Original Research Article

The study of neutrophils to lymphocyte ratio in moderately controlled diabetes (HbA1c 7-9) and its correlation with microvascular complications

Mrutyunjay B. Hiregoudar*, Dhananjaya M., Rajendrakumar Parakh

Department of General Medicine, SDM Medical College and Hospital, Dharwad, Karnataka, India

*Correspondence:
Dr. Mrutyunjay B. Hiregoudar,
E-mail: mrutjjm@gmail.com

ABSTRACT

Background: The study of neutrophils to lymphocyte ratio in moderately controlled diabetes (HbA1c 7-9) and its correlation with microvascular complications are to measure neutrophil lymphocyte ratio in patients with moderately controlled type 2 diabetes mellitus and to determine the correlation between neutrophil lymphocyte ratio and microvascular complications in moderately controlled type 2 diabetes patients.
Methods: Prospective, cross-sectional study, carried out on the patients with type 2 diabetes mellitus patients with hba1c levels 7 to 9, who are attending medicine opd and admitted under medicine. Complete blood count, fundoscopy, urine microalbumin and monofilament were analysed in these patients.
Results: This study shows that more than half (63%) of the study participants were males and 37% were females. Most of the patients came for follow up (81%). In our study it was observed that patient with microvascular complications like retinopathy, nephropathy and neuropathy had higher NLR when compared with patients with no microvascular complications.
Conclusions: Our study revealed that NLR was significantly raised in T2DM patients with microvascular complications. NLR being a simple, cost effective and easily available investigation can be used for screening tool to detect diabetic micro complications at an earliest especially in a resource constrained setup with limited laboratory facilities. Hence, NLR can be considered as a potential alternative for other costlier inflammatory markers and also a prognostic biomarker of any microvascular complications among T2DM patients.

Keywords: Type2 DM, NLR-neutrophil-lymphocyte ratio, Microvascular complications

INTRODUCTION

Type 2 diabetes mellitus (T2DM), a group of chronic common metabolic disorders, is characterized by hyperglycemia resulting from defects in insulin action, insulin secretion, or both and is contributed by the interaction of behavioural, environmental, and genetic risk factors.[1,2]

Determinants of T2DM consist of a matrix of epigenetic, genetic and lifestyle factors (like overweight, central obesity, sedentary lifestyle, smoking, medications, psychological stress) interacting with one another and operating within the larger physical–sociocultural environment. Many epidemiological studies show evidence that even with a strong genetic predisposition for T2DM, it can be prevented with lifestyle modifications.[3]

Global burden

Prevalence of DM globally in 2019 was estimated to be 9.3% (463 million people) which is expected to rise up to

10.2% (578 million people) by 2030 and by 2045 up to 10.9% (700 million) representing 51% increase from 2019, greatest increase being in developing countries of Africa, Asia and South America.[2,4] Globally it was seen that approximately 1 in every 11 adults has T2DM, and about 75% of those with T2DM are from developing countries.[3]

Diabetes status in India

In India in the past few years diabetes has reported a pointed augment in its prevalence with a rise from 7.1% in 2008 to 8.9% among adults in 2019 according to IDF. Around 25.2 million adults were reported to be pre diabetic with an estimated increase to 35.7 million in the year 2045. The number of people living with diabetes in India in 2019 was projected to be 77 million and has turned into a country with the second-largest diabetes next to China.[4,5]

Complications of diabetes

Uncontrolled diabetes can lead to increased risk of vascular disease such as cardiovascular (CV), cerebrovascular, and peripheral artery disease summarized as macrovascular and diabetic retinopathy, nephropathy, and neuropathy which are microvascular complications. One of the observational studies among 28 countries in Africa, Asia, South America and Europe showed that microvascular complications were seen in half of patients with T2DM while macrovascular complications were seen in 27% of those with T2DM. Also, cohort studies from developed countries showed a relative risk of 10-20 for microvascular disorders and 2-4 for macrovascular disorders among patients with diabetes mellitus suggesting that the risk is higher compared to those without diabetes mellitus.[3]

In 2015 it was seen that of the global health expenditure about 12% was spent on treatment of T2DM and its related complications while and 53% of the lifetime medical expenditure of a diabetic patient is attributed to treating the major complications of T2DM (nephropathy, retinopathy, neuropathy, stroke and coronary heart diseases) in the USA.[3]

Inflammatory makers in diabetes

Inflammatory pathways were suggested to be activated in recent studies in type 2 DM and those subclinical inflammations enhanced metabolic disturbances leading eventually to vascular complications. Hence nowadays inflammatory markers derived from standard blood count test are in demand.[6,7]

Total leucocyte count is a crude, but sensitive indicator of inflammation and is studied in many non-communicable diseases as an inflammatory marker such as acute myocardial infarction (MI), stroke, and heart failure. However, the subtypes, particularly the neutrophils, lymphocytes, and subsequent calculation of neutrophil–lymphocyte ratio (NLR), which is relatively more stable than individual leukocyte parameters, could be altered by various physiological, pathological, and physical factors. The NLR is a simple and cheap laboratory tool studied as an inflammatory marker that is used to predict the prognosis of many non-communicable diseases such as acute MI, stroke, heart failure, appendicitis, cardiac diseases, cancer, and DN.[2] Neutrophil – Lymphocyte ratio (NLR), which can be calculated through the easily available blood counts. NLR may be considered as a marker of chronic inflammation. It represents a combination of two markers; neutrophils, which represent the active nonspecific mediator initiating the first line of defense with a negative effects leading to endothelial damage and lymphocytes, representing the regulatory or protective antiatherosclerotic component of inflammation. NLR has been demonstrated to be a simple, cost-effective investigation.[8] Therefore, the NLR has been considered a convenient indicator for systemic inflammation.[9]

Calculation of NLR is done by dividing the number of neutrophils (complete blood count) by number of lymphocytes (differential count) which is easy to obtain and is also inexpensive compared to any other inflammatory markers. This marker is more stable even when subjected to physiologic variations like exercise, dehydration, and blood specimen handling.[10]

METHODS

Study design

Prospective, cross-sectional study was done.

Study period

The study was conducted during the period of June 2021 to May 2022.

Study participants

The present study was carried out on the patients attending medicine OPD and IPD of SDM College of Medical Sciences and Hospital, Sattur, Dharwad.

Inclusion criteria

Type 2 diabetes mellitus patients with HbA1C Levels 7 to 9 attending department of medicine of SDM College of Medical Science and Hospital, Dharwad.

Exclusion criteria

Patients with acute infections, leukocytosis or leukocytopenia, chronic cardiac, renal or hepatic disorders. Patients who are a known case of autoimmune disorders, malignancy or hematological proliferative disorders. Patients who had received anti-inflammatory or immunosuppressive therapy.

Sampling population

Patients presenting to outpatient department and inpatient department to SDM College of Medical Sciences.

Sample size calculation: Approximated to 200.

Expected proportion =0.077 (7.7% with type 2 DM), precision (%) = 5, Desired confidence level (%) = 99

Formula: $n = \frac{Z^2 pq}{d^2}$

Where: Z =standard normal variate value (Z value) =2.58 at 1% alpha error or 99% confidence, p=prevalence of type 2 DM=7.7%, Q =100-p=100-7.7=92.3%, D =margin of error=5%, sample size (n) =189 (approximately 200).

Sampling technique used is convenience sampling.

Statistics

Descriptive statistics with frequency and percentages, chi-square test for association between two attributes

Study procedure

Institutional ethical committee clearance to conduct the study was obtained. Written and informed consent from patient were taken and information sheet were provided. Patients were screened for the eligibility and those fulfilling the selection criteria were briefed about the nature of the study. History of symptoms- duration of present illness. Past history - comorbidities if any (eg: type 2 diabetes mellitus, hypertension, tuberculosis, or any chronic disease). Personal history – habits, smoking, drinking. Examination findings like vital signs, pulse rate, blood pressure, respiratory rate and SpO$_2$ were recorded. Complete general and systemic examination were performed.

All investigations performed for evaluation of the patient were noted. Relevant investigations done were: HbA1c, total leucocyte count, differential leucocyte count, urine routine, urine microalbumiuria, fundoscopy, nerve conduction study and others.

Compiling of data was done. The statistical analysis was preformed and presented as percentages and pictorial representation of the same in graphical format was done.

RESULTS

Table 1 shows that more than half (63%) of the study participants in our study were males and 74 (37%) were females. Table 2 shows that most of the study participants 162 (81%) came for follow up, 22 (11%) of them came with the complaints of burning sensation in the foot, 13 (6.5%) of them came for diminished vision and one each came for headache (0.5%), left hand weakness (0.5%) and pain in lower limb (0.5%). According to Table 3, all the study participants had diabetes, 65 (32.5%) had hypertension and one each had hypothyroidism (0.5%), chronic obstructive pulmonary disorder (COPD, 0.5%) and one was an old case of cerebrovascular accident (CVA, 0.5%), 164 (82%) of the study participants did not have any habits, 23 (11.5%) of them were alcoholics, 19 (9.5%) of them were smokers and 4 (2%) of them were tobacco chewers. As shown in Table 4 fundus examination of the study participants, it was seen that in 128 (64%) of them it was normal, 67 (33.5%) had non proliferative diabetic retinopathy, 5 (2.5%) had proliferative diabetic retinopathy, 157 (78.5%) had normal monofilament test finding while 43 (21.5%) of them showed sensory neuropathy, 139 (69.5%) of them had a microalbuminuria levels of less than 30, 56 (28%) of them had 30-300 and 5 (2.5%) had more than 300. In Table 5 descriptive data of the continuous variables in our study have been elaborated. Table 6 shows that most of the patients having NPDR and PDR in fundus examination had NLR levels of more than 3 and this association was found to be statistically significant. According to Table 7, patients with higher levels of micro albuminuria of more than 30 had NLR levels of more than 3 and this association being statistically significant. As shown in Table 8, patients with sensory neuropathy in monofilament test had NLR levels of more than 3 and this association was found to be statistically significant.

Table 9 shows presence of multiple complications associated with NLR levels and found that 27 (37.5%) of those with NLR more than 3 had both neuropathy and nephropathy, 38 (52.7%) of the patients with NLR more than 3 had both retinopathy and nephropathy.

It also shows that 29 (40.3%) of the patients with NLR more than 3 had both retinopathy and neuropathy, 30 (41.6%) of the patients with NLR levels more than 3 had all the three complications (retinopathy, neuropathy and nephropathy).

Table 1: Gender wise distribution of the study participants.

Gender	Frequency	Percentage (%)
Female	74	37.0
Male	126	63.0
Total	200	100.0

Table 2: Distribution of the study participants based on their chief complaints.

Chief complaints	Frequency	Percentage (%)
Burning sensation in the foot	22	11
Headache	1	0.5
Diminished vision	13	6.5
Follow up	162	81.0
Left hand weakness	1	0.5
Pain in lower limb	1	0.5
Total	200	100.0

Table 3: Distribution of the study participants based on their past history and habits.

Comorbidities and habits	Frequency	Percentage (%)
Diabetes mellitus	200	100
Hypertension	65	32.5
Old CVA	1	0.5
Hypothyroid	1	0.5
COPD	1	0.5
Alcoholic	23	11.5
Smoker	19	9.5
Tobacco chewer	4	2
Nil	164	82

*Multiple answers were given.

Table 4: Distribution of the study participants based of the findings of the fundus examination, monofilament test and microalbuminuria.

Fundus examination			Monofilament test			Microalbuminuria		
	Frequency	%		Frequency	%		Frequency	%
Normal	128	64	Normal	157	78.5	<30	139	69.5
Non proliferative diabetic retinopathy	67	33.5	Sensory neuropathy	43	21.5	30-300	56	28
Proliferative diabetic retinopathy	5	2.5				>300	5	2.5
Total	200	100	Total	200	100	Total	200	100

Table 5: Descriptive data of the study participants

	Mean	Std. Deviation
Age in years	58.36	13.012
DM duration in years	10.18	6.946
Pulse rate (bpm)	83.46	9.575
Respiratory rate (cpm)	16.39	1.683
SPO2	97.97	0.743
HbA1C	7.90	0.594
Hb (gm/dl)	12.54	2.04
TLC	8526.39	2611.266
Neutrophils	62.88	11.87
Lymphocytes	25.32	9.82
NLR	3.39	3.134
Platelet	3.57	12.696
Microalbuminuria	60.142	186.956

Table 6: Association between NLR and fundus examination findings

NLR	Fundus			P value
	Normal (%)	Non proliferative diabetic retinopathy (NPDR) (%)	Proliferative diabetic retinopathy (PDR) (%)	
<3	101 (78.9)	25 (37.3)	2 (40)	<0.00001
>3	27 (21.1)	42 (62.7)	3 (60)	

Table 7: Association between NLR and micro albuminuria levels.

NLR	Micro albuminuria			P value
	<30	30-300	>300	
<3	107 (77)	19 (33.9)	2 (40)	<0.00001
>3	32 (23)	37(66.1)	3 (60)	

Table 8: Association between NLR and monofilament test findings.

NLR	Monofilament test		P value
	Normal (%)	Sensory neuropathy (%)	
<3	117 (74.5)	11 (25.5)	<0.00001
>3	40 (25.5)	32 (74.5)	

Table 9: Multiple microvascular complications associated with NLR.

Variables	NLR		Total (%)
	<3 (%)	>3 (%)	
Neuropathy and nephropathy			
None	105 (82)	30 (41.7)	135 (67.5)
Either one	14 (10.9)	12 (6.7)	26 (13.0)
Both	9 (7.1)	27 (37.5)	39 (19.5)
Retinopathy and nephropathy			
None	97 (75.80)	24 (33.3)	121 (60.5)
Either one	12 (9.4)	10 (13.9)	22 (11)
Both	19 (14.9)	38 (52.7)	57 (28.5)
Retinopathy and neuropathy			
None	100 (78.1)	24 (33.3)	124 (62)
Either one	18 (14.1)	19 (26.4)	37 (18.5)
Both	10 (7.9).	29 (40.3)	39 (19.5)
Retinopathy, neuropathy and nephropathy			
None	97 (75.8)	22 (30.6)	119 (59.5)
Either one	21 (16.4)	20 (27.8)	41 (20.5)
Both	10 (7.9)	30 (41.6)	40 (20)

DISCUSSION

A prospective, cross-sectional study was conducted among 200 patients attending medicine OPD and IPD of SDM college of medical sciences and hospital, Dharwad to measure neutrophil lymphocyte ratio in patients with moderately controlled type 2 diabetes mellitus (HbA1c levels 7 to 9) and also to determine the correlation between neutrophil lymphocyte ratio and microvascular complications. The mean age of patients in our study was 58.6 years which is nearly same as Duman at al in the year 2019 in Turkey (58.6 years).[6] Study done by Kothai et al in 2020 in, Tamil Nadu showed mean age of 57.39 years.[8]

Our study had more than half (63%) male study participants and 37% female participants. In the study done by Phandais et al in 2022 in Pune 61% were males and 39% females which were similar to that of our study.[1] Similar study done by Kothai et al in 2020 in Tamilnadu had 53% males and 47% females.[8] And Duman et al study done in 2019 in Turkey had 51.9% males and 48.1% females showing male predominance in their studies.[6]

Table 2 elaborates the reasons the study participants visited the hospital for and it was seen that most (81%) came for regular follow up while 11% came with the complaints of burning sensation in the foot which might indicate peripheral neuropathy and 6.5% for diminished

vision reasons being either cataract (which can also be secondary to diabetes) or diabetic retinopathy. The present study also had 32.5% of the study participants with associated hypertension which can independently cause renal damage and hypertensive retinopathy and hence exaggerating the complications related to diabetes.

Our study had mean HbA1c of 7.9 % which is nearly same as in the study done by Phandais et al in 2022 in Pune 9.61%.[1] Similar study done by Demirtas et al in 2015 in Turkey had 8.6% in their studies.[17]

Our study had average NLR of 3.39 which is more when compared to Study done by Phandais et al in 2022 in Pune

and Duman et al had NLR of 2.6 and 2.44 respectively associated with complications.[1,6] Similar study done by Demirtas et al in 2015 in Turkey had 1.75 far less than our study.[17]

In our study on assessing the microvascular complications of diabetes it was seen that 36% had diabetic retinopathy, 21.5% had sensory neuropathy and 30.5% of them had diabetic nephropathy.

The results from our study align with a growing body of evidence supporting the use of NLR as a readily available and cost-effective inflammatory biomarker for diabetic complications.

Table 10: NLR levels in those with and without complication and comparison with different studies.

Studies	Years and place	NLR (Mean, SD)			P value
		Without complications		**With complications**	
Present study	2022, Dharwad	2.52 (1.84)		4.68 (4.07)	<0.001
Phadais et al[1]	2022, Pune	1.37 (0.57)		4.03 (0.82)	0.01
Fawwad et al[7]	2018, Turkey	3.36 (2.67)		4.34 (3.32)	<0.001
Megalla et al[13]	2015, Egypt	1.14 (0.3)		2.39 (1.01)	<0.001
Oztuk et al[15]	2013, Turkey	2.04 (0.72)		2.46 (1.26)	<0.0001
		Diabetic nephropathy (albuminuria)			
		Normal	**Micro**	**Macro**	
Present study	2022, Dharwad	2.78 (2.22)	4.95 (4.43)	4.04 (2.91)	<0.0001
Khandare et al[11]	2017, Gujarat	1.94 (0.65)	2.83 (0.85)		<0.0001
Kahraman et al[14]	2014, Turkey	1.9 (0.9)	2.6 (1.0)	3.6 (1.3)	<0.0001
		Diabetic retinopathy			
		Normal	**NPDR**	**PDR**	
Present study	2022, Dharwad	2.78 (2.42)	4.11 (2.64)	9.66 (10.79)	<0.0001
Megalla et al[13]	2015, Egypt	1.14 (0.3)	2.25 (0.72)	2.79 (1.45)	<0.001
		Diabetic neuropathy (DN)			
		With DN		**Without DN**	
Present study	2022, Dharwad	3.113 (2.57)		5.15 (5.18)	0.051
Gurmu et al[2]	2022, Ethiopia	1.65 (0.20)		2.66 (0.49)	<0.001
Xu et al[12]	2017, China	2.18 (0.61)		2.58 (0.50)	<0.001

Overall complications

The higher NLR found in our cohort with complications (mean-4.68 and SD-4.07) echoes similar findings reported by Phadais et al in Pune and Fawwad et al in Turkey, though with different mean values, reflecting potential variations in population characteristics, disease duration, and treatment protocols.[1,7] The consistent statistically significant differences (p<0.001) across these studies strengthen the argument for NLR's utility in risk stratification as seen in present study.

Diabetic nephropathy

Our finding of a progressive increase in NLR with worsening albuminuria (2.78→4.95→4.04 for normal, micro, and macro, respectively) is consistent with the literature in present study. Khandare et al and Kahraman et al reported similar trends in Gujarat and Turkey,

respectively.[11,14] The drop in mean NLR between micro- and macroalbuminuria in our study, while still significantly elevated compared to normal, could be an anomaly related to specific cohort characteristics or sample size variations within the subgroups, an area for future investigation.

Diabetic retinopathy

The stepwise increase in NLR with the severity of diabetic retinopathy observed in our study (Normal -> NPDR-> PDR -- 2.78→4.11→9.66) is supported by Megalla et al in Egypt, who also showed higher NLR values with more severe retinopathy.[13] This strengthens the role of NLR as a marker for the severity and progression of retinal damage.

Diabetic neuropathy

Our finding that patients with diabetic neuropathy had a higher NLR (5.15±5.18) compared to those without

(3.113±2.5) is in line with studies from Ethiopia and China, both of which demonstrated a significant association.[2,12] The marginal statistical significance in our study (p=0.051) warrants further investigation and may be influenced by factors such as the diagnostic criteria used for neuropathy or the relatively small sample size in this subgroup.

Our study showed a weak positive correlation between NLR and HbA1c (r=0.024) and was not found to be statistically significant. But study done by Duman et al in 2019 in Turkey showed a strong positive correlation (r=0.51) which was statistically significant.[6]

Limitations of the study

Since it's a cross-sectional study it can only show an association, it cannot determine if the elevated NLR precedes or is a consequence of the complications. While the association is clear, longitudinal studies are needed to determine if an elevated NLR precedes the onset of complications.

Narrow HbA1c Range (7-9%): Focusing only on a moderately controlled group may limit the generalizability of the findings to patients with very tight (HbA1c<7%) or very poor (HbA1c>9%) control.

Variability of NLR: NLR can fluctuate daily, and a single measurement might not accurately represent the chronic inflammatory status of the patient. The NLR cut-off values for predicting complications can vary based on population and methodology, highlighting the need for standardized thresholds.

CONCLUSION

Our study revealed that NLR was significantly raised in T2DM patients with microvascular complications. It was found that NLR positively correlated with HbA1c. DM being more prone to variety of complications which can be both short- and long-term frequently results in early mortality and is mainly due to its prevalence, insidious onset, and delay in its diagnosis. NLR being a simple, cost effective and easily available investigation can be used for screening tool to detect diabetic micro complications at an earliest especially in a resource constrained setup with limited laboratory facilities. Hence, NLR can be considered as a potential alternative for other costlier inflammatory markers and also a prognostic biomarker of any microvascular complications among T2DM patients. Based on these findings we can recommend to include NLR in clinical practice for the diagnosis and prognosis of diabetic complications.

ACKNOWLEDGEMENTS

REFERENCES

1. Phadnis N, Shiddapur GS, Harsh P, Rana N. A Comparative Study Evaluating The role of Utility of Red Blood Cell Count, Red Cell Distribution Width, And Neutrophil/Lymphocyte Ratio as Prognostic Markers in Type 2 Diabetes Mellitus patients with and without Microvascular Complications. Euro J Molecul Clin Med. 2022;9:8414-24.
2. Gurmu MZ, Genet S, Gizaw ST, Feyisa TO, Gnanasekaran N. Neutrophil–lymphocyte ratio as an inflammatory biomarker of diabetic nephropathy among type 2 diabetes mellitus patients: A comparative cross-sectional study. SAGE Open Med. 2022;10:1–7.
3. Zheng Y, Ley SH, Hu FB. Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. Endocrinology. 2018;14:88-98.
4. Pradeepa R, Mohan V. Epidemiology of type 2 diabetes in India. Indian J Ophthalmol. 2021;69:2932-8.
5. Govindaswamy S, Dhivya PS, Sangeetha SKS. Prevalence and Complications of Diabetes Mellitus in India-A Systematic Review. Ind J Pharmaceut Educ Res. 2023;57(2):213-25.
6. Duman TT, Aktas G, Atak BM, Kocak MZ, Erkus E, HS. Neutrophil to lymphocyte ratio as an indicative of diabetic control level in type 2 diabetes mellitus. Afri Health Sci. 2019;19(1):1602-6.
7. Fawwad A, Butt AM, Siddiqui IA, Khalid M, Sabir R, Basit A. Neutrophil-to-lymphocyte ratio and microvascular complications insubjects with type 2 diabetes: Pakistan's perspective. Turk J Med Sci. 2018;48:157-61.
8. Kothai G, Neha K, Bholenath Patil A. Neutrophil lymphocyte ratio as a marker of diabetic nephropathy. J. Evid. Based Med. Healthc. 2020;7(26):1223-7.
9. Wan H, Wang Y, Fang S, Chen Y, Zhang W, Xia F, et al. Associations between the Neutrophil-to-Lymphocyte Ratio and Diabetic Complications in Adults with Diabetes: A Cross-Sectional Study. J Diabetes Res. 2020;2(1):1-9.

10. DiGangi C. Neutrophil-lymphocyte ratio: Predicting cardiovascular and renal complications in patients with diabetes. J Am Assoc Nurse Practition. Brief report; 2016.
11. Khandare SA, Chittawar S, Nahar N, Dubey TN, Qureshi Z. Study of neutrophil-lymphocyte ratio as novel marker for diabetic nephropathy in type 2 diabetes. Indian J Endocr Metab. 2017;21:387-92.
12. Xu T, Weng Z, Pei C, Yu S, Chen Y, Guo W, et al. The relationship between neutrophil-tolymphocyte ratio and diabetic peripheral neuropathy in Type 2 diabetes mellitus. Medicine. 2017;96:45.
13. Moursy EY, Megallaa MH, Mouftah RF, Ahmed SM. Relationship Between Neutrophil-Lymphocyte Ratio and Microvascular Complications in Egyptian Patients with Type 2 Diabetes. Am J Internal Med. 2015;3:250-5.
14. Kahraman C, Kahraman NK, Aras B, Coşgun S, Gülcan E. The relationship between neutrophil-to-lymphocyte ratio and albuminuria in type 2 diabetic patients: a pilot study. Arch Med Sci. 2016;12(3):571–5.
15. Ozturk ZA, Kuyumcu ME, Yesil Y, Savas E, Yıldız H, Kepekci Y, et al. Is there a link between neutrophil-lymphocyte ratio and microvascular complications in geriatric diabetic patients. J Endocrinol Invest. 2013;36:593-9.
16. Chittawar S, Dutta D, Qureshi Z, Surana V, Khandare S, Dubey TN. Neutrophil-lymphocyte ratio is a novel reliable predictor of nephropathy, retinopathy, and coronary artery disease in Indians with type-2 diabetes. Indian J Endocr Metab. 2017;21:864-70.
17. Demirtas L, Degirmenci H, Akbas EM, Ozcicek A, Timuroglu A, Gurel A, et al. Association of hematological indicies with diabetes, impaired glucose regulation and microvascular complications of diabetes. Int J Clin Exp Med. 2015;8(7):11420-7.