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ORIGINAL ARTICLE

Association between Anemia Severity and Left Ventricular Hypertrophy in Patients with Chronic Kidney Disease

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ABSTRACT

Background: Anemia is one of the frequent complications that accompany chronic kidney disease (CKD) and leads to cardiovascular morbidity. Left ventricular hypertrophy (LVH), is a common disease among patients with CKD and it has poor prognosis. The severity of anemia and LVH, however, is not entirely characterized, especially in the local populations.

Objective: To establish the correlation between the severity of anemia and the existence of the left ventricular hypertrophy among the patients with chronic kidney disease visiting the medical outpatient clinics.

Methods: The study was a cross-sectional study, conducted at the Medical Teaching Institution Bannu and Medical Teaching institution DI Khan during six months between Feb 2022 and July 2022. The patients with adult CKD were recruited in a sequential manner and the demographic, clinical and laboratory information such as hemoglobin level were noted. Anemia was categorized as mild, moderate and severe. Each one of them was subjected to transthoracic echocardiography to determine the left ventricular mass and LVH. The severity of anemia and LVH were determined with chi-square and ANOVA tests and $p<0.05$ was taken as significant.

Results: Among the 120 patients studied, 70 (58.3) patients had LVH. The frequency of LVH had an emetic relation with the severity of anemia: mild anemia (29.4%), moderate anemia (60.9%), and severe anemia (80.0%) ($p<0.001$). The mean left ventricular mass index was significantly more in patients with severe anemia than mild or moderate anemia. Further factors that were related to LVH were CKD stage and hypertension.

Conclusion: The existence and extent of LVH in patients with CKD are closely related to intensified anemia. Timely detection and control of anemia could be beneficial particularly in minimizing cardiac remodelling and cardiovascular outcomes.

Keywords: Anemia; Chronic kidney disease; Left ventricular hypertrophy; Cardiovascular risk.

INTRODUCTION

Chronic kidney disease (CKD) is a phenomenon that is rapidly developing in the world, and that it comes with a lot of morbidity and mortality as far as cardiovascular health is concerned. Cardiovascular disease is the leading cause of mortality in patients with CKD and is higher than the risk of the condition developing into end-stage renal disease. The cardiac changes in the structural and functional aspects occur in the early stages during the CKD and deteriorate with worsening renal functioning[1].

One of the most common and clinically important cardiac manifestations of CKD patients is left ventricular hypertrophy (LVH). It is regarded as an independent predictor of unfavourable cardiovascular outcomes, such as heart failure, arrhythmia, and sudden cardiac death. The etiology of LVH in CKD is complex, and it includes the pressure overload, volume overload, metabolic derangement, and neurohormonal stimulation[2].

Anemia is an apparent complication to CKD, and it emerges early because of low production of erythropoietin, iron deficiency, inflammation and reduced red blood cell survival. Anemia is more common and severe with the deterioration of glomerular filtration rate, which is a major cause of reduced quality of life and cardiovascular risk in this patient group[3].

In CKD patients, anemia has a significant role in the initiation and progress of the LVH. Decreased oxygen-carrying capacity results in the tissue hypoxia with the compensatory measures like high cardiac output and myocardial overworking. The continual activation of these compensatory mechanisms causes left ventricular hypertrophy and remodelling of the myocardium[4].

Some studies have shown that there is a close relationship between decreased hemoglobin concentration and high left ventricular mass in patients with CKD. Extent of LVH has been found to be related to severity of anemia implying that there is dose response between the two. This correlation still remains despite the correction of the traditional cardiovascular risk factors like hypertension and diabetes mellitus[5].

Potential solution to avoid or reduce cardiac remodeling in CKD is the early detection and proper treatment of anemia. It has been shown that balancing of anemia with the use of erythropoiesis-stimulating agents and iron therapy could result in regression of LVH or delay its progression, although optimal targets are still a matter of discussion[6,7].

Although the connection between anemia and cardiovascular complications in CKD has been determined, there is limited local data that explores the relationship between the degree of anemia and LVH. The regional population should understand this association in order to be able to stratify risks early and maximize management to minimize cardiovascular morbidity among patients with CKD[8].

Objective: To establish the relationship between the severity of the anemia and the presence of the left ventricular hypertrophy in the patients with chronic kidney disease, who refer to a tertiary care hospital.

METHODOLOGY

Study Design: This research was carried out as a cross-sectional observational study that was conducted in a hospital to determine the relationship between the severity of anemia and left ventricular hypertrophy (LVH) among chronic kidney disease (CKD) patients.

Study Setting: The research was conducted at the Medical Teaching Institution Bannu and Medical Teaching institution DI Khan during six months between Feb 2022 and July 2022.The access to laboratory services and echocardiography services facilitated full clinical and cardiac assessment of registered participants.

These patients were adult patients that had a known history of chronic kidney disease at the age of 18 years and above regardless of their etiology or stage, visiting medical outpatient clinics or hospitalized in medical wards. Patients who had known congenital heart disease, significant valvular heart disease, previous myocardial infarction, cardiomyopathy that was not related to CKD or acute blood loss were excluded to eliminate possible confounding variables on left ventricular structure.

Sample Size and Sampling Technique: The eligible patients in the course of the study were enrolled by a non-probability consecutive non-probability sampling approach. The sample was deemed to be

sufficient when gauging the relationship between severity of anemia and LVH in the limited resources and time available in the institution.

Data Collection Procedure: After obtaining informed consent, demographic data including age and gender were recorded. Clinical parameters such as blood pressure, body mass index, duration and stage of CKD, and comorbid conditions including hypertension and diabetes mellitus were documented. Venous blood samples were collected for complete blood count to determine hemoglobin levels. Anemia severity was categorized according to standard hemoglobin thresholds. Renal function was assessed using serum creatinine and estimated glomerular filtration rate.

Data Collection Procedure: Demographic information such as age and gender was captured after they gave their informed consent. Such clinical parameters as blood pressure, body mass index, and CKD period and stage and comorbid conditions like hypertension and diabetes mellitus were recorded. Complete blood count was done on the venous blood samples to establish the levels of hemoglobin. The severity of anemia was classified based on the conventional hemoglobin levels. Serum creatinine and estimated glomerular filtration rate were used to determine the renal functioning.

Echocardiographic Assessment: Transthoracic echocardiography was conducted on all the participants by a qualified cardiologist in a standard manner. Left ventricular dimensions, wall thickness and mass were measured and left ventricular mass index was determined. The LVH was determined based on the established echocardiographic criteria based on sex-specific cut-off values.

Outcome Measures: The main consequence was the existence of left ventricular hypertrophy regarding the degree of anemia. The LVH related to CKD stage and other clinical characteristics like hypertension and diabetes mellitus were included as secondary outcomes.

Data Analysis: Statistical software was used to analyze the data. Continuous variables were represented as mean standard deviation, whereas categorical ones were as frequencies and percentages. The chi-square tests or t-tests were used to determine the association between the severity of anemia and the severity of LVH. The multivariate analysis was conducted to adapt to the possible confounders. A p-value of below 0.05 was assumed to be statistically significant.

Ethical Considerations: The Institutional Review Board of Medical Teaching Institution, Bannu, gave the ethical approval. All participants signed the informed consent forms, and patient information confidentiality was well preserved as per the ethical standards.

RESULTS

The study included 120 chronic kidney disease (CKD) patients. The average age of the participants was 52.6, and the standard deviation of it was 13.4 years with the majority of the patients being males. Most patients had anemia of different degrees and left ventricular hypertrophy (LVH) was also a frequent result of echocardiography.

The level of anemia was classified as mild, moderate and severe depending on the level of hemoglobin. The most common or moderate anemia was the most common and severe anemia came second. The severity of anemia improved progressively with the progression of LVH, which significantly proved a positive correlation.

The echocardiographic analysis of LVH showed that 58.3 percent of patients had LVH. LVH was highest among patients with severe anemia and lowest among patients with mild anemia. The statistical significance of the association between the severity of anemia and LVH was significant.

Stage of CKD was similarly found to be strongly significant with the severity of anemia as well as with LVH. Lower levels of hemoglobin and a greater incidence of LVH were related to advanced stages of CKD. Hypertension also increased the incidence of LVH specifically in the case of patients who had moderate to severe anemia.

The mean values of the left ventricular mass index (LVMI) of those with severe anemia were significantly greater than the mean values of the left ventricular mass index of those with mild anemia. This pattern promotes the dose effect proportion between decreasing hemoglobin levels and escalating left ventricular mass.

In general, the results suggest that the deterioration of anemia has a strong relationship with the existence and intensity of LVH in CKD patients regardless of age and sex.

Table 1: Baseline Characteristics of Study Participants (n = 120)

Variable	Frequency (%) / Mean ± SD
Age (years)	52.6 ± 13.4
Male gender	72 (60.0%)
Female gender	48 (40.0%)
Hypertension	86 (71.7%)
Diabetes mellitus	54 (45.0%)
Mean hemoglobin (g/dL)	9.4 ± 1.8
LVH present	70 (58.3%)

Table 2: Distribution of Anemia Severity in CKD Patients

Anemia severity	Hemoglobin level (g/dL)	Number (%)
Mild anemia	10–11.9	34 (28.3%)
Moderate anemia	8–9.9	46 (38.3%)
Severe anemia	<8	40 (33.4%)

Table 3: Association Between Anemia Severity and LVH

Anemia severity	LVH present n (%)	LVH absent n (%)	p-value
Mild	10 (29.4%)	24 (70.6%)	
Moderate	28 (60.9%)	18 (39.1%)	
Severe	32 (80.0%)	8 (20.0%)	<0.001

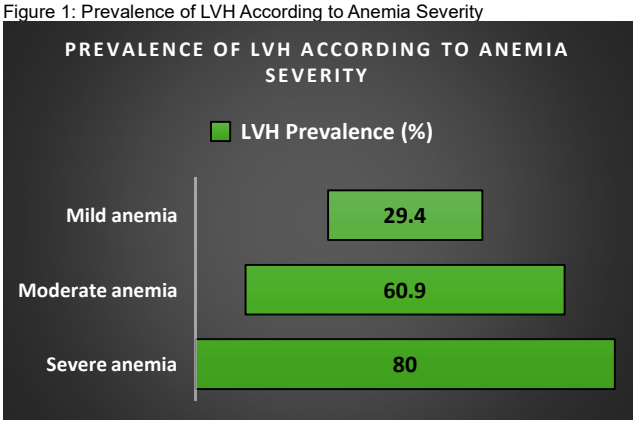
Chi-square test applied

Table 4: Mean Left Ventricular Mass Index According to Anemia Severity

Anemia severity	Mean LVMI (g/m²) ± SD
Mild anemia	108.6 ± 14.2
Moderate anemia	126.4 ± 18.5
Severe anemia	148.9 ± 22.1
p-value	<0.001

One-way ANOVA applied

Figure 1: Prevalence of LVH According to Anemia Severity



DISCUSSION

This research shows that there is a close and significant relationship between the severity of anemia and the left ventricular hypertrophy (LVH) among chronic kidney disease (CKD) patients. Over 50 percent of the study population showed LVH and the prevalence of

the same rose steadily with mild, moderate and severe anemia. These results support the idea that anemia is a significant and adjustable risk factor of negative cardiac remodeling in patients with CKD[9].

Hypoxia of the tissues caused by the decrease of hemoglobin levels in chronic conditions explains high prevalence of LVH in anemic CKD patients. The heart responds to the reduced blood supply of oxygen by increasing cardiac output by increasing stroke volume and heart rate. Chronic hemodynamic overload results in myocardial hypertrophy and left ventricular mass increase especially with co-existence of pressure overload[10].

Our findings agree with other past researchers who have indicated a direct correlation between the decreasing hemoglobin levels and the augmenting mass index of the left ventricle. A few studies have revealed that anemia patients with moderate to severe anemia are much more likely to develop LVH than those with milder anemia, after an additional factor such as blood pressure and renal performance is adjusted[11,12]. This is in favor of dose response between the severity of anemia and the hypertrophy of the myocardium.

This study linked more serious anemia and higher rate of LVH in advanced stages of CKD. Gradual kidney failure causes a decrease in erythropoietin synthesis, iron metabolic disturbances, and chronic inflammatory processes, which all make anemia worse. At the same time, uremia-induced causes like volume overload, stiffening of the arteries and the occurrence of neurohormonal mechanisms also stimulate left ventricular remodeling[13].

High levels of hypertension were observed in our cohort and it seemed to increase the influence of anemia on the development of LVH. Pertussis hypertension causes pressure overload and anemia causes volume overload, the combination of the two leads to a synergistic stimulus of myocardial hypertrophy. Other CKD-specific cardiovascular investigations have demonstrated similar interactions between anemia and hypertension in the acceleration of LVH progression[14,15].

The clinical significance of early detection and proper management of anemia in CKD patients is noted by the observed increment in the left ventricular mass index according to the severity of anemia. Previously reported interventional researches have shown that corrective interventions that involve erythropoiesis-stimulating agents and iron supplementation can result in regression or stabilization of LVH when used selectively. Nevertheless, overly high hemoglobin levels have been linked to an unfavorable cardiovascular effect, and it is important to note that balanced anemia management interventions are needed[16-18]. Recently available evidence also promotes personalized hemoglobin targets in order to limit cardiovascular remodeling without exposing to potential risks of the treatment[19,20].

Limitations: The cross-sectional study design does not provide the possibility of establishing a causal relationship between the severity of anemia and LVH. The study was a single-center study, and therefore results might not be applicable to larger CKD groups. There was no assessment of long-term cardiovascular outcomes and the impact that anemia correction had on LVH regression. Also, other variables like volume status, inflammatory markers, and iron indices were not thoroughly evaluated, which can have affected the established relations.

CONCLUSION

Left ventricular hypertrophy in chronic kidney disease patients is closely linked to the occurrence and the degree of anemia. The occurrence of LVH is progressive with the aggravation of anemia, which underscores its significant contribution to poor cardiac remodeling in addition to conventional risk factors. Timely diagnosis and proper treatment of anemia could be beneficial in preventing left ventricular hypertrophy and cardiovascular outcomes in CKD patients. Regular cardiovascular examination such as an echocardiographic study should be taken into account in anemic CKD patients in order to enable the early intervention and risk assessment.

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