.68 ± 6.66 kg/m^2. Most patients were nonsmokers (156, 69.6%). The mean duration of HD was 64.01 ± 49.11 months, and the majority (203, 90.6%) utilized arteriovenous fistulas for HD access. Hypertension was diagnosed in 158 patients (70.5%), diabetes mellitus in 129 (57.6%), and ischemic heart disease in 71 (31.7%). Regarding medication use, 32 patients (14.3%) were receiving Renin-Angiotensin-Aldosterone System (RAAS) inhibitors, 135 (60.3%) were on calcium channel blockers, 110 (49.1%) were taking antiplatelet therapy, and nearly half (103, 46.0%) were on statins.

Table 2 presents descriptive laboratory tests and dialysis-related parameters. Key findings include h-cTnT of 90.5 ± 89.4 ng/dl, CRP levels of 14.3 ± 19.0 mg/L, ferritin levels of 754.0 ± 356.9, transferrin saturation of 32.2 ± 8.4, and albumin levels averaged 3.9 ± 0.26. The monthly erythropoietin and IV iron doses were 85.5 ± 80.4 and 255.5 ± 143.0, respectively. Hemodynamic parameters over a 21-month observation period (February 2023–October 2024) revealed an average SBP at the start of HD treatment was 146.7 ± 19.8 mmHg, systolic blood pressure difference (post-SBP- pre-SBP) was – 14.2 ± 14.3, and a MAP of 98.0 ± 13.2 mmHg. Dialysis adequacy and efficiency measures included KT/V of 1.19 ± 0.26, an average blood volume processed of 70.6 ± 8.7 L, and treatment time of 3.39 ± 0.25 h. The ultrafiltration volume was 2.69 ± 0.94 L, and the ultrafiltration rate was 10.4 ± 3.4 mL/kg/hour.

After stratifying patients by h-cTnT levels into two groups (≤ 60 ng/L and > 60 ng/L), 93 patients (41.5%) had h-cTnT levels ≤ 60 ng/L, while 131 patients (58.5%) had levels > 60 ng/L. Univariate analysis using Chi-square tests identified significant associations between elevated h-cTnT (> 60 ng/L) and several categorical variables, including male gender ($p < 0.001$), age > 60 years ($p = 0.015$), history of CVA ($p = 0.007$), IHD ($p = 0.006$), and the use of RAAS inhibitors ($p = 0.001$), statins ($p < 0.001$), and doxazosin ($p = 0.046$). Conversely, no significant associations were found between h-cTnT level and BMI, hypertension, smoking status, HD access type, beta-blockers, or calcium channel blockers (Table 3).

Table 2 Laboratory and Dialysis parameters presented by (mean ± SD)

Parameter	Mean ± SD
h-cTnT (ng/dl)	90.5 ± 89.4
CRP (mg/L)	14.3 ± 19.0
HGB(g/dl)	10.5 ± 0.9
Iron Level (mcg/dL)	64 ± 13.8
Transferrin saturation (%)	32.2 ± 8.4
Ferritin (ng/dl)	754.0 ± 356.9
Albumin level (in g/dl)	3.9 ± 0.26
PTH (pg/ml)	289.2 ± 351.8
Phosphate (mg/dl)	4.4 ± 1.0
SBP (mmHg)*	146.7 ± 19.8
SBP difference (post-SBP- preSBP) (mmHg)*	-14.2 ± 14.3
MAP (mmHg)*	98.0 ± 13.2
Blood volume Processed (L)*	70.6 ± 8.7
Effective treatment time (h)*	3.39 ± 0.25
Ultrafiltration volume (L)*	2.69 ± 0.94
Ultrafiltration Rate (ml/Kg/hr)*	10.4 ± 3.4
KT/V*	1.19 ± 0.26
Average IV Iron supplement dose (mg/month)	255.5 ± 143.0
Average darbepoetin dose (mcg/month)	85.5 ± 80.4

*Average for 21 months duration, Feb.2023-Oct.2024; h-cTnT: High-sensitivity cardiac troponin T, SBP: systolic blood pressure, MAP: mean arterial blood pressure, CRP: C-reactive protein, HGB: Hemoglobin. ○ Difference between pre-SBP, systolic blood pressure before starting hemodialysis, and post-SBP, systolic blood pressure at the end of the hemodialysis treatment

Table 4 compares clinical and laboratory measures stratified by h-cTnT levels (≤ 60 and > 60). h-cTnT > 60 group exhibited significantly lower blood volume processed (69.5 ± 9.1 L vs. 72.0 ± 8.0 L, $p = 0.038$), shorter effective treatment time ($p = 0.021$), and kT/V ($p = 0.008$). Albumin levels were also slightly but significantly lower in the h-cTnT > 60 group ($p = 0.018$). These findings suggest a potential relationship between higher h-cTnT, suboptimal dialysis, and nutritional parameters.

The findings of the multivariate analysis assessing factors predicting h-cTnT levels are summarized in Table 5. Male patients were significantly more likely to have elevated h-cTnT levels than females (Adjusted OR: 5.2, 95% CI: 2.3–11.9, $P < 0.001$). Although patients with IHD had higher odds of elevated h-cTnT levels, the association was not statistically significant (Adjusted OR: 1.6, 95% CI: 0.79–3.18, $P = 0.200$).

Statin use was significantly associated with increased odds of elevated h-cTnT levels (Adjusted OR: 2.4, 95% CI: 1.3–4.5, $P = 0.008$), and patients receiving doxazosin also had higher odds of elevated h-cTnT levels (Adjusted OR: 2.3, 95% CI: 1.0–4.9, $P = 0.038$). Conversely, lower albumin levels were significantly associated with reduced odds of elevated h-cTnT levels (Adjusted OR: 0.17, 95% CI: 0.04–0.70, $P = 0.014$). Similarly, an increase in the blood volume processed during dialysis was linked to lower odds of elevated h-cTnT levels (Adjusted OR: 0.95, 95% CI: 0.911–0.997, $P = 0.038$).

Discussion

h-cTnT is a key marker for diagnosing acute myocardial infarction. However, patients on regular HD typically have elevated h-cTnT levels compared to the general population, complicating diagnosis in this group. Currently, there is no specific cutoff level for h-cTnT in patients with ESRD, as existing cutoffs are based on data from the general population without ESRD [26–28] The higher levels in the HD population can be partly explained by ventricular dysfunction, left ventricular hypertrophy, myocardial stunning, endothelial dysfunction, decreased renal clearance, the occurrence of microinfarction, and or degenerative changes [29]. Our patients had a pre-dialysis h-cTnT mean of 90.5 ± 89.4 ng/L, similar to the pre-dialysis h-cTnT means of previous studies that ranged from 52 to 111 ng/L [14, 30–33]. Further studies are needed to establish a universal h-cTnT cutoff value to improve the mortality outcome.

When comparing asymptomatic HD patients with h-cTnT levels above 0.1 mg/dl with those with levels below 0.1 mg/dl, patients with higher h-cTnT levels received higher doses of IV iron sucrose [19]. In our study, the average IV Iron supplement dose was

Table 3 Relation between patients' background and clinical characteristics and h-cTnT level

	h-cTnT ≤ 60 *n*(%)	h-cTnT > 60 *n*(%)	*P*-value*
Gender			< 0.001
Male	44(32.1%)	93(67.9%)	
Female	49(56.3%)	38(43.7%)	
Age			0.015
< 60	50(50.5%)	49(49.5%)	
> 60	43(34.4%)	82(65.6%)	
BMI			0.188
< 30	53(38.1%)	86(61.9%)	
> 30	40(47.1%)	45(52.9%)	
Hypertension			0.635
Yes	64(40.5%)	94(59.5%)	
No	29(43.9%)	37(56.1%)	
Diabetes			0.019
Yes	45(34.9%)	84(65.1%)	
No	48(50.5%)	47(49.5%)	
Ischemic Heart Disease			0.006
Yes	20(28.2%)	51(71.8%)	
No	73(47.7%)	80(52.3%)	
Cerebrovascular accident			0.007
Yes	1(7.1%)	13(92.9%)	
No	92(43.8%)	118(56.2%)	
RAAS			0.001
Yes	5(15.6%)	27(84.4%)	
No	88(45.8%)	104(54.2%)	
B blockers			0.994
Yes	54(41.5%)	76(58.5%)	
No	39(41.5%)	55(58.5%)	
Calcium channel blocker			0.771
Yes	55(40.7%)	80(59.3%)	
No	38(42.7%)	51(57.3%)	
Statin			< 0.001
Yes	29(28.2%)	74(71.8%)	
No	64(52.9%)	57(47.1%)	
Doxazosin			0.046
Yes	15(29.4%)	36(70.6%)	
No	78(45.1%)	95(54.9%)	
Anti-Platelet*(Aspirin or clopidogrel)*			0.009
Yes	36(32.7%)	74(67.3%)	
No	57(50.0%)	57(50.0%)	
Smoking status			0.544
Current smoker	17(34.7%)	32(65.3%)	
Previous smoker	8(42.1%)	11(57.9%)	
Non-smoker	68(43.6%)	88(56.4%)	
Access for hemodialysis			0.127
Arteriovenous fistula (AVF"	81(39.9%)	122(60.1%)	
Central venous catheter "CVC"	12(57.1%)	9(42.9%)	

*Chi-square test, BMI: body mass index, RAAS: Renin-Angiotensin-Aldosterone system medication

Table 4 Correlations between clinical and lab measures and h-cTnT

	h-cTnT ≤ 60 (Mean ± SD)	h-cTnT > 60 (Mean ± SD)	*P*-value*
Dialysis duration in months	66.5 ± 54.3	62.2 ± 45.2	0.524
CRP	13.1 ± 20.1	15.1 ± 18.2	0.426
Iron level (mcg/dL)	66.4 ± 13.9	63.1 ± 13.6	0.077
Ferritin (ng/dl)	749.6 ± 389.1	757.2 ± 333.6	0.876
HGB(g/dl)	10.6 ± 0.9	10.5 ± 0.8	0.284
Transferrin saturation (%)	33.5 ± 9.9	31.3 ± 7.1	0.058
Albumin level (g/dl)	4.0 ± 0.2	3.9 ± 0.3	0.018
Phosphate (mg/dl)	4.4 ± 1.1	4.4 ± 0.9	0.900
PTH(pg/ml)	377.8 ± 319.5	397.3 ± 374.1	0.684
SBP (mmHg)	143.8 ± 20.3	148.8 ± 19.2	0.060
SBP Difference (mmHg)	-13.8 ± 14.1	-14.5 ± 14.4	0.723
MAP(mmHg)	97.6 ± 14.0	98.2 ± 12.7	0.756
Blood volume Processed (L)	72.0 ± 8.0	69.5 ± 9.1	0.038
Effective treatment time (h.min)	3.44 ± 0.23	3.36 ± 0.26	0.021
Ultrafiltration volume (L)	2.66 ± 0.97	2.72 ± 0.91	0.647
Ultrafiltration Rate (ml/Kg/hr)*	10.3 ± 3.6	10.4 ± 3.1	0.782
KT/V*	1.25 ± 0.27	1.15 ± 0.24	0.008
Avg Iron supplement dose (mg/month)	246.4 ± 119.9	261.9 ± 157.5	0.424
Average erythropoietin dose (mcg/month)	80.4 ± 74.1	89.2 ± 84.8	0.421

*Independent sample t-test, SBP: systolic blood pressure, MAP: mean arterial pressure, Avg: average, CRP: C-reactive protein, HGB: hemoglobin

Table 5 Multivariate analysis of factors predicting h-cTnT level among Hemodialysis patients

	S.E.	*P* value	Adjusted OR (95%CI)
Gender *(Ref = female)*	0.418	< 0.001	5.2 (2.3–11.9)
Age *(Ref = more than 60)*	0.334	0.094	0.57 (0.30 – 1.10)
IHD *(Ref = No)*	0.357	0.200	1.6 (0.79-3.18)
Statin *(Ref = No)*	0.326	0.008	2.4 (1.3–4.5)
Doxazosin *(Ref = No)*	0.394	0.038	2.3 (1.0-4.9)
Transferrin saturation	0.037	0.126	0.95 (0.88 – 1.0)
KT/V	0.843	0.241	2.7 (0.52 – 14.0)
Iron level	0.022	0.288	1.02 (0.98- 1.07)
CRP	0.009	0.684	1.00 (0.99- 1.02)
Albumin	0.730	0.014	0.17 (0.04- 0.70)
Blood volume processed	0.023	0.038	0.95 (0.911- 0.997)
Avg Darbepoetin	0.002	0.305	1.0 (0.998- 1.007)
Avg IV Iron supplement dose	0.001	0.817	1.0 (0.997- 1.002)

255.5 ± 143.0 (mg/month), and when comparing it to h-cTnT, there was no significance between these two variables. Patients with h-cTnT levels above 60 ng/L received a median dose over 20 months of 246.4 ± 119.9 mg/month vs. 261.9 ± 157.5 for patients with lower h-cTnT levels below 60 ng/L, which was not statistically significant after multivariate analysis (P-value: 0.575). Our results are similar to a previous randomized controlled trial for non-dialysis chronic kidney disease patients taking a moderate dose of IV iron therapy, where cardiac markers such as N-terminal pro-B-type natriuretic peptide and troponin T were studied and showed results with no change, suggesting the cardiovascular safety of moderate IV iron therapy in this population [34]. A large cohort observational study of 58,058 HD patients who received doses greater than a monthly dose of 400 mg of IV iron had higher rates of cardiovascular death [35]. In another study, patients who received IV iron in the form of ferric carboxylates, compared to a control group, with a follow-up of about 3 years, had fewer cardiac events [36]. Additionally, in our study, the average darbepoetin dose is 85.5 ± 80.4 (mcg/month), and there was no significant association between it and h-cTnT (P-value: 0.421).

According to age, our study showed that higher h-cTnT levels are associated with older patients > 60 years; 82 patients (65.6%) had h-cTnT levels (> 60 ng/L). Few studies have studied the relationship between troponin levels and different age groups. It found that thresholds are greater for the older age group, which means the optimal cutoff of troponin levels may be higher in the elderly compared to younger patients [26].

Our study demonstrated that overall troponin T-level measurements are significantly lower in females than males. Previous studies indicated that women commonly have lower cardiac troponin concentrations and are less frequently diagnosed with acute myocardial infarction [37]. Lower cardiac troponin levels were likely the result of lower left ventricular mass, which is correlated with cardiac troponin concentration and was smaller in women [27].

In our multivariate analysis study, there was no statistically significant result for h-cTnT in patients with a history of IHD ($p = 0.200$). Compared with other studies, there was a positive association between history of IHD and h-cTnT in HD patients, with those who have an elevation in serial h-cTnT values being more likely to have a subsequent acute ischemic cardiac event [38, 39]. This contradiction in results may be due to the limitations of our research: We used one single h-cTnT value for each patient without taking serial levels or comparing it with the h-cTnT values post-dialysis sessions, the small sample size, and the small percentage of IHD patients in our population (31.7%).

There was a significant relation between h-cTnT and statin use ($p = 0.001$). Significance also appears in the multivariate analysis ($p = 0.008$). Statin users showed a substantial increase in h-cTnT levels; 74 patients (71.8%) had h-cTnT levels (> 60 ng/L). These findings may point to the need for further trials regarding statin use in the HD population because previous landmark trials have failed to prove the cardiovascular benefits of statins in HD patients [40, 41].

Our research shows a significant relationship between h-cTnT and doxazosin ($p = 0.046$). In a group of 51 patients who take doxazosin, 36 patients (70.6%) have h-cTnT < 60. Renal impairment doesn't affect the pharmacokinetics of doxazosin. Successful reduction in blood pressure measurements is achieved in these patients without adversely affecting their renal function [28]. This raises the need for further research to study the effect of doxazosin in cardiovascular disease prevention.

Many studies have shown that combining CRP and h-cTnT will significantly strengthen the prediction of IHD independently of each other [42–44]. In our multivariate analysis study, CRP was not statistically significant in the h-cTnT subgroups ($p = 0.684$), possibly due to the lack of serial monitoring for these independent variables and other limitations shown below. Our research found higher h-cTnT levels among patients with lower albumin levels. This could be attributed to chronic inflammation, where inflammatory markers break down the Albumin, thus causing cardiovascular complications [45].

KT/V represents the adequacy of HD, where an optimal value of 1.2 was associated with decreased mortality and morbidity [46, 47]. Our study found that patients with a higher KT/V value had lower h-cTnT levels than those with lower KT/V values, which could be attributed to more efficient dialysis, similar to the previous study [47]. However, after multivariate analysis, it showed no statistically significant results.

All previous research studied the effect of blood flow and Troponin T, where higher blood flow increases the Troponin T levels [48]. However, in our study, there was no statistically significant effect of the blood flow rate on h-cTnT levels. It's also worth mentioning that no previous research has discussed the impact of blood volume dialyzed. Our research found a significant relation between h-cTnT and blood volume dialyzed, where patients with larger amounts of blood volume dialyzed had lower h-cTnT levels.

Higher blood pressure is a risk factor for cardiovascular diseases, where high systolic blood pressure levels are associated with higher levels of h-cTnT level [49], similar to what we found in our population. There was also no significant association between the change in blood pressure after the end of the HD treatment and h-cTnT levels.

This study was limited by the following points: First, this was a retrospective cross-sectional study design, which limits our ability to establish a causal relationship between variables. Secondly, a Lack of serial troponin T levels, especially post-dialysis. Furthermore, there is a lack of ECGs and ECHO for better evaluation of patients' cardiac condition.

Conclusion

High-sensitivity troponin T (h-cTnT) is used in the early detection of cardiac injury, while elevation of its levels increases the mortality rates in ESRD patients. IV iron therapy decreases the mortality in these patients, and it is used to treat anemia as the most common complication affecting ESRD on HD. After assessing the relationship between IV iron therapy doses and the level of cardiac troponin among ESRD patients in HD, there is no significant relationship between them. Therefore, we recommend further studies that follow patients for a longer duration and compare h-cTnT levels among HD patients receiving different doses and durations of IV iron. we recommend further studies that follow patients for a longer duration and compare h-cTnT levels among HD patients receiving different doses of IV iron, we also recommend a controlled trial to assess the effect of IV iron withholding on TnT levels in dialysis patients and then challenging them with iron and observe if there are quantitative differences in levels period. we advocate further efforts in research to detect a cut-off value for h-cTnT in asymptomatic HD patients to decrease the cardiovascular morbidity and mortality among this population. we advise comparing the h-cTnT results before and after HD sessions to measure the efficacy of HD clearance of this molecule in clinical practice.

Abbreviations

Avg	Average
BMI	Body Mass Index
CRP	C-reactive protein
CVA	Cerebrovascular accident
ESRD	End-stage renal disease
ESAs	erythropoiesis-stimulating agents
h-cTnT	High-sensitivity Troponin T level
HD	Hemodialysis
HGB	Hemoglobin
HFrEF	Heart failure with reduced ejection fraction
IHD	Ischemic heart disease
IRB	Institutional Review Board
ISE	Ion-selective electrode
IV	Intravenous
KT/V	Clearance*Time/Volume
MAP	Mean arterial pressure
NNUH	An-Najah National University Hospital
PTH	Parathyroid hormone
RAAS	Renin-Angiotensin-Aldosterone System
SBP	Systolic blood pressure
SPSS	Statistical Package for Social Sciences

Acknowledgements
The authors would like to thank An-Najah National University (https://www.najah.edu/en) for the technical support provided in publishing the present manuscript, and the hemodialysis patients for their valuable contributions.

Author contributions
ZH and **AE** contributed to the initial concept and study idea. **ZN, AE,** and **ZH** were responsible for study design, methodological planning, and overall supervision of the research implementation. They also critically reviewed and finalized the manuscript. **MH** , **DO** , **BS** , and **HS** were involved in data collection. **MH** and **DO** , under the supervision of **ZN** , conducted the data analysis and drafted the initial version of the manuscript. All authors reviewed, revised, and approved the final version for submission.

Funding
The authors did not receive support from any organization for the submitted work.

Data availability
The datasets generated and analyzed during this study are available from the Corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and relevant institutional guidelines. Ethical approval was obtained from the Institutional Review Board (IRB) at An-Najah National University Hospital (Ref: Med. Dec. 2023/34). All participants were fully informed of the study's objectives and the voluntary nature of their involvement. Written informed consent was obtained from each participant prior to data collection. Participant confidentiality and data privacy were protected, with access to collected data restricted to the research team. Participants were also informed of their right to withdraw from the study at any stage without any consequences.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Medicine, Faculty of Medicine and Allied Medical Sciences, An-Najah National University, Nablus, Palestine
[2]Department of Internal Medicine, An-Najah National University Hospital, Nablus, Palestine

Received: 9 June 2025 / Accepted: 28 August 2025
Published online: 02 September 2025

References

1. Kanda H, Hirasaki Y, Iida T, et al. Perioperative management of patients with End-Stage renal disease. J Cardiothorac Vasc Anesth. 2017;31:2251–67.
2. Braun MM, Khayat M. Kidney disease: End-Stage renal disease. FP Essent. 2021;509:26–32.
3. Hashmi MF, Benjamin O, Lappin SL. End-Stage Renal Disease. 2023.
4. Collins AJ. Cardiovascular mortality in End-Stage renal disease. Am J Med Sci. 2003;325:163–7.
5. Bhandari S, Spencer S, Oliveira B, et al. UK kidney association clinical practice guideline: update of anaemia of chronic kidney disease. BMC Nephrol 2025 261. 2025;26:1–37.
6. Macdougall IC, White C, Anker SD, et al. Intravenous iron in patients undergoing maintenance Hemodialysis. N Engl J Med. 2019;380:447–58.
7. Tsukamoto T, Matsubara T, Akashi Y, et al. Annual iron loss associated with Hemodialysis. Am J Nephrol. 2016;43:32–8.
8. Ali A, Salih RM. Renal anemia syndromes in Iraqi Hemodialysis patients according to iron status. Saudi J Kidney Dis Transpl. 2018;29:127–35.
9. Walther CP, Triozzi JL, Deswal A. Iron deficiency and iron therapy in heart failure and chronic kidney disease. Curr Opin Nephrol Hypertens. 2020;29:508–14.
10. Macdougall IC. Intravenous iron therapy in patients with chronic kidney disease: recent evidence and future directions. Clin Kidney J. 2017;10:i16–24.
11. Snaedal S, Bárány P, Lund SH, et al. High-sensitivity troponins in Dialysis patients: variation and prognostic value. Clin Kidney J. 2021;14:1789–97.
12. Chuang A, Nguyen MT, Kung WM, et al. High-sensitivity troponin in chronic kidney disease: considerations in myocardial infarction and beyond. Rev Cardiovasc Med. 2020;21:191–203.
13. Levin A, THE CLINICAL EPIDEMIOLOGY OF CARDIOVASCULAR, DISEASES IN CHRONIC KIDNEY DISEASE. Clinical epidemiology of cardiovascular disease in chronic kidney disease prior to Dialysis. Semin Dial. 2003;16:101–5.
14. Chen T, Hassan HC, Qian P, et al. High-Sensitivity troponin T and C-Reactive protein have different prognostic values in hemo- and peritoneal Dialysis populations: A cohort study. J Am Heart Assoc. February 2018;7. https://doi.org/10.1161/JAHA.117.007876. Epub ahead of print.
15. Gupta R, Woo K, Yi JA. Epidemiology of end-stage kidney disease. Semin Vasc Surg. 2021;34:71–8.

16. Noppakun K, Ratnachina K, Osataphan N, et al. Prognostic values of high sensitivity cardiac troponin T and I for long-term mortality in Hemodialysis patients. Sci Rep. 2022;12:13929.
17. Chesnaye NC, Al-Sodany E, Szummer K, et al. Association of longitudinal High-Sensitivity troponin T with mortality in patients with chronic kidney disease. J Am Coll Cardiol. 2022;79:327–36.
18. Zitt E, Sturm G, Kronenberg F, et al. Iron supplementation and mortality in incident Dialysis patients: an observational study. PLoS ONE. 2014;9:e114144.
19. Guz G, Sahinarslan A, Dhondt AWC, et al. Elevated cardiac troponin T in Hemodialysis patients receiving more intravenous iron sucrose. Ren Fail. 2004;26:663–72.
20. Naalweh KS, Barakat MA, Sweileh MW et al. Treatment adherence and perception in patients on maintenance hemodialysis: a cross - sectional study from Palestine. BMC Nephrol; 18. Epub ahead of print May 2017. https://doi.org/10.1186/S12882-017-0598-2
21. Hafi E, Soradi R, Diab S, et al. Nutritional status and quality of life in diabetic patients on hemodialysis: a cross-sectional study from Palestine. J Health Popul Nutr. 2021;40:30.
22. Hamdan Z, Nazzal Z, Al-Amouri FM, et al. Factors associated with malnutrition inflammation score among Hemodialysis patients: A cross-sectional investigation in tertiary care hospital, Palestine. PLoS ONE. 2025;20:e0317132.
23. Damiri B, Khatib O, Nazzal Z, et al. Metabolic syndrome associated with tobacco and caffeine products use among refugee adolescents: risk of dyslipidemia. Diabetes Metab Syndr Obes Targets Ther. 2021;14:4121–33.
24. Kdigo. Clinical practice guideline for anemia in chronic kidney disease (CKD) 2025.
25. Breidthardt T, Burton JO, Odudu A, et al. Troponin T for the detection of Dialysis-Induced myocardial stunning in Hemodialysis patients. Clin J Am Soc Nephrol. 2012;7:1285.
26. Reiter M, Twerenbold R, Reichlin T, et al. Early diagnosis of acute myocardial infarction in patients with pre-existing coronary artery disease using more sensitive cardiac troponin assays. Eur Heart J. 2012;33:988–97.
27. Mastali M, Asif A, Fu Q, et al. Ultra-highly sensitive cardiac troponin I: age and sex differences in healthy individuals. Am Hear J Plus Cardiol Res Pract. 2022;13:100110.
28. Carlson RV, Bailey RR, Begg EJ, et al. Pharmacokinetics and effect on blood pressure of Doxazosin in normal subjects and patients with renal failure. Clin Pharmacol Ther. 1986;40:561–6.
29. Katz D, Gavin MC. Stable ischemic heart disease. Ann Intern Med. 2019;171:ITC17.
30. Kampmann JD, Hunderup MM, Petersen ERB, et al. High-sensitive troponin T, SuPAR and Beta-2-microglobulin changes in concentration during Hemodialysis. Scand J Clin Lab Invest. 2024;84:362–8.
31. Hunderup MM, Kampmann JD, Kristensen FB, et al. The short-term effect of Hemodialysis on the level of high-sensitive cardiac troponin T — A systematic review. Semin Dial. 2024;37:110–6.
32. Taylor SH. Pharmacotherapeutic stature of Doxazosin and its role in coronary risk reduction. Am Heart J. 1988;116:1735–47.
33. Osawa H, Nakamura N, Tsutaya C, et al. Role of High-sensitivity C-reactive protein in future cardiovascular events in Hemodialysis patients. Vivo (Brooklyn). 2024;38:1351–8.
34. Kassianides X, Bhandari S. Patient reported outcome measures and cardiovascular outcomes following high dose modern intravenous iron in non-dialysis dependent chronic kidney disease: secondary analysis of ExplorIRON-CKD. Sci Rep. 2023;13:18401.
35. Kalantar-Zadeh K, Regidor DL, McAllister CJ, et al. Time-Dependent associations between iron and mortality in Hemodialysis patients. J Am Soc Nephrol. 2005;16:3070–80.
36. Righini M, Dalmastri V, Capelli I, et al. Intravenous iron replacement therapy improves cardiovascular outcomes in Hemodialysis patients. Vivo. 2021;35:1617–24.
37. Kimenai DM, Shah ASV, McAllister DA, et al. Sex differences in cardiac troponin I and T and the prediction of cardiovascular events in the general population. Clin Chem. 2021;67:1351–60.
38. Kang E, Ryu H, Kim J et al. Association between high-sensitivity cardiac troponin T and echocardiographic parameters in chronic kidney disease: results from the KNOW-CKD cohort study. J Am Heart Assoc; 8. Epub ahead of print September 2019. https://doi.org/10.1161/JAHA.119.013357
39. Patel SM, Qamar A, Giugliano RP, et al. Association of serial High-Sensitivity cardiac troponin T with subsequent cardiovascular events in patients stabilized after acute coronary syndrome. JAMA Cardiol. 2022;7:1199.
40. Wanner C, Krane V, März W, et al. Atorvastatin in patients with type 2 diabetes mellitus undergoing Hemodialysis. N Engl J Med. 2005;353:238–48.
41. Fellström BC, Jardine AG, Schmieder RE, et al. Rosuvastatin and cardiovascular events in patients undergoing Hemodialysis. N Engl J Med. 2009;360:1395–407.
42. deFilippi C, Cardiac Troponin T. Protein for predicting prognosis, coronary atherosclerosis, and cardiomyopathy in patients undergoing Long-term Hemodialysis. JAMA. 2003;290:353.
43. Li W-J, Chen X-M, Nie X-Y, et al. Cardiac troponin and C-reactive protein for predicting all-cause and cardiovascular mortality in patients with chronic kidney disease: A meta-analysis. Clinics. 2015;70:301–11.
44. Mukai H, Villafuerte H, Qureshi AR, et al. Serum albumin, inflammation, and nutrition in end-stage renal disease: C-reactive protein is needed for optimal assessment. Semin Dial. 2018;31:435–9.
45. Forghani MS, Jadidoleslami MS, Naleini SN, et al. Measurement of the serum levels of serum troponins I and T, albumin and C-Reactive protein in chronic Hemodialysis patients and their relationship with left ventricular hypertrophy and heart failure. Diabetes Metab Syndr Clin Res Rev. 2019;13:522–5.
46. Iman Y, Bamforth R, Ewhrudjakpor R, et al. The impact of dialysate flow rate on haemodialysis adequacy: a systematic review and meta-analysis. Clin Kidney J. 2024;17:sfae163.
47. Barzegar H, Moosazadeh M, Jafari H, et al. Evaluation of Dialysis adequacy in Hemodialysis patients: A systematic review. Urol J. 2016;13:2744–9.
48. Mavrakanas TA, Sniderman AD, Barré PE, et al. High ultrafiltration rates increase troponin levels in stable Hemodialysis patients. Am J Nephrol. 2016;43:173–8.
49. Madan N, Lee AK, Matsushita K, et al. Relation of isolated systolic hypertension and pulse pressure to high sensitivity cardiac Troponin-T and N-terminal pro-B-type natriuretic peptide in older adults (From the atherosclerosis risk in communities Study). Am J Cardiol. 2019;124:245.

Publisher's note