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Original Article

Platelet Indices in Diabetes Mellitus Indicating Severity of Diabetic Microvascular Complications

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Abstract

Objective: The main purpose of this article was to compare the platelet volume parameter in patients with and without diabetic micro vascular complications and to evaluate the relationship and link between platelet volume indices and severity of micro vascular complications in diabetics.

Method: This cross sectional comparative study was carried out at Diabetic Clinic of Mayo Hospital Lahore from 23-01-2015 to 31-07-2015. Sample size of 444 well controlled (on oral hypoglycemic) diabetic patients above 30 years of age from both gender were taken with exclusion of having any haematological disorder, end stage renal disease, ischemic heart disease, stroke, any malignancy or usage of antiplatelet drugs. Venous blood samples of all patients were analyzed for full blood count. Midstream urine specimens of all patients were analyzed by spot urine protein to creatinine ratio for quantification of proteinuria. Fundoscopy of all patients were done by ophthalmologist of Ophthalmology Department of same hospital. Neurological examination of all patients for peripheral neuropathy was done.

Results: Four hundred and forty four patients, 185 male (41.7 %) and 259 female (58.3%) with mean age of 52.4 ±7.9 years having good control (on oral hypoglycemic) diabetic patients were enrolled for study. In this study, 222 (50%) patients were without complications, 52 (11.7%) patients were with nonproliferative retinopathy (NPDR), 14 (3.2%) patients were with proliferative retinopathy (PDR), 54 (12.2%) patients had early nephropathy, 25 (5.6%) patients had advanced nephropathy, 30 (6.8%) patients had early neuropathy, 24 (5.4%) patients had advanced neuropathy and 23 (5.2%) patients had 2 complications. Patients with diabetic microvascular damage have high MPV values as compared to diabetics without these damage ($P < 0.0001$). Same results were observed for PDW values ($P < 0.0001$).

Conclusion: Platelet volume indices (PVI) are high in diabetics with early and advanced micro vascular damage as compared to diabetics without micro vascular damage.

Keywords: Diabetes mellitus, platelet volume parameter, retinopathy, neuropathy, nephropathy.

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Introduction

Metabolic disorder marked by elevated venous glucose results from lack or reduced effectiveness of insulin is defined as Diabetes Mellitus.[1,2] Atherosclerosis is accelerated by diabetes, the major underlying factor leading to atherothrombotic disorders.[2] Morbidity and mortality from diabetes are the consequence of atherothrombotic disorders, associated with bad prognosis.[1,3,4] Several factors increase thrombotic risk in diabetics like increased circulating coagulation factors, endothelial dysfunction, suppressed fibrinolysis and alterations in platelet activity.[1,5-7] Platelets have an essential part in the development of atherothrombosis in diabetes.[8] Their main function is to arrest bleeding resulting from vascular damage.[9] Platelets gather at area of vascular damage in order to maintain normal hemostasis.[10,11]

Enhanced platelet activity of diabetic patients is due to dysregulation of several signaling pathways.[11,12] Activity of platelet is connected with size of platelet and larger platelets have enhanced platelet activity.[12] Platelet volume indices (PVI) among which, mean volume (MPV) and distribution width (PDW) of plate-

lets are the main and dominant contributory indices, being simple, easy, efficient and economical tests that should be investigated largely in our country, for predicting the possibility of thrombogenesis.[13] Platelet volume parameters values were remarkably raised in diabetic with at least one of the micro vascular complications than those without micro vascular complications.[13,14]

Monitoring of DM and preventing its vascular complications are of utmost importance for present period as the incidence of DM and its related vascular damage are increasing day by day. Platelet volume indices (PVI) are increased in diabetics with early and advanced micro vascular complications as compared to diabetics without micro vascular complications.

The main purpose of this article was to compare the platelet volume parameter in patients with and without diabetic micro vascular complications and to evaluate the relationship and link between platelet volume indices and severity of micro vascular complications in diabetics.

Methods

This article with cross sectional comparative design was performed at Diabetic clinic of Mayo Hospital Lahore from 23-01-2015 to 31-07-2015. Sample size of 444 patients (222 in each group) was estimated by non-probability convenient sampling and using 95% confidence level, 95% power of test and by taking expected mean of MPV among diabetic patients with and without complications as 8.35±0.73 and 8.20± 0.74 respectively.[10]

Inclusion Criteria:

1. Age above 30 years
2. Gender: Both males and females
3. Patients with well controlled diabetes on oral hypoglycemic medications attending the diabetic clinic without any micro vascular complications
4. Patients with well controlled diabetes on oral hypoglycemic medications attending the diabetic clinic having one or more micro vascular complications like
   - Diabetic retinopathy as per operational definition
   - Diabetic nephropathy as per operational definition
   - Diabetic neuropathy as per operational definition

Exclusion Criteria:

1. Patients having any red blood cell or platelets disorder or any other Haematological disorder were identified by complete blood count and subsequent peripheral blood film when needed.
2. Patients having end stage renal disease or any other co morbid disease or any malignancy were identified by history and further investigations when required.
3. Patients having ischemic heart disease or stroke were identified by history and further investigations when required.
4. Patients on antiplatelet drugs were identified by history, and were excluded.

The patients satisfying inclusion and exclusion criteria were enrolled after informed consent. Venous blood samples were properly stored at room temperature in dipotassium EDTA (Ethylene Diamine Tetra Acetic acid) vacated vials and to reduce errors due to sample degenerations, tests were performed within six hour of blood drawing. Improperly collected, hemolysed and clotted samples were discarded. Then full blood count was done by using Sysmex kx-21and reviewed by peripheral blood examination in hematology laboratory of Pathology Department of King Edward Medical University Lahore.

A midstream urine specimen was properly collected by selected patients in clean catch to decrease potential bacterial, cellular and artefactual contamination and was analyzed by spot urine protein to creatinine ratio for quantification of proteinuria.

Fundoscopy of selected patients was done by ophthalmologist according to defined protocol in Ophthalmology Department of KEMU Lahore. Tuning fork was used for evaluation of vibration sensation.

The statistical package for the social sciences (SPSS) V.23.0 was used for data posting and interpretation. Qualitative variables like sex and diabetic status were calculated by using frequency and percentages, while for quantitative variable like age and platelet volume indices, Mean ±S.D was computed. The comparison between groups was done by an analytic tool (Analysis of variance (ANOVA)) . The statistically significant p-value ≤0.05 was given due consideration.

Results

Four hundred and forty-four patients with well controlled diabetes on oral hypoglycemic agents were recorded in this article study. The study variables like age, duration of DM, MPV and PDW were estimated for the total cohort. Two groups were formed of diabetic patients depend on presence of complications; group A (without complications) and group B (with complications). There were 185 male patients (41.7 %) and 259 female patients (58.3%) and gender ratio was not significantly different between two groups (p= 0.500). Among these groups, female predominance was found

with 96 (43.2%) male and 126 (56.8%) female in diabetic without complications (group A) and 89 (40.1%) male and 133 (59.9%) female in diabetics with complications (group B). The group B was further subdivided into seven groups as described in Table 1.

Table 1: *Comparison of Gender between Groups*

Sr. No.	Groups	Mean Platelet Volume (MPV)		*p value
		Male	Female	
1	**Diabetics without complications (group A)**	96	126	0.500
		43.2%	56.8%	
2	**Diabetics with complications (group B)**	89	133	
		40.1%	59.9%	
i	Diabetics with Retinopathy(NPDR) (B1)	22	30	0.096
		42.3%	57.7%	
ii	Diabetics with Retinopathy (PDR) (B2)	5	9	
		35.7%	64.3%	
iii	Diabetics with Nephropathy (Early) (B3)	15	39	
		27.8%	72.2%	
iv	Diabetics with Nephropathy (Advanced) (B4)	15	10	
		60.0%	40.0%	
v	Diabetics with Neuropathy (Early) (B5)	9	21	
		30.0%	70.0%	
vi	Diabetics with Neuropathy (Advanced) (B6)	11	13	
		45.8%	54.2%	
vii	Diabetics with 2 Complications (B7)	12	11	
		52.2%	47.8%	

*p <0.05 to be considered as statistically significant.

On analysis of age group, it was seen that most patient were in age group 41-60 i.e. 361 (81.3%), while 34 patients (7.7%) were in age group ≤ 40 years and 49 patients (11 %) in age group ≥ 60 years. Mean age± SD was 52.4 ± 7.9 with mean age±SD in group A was 52.7±8.4 years and in group B was 52.1±7.3 years and found not significantly different between two groups (p value=0.376). Within the subgroup with complications B, mean age±SD in group B1 was 51.3±7.5 years, in group B2 was 52.9±9.8 years, in group B3 was 52.2±7.4 years, in group B4 was 52.1±5.5 years, in group B5 was 51.7±8.0 years, in group B6 was 53.7± 7.0 years and in group B7 was 51.6±6.8 years (p value = 0.908).

Mean duration of diabetes was 9.1±3.8 years, with 8.2 ± 3.9 in group A and 10.1± 3.5 years in group B and found significantly different between two groups (p value < 0.001). Within subgroup with complications B, mean disease duration in group B1 was 9.5±4.0 years, in group B2 10.9±3.1 years, in group B3 9.5± 2.9 years, in group B4 11.8±3.7 years, in group B5 9.1±3.6 years, in group B6 10.0±3.1 years and in group B7 as 11.7 ±3.3 years (p value =0.011).

Table 2: *Correlation of Duration of Diabetes (years) with Age, MPV & PDW among Groups*

Group A		Age (years)	Mean Platelet Volume (MPV)	Platelet Distribution Width (PDW)
Duration of Diabetes (years)	Pearson r	0.286	0.035	0.049
	*p-value	<0.001	0.604	0.468
Group B				
Duration of Diabetes (years)	Pearson r	0.277	-0.006	-0.037
	*p-value	<0.001	0.933	0.578

*p <0.05 to be considered as statistically significant.

Table 3: *Comparison of Mean Duration of Diabetes Mellitus between Groups*

Sr. No.	Groups	N	Duration of diabetes mellitus (years)		*p value
			Mean	Std. Deviation	
1	**Group A**	222	8.2	3.9	<0.001
2	**Group B**	222	10.1	3.5	
	B1	52	9.5	4.0	0.004
	B2	14	10.9	3.1	
	B3	54	9.5	2.9	
	B4	25	11.8	3.7	
	B5	30	9.1	3.6	
	B6	24	10.0	3.1	
	B7	23	11.7	3.3	

*p <0.05 to be considered as statistically significant.

Mean platelet volume was 9.5± 0.7 fl in group A and 11.3± 0.9 fl in group B (p value < 0.001). Diabetic patients in group B had raised mean platelet volume (MPV) (11.3 ± 0.9) compared to group A (9.5±0.7) with significant p value < 0.001. Within subgroup with of group B, mean platelet volume in group B1 was 11.6 ±0.8 fl , in group B2 11.2±0.8 fl, in group B3 11.2±1.2 fl, in group B4 11.1±0.6 fl, in group B5 10.9±0.7 fl, in group B6 11.1±0.8 fl and in group B7 as 11.5±0.8 fl (p value =0.004) (table 4).

Mean Platelet Distribution Width was 11.9± 1.6 fl in group A and 15.6± 2.6 fl in group B (p value < 0.001). Mean platelet distribution width (PDW) in group B

Table 4: *Comparison of Mean Platelet Volume between Groups*

Sr. No.	Groups	N	Mean Platelet Volume (MPV)		*p value
			Mean	Std. Deviation	
1	**Group A**	222	9.5	0.7	<0.001
2	**Group B**	222	11.3	0.9	
	B1	52	11.6	0.8	0.004
	B2	14	11.2	0.8	
	B3	54	11.2	1.2	
	B4	25	11.1	0.6	
	B5	30	10.9	0.7	
	B6	24	11.1	0.8	
	B7	23	11.5	0.8	

*p <0.05 to be considered as statistically significant.

was high (15.6 ± 2.6) compared to group A (11.9 ± 1.6) with significant p value < 0.001. Within the group B, mean platelet distribution width in group B1 was 16.6±2.5 fl, in group B2 15.4±2.5 fl, in group B3 15.4±2.8 fl, in group B4 15.1±1.7 fl, in group B5 14.8±2.6 fl, in group B6 15.3±2.1 fl and in group B7 as 16.1±2.8 fl (p value =0.029) as shown in table 5. Statistically significant correlation (p value < 0.005) was found between platelet distribution width (PDW) and mean platelet volume (MPV) with diabetic microvascular damage such as retinopathy, neuropathy and nephropathy.

Table 5: *Comparison of Platelet Distribution Width between Groups*

Sr. No.	Groups	N	Platelet Distribution Width (PDW)		*p value
			Mean	Std. Deviation	
1	**Group A**	222	11.9	1.6	<0.001
2	**Group B**	222	15.6	2.6	
	B1	52	16.6	2.5	0.029
	B2	14	15.4	2.5	
	B3	54	15.4	2.8	
	B4	25	15.1	1.7	
	B5	30	14.8	2.6	
	B6	24	15.3	2.1	
	B7	23	16.1	2.8	

*p <0.05 to be considered as statistically significant.

Discussion

Morbidity and mortality from diabetes are a consequence of atherothrombotic disorders, which are associated with bad prognosis.[15] Platelets have significant contribution in the progression of atherothrombosis in diabetes. Platelets of diabetic patients in early phase of disease have increased platelets reactivity that may later lead to progression of vascular complications. Platelet activity is usually measured by platelet volume parameters, which include mean platelet volume (MPV) and platelet distribution width (PDW). These are simple, easy and economical tool, can simply be analysized during routine blood count and that should be used in our country for predicting the possibility of early detection of diabetic complication.[16] Larger platelets hyperreactive and thrombogenic than smaller and younger ones has been shown in many studies. The variability in platelet size is calculated by PDW, and high values of PDW proposed high number of larger reticulated platelets.[17,18]

In present study of 444 patients with well controlled diabetes on oral hypoglycemic agents, were divided into two groups based on microvascular complications: group A without complications and group B with microvascular complications. The group B was further subdivided based on type and severity of microvascular complications. Then we determined and compared MPV and PDW between group A and B. MPV and PDW were significantly raised in group B with microvascular complications. This confirmed the association of MPV and PDW with microvascular complications in diabetics.

The group A patients has mean age 52.7±8.4 years, mean duration of diabetes 8.2±3.9 years, mean platelet volume 9.5± 0.7 and mean platelet distribution width 11.9±1.6. The group B patients has mean age 52.1 ± 7.3 years, duration of diabetes 10.1± 3.5 years, mean platelet volume 11.3± 0.9 and mean platelet distribution width 15.6± 2.6. Diabetic patients in group B had raised mean platelet volume (MPV) (11.3±0.9) compared to group A (9.5±0.7) with significant p value < 0.001. Similarly mean platelet distribution width (PDW) in group B was high (15.6±2.6) compared to group A (11.9±1.6) with significant p value < 0.001.

Ates et al. have found that mean values of MPV are strongly associated with degree of retinopathy. Diabetic patients with different stages of retinopathy like background, nonproliferative and proliferative retinopathy have following values of mean MPV 7.76±0.72 fL, 7.94±0.61 fL and 8.18±0.89 fL, respectively. MPV values of diabetics with background retinopathy was not significantly different from that of the healthy control group and diabetics with non-proliferative and proliferative retinopathy as well. However, significant association ($p< 0.05$) was found between MPV values of diabetics with proliferative retinopathy and MPV values of healthy control group. A significant correlation was found between the degree of retinopathy and mean values of MPV in diabetic patients ($r= 0.214$, $p< 0.05$).[19]

These results are similar to present study.

Jindal et al have compared platelet volume parameters (MPV, PDW and platelet-large cell ratio) in diabetic patients and non-diabetics and found that these platelet volume parameters were positively raised in diabetic patients compared ($p < 0.05$ for all) and in diabetics with complications, PDW values were significantly raised than those without complications ($p = 0.006$). Jindal et al concluded that patients with diabetes as compared to healthy control have significantly different platelet volume parameters, especially PDW, and same results were found for PDW in diabetics with and without microvascular complications.[14] Study by Jindal et al shows similar results to present study.

A study was conducted by E. Ç. Yenigün et al. in Turkey and found a strong association between MPV and type 2 diabetes mellitus and also between MPV and any of microvascular or macrovascular complications of diabetes (9.25±1.49 and 8.47±0.49, respectively) ($p<0.01$). Patients with at least one of the microvascular complications had slightly higher MPV compared to the ones without any of the complications (9.38 ±1.47 fl and 7.85±0.88 fl, respectively) ($p= 0.048$). There no significance was found regarding MPV, when the groups were analyzed individually as patients with and without retinopathy (9.48±1.60 and 9.15±1.45, $p= 0.48$), nephropathy (9.25±1.45 and 9.25±1.53, $p= 0.99$) and neuropathy (9.43 ±1.47 and 8.49±1.39, $p= 0.09$),.13 Results of this study are similar to present study.

Anupama Dayal et al compared MPV values of diabetic aptients with non-diabetic healthy controls in India in 2016 and had shown significantly high MPV in diabetics as compared to non-diabetic healthy controls (9.94± 1.07 fl versus 9.36±0.96 fl; $p=.00003$), thus establishing that MPV is mainly and individually associated with diabetes and MPV values was noticed to be increased in diabetics with HbA1c ≥ 6.5%.[20] They did not compare PDW in two groups of patients, however their findings about MPV were similar to our study.

Dindar et al have concluded that MPV values of diabetic patients with higher HbA1c values (> 7%) was positively raised as compared to patients with lower HbA1c ≤ 7% ($p < 0.001$). Diabetic patients with microvacular complications (retinopathy) have higher mean platelet volume level as compared to those without microvacular complications (retinopathy) (11.26±1.08 vs 10.68±1.68 $p = 0.04$). MPV was higher in patients with nephropathy and neuropathy, but not statistically significant (11.07 ±1.13 vs 10.80±1.09 $p = 0.34$ and 11.23±0.95 10.73± 1.16 $p = 0.09$, respectively).[15] In our study the values of MPV and PDW are not only higher in groups with diabetic complications, like the study by Dindar et al, but also showed statistically significant p- value. This is due to larger cohort in our study (444 diabetics) as compared to only 60 patients of Dindar et al.

Haji Khan Khoharo et al have conducted study on patients with diabetes mellitus in Sindh, Pakistan in 2012 and evaluated MPV values. Haji Khan Khoharo et al have found statistically significant difference in MPV values uncontrolled diabetic group as compared to with controls group and controlled diabetics group ($p=0.001$).[21]

Mustafa et al have conducted a study on patients with type II diabetes mellitus and evaluated the relationship between platelet indices (MPV) with nephropathy (microalbuminuria) and glycemic control and has found a statistical significance between between nephropathy and platelet indices. In this study patients with microvascular complication like nephropathy have higher the median MPV value 9 (8-9.5) fl while patients without it have lower MPV value 8.5 (8-9.2) fl which is strongly significant ($p=0.004$).[22] All these studies also confirm our results about MPV.

Akinsegun et al. have conducted study on diabetic patients on treatment and non diabetics in Nigeria and evaluated significance of platelet volume indices like MPV and platelet counts and has concluded that mean platelet count was higher in diabetic patients while MPV values were lower in this group (mean platelet count for the diabetics was $235.29±76.81×10^9$/L and controls, $211.32±66.44 ×10^9$/L and the MPV, for the diabetics was 8.69±0.67 fl and the controls, 8.91± 0.80 fl). MPV was lower in diabetics than healthy controls.[23] This study involved only 100 cases of diabetic patients as compared > 400 diabetics in our study and their results don't confirm to many similar studies.

A meta-analysis which includes 48 articles with 9118 patients from 2000 to 2017 published by Portland Press Limited on behalf of the Biochemical Society showed NLR (neutrophil lymphocyte ratio), MPV and PDW has a positive association with DN and DR.[24] Results of all these studies are similar to results of present study.

Numerous studies have concluded that MPV and PDW are good hematologic markers for predicting microvascular complications in diabetic patients. We detected that platelet volume parameters have stastistical significance difference between diabetic patients with and without microvascular complications. Based on these results, we have concluded that larger hyperactive platelet may pose a greater risk for acute coronary syndrome. For this reason, we think that platelet volume paramet ers (MPV and PDW measurements), which are routinely available, least invasive and easy-to-carry out, may be an good source for the discrimination, differentiation and predicting microvascular complications in diabetic

patients. Most previous studies favour the results of present study (except few studies which had a small sample size).

Conclusion

Platelet volume indices (PVI) include mean platelet volume (MPV) and platelet distribution width (PDW) are clinical parameters of platelet thrombogenic activity and are increased in diabetics with early and advanced micro vascular damage as compared to diabetics without micro vascular complications in this study. MPV and PDW can simply be used to identify patients with early and advanced complications and these patients can benefit from preventive measures and early treatment. Thus, early diagnosis and appropriate measures and treatment could thereby delay onset or progression of complications. Further promising articles are needed.

Although interpretation of the abnormal values of platelet volume indices in diabetes is a challenge, more awareness and consideration should be concentrated on platelet volume indices for better and productive management and the estimation and prognostication of cardiovascular and other vascular thrombotic events in diabetic patients.

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References

1. Ferreiro JL, Gómez-Hospital JA, Angiolillo DJ. Platelet abnormalities in diabetes mellitus. DiabVasc Dis Res. 2010;7(4):251-9.
2. Genuth S, Alberti KG, Bennett P. Follow-up report on the diagnosis of diabetes mellitus. Diabetes Care 2003; 26(11):3160-7.
3. Vazzana N, Ranalli P, Cuccurullo C, Davì G. Diabetes mellitus and thrombosis.Thromb Res. 2012; 129(3): 371-7.
4. Lüscher TF, Creager MA, Beckman JA and Cosentino F. Diabetes and vascular disease: pathophysiology, clinical consequences, and medical therapy: Part II. Circulation 2003;108(1):1655-61.
5. Creager MA, Lüscher TF, Cosentino F and Beckman JA. Diabetes and vascular disease: pathophysiology, clinical consequences, and medical therapy: Part I. Circulation. 2003;108(1):1527-32.
6. Osende JI, Badimon JJ, Fuster V. Blood thrombogenicity in non insulin dependent diabetes mellitus patients is associated with glycemic control. J Am Coll Cardiol 2001;38(5):1307-12.
7. Kim JH, Bae HY, Kim SY. Clinical marker of platelet hyperreactivity in diabetes mellitus. Diabetes Metab J. 2013;37(6):423-8.
8. Senzel L, Gnatenko DV, Bahou WF. The platelet proteome. Curr Opin Hematol. 2009; 16(5):329-33.
9. Randriamboavonjy V, Fleming I. Platelet function and signaling in diabetes mellitus. Curr Vasc Pharmacol 2012;10(5):532-8.
10. Davi G, Patrono C. Platelet activation and atherothrombosis. N Engl J Med 2007; 357(24):2482-94.
11. Kodiatte TA, Manikyam UM, Rao SB, Jagadish TM, Reddy M, Lingaiah HKM and Lakshmaiah V Mean Platelet Volume in Non insulin dependent Diabetes Mellitus. J Lab Physicians. 2012;4(1): 5-9.
12. Leader A, Pereg D, Lishner M. Are platelet volume indices of clinical use? A multidisciplinary review. Ann Med. 2012;44(8):805-16.
13. Yenigün EC, Okyay GU, Pirpir A, Hondur A, Yıldırım IS. Increased mean platelet volume in non insulin dependent diabetes mellitus. Dicle Med J 2014; 41(1): 17- 22.
14. 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(2):86-9.
15. Dindar S, Cinemre H, Sengul E, Annakkaya AN. Mean Platelet volume is associated with glycemic control and retinopathy in patients with non-insulin dependent diabetes mellitus.West Indian Med J. 2013; 62(6): 519-23.
16. Shilpi K and Potekar RM. A Study of Platelet Indices in Non-insulin dependent Diabetes Mellitus Patients. Indian J Hematol Blood Transfus. 2018 Jan; 34(1): 115-120.
17. Chu SG, Becker RC, Berger PB, Bhatt DL, Eikelboom JW, Konkle B. Mean platelet volume as a predictor of cardiovascular risk: A systematic review and meta analysis. J Thromb Haemost 2010;8(1):148 56.
18. Buch A, Kaur S, Nair R, Jain A. Platelet volume indices as predictive biomarkers for diabetic complications in Non-insulin dependent diabetic patients. J Lab Phy. 2017;9(2):84.
19. Ateş O, Kiki I, Bilen H, Keleş M, Koçer I, Kulaçoğlu DN. Association of Mean Platelet Volume With The Degree of Retinopathy in Patients with Diabetes Mellitus. Eur J Gen Med. 2009;6(2): 99–102.
20. Dayal A, Kothari S, Shah RJ and Patel SM. MPV in Diabetes Mellitus Type II. Ann Path Lab Med. 2016; 03(6):567-72.
21. Khoharo HK, Nizamani GS and Shaikh DM. Mean Platelet Volume in Type 2 Diabetes Mellitus. Elixir Physio Anatomy. 2014;71:25017-20.
22. Ünübol Ayhan M, Güney E. The relationship between mean platelet volume with microalbuminuria and glycemic control in patients with type II diabetes mellitus. Platelets 2012;23(6):475 80.
23. Akinsegun A, Olusola DA, Sarah JO, 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. PMC4215377.
24. Liu J,,Liu,X, Li Y, Quan J, Wei S, An S, Yang R and Liu J. The association of neutrophil to lymphocyte ratio, mean platelet volume, and platelet distribution width with diabetic retinopathy and nephropathy: a meta-analysis. Bioscience Reports. 2018; 38(3): BSR20180172.