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A Review on the Importance of Haematological Markers in Relation to Type 2 Diabetes Monitoring

Amala T [a*], Sukesh [b] and Swathi D [c]

[a] Allied Health Science, Srinivas University, Mangalore, Karnataka, India.
[b] Department of Pathology, Srinivas Institute of Medical Sciences & Research center, Mangalore, Karnataka, India.
[c] Department of Forensic Science, Institute of Allied Health Sciences, Srinivas University, Mangalore, Karnataka, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Diabetes mellitus is a chronic disease that occurs when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin that it produces. The most common type of diabetes is type II diabetes, which is characterized by insulin resistance or relative insulin deficiency. Diabetes mellitus shows a significant derangement in various hematological parameters such as RBC, platelet, WBC, Red cell indices and RDW. Routine screening of blood cell parameters in poorly controlled T2DM gives an awareness about further complication and should be helpful for regular management of T2DM.
This review analyzes the predictive power of hematological parameters for T2DM.

**Corresponding author: E-mail: amalamdas@gmail.com;*

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ABBREVIATIONS

CBC : Complete Blood Count
T2DM : Type2 Diabetic Mellitus
FBS : Fasting Blood Sugar
RBS : Random Blood Sugar
OGTT : Oral Glucose Tolerance Test
MCV : Mean Corpuscular Volume
MCH : Mean Corpuscular Hemoglobin
MCHC : Mean Corpuscular Hemoglobin Concentration
RDW : Red cell Distribution Width

1. INTRODUCTION

Diabetes mellitus is a chronic disease associated with the inability to produce an adequate amount of hormone insulin or to effectively use the insulin produced by the body [1]. It is a diverse set of disorders defined by different abnormalities in the control of protein, lipid, or carbohydrate metabolism [2]. Uncontrolled blood glucose levels have been associated with a number of conditions that can cause disability, such as cardiovascular disease, nerve damage that can result in different types of neuropathies and kidney damage that can lead to diabetic nephropathy, diabetic foot that can cause a drop in body temperature, and ocular diseases that primarily affect the retina and cause blindness and vision loss [3].

Long-term exposure to high glucose causes hemoglobin to be glycated by enzymes, and membrane proteins cause the aging of red blood cells, which may eventually cause hyperlipemia with a lower red blood cell count. A different process might result from a change in the fluid electrolyte balance. In T2DM patients with high blood glucose, the activity of the erythrocyte membrane cation pump protein is impaired [4].

The most widely used laboratory tests for screening and tracking blood glucose levels are HbA1C, OGTT, and FBS [5]. The HbA1C blood test indicates a patient's average blood glucose level during the previous two to three months, or the predicted life span of red blood cells [6]. The best use of HbA1C as a biomarker is for long-term blood glucose monitoring. In contrast to other glucose-based tests, it is not as affected by variables like dietary consumption, stress levels, physical activity, and immediate treatment response [7-11].

A complete blood count consists of a panel of tests that are typically used to differentiate between various forms of anemia. RBC parameters include MCV, MCH, MCHC, RDW, hemoglobin, hematocrit, and red blood cell count [12]. One potential cause of elevated RDW in T2DM patients could be hyperglycemia-induced oxidative damage and chronic inflammation. A high intracellular glucose concentration brought on by an influx of glucose to the erythrocyte via the insulin-dependent glucose transporter (GLUT1) may be the cause of an increased MCV in patients with poor glycemic control. This rapid diffusion of water into the cell flattens the biconcave disk and bloats the cell [12,13].

Even though HBA1C is still the gold standard for evaluating long-term glycemic management, poor nations have limited access due to the high cost of this test when it comes to routine diagnostic care [14]. Red cell characteristics that can be utilized to track the course of complications and diabetes control are the primary focus of this review. Thereby making them a valuable tool for the assessment of T2DM patients [15].

Therefore, the goal of the study is to assess red blood cell characteristics for monitoring type 2 diabetes patients. Our findings may help with T2DM management in the future.

2. INSULIN RESISTANT DIABETES MELLITTUS

Diabetes mellitus is a type of metabolic disease characterized by elevated blood sugar levels, which are typically caused by abnormalities in insulin secretion, flow, or both. Because of hyperinsulinemia, the body's cells and tissues are not receiving enough insulin, which leads to irregularities in the metabolism of fat, protein, and carbohydrates. Insulin-dependent diabetes mellitus (type 1) and non-insulin-dependent diabetes mellitus (type 2) are the two main forms of diabetes. Reduced insulin secretion will prevent glucose from entering the cell, which will cause hyperglycemia. It is possible for insulin to reduce hyperglycemia [16].

Type 2 diabetes mellitus is the most prevalent type of disease in adults. It is a long-term metabolic illness characterized by low insulin synthesis or insulin resistance, both of which raise blood sugar levels [17]. Chronic

hyperglycemia causes a number of physiological and pathological processes, such as oxidative stress, which impacts lipid metabolism, inflammatory response, cell growth, immunological, and hematological parameters, all of which are evident in patients with poorly controlled diabetes [18]. Increased oxidative stress causes hematological changes that impact platelets, WBCs, and RBCs in terms of their structure, function, and metabolism [19].

The primary cause of end-stage renal disease is diabetes mellitus, and a significant number of patients with diabetes mellitus experience renal complications [20].

Diabetes patients experience anemia twice as frequently as non-diabetics. When comparing individuals with diabetes nephropathy to those with nephropathy from other causes, the risk of anemia is increased [21]. Chronic hyperglycemia associated with diabetes may cause a hypoxic environment in the renal interstitum, which will reduce erythropoietin synthesis [22]

An increased leukocyte count relates to the presence of neuropathy and vasculopathy by accumulation of blood glucose which block the blood vessels or nerves [23].

It's crucial to remember that patients with diabetes are more atherogenic from dyslipidemia than people without the disease. Dyslipidemia, hypertension, and altered hematological indicators are all components of the metabolic syndrome, which includes type 2 diabetes [24].

In diabetes, macrovascular and microvascular complications are the main cause of death rather than cardiovascular disease [25,26]. The disease known as atherosclerosis is inflammatory. Nearly every blood component, including platelets, WBCs and RBCs has a part in the underlying pathophysiology of atherosclerosis [27]. It's critical to achieve HBA1C range optimization of 6.5–7% [28]. Glycated protein, urine sugar, fructosamine, glycated hemoglobin (HbA1C), urine protein such as micro albuminuria, glucose level in plasma (random sample), and urine sugar are among the laboratory tests used to monitor patients with diabetes mellitus [29,30]. Increased HbA1C is positively related to the longer duration of type 2 diabetes [31].

3. ASSOCIATION OF BLOOD CELL PARAMETERS IN DIABETES MELITTUS

The complete blood count, which consists of a panel of analytical tests typically used to distinguish RBC characteristics [32,33]. The metrics associated with red blood cells are as follows: the number of red blood cells, the hematocrit, the hemoglobin, the mean corpuscular volume, the mean corpuscular hemoglobin concentration, and the red cell distribution width [34,35].

3.1 RBC Count

Diabetes patients with HbA1C >7 have significantly lower red blood cell counts, hemoglobin levels, and hematocrit levels, which suggests that anemia is more likely to develop in people with diabetes [36,37]. Chronic exposure to high glucose causes non-enzymatic glycation of membrane protein and hemoglobin [38], which ages red blood cells and ultimately lowers the RBC count in patients with persistent hyperglycemia [39].

3.2 Red Cell Indices

Many studies have shown a relationship of RBC indices and HbA1C [40,41]. While mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration characterize the hemoglobin content of RBC, mean corpuscular volume shows the size of RBC [42,43]. Hyperglycemia affects red blood cell aggregation and deformability and shortens its lifespan [44]. MCV and MCH were significantly increase in T2DM but no significance of MCHC [45]

3.3 Red Cell Distribution Width

RDW is a measurement of size variation among circulating red cells and is calculated as part of routine CBC. The RDW along with mean cell volume, is useful in the differential diagnosis of anemia [46,47]. It can be used as a biomarker that is simple to measure and may help to identify diabetes mellitus. It had a strong positive correlation with HbA1C [48].

3.4 Hemoglobin Concentration

Hemoglobin and diabetes profiles are closely related. Blood viscosity is also significantly influenced by hemoglobin levels [49].

3.5 WBC Count

A high systemic neutrophil count is related with the presence and severity of diabetes [50]. Leukocyte count can indicate the overall inflammatory state of the body [51].

3.6 Hematocrit

There is a correlation between hematocrit and length of diabetes, body weight in patients with HbA1C >7 [52].

3.7 Platelet Function

Blood platelets are essential to the process of blood coagulation. There have been reports of altered platelet shape and function in diabetes patients. Insulin resistance in T2DM has been linked to a platelet disorder caused by insulin action. The entire coagulation cascade is defective in T2DM [53]. An increase in mean platelet volume may indicate the development of atherosclerosis, which is associated with diabetes and vascular complications [54].

Type 2 diabetes mellitus is a fundamental public health problem that has been increasing dramatically worldwide [55]. Inappropriate control of blood glucose in diabetes patients is the main key to the incidence of both micro and macrovascular problems [56]. Glycation of hemoglobin and membrane proteins causes persistent hyperglycemia in diabetes, which is linked to metabolic, structural, and functional alterations in red blood cells. Moreover, endothelial tissue damage and RBC malfunction are linked to elevated levels of oxygen free radical generation and chronic inflammation [57]. In addition, RBC glycation causes increased aggregation and decreased deformities because it decreases membrane fluidity [58,59].

4. CONCLUSION

This review states the role of haematological parameters in managing T2DM. Haematological alteration among diabetes can lead to long term complication and even death. CBC is a low cost, standard, easy test that provide significant result. This suggest that regular CBC examination is necessary for early identification and treatment of diabetes patient in primary care settings. Hence haematological parameter has a crucial role in understanding progression of disease and further improve the quality of life.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology Details of the AI usage is given below:

1.Quiibolt
2.Grammerly

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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