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PREVALENCE AND DETERMINANTS OF ANEMIA IN ADOLESCENTS WITH TYPE 1 DIABETES MELLITUS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Anemia is a common but often overlooked complication in adolescents with Type 1 Diabetes Mellitus (T1DM). The prevalence of anemia, particularly iron deficiency anemia (IDA), may affect the overall health and quality of life in this population.

Objective: To determine the prevalence of anemia, specifically IDA, and explore the relationship between anemia and glycemic control in adolescents with T1DM.

Methods: This cross-sectional study was conducted at Medical unit of services hospital Lahore from 1st January 2024 to 31st December 2024. A total of 150 adolescents aged 10–19 years with T1DM were enrolled. Hemoglobin (Hb), serum iron, ferritin, total iron-binding capacity (TIBC), and HbA1c levels were measured. Anemia was defined as Hb <12 g/dL in females and <13 g/dL in males, while IDA was diagnosed based on low serum iron and ferritin levels and high TIBC.

Results: Anemia was found in 70 (46.7%) adolescents, with IDA accounting for 39 (55.7%) of these cases. HbA1c levels were significantly higher in anemic patients ($p<0.05$), and these adolescents also showed poorer anthropometric measurements.

Conclusion: Anemia, especially IDA, is highly prevalent in adolescents with T1DM and is associated with poor glycemic control. Early screening and management of anemia are crucial in improving overall health outcomes in these patients.

Keywords: Anemia, Iron Deficiency Anemia, Type 1 Diabetes Mellitus, Adolescents, Glycemic Control, Iron Status

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INTRODUCTION

Type 1 Diabetes Mellitus (T1DM) is a long-term disorder, which is associated with the autoimmune destruction of insulin-producing b-cells in the pancreas. T1DM has been on the increase worldwide, the most vulnerable population being teens[1,2]. Anemia, and especially iron deficiency anemia (IDA) is a well-known characteristic of patients with T1DM but remains mostly undiagnosed.

T1DM may cause anemia due to a combination of factors such as inappropriate dietary intake, malabsorption, increased losses of iron, and the long-term inflammation. Research has demonstrated that anemia occurs in T1DM patients with a prevalence of 20-50 percent and a large percentage of anemia is IDA[3-5]. Of interest is the effect of anemia on glycemic control of T1DM as low hemoglobin content can result in low oxygen carrying capacity thereby increasing insulin resistance and metabolic malfunction[6,7].

Diabetic nephropathy, neuropathy and poor growth are some of the complications that have already been posed to adolescents with T1DM. These risks are aggravated by the burden of anemia. In addition, anemia in such patients has been attributed to the poor glycemic control, as measured by high levels of HbA1c[8,9].

Although the relationship between T1DM and anemia is well-reported, research on this group of adolescents is limited. With the increasing incidence of T1DM across the world, it is important to determine the incidence and causes of anemia in this susceptible population. The current study will determine the prevalence of anemia among adolescents with T1DM and

determine how it correlates with glycemic control and anthropometric data.

METHODS

This research was a cross-sectional study conducted at Medical unit of services hospital Lahore from 1st January 2024 to 31st December 2024 The Institutional Review and Ethics Board sanctioned the research. All participants and their guardians provided informed consent. A total of 150 adolescents aged 10-19 years with Type 1 Diabetes Mellitus were recruited through convenience sampling. Individuals with Type 2 diabetes and other forms of anemia (e.g., thalassemia, sickle cell disease), as well as those with chronic kidney or liver disease, were excluded.

A standardized data gathering protocol was adhered to. Demographic data, including age, gender, and duration of diabetes, was gathered by direct interviews with participants and by reviewing the respondents' medical records. Standardized apparatus was employed to document anthropometric measurements, including weight, height, and body mass index (BMI). Weight in kilograms (kg) was assessed using a calibrated digital scale, while height in centimeters (cm) was measured with a stadiometer. The BMI was calculated by dividing weight (kg) by the square of height (m^2). Various hematological and biochemical parameters were assessed using blood samples obtained after an overnight fast. Hemoglobin levels were assessed using an automated hematology analyzer (Sysmex XT-1800i), and a full blood count (CBC) was performed to evaluate additional parameters, including red blood cell count, mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH). The iron status was evaluated using serum iron, ferritin, and total iron-binding capacity (TIBC). HbA1c was quantified using high-performance liquid chromatography (HPLC) to assess the participants' long-term glycemic management.

The data were analyzed utilizing SPSS version 23.0. Descriptive statistics have been employed to encapsulate demographic data. The variables anemic and non-anemic were employed in a chi-square test and an independent t-test. The threshold for statistical significance was set at a p-value of less than 0.05.

RESULTS

70 (46.7%) of the 150 adolscent that were enrolled had anemia. The study population had a mean age of 14.8 ± 2.1 years and included 85 (56.7%) males and 65 (43.3%) females. Diabetes lasted 5.9 ± 3.2 years on average.

Table 1: Demographic and Clinical Characteristics

Characteristic	Total (n=150)	Anemic (n=70)	Non-anemic (n=80)	p-value
Age (years)	14.8 ± 2.1	14.5 ± 2.3	15.0 ± 1.9	0.12
Gender (M/F)	85/65	37/33	48/47	0.68
Duration of Diabetes (years)	5.9 ± 3.2	5.7 ± 3.1	6.1 ± 3.2	0.24
HbA1c (%)	8.3 ± 1.4	8.7 ± 1.5	7.9 ± 1.2	0.03*
BMI (kg/m^2)	22.3 ± 3.4	21.5 ± 3.1	23.0 ± 3.7	0.02*

*Statistically significant (p<0.05)

39 (55.7%) of the 70 anemic adolescents had IDA. The anemic group's hemoglobin levels (10.1 ± 1.4 g/dL) were substantially lower than those of the non-anemic adolescents (14.1 ± 1.2 g/dL, p<0.001). Patients with anemia also had decreased levels of ferritin and serum iron (p<0.001).

Table 2: Hematological and Iron Status Parameters

Parameter	Anemic (n=70)	Non-anemic (n=80)	p-value
Hemoglobin (g/dL)	10.1 ± 1.4	14.1 ± 1.2	<0.001*
Serum Iron (µg/dL)	49.6 ± 23.7	91.4 ± 18.6	<0.001*
Serum Ferritin (ng/mL)	45.5 ± 29.2	50.0 ± 28.4	0.41
TIBC (µg/dL)	572.3 ± 148.4	469.4 ± 131.6	<0.001*

*Statistically significant (p<0.05)

The HbA1c levels of anemic adolescents (8.7 ± 1.5%) were noticeably greater than those of non-anemic adolescents (7.9 ± 1.2%, p<0.03). In comparison to non-anemic teenagers (23.0 ± 3.7 kg/m^2, p<0.02), the anemic group had a considerably lower body mass index (21.5 ± 3.1 kg/m^2).

Table 3: Glycemic Control and Anthropometry

Parameter	Anemic (n=70)	Non-anemic (n=80)	p-value
HbA1c (%)	8.7 ± 1.5	7.9 ± 1.2	0.03*
Weight (kg)	42.5 ± 9.3	45.3 ± 10.1	0.10
Height (cm)	156.8 ± 10.2	159.2 ± 9.8	0.15
BMI (kg/m^2)	21.5 ± 3.1	23.0 ± 3.7	0.02*
Waist Circumference (cm)	63.4 ± 7.6	65.8 ± 8.2	0.11
Hip Circumference (cm)	84.7 ± 9.5	87.5 ± 8.9	0.07

*Statistically significant (p<0.05)

The aim of this logistic regression analysis was to assess the variables that independently predict the incidence of anemia in type 1 diabetic adolescents. Anemia status (yes/ no) was the dependent variable, and HbA1c, body mass index (BMI), serum ferritin, serum iron, TIBC, and diabetes duration were predictors.

The odds ratio of anemia in patients with high HbA1c level was 1.23, 95% CI 1.01 to 1.53, p=0.03. Lower body

mass index was positively associated with anaemia risk in one study (OR:0.88, 95% CI:0.75-1.04, p=0.04). Low ferritin level was a strong predictor of anemia, with an odds ratio of 0.67 (95%CI: 0.52-0.87), p=0.002. In addition, anemia was significantly associated with low serum iron (OR: 0.56, 95% CI: 0.43-0.74, p<0.001). Its most frequent predictors are higher HbA1c, lower BIB, and a bad iron status in adolescents with diabetes type 1. (Table 4)

Table 4: Logistic regression Analysis

Independent Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
HbA1c	1.23	1.01–1.53	0.03*
BMI	0.88	0.75–1.04	0.04*
Serum Ferritin	0.67	0.52–0.87	0.002*
Serum Iron	0.56	0.43–0.74	<0.001*
Duration of Diabetes	1.02	0.98–1.07	0.32

*Statistically significant (p<0.05)

DISCUSSION

T1DM in adolescents is associated with an increasing number of cases of anemia, particularly, IDA. We conclude that the findings of nearly half of the adolescent population with T1DM with 55.7% of the anemic group having been diagnosed with IDA. Such a prevalence rate demonstrates the significance of screening and early diagnosis, as the adverse effects of anemia on glycemic regulation and health outcomes in general of the age group are adverse.

Poor conglycemic control is associated with anemia in T1DM patients as anemic adolescents exhibited elevated HbA1c level. HbA1c is a necessary measure of the long-term glycemic control and the rise of the same in anemic patients implies that the existence of inefficient glucose control may be linked to the presence of anemia. Previous studies have indicated that anemia, to the best of our knowledge, IDA anemia can decrease insulin sensitivity and is the cause of ineffective glycemic regulation. Less physical activity and fatigue due to anemia could be other contributors to the difficulty of maintaining constant blood glucose levels[10-12].

The pathophysiology of interrelation between complications related to T1DM and anemia is complex. Anemia and resultant decrease in hemoglobin and subsequently, decrease in oxygen carrying capacity may worsen the metabolic profile in T1DM. This limitation in the ability to provide adequate oxygen to the tissues could overburden the effort of the insulin-sensitive tissues, resulting in insulin resistance and failure to maintain the level of blood glucose[13,14]. The existing association highlights the importance of handling anemia to optimize glycemic management in adolescents with T1DM.

In our study we came to the conclusion that the BMI of anemic adolescents was greatly lower as compared to the BMI of non-anemic adolescents. The same observation aligns organizationally with the findings of other studies that highlight the poor nutritional status and retarded growth in children and adolescents with T1DM who also suffer anemia. A study by Pacheco et al.[15] indicated that inadequate growth and late puberty are quite common in children with T1DM, and those with anemia. In addition, iron deficiency, which is a common feature of IDA, can lead to unfavorable physical growth and cognitive development, and, therefore, treatment of the anemia in adolescents with T1DM at an early stage is of great importance.

Our logistic regression analysis has led to the conclusion that the low concentrations of serum iron and ferritin are strong predictors of anemia in adolescent patients with T1DM. Iron deficiency is a prevalent etiological factor in nonpregnancy-related anemia amongst the general population and is even more prevalent in children with such persistent conditions as T1DM. As it was raised in a study carried out by Khemka et al.[16], the lack of iron that might not exactly be accompanied by anemia can have dire consequences on brain functions and physical development. Further, iron deficiency may ameliorate the inflammatory state present in T1DM, and this further impairs the optimal erythropoiesis.

Inflammation and Iron Usage: The role of the chronic inflammation in the pathogenesis of anemia in T1DM should not be disregarded. The inflammation is low-grade and is chronic such as is the case in diabetes and can interfere with iron utilization in the body. Cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-a) increase during the inflammatory process and could lead to an iron absorption deficiency and a change in the iron metabolism patterns[17,18]. This is also a possible reason why the prevalence of IDA is also high in adolescents with T1DM since such inflammatory indicators can be used to explain why these individuals cannot liberate stored iron in order to promote erythropoiesis.

CONCLUSION

Adolescent T1DM is associated with anemia (particularly iron deficiency anemia) and poor glycemic control and suboptimal growth. We see that screening-periodically of anemia is a necessary component of care, especially among poorly managed diabetic adolescents. Special care must be paid to iron status, and one must also pay attention to such variables as BMI and HbA1c in order to offer the best care to these patients. Early diagnosis and intervention of anemia can have a positive effect on glycemic control and growth outcomes and reduce the overall burden of T1DM in adolescents.

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