

A Study to Evaluate Platelet Parameters in Patients with Type 2 Diabetes Mellitus: A Case-Control Study

Sawer Sabri Ahmed

Medical Laboratory Department, College of Health and Medical Technology, Duhok Polytechnic University, Shekhan, Duhok, Iraq

Abstract

Background: Diabetes mellitus is a multifactorial disorder characterized by persistent elevation of plasma glucose and permanent complications of both small and large vessels. The high mortality rates, a decline in quality of life, and high morbidity rates are mostly caused by these problems. When blood vessels are injured, the normal hemostatic process depends heavily on platelets to maintain their integrity. **Objectives:** This study aimed at comparing various platelet indices between people with type II diabetes and people who appeared to be in good health status. **Materials and Methods:** This case-controlled study was carried out at the Azadi Teaching Hospital's Laboratory in Duhok. Four milliliters of blood were collected from diabetics and non-diabetic controls into ethylenediaminetetraacetic acid anticoagulant tubes. Glycated hemoglobin and complete blood count were evaluated by automated chemistry analyzer Cobas 6000 (Roche) and automated blood count analyzer (Coulter, Sweden), respectively; platelet parameters including platelet count, platelet distribution width, mean platelet volume, platelet-large cell ratio, and platelet crit were obtained. Diabetic patients were divided into two groups: Group 1 with good glycemic control ($HbA1c < 7\%$) and Group 2 with poor glycemic control ($HbA1c \geq 7\%$). Statistical software SPSS 26.0 was used. **Results:** The mean age of diabetic patients in this study was 50.97 ± 10.91 years. The mean values of platelet parameters except for platelet counts were significantly higher among diabetic patients when compared to non-diabetic subjects as well as among diabetic patients with poor glycemic controls compared to those with good glycemic control. **Conclusion:** All platelet indices apart from platelet count were significantly elevated among patients with diabetes mellitus than healthy subjects and also in relation to the degree of glycemic control of the disease with a P value of < 0.05 .

Keywords: Diabetes duration, diabetes mellitus, glycemic control, platelet indices

INTRODUCTION

Diabetes is a long-lasting metabolic condition characterized by high blood sugar levels which occurs as a result of insufficient insulin production or the body's insulin insensitivity.^[1] The $HbA1c$ test is the gold standard for the diagnosis and follow-up of patients after treatment. However, due to a lack of laboratory resources, the $HbA1c$ test may not be available in rural areas.^[2] Platelets (PLTs) are dynamic blood molecules that carry out a variety of physiological tasks, including initiation of hemostasis with coagulation factors to stop excessive bleeding and improve host defense against pathogens and inflammatory triggers.^[3] Platelet indices (PI) are indicators of platelet function activation and are interconnected to platelet shape and proliferation capacity of platelets, it includes platelet count, mean platelet volume (MPV),

platelet distribution width (PDW), platelet-large cell ratio (P-LCR), and platelet crits (PCT) and are obtained by automated blood count analyzers.^[4]

Platelet indices including MPV, PCT, and PDW are the markers of augmented platelet activity.^[5,6]

Diabetes mellitus (DM) is reported to have a high MPV, which measures the average size and activity of the platelets, and it is thought to be a risk factor for heart disease. Similarly, PDW is a measure of platelet size

Address for correspondence: Dr. Sawer Sabri Ahmed,
Medical Laboratory Department, College of Health and Medical Technology,
Duhok Polytechnic University, Shekhan, Duhok, Iraq.
E-mail: sawer.ahmed@dpu.edu.krd

Submission: 08-Apr-2023 **Accepted:** 06-Jul-2023 **Published:** 09-May-2024

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Ahmed SS. A study to evaluate platelet parameters in patients with type 2 diabetes mellitus: A case-control study. Med J Babylon 2024;21:124-8.

Access this article online

Quick Response Code:



Website:
<https://journals.lww.com/mjby>

DOI:
10.4103/MJBL.MJBL_408_23

variation and may be an indication of active platelet release. PDW and MPV have a direct relationship with the P-LCR.^[7] Moreover, MPV and PDW are also known to become higher in diabetic patients.^[8] Another indicator of platelet activity is the PLCR, which is calculated as a percentage of all circulating platelets with a volume ≥ 12 fl, characteristically, it falls between 15% and 35%.^[9]

PDW, which rises in response to platelet activation, measures differences in the size of platelets produced by megakaryocytes.^[10]

Prior researches have demonstrated the correlation between elevated levels of MPV, PDW, P-LCR, platelet count, and cell adhesion molecules in the blood with illnesses including metabolic syndrome and diabetes that are linked to endothelial dysfunction.^[11,12]

The current study compared various platelet parameters (PC, PCT, MPV, P-LCR, and PDW) between patients with type 2 diabetes and controls in order to assess these parameters and determine the effects of glycemic status and the length of diabetes on these parameters.

MATERIALS AND METHODS

This case-control study was approved at Azadi Teaching Hospital in Duhok City, and it was carried out over the course of five months, from October 2022 to March 2023. After receiving official ethical consent and approval from each subject, the study was then carried out. Patients diagnosed with type II DM with fasting blood glucose ≥ 126 mg/dL and/or HbA1c $\geq 6.5\%$, who aged from 30 to 60 years attending the Diabetes Center Clinic of the hospital were enrolled, they were first asked for some clinical information and their medical history.

Exclusion criteria

- Diabetes mellitus type I
- Patients with hematological conditions such as anemia, thrombocytopenia, cancer, or a recent history of blood transfusions
- Chronic renal or liver diseases
- Autoimmune diseases like rheumatoid arthritis
- Thyroid illnesses
- Patients receiving chemotherapeutic agents
- Pregnant women

According to the 2013 American diabetes association criteria, the individuals were divided into two groups based on the HbA1c level. Patients were classified as having controlled diabetes if their HbA1c was below 7% and as having uncontrolled diabetes if their HbA1c was above 7%.^[13]

Following the precautions required for measuring glycated hemoglobin (HbA1c) and performing complete blood

count (CBC), 4 mL of blood were drawn and placed in two ethylenediaminetetraacetic acid tubes by venipuncture of the median cubital vein under perfectly sterile conditions. The instrument used for HbA1c and other glucose parameters was Cobas 6000, ROCHE, Germany.

Coulter counter (Swedish) was used for CBC analysis, and platelet indices including platelet count, MPV, PDW, P-LCR, and platelet count (PC) were all recorded. The processing of samples, calibration of the equipment, and instrument standardization all were done according to the manufacturer's recommendations.

Statistical analysis

The IBM SPSS version 26.0 (SPSS, IBM Company, Chicago, IL 60606, USA) was used for data entry and analysis. To determine the statistical significance and correlation between PI in the different groups (controls, DM, and patients with HbA1c $< 7\%$ and those with HbA1c $\geq 7\%$), statistical tests including the student's independent *t* test and analysis of variance (ANOVA) were used. Data were expressed as mean $\pm$ standard deviation. A *P* value < 0.05 was considered statistically significant.

Ethical approval

The study was carried out in compliance with the ethical guidelines found in the Declaration of Helsinki. Prior to taking the sample, the patient's verbal and analytical consent was obtained. With a registration number 06112022-11-8 on November 6, 2022, a local ethics committee evaluated and approved the study protocol as well as the subject information and permission form.

RESULTS

In this study, the blood glucose and HbA1c levels of 250 diabetic patients and 250 healthy people with normal CBC parameters were compared. The mean age of diabetic patients was 50.97 ± 10.91 years. In the diabetes group, there were 130 women and 120 men, regarding healthy subjects, the numbers of men and women were equal and was 125 for each gender.

We have calculated the mean values of the MPV, PDW, P-LCR, and PCT in both diabetics and non-diabetics groups were calculated. Our study observed the values of MPV, PDW, P-LCR, and PCT were significantly higher in diabetic patients with a *P* value of < 0.05 [Table 1].

Diabetic patients were further subdivided into two groups according to their HbA1c levels. Group 1 with HbA1c level of $< 7\%$ and Group 2 with HbA1c level of $\geq 7\%$. Of the 250 patients in the diabetic group, 60 (24%) patients had an HbA1c value of $< 7\%$, and 190 (76%) had HbA1c of $\geq 7\%$. Patients in group 2 had considerably higher levels of glycated hemoglobin. The mean HbA1c values for groups 1 and 2 were $6.58 \pm 0.28\%$ and 8.81 ± 1.58 , respectively.

Table 1: Comparison of selected parameters between controls and diabetics

Parameters	Controls Mean $\pm$ SD	Patients Mean $\pm$ SD	T test	P value	Statistical significance
PLT	236.09 $\pm$ 51.64	234.79 $\pm$ 43.99	0.3030	0.7620	NS
MPV	7.96 $\pm$ 1.09	10.21 $\pm$ 1.48	19.3569	0.0001	S
PDW	11.48 $\pm$ 1.43	15.12 $\pm$ 2.03	23.1695	0.0001	S
P-LCR	19.04 $\pm$ 4.16	30.72 $\pm$ 6.69	23.4342	0.0001	S
PCT	0.185 $\pm$ 0.04	0.24 $\pm$ 0.05	11.7244	0.0001	S
HbA1c	5.17 $\pm$ 0.54	8.31 $\pm$ 1.68	28.0263	0.0001	S

Table 2: Comparison of platelet parameters between diabetics with HbA1c <7 and HbA1c $\geq$ 7

Parameters	HbA1c < 7 No = 60	HbA1c $\geq$ 7 No = 190	T test	P value	Statistical significance
PLT	227.45 $\pm$ 37.91	235.18 $\pm$ 45.22	1.197	0.2323	NS
MPV	8.83 $\pm$ 1.079	10.625 $\pm$ 1.346	9.3774	0.0001	S
PDW	13.297 $\pm$ 1.583	15.637 $\pm$ 1.847	8.8418	0.0001	S
P-LCR	24.587 $\pm$ 5.153	32.402 $\pm$ 6.151	8.9014	0.0001	S
PCT	0.1992 $\pm$ 0.04	0.2496 $\pm$ 0.05	6.3874	0.0001	S
HbA1C	6.5833 $\pm$ 0.28	8.8145 $\pm$ 1.584	10.8353	0.0001	S

Table 3: Comparison of selected parameters among diabetic patients in relation to diabetes duration in years

Parameters	DM duration <10 years Mean $\pm$ SD No = 210	DM duration $\geq$ 10 years No = 40	T test	P value	Statistical significance
PLT	232.62 $\pm$ 42.70	237.03 $\pm$ 48.65	-0.584	0.559	NS
MPV	10.109 $\pm$ 1.514	10.650 $\pm$ 1.319	-2.111	0.036	S
PDW	14.990 $\pm$ 2.008	15.525 $\pm$ 2.208	-1.520	0.130	NS
P-LCR	30.037 $\pm$ 6.651	33.090 $\pm$ 7.059	-2.634	0.009	S
PCT	0.2354 $\pm$ 0.058	0.2483 $\pm$ 0.0522	-1.297	0.196	NS
HbA1C	8.1945 $\pm$ 1.6634	8.7225 $\pm$ 1.7455	-1.8254	0.069	NS

Table 4: Comparison of parameters among controls and diabetics with HbA1c $\geq$ 7 and HbA1c < 7

Parameters	Controls Mean $\pm$ SD No = 250	HbA1C <7% Mean $\pm$ SD No = 60	HbA1C $\geq$ 7% Mean $\pm$ SD No = 190	P value	Statistical significance
Age	31.53 $\pm$ 5.35	47.03 $\pm$ 10.47	52.18 $\pm$ 11.00	0.000	S
PLT count	236.09 $\pm$ 51.64	227.45 $\pm$ 37.91	235.18 $\pm$ 45.22	0.448	NS
MPV	7.96 $\pm$ 1.09	8.83 $\pm$ 1.079	10.62 $\pm$ 1.34	0.000	S
PDW	11.48 $\pm$ 1.43	13.29 $\pm$ 1.58	15.63 $\pm$ 1.84	0.000	S
P-LCR	19.04 $\pm$ 4.16	24.58 $\pm$ 5.15	32.40 $\pm$ 6.15	0.000	S
PCT	0.185 $\pm$ 0.04	0.20 $\pm$ 0.04	0.25 $\pm$ 0.05	0.000	S
HbA1c	5.17 $\pm$ 0.54	6.58 $\pm$ 0.28	8.81 $\pm$ 1.58	0.000	S

One-way ANOVA test

With a *P* value of 0.000, this difference between the two groups was statistically very significant [Table 2].

Except for platelet count, the mean values of glycated hemoglobin and other platelet indices (MPV, PDW, P-LCR, and PCT) were found to be higher in group 2 with HbA1c $\geq$ 7%. This difference in the mean values of the two groups was statistically significant with a *P* value of 0.000. Furthermore, the study found a statistically significant difference in the mean values of MPV, P-LCR between the two groups of patients with <10 years and those with >10-year duration of the disease with a *P* value 0.036 and 0.009, respectively [Table 3].

When we compared the mean values of the platelet indices between the control group and diabetics, we found that they increased with increasing HbA1c level [Table 4].

DISCUSSION

In this study, platelet indices of diabetics which include platelet count, MPV, PDW, P-LCR, and PC parameters, were compared to their glycemic management. We found a linear association between these parameters and both the duration of the disease and HbA1c levels.

Different hematological markers have been used during routine clinical practice as changes in these markers have

served as prognostic markers for diseases severity and comorbidity.^[5,14,15]

The number of diabetic patients with HbA1c levels less than 7% was lower than those whose HbA1c levels were $\geq 7\%$; this finding was similar to the figures reported by Kodiatte *et al.*^[16] This may have been brought on by bad eating habits and a lack of awareness regarding the diabetes-specific diets, exercise regimens with poor compliance of patients and adherence to the specific management that must be followed.^[17]

Assessment of the relationship between glycemic control and platelet indices in DM patients:

PC: In our study, we found platelet count was almost equal in diabetic and control groups this finding is in agreement with studies done by Maheshwari *et al.* and Ozder *et al.* respectively.^[18,19] However, they were discordant with those reported by other researchers.^[20,21]

Furthermore, there were no considerable differences in PC between controlled and uncontrolled diabetic patients; Samaddar *et al.*^[22] reported a similar finding. However, our findings disagree with those of the study of Akinsegun *et al.*^[23] where they revealed that diabetics' mean platelet counts were significantly higher than those of controls.

MPV: Platelet volume is a measure for platelet function and activity. The findings of the current study were similar to those of other authors,^[19,20,24,25] but were significantly different from those found by Akinsegun *et al.*,^[23] the MPV between controls and patients varied significantly. Additionally, MPV was substantially higher in patients with poorer glycemic control than those with good control, with a *P*-value of 0.000. These findings are consistent with those of Shipli *et al.*^[26]

PDW: It is a measure of both platelet activation and the distribution of platelet size.^[12] In the current investigation, there was a statistically significant difference in the mean PDW between diabetes and healthy subjects, with a *P* value of <0.000 , and similar results were noted in other studies done by^[25-28] who found a significantly higher value of PDW among diabetics compared to non-diabetics.

Furthermore, we also found a statistically significantly higher value of PDW among patients with HbA1c levels $\geq 7\%$ than those with HbA1c levels $< 7\%$, our finding were in concordance with the study done by Samaddar *et al.* and Jindal *et al.*^[22,29]

P-LCR: Our study showed a significant difference between controls and diabetic patients and among good and poorly controlled diabetic patients with a *P* value of 0.000, This is in agreement with the studies done by Shipli and Jindal *et al.*,^[26,29] but contrasts with Buch's findings.^[30]

PCT: It measures total platelet mass and its normal reference value is 0.22%–0.24%.^[4] The mean PCT value was higher

in diabetic patients compared to healthy participants and among uncontrolled patients in comparison to those with well controlled disease, this finding was agreeing with that reported by Demirtas *et al.*^[25]

Platelet indices (MPV, PDW, P-LCR, and PCT) in the current study were significantly higher among diabetics than non-diabetic subjects, similar findings were reported in Rajas' study.^[31] Moreover, the present study showed a significantly higher levels of some platelet parameters between healthy and diabetic participants and also in relation to glycemic control, these findings are similar to those reported by other researchers.^[25,26,32]

However, our results differed from those of a study conducted by Pawan *et al.*,^[33] where they concluded no significant difference in platelet indices (platelet count, P-LCR, and PCT) between controls and patients, as well as between diabetic patients with and without glycemic control.

Contrary to our findings, Jiskani^[34] found platelet indices MPV, PCT, and P-LCR and PC apart from PDW were higher in controls than in the studied patients, additionally, the same changes in platelet indices were noted in relation to glycemic control (HbA1C $< 7\%$ vs. $\geq 7\%$).

We also found that the MPV and P-LCR were significantly higher in patients with diabetes with more than 10 years duration of the disease, and this finding is similar to that of Swaminathan^[35] for MPV but was in contrast to the results of other researchers.^[16,32,36]

CONCLUSION

The current study demonstrates considerable variations in platelet parameters between healthy participants and patients with T2DM, especially those with poor glycemic control. PI analysis is a quick and affordable diagnostic tool, it can be utilized to identify people with poorly controlled disease and to lower their morbidity and mortality.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Atlas D. IDF Diabetes Atlas, 9th ed. International Diabetes Federation; 2019. Available from: <http://www.idf.org/about-diabetes/facts-figures>. [Las accessed on 18 Apr 2022].
2. Sherwani SI, Khan HA, Ekhzaimy A, Masood A, Sakharkar MK. Significance of HbA1c test in diagnosis and prognosis of diabetic patients, Biomark Insights 2016;11:BMI.S38440.
3. Golebiewska EM, Poole AW. Platelet secretion: From haemostasis to wound healing and beyond. Blood Rev 2015;29:153-62.
4. Budak YU, Polat M, Huysal K. The use of platelet indices, plateletcrit, mean platelet volume and platelet distribution width in

- emergency non-traumatic abdominal surgery: A systematic review. *Biochem Med* 2016;26:178-93.
5. Alberca RW, Solis-Castro RL, Solis-Castro ME, Cardoso F, Duarte AJS, de Mendonça OL, *et al.* Platelet-based biomarkers for diagnosis and prognosis in COVID-19 patients. *Life* 2021;11:1005.
 6. Korniluk A, Koper-Lenkiewicz OM, Kamińska J, Kemona H, Dymicka-Piekarska V. Mean platelet volume (MPV): New perspectives for an old marker in the course and prognosis of inflammatory conditions. *Mediators Inflamm* 2019;2019:9213074.
 7. Mishra J, Shah P, Sanil R. Hematological disorders from the Kota tribes of the Nilgris, India. *Asian J Biochem Pharm Res* 2012;2:156-62.
 8. Jabeen F, Fawwad A, Rizvi HA, Alvi F. Role of platelet indices, glycemic control and hs-CRP in pathogenesis of vascular complications in type-2 diabetic patients. *Pak J Med Sci* 2013;29:152-6.
 9. Hong H, Xiao W, Maitta RW. Steady increment of immature platelet fraction is suppressed by irradiation in single-donor platelet components during storage. *PLoS One* 2014;9:e85465.
 10. Osselaer J-C, Jamart J, Scheiff J-M. Platelet distribution width for differential diagnosis of thrombocytosis. *Clin Chem* 1997;43:1072-6.
 11. Abdullah R, Abdulrahman I. Circulating cell adhesion molecules level in type 2 diabetes mellitus and its correlation with glycemic control and metabolic syndrome: A case-control study. *Med J Babylon* 2023;20:64-70.
 12. Zaccardi F, Rocca B, Pitocco D, Tanese L, Rizzi A, Ghirlanda G. Platelet mean volume, distribution width, and count in type 2 diabetes, impaired fasting glucose, and metabolic syndrome: A meta-analysis. *Diabetes Metab Res Rev* 2015;31:402-10.
 13. A. D. A. S. o. C. f. Diabetes. Brief summary of screening and diagnosis of type 2 diabetes and its complications. *Diabetes Care* 2013;36:S11-61.
 14. Bayleyegn B, Asrie F, Yalew A, Woldu B. Role of platelet indices as a potential marker for malaria severity. *J Parasitol Res* 2021;2021:1-8.
 15. Xu F, Qu S, Wang L, Qin Y. Mean platelet volume (MPV): New diagnostic indices for co-morbidity of tuberculosis and diabetes mellitus. *BMC Infect* 2021;21:1-9.
 16. Kodiatte TA, Manikam UK, Rao SB, Jagadish TM, Reddy M, Lingaiah HKM, Lakshmaiah V. Mean platelet volume in type 2 diabetes mellitus. *J Lab Physicians* 2012;4:005-9.
 17. Baiee H, Makai M. Medication adherence in hypertensive diabetic patients. *Med J Babylon* 2022;19:569-74.
 18. Uma Maheswari MRDK. A study on platelet indices in controlled and uncontrolled hypertensive and diabetic subjects. *J Res Med Dent Sci* 2021;9:9.
 19. Ozder A, Eker HH. Investigation of mean platelet volume in patients with type 2 diabetes mellitus and in subjects with impaired fasting glucose: A cost-effective tool in primary health care? *Int J Clin Exp Med* 2014;7:2292-7.
 20. Sharma A, Arora S, Singh S. Correlation of platelet indices with glycaemic control and vascular complications in diabetic patients in a tertiary hospital based study. *J Med Sci Clin Res* 2021;9:189-94.
 21. Zuberi B, 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.
 22. Samaddar A, Talukdar M, Sinha A. Platelet indices in controlled and uncontrolled type 2 diabetes mellitus: A cross sectional study. *Panacea J Med Sci* 2022;12:53337.
 23. Akinsegun A, Akinola Olusola D, Sarah J-O, Olajumoke O, Adewumi A, Majeed O, *et al.* Mean platelet volume and platelet counts in type 2 diabetes: Mellitus on treatment and non-diabetic mellitus controls in Lagos, Nigeria. *Pan Afr Med J* 2014;18:42.
 24. Haile K, Kedir R, Timerga A, Mose A, Arkew M. Role of platelet indices as diagnostic and predictive biomarkers for comorbidity of diabetes and metabolic syndrome in southern Ethiopia: A comparative cross-sectional study. *PLoS ONE* 2022;17:e0277542.
 25. Demirtas L, Degirmenci H, Akbas EM, Ozcicek A, Timuroglu A, Gurel A, Ozcicek F. Association of hematological indices with diabetes, impaired glucose regulation and microvascular complications of diabetes. *Int J Clin Exp Med* 2015;8:11420-7.
 26. Shilpi K, Potekar RM. A study of platelet indices in type 2 diabetes mellitus patients. *Indian J Hematol Blood Transfus* 2018;34:115-20.
 27. Jabeen F, Rizvi HA, Aziz F, Wasti AZ. Hyperglycemic induced variations in hematological indices in type 2 diabetics. *IJAR* 2013;1:322-34.
 28. Dalamaga M, Karmaniolas K, Lekka A, Antonakos G, Thrasyvoulides A, Papadavid E, *et al.* Platelet markers correlate with glycemic indices in diabetic, but not diabetic-myelodysplastic patients with normal platelet count. *Dis Markers* 2010;29:55-61.
 29. 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;16:86-9.
 30. 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;9:084-8.
 31. Walinjar RS, Khadse S, Kumar S, Bawankule S, Acharya S. Platelet indices as a predictor of microvascular complications in type 2 diabetes. *Indian J Endocrinol Metab* 2019;23:206-10.
 32. Iqbal S, Arbab KN, Khattak MT, Ali A, Banori A, Khan MI. A study of platelet indices in type 2 diabetes mellitus patients: A cross-sectional study design. *Pakistan J Med Health Sci* 2022;16:850-2.
 33. Goyal P, Mahajan S, Parmar C. Evaluation of platelet function in subjects with type-2 diabetes mellitus: A case control study. *Natl J Phys Pharma Pharmacol* 2020;10:667-667.
 34. Jiskani SA, Singh D. Platelets indices as biomarkers of glycemic control and progression of complications in patients of diabetes mellitus type II. *J Haematol Stem Cell Res* 2021;1:21-4.
 35. Swaminathan A, Amitkumar K, Ganapathy S, Ayyavoo S. Evaluation of mean platelet volume and other platelet parameters in subjects with Type-2 diabetes mellitus. *Natl J Physio Pharma Pharmacol* 1970;7:51-51.
 36. Yenigün EC, Okyay GU, Pirpir A, Hondur A, Yildirim S. Increased mean platelet volume in type 2 diabetes mellitus. *Dicle Med J* 2014;41:17-22.