ORIGINAL RESEARCH ARTICLE

Glycemic Variability in Different Stages of Chronic Kidney Disease with Type 2 Diabetes Mellitus: A Cross-sectional Study

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Abstract

Aim and background: Hemoglobin A1c levels and complete blood count (CBC) is a diagnostic test used for diabetes and to determine the development of diabetic complications. The level of HbA1c is affected by factors, such as the Hb, the age of red blood cells (RBCs) in the blood circulation, and the Hb glycation rate. Our study aims to assess glycemic variability (GV) in diabetic patients at different stages of chronic kidney disease (CKD) and its relation to Hb and RBC levels to their HbA1c in different CKD stages.

Materials and methods: This was a cross-sectional analysis of 156 adults with type 2 diabetes mellitus (T2DM) carried out in Parul Sevashram Hospital, Vadodara from November 2022 to May 2023. Chronic kidney disease stages were defined according to the modification of diet in renal disease (MDRD) equation stages I-V. HbA1c, RBC count, and RBS were estimated for the patients belonging to each stage. Statistical analyses were performed using SPSS software version 26.0 and Microsoft Excel 2019.

Results: Out of the total diagnosed patients (n = 156), 58.3% were males and 41.6% were females. It was important to note that the maximum number of patients in the end-stage, that is, stage V, was detected with the HbA1c range of 4–7%. The inconsistencies in blood sugar levels with HbA1c were an alarming indication of other underlying issues such as renal anemia.

Conclusion: Chronic kidney disease occurs due to diabetes and hypertension also contributes to renal anemia. In the later stages of CKD with T2DM, a low level of HbA1c ranging from 4 to 7% has been found due to low RBC count and Hb. Therefore, the clinical significance of this study is the non-reliability of HbA1c tests in advanced stages of CKD patients because of lower RBC counts giving rise to false glycated hemoglobin percentage.

Keywords: Chronic kidney disease, Diabetic nephropathy, Estimated glomerular filtration rate, HbA1c, Renal anemia, Type 2 diabetes mellitus.

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Introduction

Chronic kidney disease (CKD) is a progressive and long-term condition where the kidneys are damaged and can no longer filter blood effectively.[1] Chronic kidney disease is divided into five different stages. The stages are based on the glomerular filtration rate (GFR) test, which helps to know how well kidneys are working to filter waste and excess fluid from the blood in the body. As the stages increase, the kidney disease gets worse and the kidneys work less. The stages can get worse over time. In the early stages (stages I–III), kidneys are still able to filter waste products from the blood. In the later stages of CKD (stages IV–V), kidneys have to work harder to filter the blood and may stop working altogether. Further, it can lead to dialysis.[2]

Diabetes is a condition that happens when the blood sugar (glucose) is too high. It is characterized by the impaired ability of the body to produce or respond to insulin and thereby maintain proper levels of sugar in the blood. Diabetes affects people of all ages. Most forms of diabetes are chronic (lifelong). It is a major cause of morbidity and mortality, though these outcomes are not due to the immediate effects of the disorder.[3]

Health-related quality of life is significantly diminished with the progression of CKD. Compared with people without diabetes, those with type 2 diabetes mellitus (T2DM) are more likely to experience poor physical and mental health outcomes. Approximately, 40% of CKD patients with T2DM are associated with an increased risk of end-stage kidney disease (ESKD). Chronic kidney disease, a broad term for a group of related illnesses, is usually associated with diabetes, nephritis, hypertension, and immune system dysfunction. As the etiologically unique cause continues, a common kidney pathological presentation, including glomerulosclerosis and/or interstitial fibrosis occurs.[4] Chronic kidney disease in patients with T2DM also accounts for most patients with ESKD globally and is associated with high morbidity, mortality, and poor quality of life.[5] Patients with CKD and type 2 diabetes have high residual cardiorenal morbidity and mortality despite current therapies, and the risk of renal failure and cardiovascular events increases with the severity and stage of CKD, compared with patients with advanced kidney disease. Diseases that are more likely to progress

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to dialysis.[6] Over time, high blood sugar from diabetes can damage blood vessels in the kidneys as well as nephrons so they do not work efficiently. Many people with diabetes also develop high blood pressure, which can damage kidneys too.[7] Since GFR is based on high intra- and trans-glomerular pressure glomerular hypertension and hyperfiltration may become the culprit of progression of CKD.[8]

Glycemic variability (GV) becomes increasingly complicated in patients with CKD and T2DM. There is an increased risk of detection of false hypoglycemia, that is, low glycated hemoglobin (HbA1c) in patients with CKD whose estimated GFR is <60 mL/min/1.73 m^2 along with T2DM.[9] Moreover, the HbA1c test, which reflects average blood glucose (ABG) levels over the previous 2 or 3 months, has limitations due to its imprecision in patients with CKD. As eGFR falls, red blood cell (RBC) survival times become shorter, resulting in a reduction in measured HbA1c.[10] For this reason, HbA1c results should be interpreted carefully in patients with CKD and T2DM.

HbA1c is not affected by blood sugar levels alone. There are various confounding factors when measuring HbA1c, such as RBC counts and likewise hemoglobin (HB). This research focuses on the study of GV in different stages of CKD patients having T2DM by capturing two different parameters such as the blood sugar level of the patient and the RBC/hemoglobin count which can help in the identification of false HbA1c results.

Materials and Methods

Study Design

In this cross-sectional study, we recruited 156 CKD patients having T2DM inclusive of both males and females who were above 30 years of age. Hemodialysis (HD) patients were also included in stage V.

Sample Size

The sample size was determined by non-probability, characteristic, and convenient sampling method with a 95% confidence level, using the Open EPI online statistical tool.[11] The sample size of this cross-sectional study comprised of a total 156 individuals, with stage I–V CKD and T2DM as defined by the World Health Organization for this study.[12] CKD stages were defined as follows: stage I, with normal or high eGFR >90 mL/min/1.73 m^2; stage II, eGFR of 60–89 mL/min/1.73 m^2; stage III, eGFR of 30–59 mL/min/1.73 m^2; stage IV, eGFR of 15–29mL/min/1.73 m^2; and stage V, eGFR less than 15 mL/min/1.73 m^2 based on staging criteria from the National Kidney Foundation Kidney Disease Outcomes Quality Initiative (KDOQI).[11] The eGFR of the participants was calculated using the simplified modification of diet in renal disease (MDRD) study equation: GFR (mL/min/1.73 m^2) = $175 \times (S_{cr})^{-1.154} \times (Age)^{-0.203} \times$ (0.742 if female) × (1.212 if African American).[13]

Sociodemographic Data

All participants were followed at hospital visits periodically for routine biochemical and hematological blood exams and evaluation of CKD complications. The institutional review board of PSH approved the study protocol, and informed consent was obtained from all participants. The methods were carried out in accordance with the declaration of University ethical principles for medical research.

Inclusion/Exclusion Criteria

The study included both newly and follow-up registered CKD patients with T2DM and hypertension attending the hospital. Patients belonging to both genders (male and female) above 30 years were considered. Alcoholic and non-alcoholic patients were included in this study. We excluded patients having other diseases than CKD, T2DM, and Hypertension. Individuals less than 30 years, smokers and pregnant women, any type of surgery and blood donated in the last 6 months, UTI, kidney stone, heart failure, females having menorrhagia, and breastfeeding women were kept out of the scope of the study.

Data Collection

A unified and predesigned data collection was executed manually by questionnaire form along with a patient consent form and further documented. The data were collected from all the subjects with the help of laboratory reports with pre-specified data variables from PSH. The collected data were only used for the benefit of the study. We obtained the age of patients, sex, weight, and laboratory reports through the data collection. The privacy and integrity of collected data were ensured.

Sample Collection

About 5 mL venous blood was drawn from each participant and divided into two tubes: 2 mL was drawn into ethylene diamine tetra acetic acid (EDTA) tubes to measure the hematological parameter; complete blood count (CBC), and biochemical parameter; HbA1c. 3 mL was drawn into a plain tube with no anticoagulant to measure the biochemical parameter such as creatinine and random blood sugar (RBS).

Study Procedure

Participant demographic information was gathered upon their visit, and their medical histories were obtained using a written questionnaire and consent form. The MDRD equation was applied to evaluate CKD prevalence and dialysis initiation. The HbA1c values were measured as clinically indicated by the hospital laboratory using the boronate affinity method. Hb and RBC count were measured as a part of the CBC using Mindray BC-6200 Auto Hematology Analyzer. RBS was measured by a Fully Automated EM-200 XL System Pack. Average blood glucose (avBG) values were taken from Breathe well-being reference chart.[10] We adhered to the World Health Organization (WHO) guidelines for all the tests. According to these guidelines, the HbA1c value >7% is defined as hyperglycemia, the normal RBC count for males is 4.0–5.9 million/mm^3, and for females, it is 3.8–5.2 million/mm^3, the normal hemoglobin value for males is 13.5–17.5 gm/dL and for females, it is 12.0–16.0 gm/dL. RBS values >200 mg/dL were considered as high blood sugar (Fig. 1).

Statistical Analysis

Descriptive statistics were expressed as counts and percentages for the categorical data. The means with standard deviations (SD) were determined for continuous variables. Differences in baseline characteristics between groups were analyzed using the Kruskal–Wallis H test for continuous variables. Correlation between different variables was measured using Kendall's tau-b correlation coefficient and Spearman's rho correlation coefficient. A *p*-value of less than 0.05 was considered statistically significant. Data were analyzed by using SPSS 26 (Statistical Package for the Social Sciences; IBM) for Windows.

Results

Characteristics of CKD Patients with T2DM

The average age of the study population was 53.9 years with most of the patients belonging to age greater than 60 years (30.3%), followed by 40–59 years (15.8%). A total of 156 adults having CKD

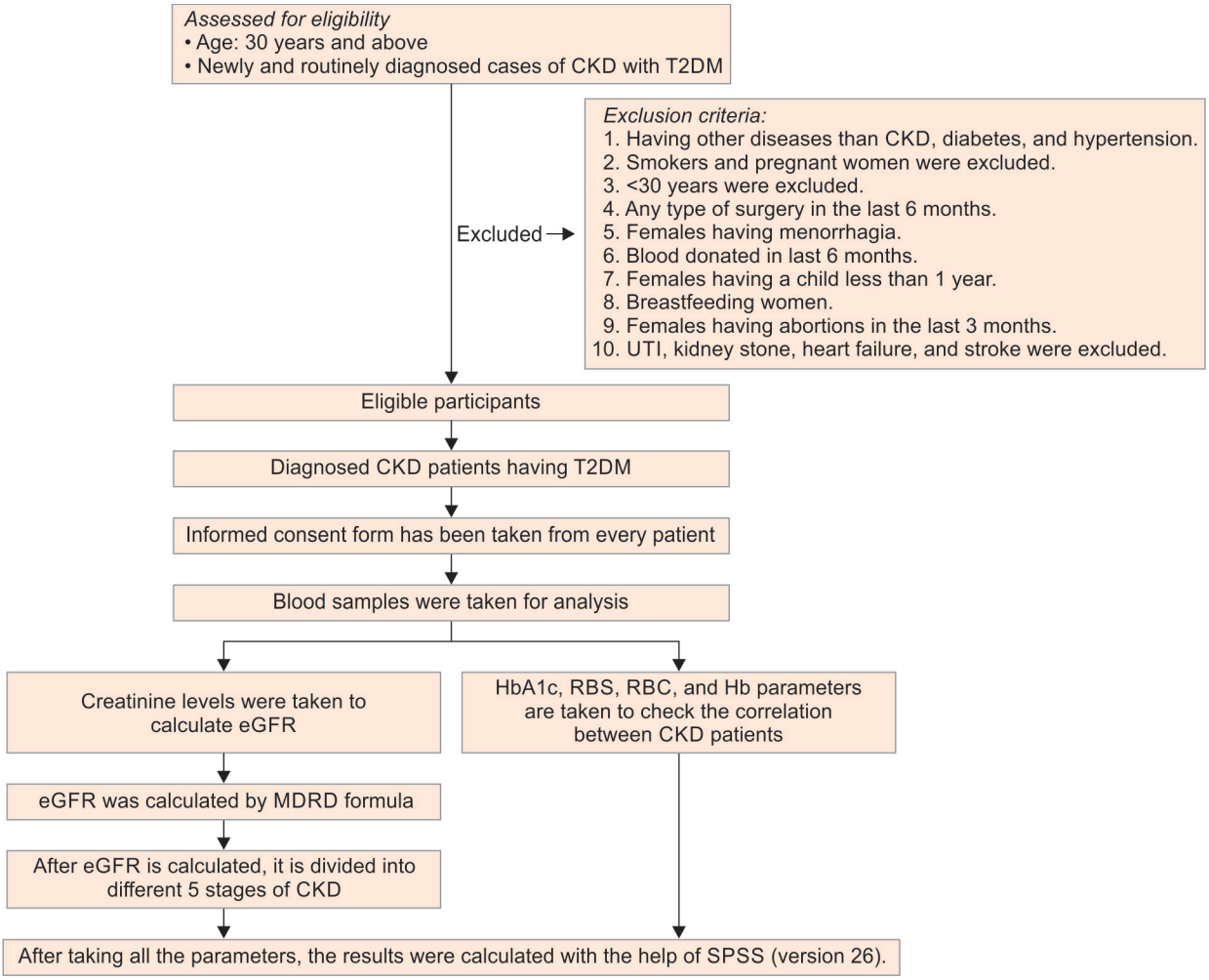

Fig. 1: Schematic representation of study flow

with T2DM were reported between December 2022 and May 2023. Out of the total diagnosed patients (54.1 ± 11.1) 58.3% ($n = 91$) were males and (53.7 ± 11.0) 41.6% ($n = 65$) were females. Almost 90% of patients were having concomitant hypertension. Stage V mainly consisted of HD patients.

Occurrence of CKD Stagewise

The overall estimated eGFR was calculated by the MDRD equation with a mean eGFR ± standard deviation (SD) of 17.7 ± 14.2 mL/min/1.73m^2. The occurrence of CKD stage I; 69.1 ± 64.2 (eGFR ≥90 mL/min/1.73 m^2) and stage II; 38.7 ± 21.8 (eGFR 60–89 mL/min/1.73 m^2) having T2DM was much lower as compared with stages III; 37.1 ± 5.69 (eGFR 30–59 mL/min/1.73 m^2), stage IV; 20.7 ± 4.09 (eGFR 15–29 mL/min/1.73 m^2), and stage V; 9.08 ± 3.39 (eGFR <15 mL/min/1.73 m^2). The number of CKD patients stagewise was found to be 1.3% in stage I, 1.3% in stage II, 13.3% in stage III, 31.3% in stage IV, and 52.7% in stage V, respectively (Table 1).

Variation of Parameters in CKD Patients having T2DM

All the cases of CKD were divided into V different stages based on eGFR as given in Table 1. The normal ratio of RBC/Hb is 5.15 ± 0.95 *10^{12}/L/15 ± 3 gm/dL along with HbA1c is 6.05 ± 0.45%, respectively. It was also noted that RBC count and hemoglobin (RBC/Hb) were decreasing in the later stages of CKD (as given in Table 1). Stage I; 3.94 ± 0.81*10^{12}/L/10.65 ± 2.85 gm/dL, Stage II; 3.88 ± 0.42 *10^{12}/L /10.25 ± 0.25 gm/dL, Stage III; 3.37±0.72 *10^{12}/L /10.21 ± 2.26 gm/dL, stage IV; 3.11 ± 0.60 *10^{12}/L/9.61 ± 2.11 gm/dL, stage V; 2.72 ± 0.49*10^{12}/L /8.51 ± 1.67 gm/dL, along with HbA1c stage I; (6.75 ± 0.05%), stage II; (7.5 ± 1.5%), stage III; (7.43 ± 2.60%), stage IV; (6.65 ± 1.51%), and stage V; (5.43 ± 0.64%). The p-value is calculated for all the parameters by the Kruskal–Wallis's test, and the results are presented in Table 1. It was noted that the HbA1c, RBC count, and hemoglobin ($p < 0.01$), ($p < 0.00$), and ($p < 0.00$) were significant whereas RBS and avBG failed to show any association in different stages of CKD ($p > 0.05$).

Correlation between RBS and HbA1c with Respect to Average Blood Glucose (avBG) in Different Stages of CKD

The avBG mentioned here in Table 1 is according to the reference range mentioned in Breathe well-being chart (Table 1). The normal ratio of (avBG/RBS) is 85 ± 15 mg/dL/170 ± 30 mg/dL with respect to their HbA1c 6.05 ± 0.45%, respectively. It was noted that the RBS level of patients was comparatively higher with respect to their HbA1c levels and so for avBG levels (avBG/RBS) with mean HbA1c as follows. Chronic kidney disease stage I;

Table 1: Table showing the stage-wise distribution of CKD with different parameters

	CKD stages					
	Stage I	*Stage II*	*Stage III*	*Stage IV*	*Stage V*	
Variables	*(n = 2) eGFR ≥90 mL/min/1.73 m²*	*(n = 2) eGFR 60–89 mL/min/1.73 m²*	*(n = 20) eGFR 30–59 mL/min/1.73 m²*	*(n = 52) eGFR 15–29 mL/min/1.73 m²*	*(n = 80) eGFR <15 mL/min/1.73 m²*	*p-value*
Age (in numbers)	50 ± 5	47 ± 4	51.6 ± 10.9	54.8 ± 11.1	53.3 ± 12.6	0.49 (Not significant)
HB (gm/dL)	10.65 ± 2.85	10.25 ± 0.25	10.21 ± 2.26	9.61 ± 2.11	8.51 ± 1.67	0.00 (Highly significant)
RBC count *10^{12}/L	3.94 ± 0.81	3.88 ± 0.42	3.37 ± 0.72	3.11 ± 0.60	2.72 ± 0.49	0.00 (Highly significant)
RBS (mg/dL)	167.5 ± 2.5	197.5 ± 67.5	348.8 ± 212.4	300.9 ± 177.6	319.6 ± 200.7	0.95 (Not significant)
HbA1c (%)	6.75 ± 0.05	7.5 ± 1.5	7.43 ± 2.60	6.65 ± 1.51	5.43 ± 0.64	0.01 (Highly significant)
avBG (mg/dL)	170.5 ± 9.5	205 ± 75	186 ± 90.2	159.0 ± 54.2	145.3 ± 51.2	0.05 (Not significant)

- Kruskal–Wallis H test was used for the comparison of mean values in each group.
- Mean ± SD were calculated.
- ±eGFR in mL/min per 1.73m² BSA were calculated by MDRD formula.
- avBG, average blood glucose; BSA, body surface area; eGFR, estimated glomerular filtration rate; HB, hemoglobin; HbA1c, glycated hemoglobin; MDRD, modification of diet in renal disease; RBC count, red blood cell count; RBS, random blood sugar

Table 2: Non-parametric correlation of HbA1c with different parameters by Kendall's tau-b and Spearman's rho tests.** Correlation is significant at the 0.01 level (1-tailed)

Correlation table for different parameters				
HbA1c	*Method*	*Correlation coefficient (r)*	*p-value*	*Remarks*
RBS	Kendall's tau-b	$r = 0.051$	$p > 0.05$	Negative correlation
	Spearman's rho	$r = 0.072$	$p > 0.05$	Negative correlation
RBC	Kendall's tau-b	$r = 0.183$**	$p < 0.01$	Positive correlation
	Spearman's rho	$r = 0.266$**	$p < 0.01$	Positive correlation
HB	Kendall's tau-b	$r = 0.256$**	$p < 0.01$	Positive correlation
	Spearman's rho	$r = 0.374$**	$p < 0.01$	Positive correlation

Hb, hemoglobin; RBC, red blood cell count; RBS, random blood sugar

170.5 ± 9.5 mg/dL/167.5 ± 2.5 mg/dL (HbA1c% = 6.75 ± 0.05), CKD stage II; 205 ± 75 mg/dL/197.5 ± 67.5 mg/dL (HbA1c% = 7.5 ± 1.5), CKD stage III; 186 ± 90.2 mg/dL/348.8 ± 212.4 mg/dL (HbA1c% = 7.43 ± 2.60), CKD stage IV; 159.0 ± 54.2 mg/dL/300.9 ± 177.6 mg/dL (HbA1c% = 6.65 ± 1.51), and CKD stage V; 145.3 ± 51.2 mg/dL/319.6 ± 200.7 mg/dL (HbA1c% = 5.43 ± 0.64), respectively. Clearly, the results indicate maximum variability of HbA1c with respect to RBS in stage V followed by stage IV when compared with the avBG. Not much difference was observed in stage III where the avBG/RBS values are comparable to each other.

As the results indicate the mean RBC/Hb values with respect to their HbA1c levels for different CKD stages, stage I: 3.94 ± 0.81*10^{12}/L/10.65 ± 2.85 gm/dL (HbA1c% = 6.75 ± 0.05); stage II: 3.88 ± 0.42*10^{12}/L/10.25 ± 0.25 gm/dL (HbA1c% = 7.5 ± 1.5), stage III: 3.37 ± 0.72*10^{12}/L/10.21 ± 2.26 gm/dL (HbA1c% = 7.43 ± 2.60); stage IV: 3.11 ± 0.60*10^{12}/L/9.61 ± 2.11 gm/dL (HbA1c% = 6.65 ± 1.51), and stage V: 2.72*10^{12}/L 8.51 ± 1.67 gm/dL (HbA1c% = 5.43 ± 0.64), respectively. The normal ratio of RBC/Hb is 5.15 ± 0.95*10^{12}/L/15 ± 3 gm/dL along with HbA1c is 6.05 ± 0.45%, respectively. This states that the RBC and Hb levels drastically declined in stage V, and hence their HbA1c (Table 1).

Correlation of HbA1c with Different Parameters

Kendall's tau-b test shows a significant negative correlation between HbA1c and RBS ($R = 0.051$, $p > 0.05$); weak positive correlation of HbA1c and RBC ($R = 0.183$**, $p < 0.01$); HbA1c and HB ($R = 0.256$**, $p < 0.01$), respectively. Spearman's rho test also shows a significant negative correlation between HbA1c and RBS ($R = 0.072$, $p > 0.05$); weak positive correlation of HbA1c and RBC ($R = 0.266$**, $p < 0.01$); HbA1c and HB ($R = 0.256$**, $p < 0.01$), respectively. Hence, all the parameter show a negative or weakly positive correlation with HbA1c (Table 2).

Variation of HbA1c in CKD Stages

The HbA1c levels were divided into three groups, that is, group I, group II, and group III having the range of 4–7, 7–11, and 11–15%, respectively. Out of 156 patients, 107 (68.5%) of the cases are falling in group I, 43 (27.5%) cases in group II, and 6 (3.85%) cases in group III (Tables 1 and 3).

Prevalence of Glycemic Variability in CKD Stages

The prevalence of GV was observed in stage V maximally followed by stage IV (Tables 1 and 3). The GV (*n*) is given stagewise: stage I,

Table 3: Table showing stage-wise distribution of CKD between the three subgroups of HbA1c

Ranges	*CKD stages*						
HbA1c (%)	*Stage I*	*Stage II*	*Stage III*	*Stage IV*	*Stage V*	*Total*	*Prevalence of glycemic variability (%)*
Group I (4–7)	2	1	11	28	65	107	68.6%
Group II (7–11)	0	1	7	21	14	43	27.6%
Group III (11–15)	0	0	2	3	1	6	3.8%
Total	2	2	20	52	80	156	
%	1.2%	1.2%	12.8%	33.3%	51.2%		

stage II, stage III, stage IV, and stage V are 2 (1.2%), 2 (1.2%), 20 (12.8), 52 (33.3%), and 80 (51.2%), respectively.

The maximum number of patients in group I (n = 65) fell in the category of stage V with an HbA1c range equal to 4–7%, and in group II, most of the patients (n = 21) showed the HbA1c range equal to 7–11% in stage IV. Whereas in group III (HbA1c; 11–15%) the maximum number of patients (n = 3) were reported in stage III (Table 1 and 3).

Discussion

Chronic kidney disease is a condition specified by cautious damage of kidney function over time. T2DM and hypertension are responsible for two-thirds of CKD cases. The early stages of CKD are asymptomatic. Therefore, people rarely go out for routine health check-ups and patients visit the hospital only after developing severe symptoms or complications. Although the difficulties of T2DM take a few years to develop, often those complications are identified only at the time of diagnosis. Therefore, delayed diagnosis of T2DM can also lead to CKD.[14,15]

As in the current study, the same pattern was observed in CKD with 52.7% in stage V, 31.3% in stage IV, and 13.3% in stage III. Hardly 1.3% of total patients were diagnosed with stages I and II. Since most people with stage I CKD do not have any symptoms generally which is why it remains undiagnosed. According to the American Kidney Fund, in stage II CKD, the damage to the kidney is still mild and the eGFR is between 60 and 89 mL/min/1.73 m^2 (stage III). A common sign of kidney damage is when protein is detected in urine.

The Correlation of HbA1c with CKD Stages (I–V) with Respect to Their Different Parameters

We investigated the association between the GV and CKD stages I–V in T2DM patients for 6 months. The glycated hemoglobin, that is, HbA1c showed maximum variation in stage V as compared with stages IV and III.

Probably factor such as older age has an increased risk of developing other comorbidities, such as diabetes, hyperlipidemia, anemia, etc. which play a major role as the culprit behind fluctuations in HbA1c levels. This leads to the maximum variability outcomes in the end stages.[16,17] Although, the current study did not find old age as a reason for the progression of CKD. The age factor was found non-significant ($p > 0.05$).

It was important to note that the maximum number of patients in the end-stage, that is, stage V was detected with the HbA1c range 4–7% which is grouped under I (group I) with mean avBG 151 mg/dL (Breathe well-being reference chart)[13] whereas the mean RBS values were 319.6 ± 200.7 mg/dL. The inconsistencies in HbA1c when compared with average blood sugar (avBG) with the help of Breathe well-being chart and random blood glucose (RBS) were an alarming indication of other underlying issues, such as renal anemia which can be further explained due to the deficiency of RBC in the end stages of CKD.[18,19]

A relative decrease in mean RBC count was observed in stages IV and V with the values 3.11 ± 0.60*10^{12}/L and 2.72 ± 0.49*10^{12}/L, respectively. Hence, there is a drop of 12.54% in RBC levels when compared between these two stages.

Various studies indicate that anemia is a common obstacle in CKD stages also known as renal anemia. As the eGFR declines the severity of anemia increases. Several studies focused on the prevalence of anemia not only in CKD dialysis-dependent (DD) cases but in non-dialysis-dependent (NDD) cases as well.[20,21]

Renal anemia has been related to abnormalities of iron, ferritin, and risk factors related to vitamin B, folic acid, and vitamin B12 deficiency.[22]

As it is known that HbA1c level has an important role in the clinical diagnosis of diabetes has been affected by anemia. In the current study, it was observed that stagewise the RBC count is decreasing and so with Hb (Table 1). The results of some studies support this notion that among 128 patients with T2DM and stage I–V CKD, a decline in HbA1c was correlated with CKD stages, but this relationship disappeared after adjustment for hemoglobin.[23] According to Jiu-Hong Li et al. 2021, a study showed that RBC lifespan shortening, which reflects the speed of RBC rupture has been associated with CKD majorly at advanced CKD stages. Anemia occurs when there is an imbalance between erythropoiesis and RBC degradation. In the cohort study of 74 CKD patients, RBC lifecycle shortening developed as a primary correlate of renal anemia, with other concerned factors, especially erythropoietin (EPO) levels.[24,25]

A similar kind of observation was witnessed in another paper which says that in CKD patients, EPO levels are inadequately low to the degree of anemia. Erythropoietin deficiency starts early during CKD, but it appears that when eGFR falls below 30 mL/min per 1.73 m^2, this deficiency becomes more severe.[26]

In Table 1, it is quite evident that HbA1c levels were declining stagewise whereas RBS was increasing which depicts discrepancies and inconsistent outcomes. In addition, Freedman et al. 2010, confirmed in diabetic patients with 3–4 CKD stage, an inverse correlation between RBS and eGFR/HbA1c, which specified that HbA1c could be falsely low in lower eGFR.[27]

Hence, HbA1c levels appear to be falsely low in subjects with T2DM in advanced CKD. Our study confirms the positive correlation between HbA1c and eGFR (stages IV and V CKD), but there is a consequent waning of HbA1c due to the declination of RBC and Hb clearly in stage V. A negative correlation is apparent between HbA1c and RBS levels which gives rise to false HbA1c levels in CKD (stages III–V). HbA1c level may not exactly indicate glycemic control during the deterioration of kidney role, and based on our study it is less prognostic in stages IV and V CKD.

Doctors long assumed the importance of HbA1c-predicted outcomes in diabetes. This test is not projecting the real outcomes

in diabetic patients with kidney disease. End-stage renal disease (ESRD) patients and doctors get a false sense of security because their lower HbA1c essentially relates to shorter red cell survival until now recommended diabetes control is better than it is the way it works. Hemoglobin takes RBCs through the body which carry oxygen. Blood sugar will interact with the hemoglobin and come up with HbA1c, which is only accurate when red cells have a regular lifespan. However, ESRD patients have a shorter red cell lifespan, which means the time that sugar is in the bloodstream to interact with hemoglobin is reduced and causes lower HbA1c values.[26,28]

Conclusion

The present study shows that CKD most commonly occurs due to diabetes and hypertension. Anemia is a common complication of CKD and the degree of anemia increases as CKD worsens. Most of the prevalence was found in stage V and their HBA1c values were abnormal. It has also been shown that among CKD cases, the median value of HbA1c in the end stage decreases with the severity of the disease, it is due to low levels of RBC count in the body. However, RBS and avBG correlate negatively with respect to their HbA1c because of false results of HbA1c. As defined by HbA1c, dysglycemia status was influenced by abnormal RBC based on low Hb. Mostly, the reduced levels of RBCs are due to dialysis. (patients ongoing with dialysis). Chronic kidney disease patients have lower hematological indices and the degree of changes depends on the severity of the same. However, the HbA1c test gives false result in T2DM patients having CKD. Consequently, it may be used as a marker of glycemic status. It is crucial to determine the role of HbA1c by establishing HbA1c cut-offs for the early identification of dysglycemia in CKD stages.

Clinical Significance

The clinical significance of this study is the non-reliability of HbA1c tests in advanced stages of CKD patients because of lower RBC counts giving rise to false HbA1c percentage.

Limitations

As in the present study, less number of patients were obtained in stage I and stage II which is possibly due to the convenient sampling and accidental diagnosis. Due to this, there was a drastic difference between the number of patients, found in all stages of CKD. A population-based study is required in order to check the widespread presence of different stages of CKD. The renal anemia can be further cross-checked by the endogenous erythropoietic marker detection (such as reticulocyte %) which can confirm the relative degree of anemia and inhibition of erythropoiesis. Also the CKD patients are generally hypertensive hence, the study related to same is lacking here in this study. The duration of T2DM can be checked further to associate with the progression of CKD in time time-dependent manner. A detailed study is required to confirm the findings on a larger scale and to examine the exact mechanism behind the decreasing RBC count and HbA1c drop.

Ethical Approval

This study was approved by the ethical committee of Parul University of Institutional Ethics Committee for Human Research (PUIECHR) in November 2022 and was conducted according to the Declaration of Parul Sevashram Hospital (PSH), where written consent was obtained prior to study participation. Patients were recruited from the Department of Nephrology, PSH in Vadodara, from November 2022 to May 2023.

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