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Original Research Article

Study on the Effect of Iron Deficiency Anaemia on HbA1c Levels in Non-Diabetic Adults

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Abstract:

Background: The most common kind of anemia in India is iron deficiency anemia. Glycated hemoglobin (HbA1c) is a marker used to show the glucose levels during a three-month period. HbA1c readings are influenced by factors such as blood sugar levels, hemoglobin variability, hemolytic anemia, nutritional anemias, uremia, pregnancy, and acute blood loss. On the other hand, data about the impact of iron deficiency anemia on HbA1c levels are not entirely consistent. Our goal was to assess and contrast the levels of glycosylated haemoglobin (HbA1c) in non-diabetic patients who were anemic and those who were not in order to determine the diabetes parameters.

Methods: From July 2023 to December 2023, 50 non-diabetic IDA patients were included as cases in this comparative study at the Department of Medicine, SKMCH, Muzaffarpur, and Bihar. Fifty non-diabetic non-anaemic people were enlisted as controls. At baseline, the iron profile and HbA1c levels were assessed and contrasted. After receiving iron supplements for three months to correct their iron deficiency, IDA patients' HbA1c levels were observed and examined. The Statistical Package for Social Sciences (SPSS) version 21.0 was used to analyze the data, which had been entered into an MS Excel spreadsheet. A statistically significant P value was defined as one that was less than 0.05.

Results: Anaemic individuals were shown to have considerably higher random and fasting blood sugar levels, with a greater proportion of patients falling into the pre-diabetic range based on HbA1c levels. Patients in Group A had considerably higher levels of glycosylated hemoglobin. ($p<0.05$). At the three-month follow-up, every haematological parameter showed a significant improvement following the start of IDA treatment. After three months of anemia treatment, the HbA1c levels significantly decreased. ($p<0.0001$).

Conclusion: The relationship between iron deficiency anemia and HbA1c levels is inverse. In the majority of cases, the anemic participants' HbA1c levels decreased to values that were almost normal once their iron deficiency was corrected.

Keywords: Iron Deficiency Anemia, HbA1c, Glycated Hemoglobin, Non- Diabetics.

Introduction

Glycated hemoglobin A1c, or HbA1c, accounts for about 5% of total hemoglobin in individuals who do not have diabetes. Because it provides a more accurate estimate of average glycemic control than standard blood glucose concentration tests, it is the most commonly used indicator of chronic glycemia. [1]

Glycation happens when glucose attaches, through a non-enzymatic process, to the valine and lysine amino groups of hemoglobin. Because the glycation reaction is irreversible, the total amount of glucose that erythrocytes are exposed to during the course of their three-month life cycle120 days on average determines the HbA1c levels. [2]

The average blood glucose level for the two to three months prior is thus measured by HbA1c. Glycated hemoglobin is created when glucose is added to the beta chain of hemoglobin at the N-terminus over the course of a healthy circulatory system. [3] This nonenzymatic process depicts the average glucose exposure of hemoglobin over a period of approximately two to three months. HbA1c levels are influenced by more than just blood sugar levels. Changes in HbA1c levels are

caused by hemolytic anemias [4], hemoglobinopathies [5,6], acute and chronic blood loss [5,6], pregnancy [7-9], and uremia [10]. Anemia brought on by a deficiency in iron, folate, or vitamin B12 can also affects HbA1c values.

There is no other nutritional shortfall that is more prevalent than anemia in both industrialized and developing nations. Around the world, 50% of the anemic burden is caused by iron deficiency. [11–12] Because iron is involved in most important metabolic processes, including as electron transport, deoxyribonucleic acid (DNA) synthesis, cell formation and differentiation, and oxygen transfer, it affects how many systemic illnesses manifest clinically. [13–15]

Elevated HbA1c levels16 and iron deficiency anemia (IDA) are linked to blood loss, hemolysis, hemoglobinopathies, red cell disorders, and myelodysplastic disease. The study found that variations in iron levels have been associated with a higher risk of diabetes [17]. Decreased serum ferritin or blood iron levels have been linked to elevated HbA1c glycation. [18,19] Elevated iron concentrations impact insulin [19] secretion and activity, indicating a reciprocal relationship between iron metabolism and glucose homeostasis.

Material and Methods

From July 2023 to December 2023, this prospective comparative study was carried out in the medicine department of Sri Krishna Medical College and Hospital in Muzaffarpur, Bihar. The study comprised of patients in two groups: Group A: 50 non-diabetic anaemic patients and Group B comprised of 50 non-diabetic non-anaemic patients. Total sample size taken is 100 (50 patients per group).

Age ≥ 18 years, a peripheral blood smear with a microcytic hypochromic appearance, and, in accordance with the WHO classification, hemoglobin values <12 g/dL for females and <13 g/dL for males were the inclusion criteria. Twenty Group B consisted of fifty patients who were not anemic or diabetic. Patients who met the ADA's 2016 criteria for diabetes mellitus (DM), had hemolytic anemia, known hemoglobinopathy, chronic kidney disease, liver disease, pregnancy, alcohol abuse, a confirmed diagnosis of cancer, hypothyroidism, history of acute or chronic blood loss, or history of recent blood transfusion were not allowed to participate in the study. Following patient selection, informed written consent was acquired. A thorough medical history, including information on co-morbidities, treatment received, length of illness, symptoms, and iron deficiency symptoms, was gathered along with demographic data. A clinical assessment was conducted.

A proforma was used to record information regarding the history and examinations. The following tests were performed: ferritin, liver function tests, serum urea, serum creatinine, TSH if necessary, peripheral blood film, complete hemogram, FBS, RBS, HbA1c, MCV, MCH, and MCHC, and USG abdomen.

For three months, all IDA patients received oral iron supplementation in the form of 32.8 mg elemental iron (160 mg ferric ammonium citrate) daily. Following this time, lab tests were redone. At the time of enrollment, the controls underwent one lab investigation.

The Mann-Whitney Test was utilized to compare quantitative variables between the two groups, and the Wilcoxon signed rank test was employed to compare results at baseline and after therapy. The Fisher's exact test and the Chi-Square test were used to correlate the qualitative variables. A P-value of less than 0.05 was deemed statistically noteworthy. The Statistical Package for Social Sciences (SPSS) version 21.0 was used for analysis after the data was entered into an MS Excel spreadsheet.

Results

The patients in groups A and B had mean ages of 45.02 ± 16.84 years and 43.98 ± 17.18 years, respectively. (p>0.05) In groups A and B, there were an equal number of females (58% each) and males (42% each). Table 1 shows the distribution of ages.

Table 1: Age Distribution of both (Case and Control) Groups

Age groups in years	No. of participants		Percentage	
	Case	Control	Case	Control
≤30	12	12	24%	24%
31-40	10	13	20%	26%
41-50	12	9	24%	18%
51-60	6	7	12%	14%
61-70	5	4	10%	8%
70-80	4	3	8%	6%
>80	1	2	2%	4%

Table 2 demonstrates that HB, MCV, MCH, MCHC, HCT, and serum ferritin levels were considerably lower in Group A anemic patients compared to Group B non-anemic individuals (p<0.05).

Table 2: Comparison of Haematological Parameters among the Study Groups

Parameters		Group		Total	P - value
		A(n=50)	B(n=50)		
Haemoglobin (gm/dl)	Mean±S.D.	8.77±1.53	13.57±0.93	11.17±2.72	
	Median(IQR)	8.4 (7.500-9.800)	13.4 (12.900-14.500)	11.75 (8.400-13.400)	<.0001
Mean Corpuscular volume(fl)	Mean±S.D.	67.5±6.61	89.3±4.52	78.4± 12.32	<.0001
	Median(IQR)	66.5 (62-74)	89 (87-94)	80 (66.500-89)	
Mean corpuscular haemoglobin(pg/cell)	Mean±S.D.	22.5±2.08	29.4±1.44	25.95±3.9	
	Median(IQR)	22.5 (21-24)	29.5 (28-30)	26.5 (22.500-29.500)	<.0001
Mean corpuscular haemoglobin concentration(gm/dl)	Mean±S.D.	28.32±1.55	32.86±0.8	30.59±2.59	
	Median(IQR)	28.35 (27-29.200)	32.9 (32-33.500)	31.6 (28.350-32.900)	<.0001
Haematocrit(%)	Mean±S.D.	30.5±2.08	41.63±2.06	36.06±5.96	
	Median(IQR)	30.5(29-32)	41.5(40-43)	36(30.500-41.500)	<.0001
Serum ferritin(ng/ml)	Mean±S.D.	10.91±5.51	59.3± 17.56	35.1± 27.55	
	Median(IQR)	9 (7-16)	65 (50-70)	25.5 (9-65)	<.0001

Anaemic individuals were shown to have considerably higher random and fasting blood sugar levels, with a greater proportion of patients falling into the pre-diabetic range based on HbA1c levels. Patients in Group A had considerably higher levels of glycosylated hemoglobin. ($p<0.05$) as shown in Table 3.

Table 3: Comparison of Diabetic Parameters among the Study Groups

Group			Total	P Value
	A (n=50)	B (n=50)		
FBS(mg/dl)				
Mean±S.D.	107.72± 11.06	89.4±5.15	103.96± 11.85	
Median(IQR)	110 (100-116)	89.5 (85-92)	101 (96.500-114)	<.0001
RBS(mg/dl).				
Mean±S.D	113±16.84	102.5± 12.41	107.75± 15.63	
Median(IQR)	112 (101-127)	100 (92-114)	110 (97-118.500)	0.001
HbA1c (%)				
HbA1cinpre-diabeticrange (5.7 – 6.4%)	40 (80.00%)	0(0.00%)	40 (40.00%)	<.0001
NormalHbA1c(<5.7%)	10 (20.00%)	50 (100.00%)	60 (60.00%)	
Mean±S.D.	5.92±0.37	5.11±0.3	5.52±0.53	
Median(IQR)	6(5.700- 6.200)	5.1(4.800- 5.300)	5.45(5.100-6)	<.0001

At the three-month follow-up, every haematological parameter showed a significant improvement following the start of IDA treatment. (Table 4)

Table 4: Effect of IDA Treatment on Haematological Parameters

Parameters		Before Treatment (n=50)	After Treatment (n=50)	PValue
Haemoglobin(gm/dl)	Mean±S.D.	8.77±1.53	12.86±0.97	
	Median(IQR)	8.4 (7.500- 9.800)	12.7 (12.300-13.500)	<.0001
Mean corpuscular Volume(fl)	Mean±S.D.	67.5±6.61	81.44±5.06	<.0001
	Median(IQR)	66.5 (62-74)	82(77-85)	
Mean corpuscularHaemoglobin(pg/cell)	Mean±S.D.	22.5±2.08	28.6±2.22	
	Median(IQR)	22.5 (21-24)	28(27-31)	<.0001
Mean corpuscular haemoglobin-concentration(gm/dl)	Mean±S.D.	28.32±1.55	33.02±0.87	
	Median(IQR)	28.35 (27-29.200)	33.2 (32-33.800)	<.0001
Haematocrit(%)	Mean±S.D.	30.5±2.08	40.5±3.99	<.0001
	Median(IQR)	30.5 (29-32)	41 (38-43)	
Serum ferritin (ng/ml)	Mean±S.D.	10.91±5.51	41.44± 20.93	<.0001
	Median(IQR)	9 (7-16)	40 (22-57)	
Iron deficiency anaemia		50(100.00%)	0(0.00%)	<.0001
Normal		0(0.00%)	50(100.00%)	

After three months of anemia treatment, the HbA1c levels significantly decreased. The pre-diabetic range of individuals in Group A considerably fell from 80% to 30% (p<0.0001) among the anemic patients. (Table 5).

Table 5: Effect of IDA Treatment on HbA1c

HbA1c (%)	Before Treatment (n=50)	After Treatment (n=50)	PValue
HbA1cinpre-diabeticrange (5.7 – 6.4%)	40(80.00%)	15(30.00%)	<.0001
NormalHbA1c(<5.7%)	10(20.00%)	35(70.00%)	
Mean±S.D.	5.92±0.37	5.49±0.42	<.0001
Median(IQR)	6(5.700- 6.200)	5.5(5.200- 5.700)	

Discussion

The body's ability to control its sugar and HbA1c levels can be greatly impacted by anemia. The current investigation demonstrated a strong correlation between anemia and diabetes parameters, with a noteworthy improvement in HbA1c values following IDA treatment.

The patients in groups A and B had mean ages of 43.98 ± 17.18 and 45.02 ± 16.84 years, respectively, in the current investigation. There were an equal number of females (58% each) and males (42% each) in each group. In a study by Bharadwaj et al., [21] there were 66% females in the study group and 40% in the controls group. The mean age of patients in the study group was 30.3 years, compared to 36.24 years in the controls group. The results of this research collectively imply that iron insufficiency is more common in females.

The two study groups were similar in terms of age and gender. Similar findings to our study were found in other case control studies by Christy A et al., [22] Aggarwal et al., [23], and Kalasker V et al., [24]. 50 cases of non-diabetic IDA and 50 healthy non-diabetic patients were compared in our study. Similar to Bharadwaj et al., [21] Aggarwal et al., [23] and Christy A. et al., [24] who reported that microcytic hypochromic anemia was observed in all IDA patients, all cases exhibited this condition.

In our investigation, group A's Mean Hb, MCV, MCH, MCHC, HCT, and ferritin were considerably lower than group B's (p<0.0001). Other investigations also found similar results. Variables such as hemoglobin, haematocrit, MCV, MCH, MCHC, and serum ferritin were shown to be relatively lower in patients with IDA, according to reports by Bharadwaj et al., [21] and Aggarwal et al., [23]. Monitoring serum ferritin is crucial for early identification and treatment of IDA since it is the first sign to decline. Other indicators only start to decline and smear abnormalities such microcytosis and hypochromia emerge after an extended iron deficiency. The WHO has established criteria for diagnosing anemia in males and females, respectively, based on Hb values <13 g/dL and <12 g/dL. All of the individuals in our investigation met these criteria. Based on additional indicators such as serum ferritin, microcytosis, and hypochromia on PBF, every case of IDA was identified and treated under observation.

In our investigation, patients with IDA had higher levels of all diabetes-related biochemical indicators, such as FBS and RBS. The analysis of three months' average sugar, or HbA1c, showed a significant difference between groups A and B (5.92% vs. 5.11%; P<0.0001). In comparison to all normal patients in group B, 80% of patients in group A had pre-diabetes at baseline, based on the metrics. Corroborating findings to our study were observed in other investigations that measured HbA1c levels in individuals with IDA.

Mean HbA1c values in IDA patients were substantially higher, according to Coban et al. (7.4% vs. 5.9%), Brooks et al. (9.9% vs. 7.9%), Aggarwal et al. (6.1% vs. 4.1%), Bharadwaj et al. (6.6% vs. 5.48%), and Kumar M et al. Kalasker V et al., [22] and Sinha et al., 28 found that the mean HbA1c levels were considerably lower in anemic patients than in controls, which is in contradiction to our study.

The mean Hb, MCV, MCH, MCHC, HCT, and ferritin levels in all of the patients in our study increased significantly (p<0.0001) following IDA treatment. Our study's improved outcomes were consistent with those of other studies.

In a research by Bharadwaj et al., [21] after three months of treatment, the patients' mean hemoglobin levels rose, but they were still lower than the control values, and this difference was statistically significant (p<0.01). Similarly, after three months of treatment, mean HCT, MCV, and MCH values increased in comparison to baseline. After three months of treatment, the mean levels of ferritin, MCHC, MCV, MCH, Hb, and HCT increased, according to reports from Kumar et al., [27] and Sinha et al., [28]. After receiving IDA treatment, the number of pre-diabetics fell from 80% to 30% and the HbA1c showed a substantial decrease (5.92% to 5.49%, P<0.0001) among the diabetic indicators. Bharadwaj et al. study, which contrasts with ours, [21] shown that following IDA treatment, HbA1c dropped from 6.6% to 5.74%. After receiving IDA medication, HbA1c improved from 5.13% to 4.72%, according to Kumar et al. 27 Nonetheless, following IDA treatment, the HbA1c in the Sinha et al. study [28] increased from 4.6% to 5.9%.

The entire study findings demonstrate a strong correlation between IDA improvement and a drop in average blood sugar (HbA1c). According to a study by Horton et al. [29], the explanation for the decreased HbA1c is attributed to the shorter RBC life span. In a different study conducted by Brooks et al., [26] patients with IDA had higher baseline HbA1c values, which decreased with therapy. They provided the following explanation for this: there is a shift in the quaternary structure of hemoglobin and beta globin chain glycation, which occurs more easily in environments with comparatively low iron levels.

Sluiter et al. [34] provided an alternative explanation for the findings of the Brooks et al. study. [26] They believed that the process of glycated hemoglobin production is irreversible. As a result, the HbA1c concentration in a single erythrocyte will increase linearly with cell age. After receiving IDA treatment, patients with normal blood glucose levels but younger-looking red blood cells saw a decrease in HbA1c concentration. Furthermore, a prolonged presence of IDA causes a decrease in the rate of red cell synthesis, which raises the average age of circulating erythrocytes above normal and raises HbA1c levels in addition to causing anemia.

El-Agouza et al., [30] put it this way: there is a balanced relationship between HbA1c and plasma glucose levels, so a decrease in haemoglobin concentration will result in an increase in glycated fraction. Tarim et al., [31] suggested that the patient's iron status should be taken into consideration when interpreting HbA1c concentrations. Rai et al., [32] looked into various methods of estimating HbA1c and found no differences between colorimetry, ion-exchange chromatography, and affinity chromatography.

Studies by Mitchell et al. [33] and Heyningen et al. [35] found no difference in IDA patients' baseline and treatment-related HbA1c (%) levels. They reasoned that the variations observed earlier might have resulted from using various techniques to calculate HbA1c rather than red cell age. Simple association exists between IDA and HbA1c levels; the two are inversely correlated. This indicates that when the degree of iron deficiency increases in anaemic patients, the hemoglobin level falls and the levels of HbA1c rise in tandem. Moreover, the anemic individuals' HbA1c levels decreased to nearly normal ranges upon IDA correction. It can be inferred that factors other than glucose have a significant influence in the calculation of HbA1c, which is used to determine the glycaemic status of the previous three months.It is generally advisable to take these additional aspects into account before making a treatment decision change.

When elevated levels of HbA1c are found, IDA should always be checked out because it is a very common ailment in Indian settings. Correcting the HbA1c should be done first in order to reach actual levels. Since India is the world's center for diabetes and HbA1c is a frequently performed test in routine medical practice, HbA1c readings should always be carefully interpreted taking into account all the factors that affect its value, including some extremely common ones like IDA.

Conclusion

At the outset, those with IDA had greater baseline levels of diabetes-related biochemical markers, such as FBS, RBS, and HbA1c, than did those without IDA. HbA1c significantly decreased in IDA cases when iron deficiency was corrected and IDA treatment was administered.

Therefore, it can be said that persistent iron deficiency may cause HbA1c readings to rise. Iron status and diabetic risk should be considered when making diagnostic or treatment decisions for treating IDA and glycaemic states in any patient.

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