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Usefullnes of atherogenic indices and Ca-LDL level to predict subclinical atherosclerosis in patients with psoriatic arthritis?

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Abstract

Background: To investigate the link between carbamylated low-density lipoprotein (ca-LDL), atherogenic index of plasma (AIP), atherogenic coefficient (AC), Castelli's risk indices I and II (CRI I and II) and subclinic atherosclerosis in psoriatic arthritis (PsA).

Methods: Thirty-ninepatients and 19 age, sex, body mass index matched healthy controls were included. Insulin resistance (IR) was assessed with homeostasis of model assessment-IR (HOMA-IR). Carotid intima-media thickness (CIMT) was measured at both common carotid arteries and mean CIMT was calculated.

Results: The mean age was 49.50 ± 11.86 years and 64.1% were females in PsA group. In the PsA group, CIMT and HOMA-IR were significantly higher ($p = 0.003$, $p = 0.043$, respectively). AIP, AC, TG/HDL, CRI-1, CRI-2 and ca-LDL levels were similar between groups. In PsA group, CIMT was positively correlated with HOMA-IR, TG/HDL and AIP. Although ca-LDL was positively correlated with serum amyloid A ($r = 0.744$, $p < 0.001$), no correlation was detected between ca-LDL and CIMT ($r = 0.215$, $p = 0.195$). PsA patients with IR tended to have higher ca-LDL levels than patients without IR, but this difference lacked statistical significance (33.65 ± 26.94, 28.63 ± 28.06, respectively, $p = 0.237$).

Conclusions: A significant increase in CIMT was seen in PsA patients without clinically evident cardiovascular disease or any traditional atherosclerosis risk factors. CIMT was correlated with HOMA-IR, TG/HDL and AIP.

Keywords: Atherogenic indexes, Atherosclerosis, Ca-LDL, Carotid intima-media thickness, Psoriatic arthritis

Introduction

Psoriatic arthritis (PsA) is an inflammatory arthritis that can lead to significant joint damage and disability. A recent meta-analysis of observational studies reported a 43% increased risk of cardiovascular disease (CVD) and 55% increased risk of incident cardiovascular events in patients with PsA compared to the general population. In addition, an increased morbidity risk for myocardial infarction, stroke and heart failure of 68, 22 and 31%, respectively, in patients with PsA was reported in that meta-analysis [1]. When compared with patients with rheumatoid artrhritis and non- PsA spondyloarthritis, cardiovascular and metabolic comorbidities, such as hypertension, hyperglycemia, obesity, hyperlipidemia and the metabolic syndrome, were significantly higher in PsA patients [2–4]. Vascular comorbidities is higher in patients with PsA compared with psoriatic patients without arthritis [4–7]. This difference is independent of traditional cardiovascular risk factors and correlates with disease duration of PsA, severity of skin disease and erythrocyte sedimentation rate (ESR) [8].

Assessing clinical endpoints, such as myocardial infarction or stroke, in prospective cohort studies requires following large patients cohorts for extended periods of

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time. Due to this limitation, surrogate endpoints such as imaging modalities of atherosclerosis or serum biomarkers vascular and metabolic function are commonly investigated to reveal the link between PsA and CVD [9]. Among the imaging modalities, ultrasonographic assessment of carotid intima-media thickness (CIMT) is a non- invasive and reproducible imaging modality for subclinical atherosclerosis and has been widely accepted as one of the strongest predictors of major cardiovascular events [10–12].

For an absolute CIMT difference of 0.1 mm, the future risk of myocardial infarction increases by 10–15%, and the stroke risk increases by 13–18% [13]. Increased CIMT were reported in PsA patients without clinically evident cardiovascular disease or any traditional atherosclerosis risk factors [14].

Carbamylation is a post-translational modification in which cyanate binds to primary amino or thiol groups. Inflammation, renal insufficiency and smoking can stimulate the degree of carbamylation. Several proteins, particularly long lived proteins, can undergo carbamylation in different pathophysiological conditions [15, 16]. Antibodies against carbamylated proteins have been detected in PsA patients and are correlated with disease activity [17]. Ca-LDL can exhibits a variety of biological effects relevants to atherosclerosis, such as induction of injury to endothelial cells, cell adhesion molecule expression, attraction of monocytes, endothelial and vascular smooth muscle cells proliferation [18–22]. Atherogenic effect of ca-LDL has been widely studied in chronic kidney disease [20].

Atherogenic indices such as atherogenic index of plasma (AIP), atherogenic coefficient (AC), Castelli's risk indices I and II (CRI I and II) are the novel indexes used for identifying cardiovascular disease. In this study we aimed to investigate the link between ca-LDL, AIP, AC, CRI and subclinic atherosclerosis in patients with PsA.

Materials and methods

Thirty-nine patients with PsA who fulfilled the Classification criteria for psoriatic arthritis and 19 age and sex matched healty controls were included in this cross sectional study [23]. Those with history of smoking, diabetes mellitus (glycated hemoglobina1c ≥ 6.5), hypertension, coronary artery disease, heart failure, symptomatic carotid artery disease, peripheral artery disease, aortic aneurysm, a history of cerebrovascular disease, pregnacy, malignancy, active infection, acute or chronic renal failure, nonalcoholic fatty liver disease, chronic liver disease, chronic obstructive pulmonary disease, obstructive sleep apnea, thyroid dysfunction and concomitant rheumatic disease were excluded from this study. Patients who were receiving systemic steroids were also excluded.

The study protocol was approved by the Local Research Ethics Committee. A written informed consent form was signed by the all participants. Demographic and clinical data were recorded. After a 12 h fasting period, venous blood samples was collected from all the subjects in the morning. The following parameters were analysed: ESR, c-reactive protein (CRP), fasting blood glucose (FBG), insulin, total cholesterol (TC), high density lipoprotein cholesterol (HDL-C) and low- density lipoprotein cholesterol (LDL-C), triglyceride (TG), serum amyloid A protein (SAP) and Ca-LDL levels. Ca-LDL level was measured with Human carbamylated LDL (cLDL) ELISA Kit (Sunred Bio, Shanghai, China). The Atherogenic Index of Plasma (AIP) was calculated by using base 10 logarithm of ratio TG to HDL-c [24]. Atherogenic Coefficient (AC) was calculated as total cholesterol - HDL cholesterol / HDL cholesterol (TC-HDL-c)/HDL-c [25]. Castelli risk index 1 and Castelli risk index 2 were calculated as TC/HDL-c and LDL/HDL-c, respectively. The homeostasis model assessment (HOMA) index was used to estimate insulin resistance and calculated as fasting serum insulin (in microunits per milliliter) × fasting serum glucose (in millimolar)/22.5 [26]. An index > 2.5 reflects the clinical state of insulin resistance.

CIMT was measured by an experienced physician, who was blinded to the clinical characteristics of the partipicant. To avoid interobserver variability all measurements were performed by the same examiner. All subjects were examined using a high resolution Doppler ultrasound with a 7.5 MHz scanning frequency in B mode. Mean CIMT was calculated by taking the average of the three measurements taken from both carotid arteries [27].

All data were analyzed using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) 16.0 program for Windows. The variables were investigated using visual and analytical methods to determine whether they were normally distributed. Normally distributed continuous values were expressed as mean ± standard deviation (SD) and categorical variables as number and percentage. Non-normally distributed parameters were reported as median values with inter-quartile range (IQR) (25th and 75th percentiles). Student's t-test was used for comparison of normally distributed data, and the Mann-Whitney U test was used for comparison of non-normally distributed data. The chi squared test was used for categorical variables. Spearman's correlation coefficient were used in the PsA group, to evaluate the linear relationship between CIMT and other variables. A value of $p < 0.05$ was considered statistically significant.

Results

The mean age was 49.50 ± 11.86 years and 64.1% were females in PsA group. Patients were on the following medications: methotrexate or leflunomide in 14 (35.9%) patients,

combined DMARDs in 7 (17.9%) patients, anti-tumor necrosis factor alpha in 7 (17.9%) patients, anti-TNF with methotrexate in 9 (23.1%) patients, cyclosporine A in 1 (2.6%) patient, non-steroidal anti-inflammatory drugs in 1(2.6%) patient. Clinical characteristics and laboratory results of participants were summarized in Table 1. Mean CIMT levels in the PsA group were higher than the healthy volunteers ($p = 0.003$). Difference in ca-LDL levels was not statistically significant between groups. In PsA group, although CIMT was positively correlated with HOMA-IR, TG/HDL and AIP, there was no correlation between ca-LDL, AC, CRI-1, CRI-2 and CIMT (Table 2). In addition, CIMT was not correlated with ESR, CRP and SAP (p: 0.481, r: 0.118; p: 0.463, r: 0.123; p: 0.062 r: 0.306 respectively). Ca-LDL was positively correlated with only serum amyloid A protein level ($r = 0.744$, $p < 0.001$).

Insulin resistance as reflected by the HOMA-IR was significantly increased in the PsA patients compared with the controls (Table 1). PsA patients with IR tended to have higher ca-LDL levels than patients without IR, but this difference lacked statistical significance (33.65 ± 26.94, 28.63 ± 28.06, respectively, $p = 0.237$).

Discussion

To our knowledge, this is the first study evaluated the level of caLDL in patients with PsA. Ca-LDL levels were not significantly different between groups. In PsA patients, although ca-LDL level was not correlated with CIMT, it was positively correlated with SAP level. SAP, which secreted mainly by the liver under the transcriptional control of IL-1 and IL-6, is a major acute-phase protein present in serum. SAP levels increases up to 1000 fold following an inflammatory stimulation [28]. It is likely to be more than a biomarker of cardiovascular disease and is a participant in the early atherogenic process [29]. It is well recognized that SAP plays an important role in lipid metabolism, but how SAP impacts lipid metabolism remains incompletely understood [30]. During the acute-phase response, SAP causes HDL remodeling and reducing the cholesterol efflux capacity and antiinflammatory ability of the HDL [29, 30].

Proinflammatory cytokines alter the function of the adipose tissue, the skeletal muscle, the liver and the vascular endothelium, to generate a spectrum of proatherogenic changes that includes insulin resistance, dyslipidemia, prothrombotic effects, prooxidative stress, and endothelial dysfunction [31, 32]. Adipokines such as resistin, visfatin and leptin act as insulin antagonists and are elevated in patients with PsA [33–35]. Insulin resistance increases the risk for coronary artery disease even in the absence of hyperglycemia [36]. The HOMA-IR reflects dysregulation of fasting glucose and insulin [37]. Also, the TG/HDL-C reflects the dyslipidemia seen in insulin resistance [38]. Our study showed that PsA patients were more insulin resistant than healthy subjects. In addition, HOMA-IR and TG/HDL were positively correlated with CIMT.

AIP, reflect the true relationship between protective and atherogenic lipoprotein and is associated with the size of pre and anti-atherogenic lipoprotein particle [39]. In this study, AIP was positively correlated with CIMT in patients with PsA. Similarly, Sunitha et al. reported that AIP was significantly increased in patients with

Table 1 Clinical characteristics and laboratory results of patients and healthy volunteers

	PsA	Healty controls	*p* value
Age (mean ± SD, years)	49.50 ± 11.86	46.82 ± 5.703	0.356
Female	25 (64.1%)	11 (57.9%)	0.647
Insulin	11.7 (10.18–15.35)	8.6 (6.35–12.40)	**0.032**
FPG	91 (81.75–111.50)	88 (80.50–91)	0.212
HOMA-IR	2.67 (1.97–4.00)	1.93 (1.31–2.68)	**0.043**
SAP	40.20 (34.35–72.75)	40.2 (35.15–74.30)	0.920
Total cholesterol	190 (118–308)	190 (173.50–213.50)	0.827
HDL cholesterol	44.50 (34.70–50.75)	45 (37.00–51.50)	0.862
LDL cholesterol	113.50 (87.76–132.25)	126 (118.50–142.50)	0.079
Triglyceride	121.50 (89.75–178)	132 (71.00–166.50)	0.927
TG/HDL	2.97 (1.86–4.53)	3.36 (1.60–3.92)	0.771
AC	3.46 (2.69–4.24)	3.27 (2.41–4.20)	0.743
AIP	0.47 (0.27–0.66)	0.52 (0.20–0.59)	0.771
CRI-1	4.46 (3.67–5.24)	4.27 (3.41–5.20)	0.743
CRI-2	2.71 (2.22–3.05)	2.80 (2.18–3.52)	0.423
Ca-LDL	15.74 (13.52–50.95)	33.38 (13.81–80.08)	0.267
Mean CIMT	0.70 (0.60–0.81)	0.55 (0.53–0.63)	**0.003**

Results are expressed as median (IQR), mean ± SD or number (%), where appropriate
SD standard deviation, *FPG* fasting plasma glucose, *SAP* serum amyloid A protein, *AC* atherogenic coefficient, *AIP* atherogenic index of plasma, *CRI* Castelli's risk indices, *CIMT* carotid intima-media thickness
Bold values indicate statistically significant differences

Table 2 Univariate correlation of mean CIMT with selected variables in patients with PsA

	r	*p*
Erythrocyte sedimentation rate	0.118	0.481
C-reactive protein	0.123	0.463
Serum amyloid A protein	0.306	0.062
HOMA	0.455	0.004
Atherogenic Coefficient	0.193	0.246
TG/HDL	0.343	0.035
Atherogenic Index of Plasma	0.343	0.035
Castelli Risk index −1	0.193	0.246
Castelli Risk index −2	0.065	0.699
Ca-LDL	0.215	0.195

CIMT Carotid intima-media thickness

psoriasis than healthy controls and positively correlated with psoriasis area severity index [40]. Also, it has recently been reported that the AIP may be a good biomarker for the early detection of subclinical atherosclerosis in patient with various rheumatologic diseases, such as ankylosing spondylitis, rheumatoid arthritis, Behçet's disease, systemic lupus erythematosus, and familial Mediterranean fever [41–45].

AC is ratio relying on the significance of HDL-C in predicting the risk of cardiovascular disease [25]. CRI-1 anda CRI-2 are another parameters which are significant vascular risk indicators and their predictive value is greater than isolated parameters [46]. In this study, CIMT was not correlated with AC and CRI.

The relationship between inflammatory biomarkers levels and atherosclerosis has been merely speculative in patients with PsA. In our study, we did not find any correlation between CIMT and ESR, CRP, SAA. Similarly to our study, Gonzalez-Juanatey et al. demonstrated there was no significant correlation between ESR, CRP and CIMT [14]. Garg et al. observed no correlation between ESR, CRP, IL-1 and CIMT although CIMT was positively correlation with IL-6 [47].

Small sample size, lack of the information on skin involvement severity in PsA patients were major limitation of our study. Another limitation of our study is cross-sectional comparative design. Our results do not provide adequate results to explore potential causality and not reflect changes in these variables with disease duration, disease activity and therapy response.

Conclusions

As a conclusion, our findings contribute to the body of evidence showing increased premature atherosclerosis in PsA patients without clinically evident cardiovascular disease or any traditional atherosclerosis risk factors. TG/HDL ratio and AIP may be useful to screening premature atherosclerosis. Prospectively, long-term follow up further studies are needed to determine changes in these variables over time. Understanding the relationship between atherogenic indices and disease activity in PsA may help screen and risk stratify PsA patients in terms of CVD risk.

Abbreviations

AC: Atherogenic coefficient (AC); AIP: Atherogenic index of plasma; Ca-LDL: Carbamylated low-density lipoprotein; CIMT: Carotid intima-media thickness; CRI I and II: Castelli's risk indices I and II; CRP: c-reactive protein; CVD: Cardiovascular disease; ESR: Erythrocyte sedimentation rate; FBG: Fasting blood glucose; HDL-C: High density lipoprotein cholesterol; HOMA: Homeostasis model assessment; IR: Insulin resistance; LDL-C: Low-density lipoprotein cholesterol; PsA: Psoriatic arthritis; SAP: Serum amyloid A protein; TC: Total cholesterol; TG: Triglyceride

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Authors' contributions

All authors had contributions to the conception, design, acquisition, analysis, interpretation of the results, write of the paper. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study protocol was approved by the Committee on Human Research Ethics of Turkish Ministry of Health Zekai Tahir Burak Women's Health, Training and Research Hospital (decision number: 60/2017). A well written informed consent and consent to publish was obtained from all the partipicants included in this study.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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References

1. Polachek A, Touma Z, Anderson M, Eder L. Risk of cardiovascular morbidity in patients with psoriatic arthritis: a meta-analysis of observational studies. Arthritis Care Res. 2017;69(1):67–74.
2. Haque N, Lories RJ, de Vlam K. Comorbidities associated with psoriatic arthritis compared with non-psoriatic spondyloarthritis: a cross-sectional study. J Rheumatol. 2016;43(2):376–82.
3. Labitigan M, Bahce-Altuntas A, Kremer JM, Reed G, Greenberg JD, Jordan N, et al. Higher rates and clustering of abnormal lipids, obesity, and diabetes mellitus in psoriatic arthritis compared with rheumatoid arthritis. Arthritis Care Res. 2014;66(4):600–7.
4. Radner H, Lesperance T, Accortt NA, Solomon DH. Incidence and prevalence of cardiovascular risk factors among patients with rheumatoid arthritis, psoriasis, or psoriatic arthritis. Arthritis Care Res. 2017;69(10):1510–8.
5. Chin YY, Yu HS, Li WC, Ko YC, Chen GS, Wu CS, et al. Arthritis as an important determinant for psoriatic patients to develop severe vascular events in Taiwan: a nation-wide study. J Eur Acad Dermatol Venereol. 2013; 27(10):1262–8.
6. Lin YC, Dalal D, Churton S, Brennan DM, Korman NJ, Kim ES, et al. Relationship between metabolic syndrome and carotid intima-media thickness: cross-sectional comparison between psoriasis and psoriatic arthritis. Arthritis Care Res. 2014;66(1):97–103.
7. Husted JA, Thavaneswaran A, Chandran V, Eder L, Rosen CF, Cook RJ, et al. Cardiovascular and other comorbidities in patients with psoriatic arthritis: a comparison with patients with psoriasis. Arthritis Care Res. 2011;63(12): 1729–35.
8. Eder L, Jayakar J, Shanmugarajah S, Thavaneswaran A, Pereira D, Chandran V, et al. The burden of carotid artery plaques is higher in patients with psoriatic arthritis compared with those with psoriasis alone. Ann Rheum Dis. 2013;72(5):715–20.
9. Sobchak C, Eder L. Cardiometabolic disorders in psoriatic disease. Curr Rheumatol Rep. 2017;19(10):63.

10. Di Minno MN, Ambrosino P, Lupoli R, Di Minno A, Tasso M, Peluso R, et al. Cardiovascular risk markers in patients with psoriatic arthritis: a meta-analysis of literature studies. Ann Med. 2015;47(4):346–53.
11. Persson J, Stavenow L, Wikstrand J, Israelsson B, Formgren J, Berglund G. Noninvasive quantification of atherosclerotic lesions. Reproducibility of ultrasonographic measurement of arterial wall thickness and plaque size. Arterioscler Thromb. 1992;12(2):261–6.
12. Stein JH, Korcarz CE, Hurst RT, Lonn E, Kendall CB, Mohler ER, et al. Use of carotid ultrasound to identify subclinical vascular disease and evaluate cardiovascular disease risk: a consensus statement from the American society of echocardiography carotid intima-media thickness task force. Endorsed by the society for vascular medicine. J Am Soc Echocardiogr. 2008;21(2):93–111 quiz 89-90.
13. Lorenz MW, Markus HS, Bots ML, Rosvall M, Sitzer M. Prediction of clinical cardiovascular events with carotid intima-media thickness: a systematic review and meta-analysis. Circulation. 2007;115(4):459–67.
14. Gonzalez-Juanatey C, Llorca J, Amigo-Diaz E, Dierssen T, Martin J, Gonzalez-Gay MA. High prevalence of subclinical atherosclerosis in psoriatic arthritis patients without clinically evident cardiovascular disease or classic atherosclerosis risk factors. Arthritis Rheum. 2007;57(6):1074–80.
15. Shi J, van Veelen PA, Mahler M, Janssen GM, Drijfhout JW, Huizinga TW, et al. Carbamylation and antibodies against carbamylated proteins in autoimmunity and other pathologies. Autoimmun Rev. 2014;13(3):225–30.
16. Verbrugge FH, Tang WH, Hazen SL. Protein carbamylation and cardiovascular disease. Kidney Int. 2015;88(3):474–8.
17. Chimenti MS, Triggianese P, Nuccetelli M, Terracciano C, Crisanti A, Guarino MD, et al. Auto-reactions, autoimmunity and psoriatic arthritis. Autoimmun Rev. 2015;14(12):1142–6.
18. Apostolov EO, Basnakian AG, Ok E, Shah SV. Carbamylated low-density lipoprotein: nontraditional risk factor for cardiovascular events in patients with chronic kidney disease. J Ren Nutr. 2012;22(1):134–8.
19. Apostolov EO, Ok E, Burns S, Nawaz S, Savenka A, Shah S, et al. Carbamylated-oxidized LDL: proatherosclerotic effects on endothelial cells and macrophages. J Atheroscler Thromb. 2013;20(12):878–92.
20. Ok E, Basnakian AG, Apostolov EO, Barri YM, Shah SV. Carbamylated low-density lipoprotein induces death of endothelial cells: a link to atherosclerosis in patients with kidney disease. Kidney Int. 2005;68(1):173–8.
21. Asci G, Basci A, Shah SV, Basnakian A, Toz H, Ozkahya M, et al. Carbamylated low-density lipoprotein induces proliferation and increases adhesion molecule expression of human coronary artery smooth muscle cells. Nephrology (Carlton). 2008;13(6):480–6.
22. Apostolov EO, Shah SV, Ok E, Basnakian AG. Carbamylated low-density lipoprotein induces monocyte adhesion to endothelial cells through intercellular adhesion molecule-1 and vascular cell adhesion molecule-1. Arterioscler Thromb Vasc Biol. 2007;27(4):826–32.
23. Taylor W, Gladman D, Helliwell P, Marchesoni A, Mease P, Mielants H, et al. Classification criteria for psoriatic arthritis: development of new criteria from a large international study. Arthritis Rheum. 2006;54(8):2665–73.
24. Dobiasova M, Frohlich J. The plasma parameter log (TG/HDL-C) as an atherogenic index: correlation with lipoprotein particle size and esterification rate in apoB-lipoprotein-depleted plasma (FER(HDL)). Clin Biochem. 2001;34(7):583–8.
25. Brehm A, Pfeiler G, Pacini G, Vierhapper H, Roden M. Relationship between serum lipoprotein ratios and insulin resistance in obesity. Clin Chem. 2004; 50(12):2316–22.
26. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia. 1985;28(7):412–9.
27. Homma S, Hirose N, Ishida H, Ishii T, Araki G. Carotid plaque and intima-media thickness assessed by b-mode ultrasonography in subjects ranging from young adults to centenarians. Stroke. 2001;32(4):830–5.
28. Scarpioni R, Ricardi M, Albertazzi V. Secondary amyloidosis in autoinflammatory diseases and the role of inflammation in renal damage. World J Nephrol. 2016;5(1):66–75.
29. Getz GS, Krishack PA, Reardon CA. Serum amyloid a and atherosclerosis. Curr Opin Lipidol. 2016;27(5):531–5.
30. Sun L, Ye RD. Serum amyloid A1: structure, function and gene polymorphism. Gene. 2016;583(1):48–57.
31. Sattar N, McCarey DW, Capell H, McInnes IB. Explaining how "high-grade" systemic inflammation accelerates vascular risk in rheumatoid arthritis. Circulation. 2003;108(24):2957–63.
32. Boehncke WH, Boehncke S, Tobin AM, Kirby B. The 'psoriatic march': a concept of how severe psoriasis may drive cardiovascular comorbidity. Exp Dermatol. 2011;20(4):303–7.
33. Dikbas O, Tosun M, Bes C, Tonuk SB, Aksehirli OY, Soy M. Serum levels of visfatin, resistin and adiponectin in patients with psoriatic arthritis and associations with disease severity. Int J Rheum Dis. 2016;19(7):672–7.
34. Eder L, Jayakar J, Pollock R, Pellett F, Thavaneswaran A, Chandran V, et al. Serum adipokines in patients with psoriatic arthritis and psoriasis alone and their correlation with disease activity. Ann Rheum Dis. 2013;72(12):1956–61.
35. Feld J, Nissan S, Eder L, Rahat MA, Elias M, Rimar D, et al. Increased prevalence of metabolic syndrome and adipocytokine levels in a psoriatic arthritis cohort. J Clin Rheumatol. 2018;24:302.
36. DeFronzo RA. Insulin resistance, lipotoxicity, type 2 diabetes and atherosclerosis: the missing links. The Claude Bernard lecture 2009. Diabetologia. 2010;53(7):1270–87.
37. Bonora E, Targher G, Alberiche M, Bonadonna RC, Saggiani F, Zenere MB, et al. Homeostasis model assessment closely mirrors the glucose clamp technique in the assessment of insulin sensitivity: studies in subjects with various degrees of glucose tolerance and insulin sensitivity. Diabetes Care. 2000;23(1):57–63.
38. McLaughlin T, Reaven G, Abbasi F, Lamendola C, Saad M, Waters D, et al. Is there a simple way to identify insulin-resistant individuals at increased risk of cardiovascular disease? Am J Cardiol. 2005;96(3):399–404.
39. Dobiasova M, Frohlich J, Sedova M, Cheung MC, Brown BG. Cholesterol esterification and atherogenic index of plasma correlate with lipoprotein size and findings on coronary angiography. J Lipid Res. 2011;52(3):566–71.
40. Sunitha S, Rajappa M, Thappa DM, Chandrashekar L, Munisamy M, Revathy G, et al. Comprehensive lipid tetrad index, atherogenic index and lipid peroxidation: surrogate markers for increased cardiovascular risk in psoriasis. Indian J Dermatol Venereol Leprol. 2015;81(5):464–71.
41. Cure E, Icli A, Uslu AU, Sakiz D, Cure MC, Baykara RA, et al. Atherogenic index of plasma: a useful marker for subclinical atherosclerosis in ankylosing spondylitis : AIP associate with cIMT in AS. Clin Rheumatol. 2018;37(5):1273–80.
42. Parveen S, Jacob R, Rajasekhar L, Srinivasa C, Mohan IK. Serum lipid alterations in early rheumatoid arthritis patients on disease modifying anti rheumatoid therapy. Indian J Clin Biochem. 2017;32(1):26–32.
43. Cure E, Icli A, Ugur Uslu A, Aydogan Baykara R, Sakiz D, Ozucan M, et al. Atherogenic index of plasma may be strong predictor of subclinical atherosclerosis in patients with Behcet disease. Z Rheumatol. 2017;76(3): 259–66.
44. Uslu AU, Kucuk A, Icli A, Cure E, Sakiz D, Arslan S, et al. Plasma atherogenic index is an independent Indicator of subclinical atherosclerosis in systemic lupus erythematosus. Eurasian J Med. 2017;49(3):193–7.
45. Icli A, Cure E, Uslu AU, Sakiz D, Cure MC, Ozucan M, et al. The relationship between atherogenic index and carotid artery atherosclerosis in familial Mediterranean fever. Angiology. 2017;68(4):315–21.
46. Millan J, Pinto X, Munoz A, Zuniga M, Rubies-Prat J, Pallardo LF, et al. Lipoprotein ratios: physiological significance and clinical usefulness in cardiovascular prevention. Vasc Health Risk Manag. 2009;5:757–65.
47. Garg N, Krishan P, Syngle A. Atherosclerosis in psoriatic arthritis: a multiparametric analysis using imaging technique and laboratory markers of inflammation and vascular function. Int J Angiol. 2016;25(4):222–8.

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