



## A STUDY OF MEAN PLATELET VOLUME IN TYPE 2 DIABETES MELLITUS PATIENTS WITH AND WITHOUT VASCULAR COMPLICATIONS : A COMPARATIVE STUDY

Dr. Nishit Mashru<sup>1</sup>, Dr. Shilpa Patil<sup>2</sup>

**Article History:** Received: 12.12.2022

Revised: 29.01.2023

Accepted: 15.03.2023

### Abstract

**Background:** Diabetes has many vascular complications including Coronary Artery Disease, Acute Ischemic Cerebrovascular Accident and Diabetic Retinopathy. Many platelet parameters can detect these vascular complications by analyzing the prothrombotic stage of platelets. To evaluate this we studied the Mean Platelet Volume in patients with Type 2 Diabetes Mellitus with the vascular complications and without the vascular complications.

**Methods:** This was a single centre hospital-based prospective study conducted in patients admitted to the Krishna hospital under medicine wards and ICU over a period of 18 months from January 2021 to June 2022. We divided the study participants in two groups, type 2 diabetes patients with complications (Group A) and without complications (Group B). We studied various parameters in these groups and correlated them with MVP.

**Results:** Most common age group was 61 to 70 years in both the groups. Group A patients had 31 males (51.67%) and in Group B patients there were 38 males (63.33%). Significant difference was seen in the duration of diabetes of the two groups. ( $p < 0.001$ ). Group A patients had mean HbA1c levels of  $8.12 (\pm 2.36)$  while in Group B patients the mean HbA1c levels of  $6.92 (\pm 1.45)$ . The HbA1c was statistically significantly raised in patients with Type 2 Diabetes mellitus with vascular complications ( $p < 0.001$ ). There was weak positive correlation of Mean Platelet Volume with HbA1c, Fasting Blood Sugar, Post Prandial Blood Sugar, (0.303, 0.390, 0.314) respectively in Group A as compared to very weak positive correlation of Mean Platelet Volume with HbA1c, Fasting Blood Sugar, Post Prandial Blood Sugar, (0.007, 0.018, 0.072) respectively in Group B.

**Conclusion:** In present study we observed that in diabetes mellitus patients with vascular complications had significantly raised Mean Platelet Volume (MPV) and Platelet Distribution Width (PDW). We conclude that the MPV can be utilized as a screening tool to look for diabetes cases that may have vascular problems.

**Keywords:** MPV – Mean platelet volume, Type 2 DM, vascular complications

<sup>1</sup>Resident, Department of Medicine, Krishna Institute of Medical Sciences, Karad, Maharashtra

<sup>2</sup>Associate Professor, Department of Medicine, Krishna Institute of Medical Sciences, Karad, Maharashtra

DOI: 10.31838/ecb/2023.12.s2.023

## 1. Introduction

A collection of common metabolic illnesses with the phenotype of hyperglycemia are referred to together as diabetes mellitus (DM). Depending on the cause of the disease, lower insulin secretion, decreased glucose absorption, and increased glucose production are all variables that might lead to hyperglycemia. A significant burden is placed on the DM patient as well as the healthcare system by the secondary pathophysiologic alterations brought on by the metabolic dysregulation associated with DM in a number of organ systems.<sup>1</sup>

Diabetes mellitus (DM) has become a global health problem in the modern world. The International Diabetes Federation (IDF) has released new figures showing that 537 million adults are now living with diabetes worldwide — a rise of 16% (74 million) since the previous IDF estimates in 2019. By 2045, this is projected to increase to 629 million people worldwide and 151 million people in South East Asia. According to estimates, 77% of the world's burden of the diabetes epidemic will fall on developing nations in the twenty-first century. Diabetes currently affects 8.8% of persons in India.<sup>2</sup> Diabetes is characterized by hyperglycemia, which results in a variety of long-term systemic problems. Given that the disease generally strikes people when they are at their peak of productivity, they have a significant effect both on the patient and society. In general, macrovascular complications (Coronary Artery Disease, Peripheral Arterial Disease, Cerebrovascular Accident) and microvascular complications are used to classify the harmful effects of hyperglycemia (Diabetic Retinopathy, Diabetic Nephropathy, Diabetic Neuropathy).<sup>3</sup> Platelets may be a contributing factor in the development of micro- and macrovascular disease in diabetic individuals due to altered platelet shape and function. Due to prolonged hyperglycemia and insulin resistance, which damage pericytes and endothelium, DM is defined by the prothrombotic condition of platelets. The vascular consequences of this metabolic condition are thought to occur as a result of the elevated platelet activity.<sup>4</sup>

Platelet indices serve as a functional indicator for appropriate homeostasis because platelets are crucial to maintaining its integrity. Larger platelets are more potent and thrombogenic because they contain more dense granules. Throughout the course of a platelet's existence, both the quantity and size of its granules remain constant. Diabetes mellitus, the metabolic syndrome, cerebrovascular accidents, coronary artery disease, and increased mean platelet volume (MPV) have all been linked to this condition (DM). According to a few studies, diabetics' platelet indices are much higher than those of non-diabetics.<sup>5,6</sup>

Long-term problems are the main cause of death and poor quality of life in this population and are closely related to endothelial dysfunction, which is mostly brought on by inadequate glycemic management. It is difficult to find diagnostic techniques to make an early diagnosis of these issues, but new research has shown that platelets are one of the coagulation system components that play a role in the emergence of these events.<sup>7,8</sup>

Since a few years ago, platelet properties can be obtained in the laboratory using blood cell counters. These include platelet large cell ratio (P-LCR), plateletcrit (PCT), platelet distribution width (PDW), and MPV. With the aid of these platelet parameters, the prothrombotic stage of platelets can be easily detected using more recent haematological analyzers.<sup>8</sup>

Hence, present study was conducted to study the Mean Platelet Volume in patients with Type 2 Diabetes Mellitus with the vascular complications and without the vascular complications.

## 2. Methodology

This was a single centre hospital-based cross-sectional study conducted in patients admitted to the Krishna hospital under medicine wards and ICU over a period of 18 months from January 2021 to June 2022.

We divided the study participants in two groups, type 2 diabetes patients with complications and without complications. According to a study conducted by **Ulutas KT et al**<sup>9</sup> the mean and standard deviation of MPV (fl) in two groups was  $7.95 \pm 0.72$  and  $8.35 \pm 0.724$ . Using the formula to calculate sample size for each comparative group in the studies with comparison between the groups, The sample size for each group came as  $n_1 = n_2 = 52$ , which we rounded off to 60 in each group to a total of 120 cases. These 120 cases we took from two groups, Group A - Diagnosed cases of diabetes with vascular complications and Group B - Diagnosed cases of diabetes without vascular complications. Male patient with Hb below 13mg/dl and female patient with Hb 12 mg/dl were excluded. Diabetic patients on anti-platelet drugs, antibiotics causing thrombocytopenia, Patients suffering from pyrexia, Gestational diabetes cases, Cirrhosis of liver cases and Subjects with known malignancy were excluded.

Ethics Committee approval: The clearance for the study was taken from institutional ethics committee after discussion of the study protocol with committee, patients were included in the study only after they give written informed consent to participate.

Statistical Analysis: Data was collected using a semi-structured pretested questionnaire, data

Collected was entered in Microsoft Excel. Data is represented in frequencies and percentages, charts and graphs. Mean and standard deviation of quantitative variables is shown. Appropriate statistical tests are applied using SPSS software version 21 for analysis. Chi square test is used for association and student's t-test is used for comparison wherever applicable. Pearson's Correlation is used to check the correlation between platelet indices and FBS, PPBS and HbA1c, where 'r' value denotes the correlation coefficient and p value if less than 0.05 shows significant correlation. Other statistical tests are used as per study requirements. P value < 0.05 is taken as statistical significance.

### 3. Observations and Results

#### Group A: Diabetic with Vascular complications

#### Group B: Diabetic without Vascular complications

Most common age group was 61 to 70 years in both the groups. There were 28 cases in Group A patients of Diabetic with Vascular complications aged 61 to 70 years (46.67%) and 23 cases in Group B patients of Diabetic without Vascular complications aged 61 to 70 years (38.33%). Group A patients of Diabetic with Vascular complications had 31 males (51.67%) and 29 females (48.33%) while in Group B patients of Diabetic without Vascular complications there were 38 males (63.33%) and 22 females (36.67%). Significant difference was seen in the duration of diabetes of the two groups. ( $p < 0.001$ ). Group A patients of Diabetic with Vascular complications had mean duration of diabetes of  $8.54 \pm 4.83$  years while in Group B patients of Diabetic without Vascular complications the mean duration of diabetes was  $5.46 \pm 2.38$  years.

Table 1: Comparison of mean and standard deviation of numerical variables in study population

Study parameters	Diabetic with Vascular complications	Diabetic without Vascular complications	P value
BMI levels	$26.59 \pm 8.34$	$25.42 \pm 7.89$	0.15
Diabetes Duration	$8.54 \pm 4.83$	$5.46 \pm 2.38$	< 0.001
FBS (mg/dl)	$193.6 \pm 105.28$	$112.65 \pm 70.98$	<0.001
PPBS	$239.56 \pm 121.14$	$161.35 \pm 72.07$	<0.001
HbA1c	$8.12 \pm 2.36$	$6.92 \pm 1.45$	<0.001
MPV (fl)	$11.17 \pm 2.12$	$10.01 \pm 1.83$	<0.001
Platelet Distribution width (fl)	$11.86 \pm 2.33$	$10.77 \pm 1.37$	<0.001
PCT (%)	$0.267 \pm 0.12$	$0.131 \pm 0.05$	<0.001

Comparison of Body Mass Index (BMI) among the study group :

Group A patients of Diabetic with Vascular complications had mean BMI of  $26.59 (\pm 8.34)$  kg/m<sup>2</sup> while in Group B patients of Diabetic without Vascular complications the mean BMI was  $25.42 (\pm 7.89)$  kg/m<sup>2</sup>. There was no significant difference in the BMI of the two groups ( $p = 0.15$ )

Comparison of Duration of Diabetes mellitus among study groups :

Group A had mean duration of diabetes of  $8.54 (\pm 4.83)$  years while in Group B the mean duration of diabetes was  $5.46 (\pm 2.38)$  years. The duration of diabetes was statistically significantly longer in patients with Type 2 Diabetes mellitus with vascular complications ( $p < 0.001$ ).

Comparison of Fasting Blood Sugar (FBS) levels among study groups:

Group A patients had mean fasting blood sugar levels of  $193.6 (\pm 105.28)$  while in Group B patients the mean fasting blood sugar levels of  $112.65 (\pm 70.98)$ . The Fasting Blood Sugar was statistically

significantly raised in patients with Type 2 Diabetes mellitus with vascular complications ( $p < 0.001$ ).

Comparison of Post Prandial Blood Sugar (PPBS) levels among study groups:

Group A patients had mean post prandial blood sugar levels of  $239.56 (\pm 121.14)$  while in Group B patients the mean post prandial blood sugar levels of  $161.35 \pm (72.07)$ . The Post Prandial Blood Sugar was statistically significantly raised in patients with Type 2 Diabetes mellitus with vascular complications ( $p < 0.001$ ).

Comparison of HbA1c levels among study groups:

Group A patients had mean HbA1c levels of  $8.12 (\pm 2.36)$  while in Group B patients the mean HbA1c levels of  $6.92 (\pm 1.45)$ . The HbA1c was statistically significantly raised in patients with Type 2 Diabetes mellitus with vascular complications ( $p < 0.001$ ).

Comparison of Mean Platelet Volume (MPV) among study groups: 37

Group A patients had mean MPV levels of  $11.17 (\pm 2.12)$  while in Group B patients the mean MPV

levels of  $10.01 (\pm 1.83)$ . The Mean Platelet Volume was statistically significantly raised in patients with Type 2 Diabetes mellitus with vascular complications ( $p < 0.001$ ).

Comparison of Platelet Distribution Width (PDW) among study groups:

Group A patients had mean Platelet Distribution width levels of  $11.86 (\pm 2.33)$  while in Group B patients the mean Platelet Distribution width levels of  $10.77 \pm (1.37)$ . The Platelet Distribution Width was statistically significantly raised in patients with Type 2 Diabetes mellitus with vascular complications ( $p < 0.001$ ).

Comparison of Plateletcrit (PCT) among study groups:

Group A patients had mean PCT levels of  $0.267 (\pm 0.12)$  while in Group B patients the mean PCT levels of  $0.131 (\pm 0.05)$ . The Plateletcrit was statistically significantly raised in patients with Type 2 Diabetes mellitus with vascular complications ( $p < 0.001$ ).

Table 2: Correlation of MPV and HbA1c

Correlation between MPV and HbA1c		MPV
HbA1c	Pearson Correlation	<b>0.762</b>
	Sig. (2 tailed p value)	<b>&lt;0.001</b>
	N	<b>60</b>

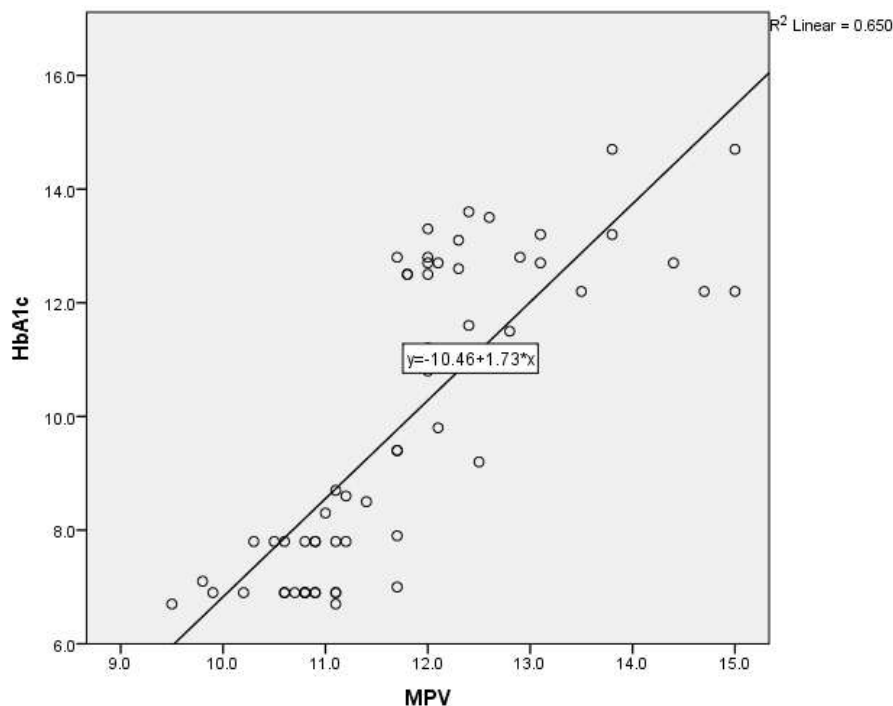


Fig 1: Correlation of MPV and HbA1c

Table 3: Correlation of MPV and various parameters in study

	Diabetes mellitus patients with vascular complications (Group A)		Diabetes mellitus patients without vascular complications (Group B)
	<i>r</i>	p value	<i>r</i>
MPV& HbA1c	0.303	0.018	0.007
MPV& FBS	0.390	0.002	0.018
MPV& PPBS	0.314	0.015	0.072
<i>r</i> :- correlation coefficient , MPV :- Mean Platelet Volume , FBS :- Fasting Blood Sugar, PPBS :- Post Prandial Blood Sugar			

There was weak positive correlation of Mean Platelet Volume with HbA1c, Fasting Blood Sugar, Post Prandial Blood Sugar, (0.303, 0.390, 0.314) respectively in Group A as compared to very weak positive correlation of Mean Platelet Volume with HbA1c, Fasting Blood Sugar, Post Prandial Blood Sugar, (0.007, 0.018, 0.072) respectively in Group B.

#### 4. Discussion

The present prospective study was conducted to study the correlation of mean platelet volume in patients with Type 2 Diabetes mellitus (Type 2 DM) with vascular complications (Coronary Artery Disease, Cerebrovascular Accident, Diabetic Retinopathy) and without vascular complications in tertiary care hospital.

In the present study, the mean age in diabetes mellitus patients with vascular complications was 58.21(±12.73) years and in the diabetes mellitus patients without vascular complications group it was 59.06 (±12.54) years. There was no significant difference in the age of two study groups. Similar results were reported by the Sonali Jindal et al with mean age of 60(± 8.06) years in their patients with the diabetes mellitus.<sup>10</sup>

In a study done by AV Gupta et al on the platelet indices and endothelial dysfunction in the patients of diabetes mellitus Type 2, they observed that the mean age among 50 diabetes mellitus patients was 56.7 (± 7.86) years.<sup>11</sup>

In the Group A mean fasting blood sugar levels were 193.6 (±105.28) mg/dl and in Group B 112.65 (±7.98) mg/dl. This difference in mean fasting blood sugar observed among the patients in the two study groups was found to be statistically significant. (p<0.05)

The mean post prandial blood sugar levels in the Group A patients was found to be 239.56 (±121.14) mg/dl and in the Group B patients it was found 161.35 (± 22.07) mg/dl. This difference in the mean post prandial blood sugar levels among these patients in two groups was found to be statistically significant. (P<0.05)

The mean HbA1c levels found in Group A patients was observed 8.12 (± 2.36) % and in Group B patients it was found to be 6.92 (± 1.45) %. This difference in mean HbA1c among patients in two groups was found to be statistically significant. (p <0.05)

In a study done by R. S. Walinjar et al included correlation between the platelet indices and the microvascular complications in Type 2 DM cases, they observed that the mean blood sugar levels (FBS, PPBS & HbA1c) were significantly greater in the Diabetes mellitus patients with vascular complications as compared to the cases without vascular complications.<sup>12</sup>

In a study done by K. J. Brahmabhatt et al on association of mean platelet volume with the vascular complications in patients with Type 2 DM, they observed that mean blood sugar levels (FBS, PPBS and HbA1c) were greater in the diabetes mellitus patients with vascular complications compared to the patients without the vascular complications. These findings were similar to present study.<sup>13</sup>

The mean MPV found in the Group A patients was 11.17 (±2.12) fl and in the Group B patients was 10.01 (±1.83) fl. This difference in the MPV among patients in two groups was found to be statistically significant.

The mean PDW in the Group A patients was 11.86 (±2.33) fl and in the Group B patients was 10.77 (±1.37) fl. This difference in mean Platelet Distribution width among the patients in two groups was found to be statistically significant.

The mean PCT (%) in Group A patients was 0.267 (±0.10) % and in Group B patients was 0.231 (±0.01) %. This difference in mean PCT (%) among patients in two groups was statistically significant.

K. R. Alhadas et al evaluated the platelet parameters in diabetes mellitus patients and they observed an increase in the plateletcrit (PCT): 0.21 (± 0.054)% vs 0.20 (± 0.045)% (p =0.020); in the mean platelet volume (MPV): 8.69 (± 1.28)fl vs 8.27 ± (1.24)fl (p = 0.018); and in the platelet distribution width (PDW): 17.8 (±1.06)fl vs 17.5 (± 0.87)fl (p = 0.039) in the Type 2cDM and in the control groups, respectively.<sup>14</sup>



In a similar study done by AV Gupta et al <sup>11</sup> on the platelet indices and endothelial dysfunction, they observed that in patients of the Type 2 DM the MPV values of  $8.92 (\pm 1.92)$  fL were significantly higher and PDW values of  $19.18 (\pm 1.52)$  10 (GSD) were seen raised in the Diabetes mellitus patients compared to the controls MPV  $7.51 (\pm 2.53)$  fL and PDW  $18.91 (\pm 1.06)$ . Similar results were reported by S Jindal et al <sup>10</sup> where they observed that the platelet indices were higher in diabetic cases ( $n=75$ ), mean PDW  $15.39 (\pm 3.12)$  as compared to that of the controls ( $n=50$ ), mean PDW  $17.21 \pm 3.52$ . [145] Similar results were reported by Z Hekimsoy et al <sup>15</sup> in a study on the Mean platelet volume in Type 2 DM in which the MPV was significantly higher in diabetic cases as compared to the age- and sex-matched non diabetic healthy controls [ $10.63 (\pm 1.72)$  fL vs.  $9.18 (\pm 0.82)$  fL ( $p < 0.001$ )], respectively. K. R. Alhadas et al studied the platelet parameters in diabetes mellitus patients and correlated these indices with the disease's microvascular and macrovascular complications seen in those patients,

they observed that there was a positive correlation between platelet count and MPV with HbA1c levels. These findings were similar to our study. <sup>14</sup>

In a similar study done by AV Gupta et al on-platelet indices and endothelial dysfunction in patients of Type 2 DM, it was observed that when platelet indices were compared to the glycemic control of the diabetes mellitus cases, the platelet indices of MPV and PDW were higher in the diabetes mellitus cases with poor glycemic control. <sup>11</sup>

In a study looking at the relationship between MPV and blood glucose levels following glucose loading in normoglycemic and prediabetic patients, it was found that the two-hour post-challenge glucose level was positively correlated with MPV. <sup>10</sup> According to a meta-analysis of MPV levels in diabetic retinopathy, patients with the condition had considerably greater MPV levels than those who did not have it. <sup>16</sup> Similar to prior research, <sup>17, 18</sup> our investigation discovered that higher MPV levels were related with a higher frequency of microvascular and macrovascular problems.

Table 4: Comparisons of previous studies with our study findings

Sr.	Author (Year)	Study type	Sample Size	Interpretation
1	K. J. Brahmabhatt et al <sup>13</sup> (2022)	Cross Sectional	300	Observed that the association of mean platelet volume with the vascular complications in cases with T2DM observed that significant associations were found between the microvascular complications and increasing MPV.
2	R. S. Walinjar et al <sup>12</sup> (2019)	Case Control	250	Observed that platelet indices, namely MPV, PDW, PCT, and P-LCR were found to be significantly higher in the individuals with diabetes as compared to the non-diabetic controls. They observed that MPV, PDW, and P-LCR were deranged in the diabetic cases with complications as compared to those without any complications.
3	K. R. Alhadas et al <sup>14</sup> (2016)	Descriptive	127	Observed the MVP was greater in diabetes cases as compared to the controls.
4	AV Gupta et al <sup>11</sup> (2016)	Prospective	80	MPV values of $8.92 \pm 1.92$ fL were significantly higher and PDW values of $19.18 \pm 1.52$ 10 (GSD) were seen raised in the diabetic patients compared to the controls (MPV $7.51 \pm 2.53$ fL and PDW $18.91 \pm 1.06$ .)
5	M Citirik <sup>19</sup> (2015)	Prospective	280	MVP levels in diabetic patients with vascular complications of retinopathy were higher than patients without vascular complications.
6	T Kidiatte <sup>20</sup> (2012)	Case Control	600	Observed that the mean platelet counts and MPV were higher in diabetics compared to the nondiabetic subjects [ $277.46 \pm 81$ X $10^9/l$ vs. $269.79 \pm 78$ X $10^9/l$ ( $P = 0.256$ )], $8.29 \pm 0.74$ fl

				versus $7.47 \pm 0.73$ fl ( $P=0.001$ ), respectively. MPV showed a strong positive correlation with fasting blood glucose, postprandial glucose and HbA1C levels ( $P=0.001$ ).
7	S Jindal et al. <sup>10</sup> (2011)	Case control	125	Observed that the platelet indices were higher in diabetic cases ( $n=75$ ), mean PDW $15.39 \pm 3.12$ as compared to that of the controls ( $n=50$ ), mean PDW $17.21 \pm 3.52$ .
8	R Demirtunc <sup>21</sup> (2009)	Case control	110	Observed that MPV was significantly higher in patients with DM than in controls ( $8.7 \pm 0.8$ fl vs. $8.2 \pm 0.7$ fl, $P=0.002$ ). In diabetic patients, there was a significant positive correlation between MPV and HbA1c levels ( $r=0.39$ , $P=0.001$ ) but not diabetic vascular complications. When we compared the two diabetic groups, Group B patients had significantly higher MPV than Group A ( $9.0 \pm 0.7$ fl vs. $8.4 \pm 0.8$ fl, $P=0.01$ ).
9	Z Hekimsoy et al. <sup>22</sup> (2004)	Prospective	145	MPV was significantly higher in diabetic cases as compared to the age- and sex-matched non diabetic healthy controls [ $10.63 \pm 1.72$ fL vs. $9.18 \pm 0.82$ fL ( $P < 0.001$ )], respectively.
10	Present study (2022)	Prospective study	120	Mean platelet volume (MPV) in diabetes cases with vascular complications showed significant correlation with HbA1c, FBS and PPBS ( $p < 0.05$ ) as compared to diabetes cases without vascular complications. Mean Platelet volume can be used as a screening tool to evaluate cases of diabetes with vascular complications.

## 5. Conclusion

In present study we observed that in diabetes mellitus patients with vascular complications had significantly raised Mean Platelet Volume (MPV) and Platelet Distribution Width (PDW). Additionally, we observed that in diabetes mellitus patients with vascular complications, the MPV exhibits a statistically significant positive correlation with fasting blood sugar, postprandial blood sugar, and HbA1c. We observed that there is a substantial positive link between the MPV and glycemic parameters in diabetes cases with vascular complications. We conclude that the MPV can be utilized as a screening tool to look for diabetes cases that may have vascular problems.

Conflict of interest: None

Source of funding: This was a self-funded project.

## 6. References

Tabish SA. Is diabetes becoming the biggest epidemic of the twenty first century? *Int J Health Sci (Qassim)* 2007;1:V VIII.  
IDF Diabetes Atlas. International Diabetes Federation. IDF Diabetes Atlas. 8th ed. Brussels, Belgium: International Diabetes

Federation; 2021. Available from: <http://www.diabetesatlas.org>

Fowler MJ. Microvascular and macrovascular complications of diabetes. *Clin Diabetes* 2008;26:77-82.  
Buch A, Kaur S, Nair R, Jain A. Platelet volume indices as predictive biomarkers for diabetic complications in Type 2 diabetic patients. *J Lab Physicians* 2017;9:84-8.  
Zuberi BF, Akhtar N, Afsar S. Comparison of mean platelet volume in patients with diabetes mellitus, impaired fasting glucose and non diabetic subjects. *Singapore Med J* 2008;49:114-6.  
Khandekar MM, Khurana AS, Deshmukh SD, Kakrani AL, Katdare AD, Inamdar AK. Platelet volume indices in patients with coronary artery disease and acute myocardial infarction: An Indian scenario. *J Clin Pathol* 2006;59:146-9.  
Corash L. The relationship between megakaryocyte ploidy and platelet volume. *Blood Cells* 1989;15:81-107.  
Pereira J, Cretney C, Aster RH. Variation of class I HLA antigen expression among platelet density cohorts: A possible index of platelet age? *Blood* 1988;71:516-9.  
Ulutas KT, Dokuyucu R, Sefil F, Yengil E, Sumbul AT, Rizaoglu H et al. Evaluation of MPV in

- patients with Type 2 diabetes mellitus and blood glucose regulation: A marker of atherosclerosis. *Int J ClinExp Med*. 2014;7:955-61.
- Jindal S, Gupta S, Gupta R, Kakkar A, Singh HV, Gupta K, Singh S. Platelet indices in diabetes mellitus: indicators of diabetic microvascular complications. *Hematology*. 2011 Mar;16(2):86-9.
- Gupta AV, Gupta AV, Mukherji A. Platelet Indices and Endothelial Dysfunction in Patients of Diabetes Mellitus Type 2. *Sch J App Med Sci*. 2016;4(3D):877-86.
- Walinjkar RS, Khadse S, Kumar S, Bawankule S, Acharya S. Platelet indices as predictor of microvascular complications in Type 2 diabetes. *Indian J Endocr Metab* 2019;23:206-10.
- Brahmbhatt KJ, Chaudhary B, Raval DM, Mallik S, Khan S, Patel M, Patel N. Association of Mean Platelet Volume With Vascular Complications in the Patients With Type 2 Diabetes Mellitus. *Cureus*. 2022 Sep 19;14(9):1-5.
- Alhadas KR, Santos SN, Freitas MM, Viana SM, Ribeiro LC, Costa MB. Are platelet indices useful in the evaluation of Type 2 diabetic patients? *Jornal Brasileiro de Patologia e Medicina Laboratorial*. 2016 Apr 26;52:96-102.
- Hekimsoy Z, Payzin B, Örnek T, Kandoğan G. Mean platelet volume in Type 2 diabetic patients. *Journal of Diabetes and its Complications*. 2004 May 1;18(3):173-6.
- Ji S, Zhang J, Fan X, et al.: The relationship between mean platelet volume and diabetic retinopathy: a systematic review and meta-analysis. *Diabetol Metab Syndr*. 2019, 11:10-7.
- Cadirci K, Olcaysu O, Yigit D, Carlioglu A, Durmaz SA: Mean platelet volume in Type 2 diabetic patient: is there a relationship between mean platelet volume and diabetic microvascular complications?. *Endocr Abstr*. 2014, 35:10-5.
- Amer HM, Makboul KM, Mostafa BM, Girgis CA, Mohammed YA: The study of mean platelet volume (MPV) as a potential risk factor for macrovascular complications (ischemic heart disease and cerebrovascular stroke) in Type 2 diabetes mellitus. *QJM-Int J Med*. 2020, 113:10.
- M Citirik, E Beyazyildiz, M Simsek, O Beyazyildiz, and Ibrahim C Haznedaroglu MPV may reflect subclinical platelet activation in diabetic patients with and without diabetic retinopathy. *Eye (Lond)*. 2015 Mar; 29(3): 376–379.
- Thomas Alex Kodiatte, Udaya Kumar Manikyam, Suraksha Bellur Rao, Thej Mothakapalli Jagadish, Madhavi Reddy, Harendra Kumar Malligere Lingaiah, and Venkataswamy Lakshmaiah. Mean Platelet Volume in Type 2 Diabetes Mellitus. *J Lab Physicians*. 2012 Jan-Jun; 4(1): 5–9.
- Demirtunc R, Duman D, Basar M, Bilgi M, Teomete M, Garip T. The relationship between glycemic control and platelet activity in Type 2 diabetes mellitus. *J Diabetes Complications*. 2009 Mar-Apr;23(2):89-94.
- Dey, N., Kamatchi, C., Vickram, A. S., Anbarasu, K., Thanigaivel, S., Palanivelu, J., ... & Ponnusamy, V. K. (2022). Role of nanomaterials in deactivating multiple drug resistance efflux pumps—A review. *Environmental Research*, 204, 111968.
- Hekimsoy Z, Payzin B, Örnek T, Kandoğan G. Mean platelet volume in Type 2 diabetic patients. *Journal of Diabetes and its Complications*. 2004 May 1;18(3):173-6.