The lipid paradox is also present in early axial spondyloarthritis: results from the Swedish part of the SPondyloArthritis Caught Early (SPACE) cohort

Jacobsson, L.T.H.; d'Elia, H.F.; Husmark, T.; Soler, J.L.; Nilsson, N.; Lindström, U.; ... ; Exarchou, S.

Scandinavian Journal of Rheumatology

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/irhe20

The lipid paradox is also present in early axial spondyloarthritis: results from the Swedish part of the SPondyloArthritis Caught Early (SPACE) cohort

LTH Jacobsson, H Forsblad d'Elia, T Husmark, J Lopis Soler, N Nilsson, U Lindström, E Klingberg, M Linnerud Keshvarz, M Rizk, P Larsson, FA van Gaalen, C Turesson & S Exarchou

To cite this article: LTH Jacobsson, H Forsblad d'Elia, T Husmark, J Lopis Soler, N Nilsson, U Lindström, E Klingberg, M Linnerud Keshvarz, M Rizk, P Larsson, FA van Gaalen, C Turesson & S Exarchou (11 Oct 2024): The lipid paradox is also present in early axial spondyloarthritis: results from the Swedish part of the SPondyloArthritis Caught Early (SPACE) cohort, Scandinavian Journal of Rheumatology, DOI: 10.1080/03009742.2024.2388404

To link to this article: https://doi.org/10.1080/03009742.2024.2388404

The lipid paradox is also present in early axial spondyloarthritis: results from the Swedish part of the SPondyloArthritis Caught Early (SPACE) cohort

LTH Jacobsson[1,2], H Forsblad d'Elia[1,2], T Husmark[3], J Lopis Soler[4], N Nilsson[1,2], U Lindström[1,2], E Klingberg[1,2], M Linnerud Keshvarz[5], M Rizk[6], P Larsson[7], FA van Gaalen[8], C Turesson[9,10], S Exarchou[9,10]

[1]Department of Rheumatology and Inflammation Research, Institute of Medicine at Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[2]Department of Rheumatology, Region Västra Götaland, Sahlgrenska University Hospital, Göteborg, Sweden
[3]Department of Rheumatology, Falu Hospital, Falun, Sweden
[4]Department of Rheumatology, Skaraborgs Hospital, Skövde, Sweden
[5]Department of Rheumatology, Mälarsjukshuset, Eskilstuna, Sweden
[6]Rheumatology Clinic, Västmanlands Hospital, Västerås, Sweden
[7]Center for Rheumatology, Karolinska Institute, Stockholm, Sweden
[8]Department of Rheumatology, Leiden University Medical Center, Leiden, The Netherlands
[9]Rheumatology, Department of Clinical Sciences, Lund University, Malmö, Sweden
[10]Department of Rheumatology, Skåne University Hospital, Malmö, Sweden

Objective: Inverse associations between systemic inflammation and cholesterol ('the lipid paradox') have been reported in rheumatoid arthritis (RA) and, in established axial spondyloarthritis (axSpA), but little is known about this relationship in early axSpA, which is the focus of the present study.

Method: In the Swedish part of the SPondyloArthritis Caught Early (SPACE) cohort (patients with chronic back pain for ≥3 months, ≤2 years; age at onset <45 years), serum levels of total cholesterol (TC) and apolipoproteins ApoA1 and ApoB were measured at inclusion, together with parameters reflecting inflammatory disease activity [C-reactive protein (CRP), Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), and sacroiliitis by magnetic resonance imaging (MRI) following Assessment of SpondyloArthritis international Society (ASAS) criteria]. All patients included in the analysis either had axSpA based on a high physician's level of confidence or fulfilled the ASAS criteria for axSpA. Associations between lipids/lipoproteins and inflammation were assessed using multivariable linear regression models.

Results: In the 64 patients included, there were inverse associations for CRP with TC, ApoA1, and ApoB in age–sex-adjusted models. The negative associations with CRP remained significant for TC and ApoB in multivariable models adjusted for age, sex, BASDAI, and current smoking ($p = 0.048$). There were no significant associations for the lipid parameters with BASDAI or inflammation on MRI of the sacroiliac joints.

Conclusion: Inverse associations between systemic inflammation and lipids, particularly TC and ApoB, are present in early axSpA, similar to those shown for other inflammatory joint diseases. These patterns must be considered when including lipids in the evaluation of cardiovascular disease risk.

Traditional risk factors for cardiovascular disease (CVD), such as sex, age, smoking status, hypertension, hyperlipidaemia, obesity, and diabetes mellitus, are included in the assessment of CVD risk in the general population (1, 2). These risk factors are more prevalent in inflammatory joint diseases, such as rheumatoid arthritis (RA) (3), psoriatic arthritis (PsA) (4), and axial spondyloarthritis (axSpA) (4), and are likely to contribute to the increased risk of CVD events, by up to 50%, found in these diseases (5).

In RA, it has long been known that disease activity is inversely correlated with total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C), whereas associations with high-density lipoprotein cholesterol (HDL-C) are less consistent (6, 7). Furthermore, retrospective

LTH Jacobsson, Department of Rheumatology and Inflammation Research, Sahlgrenska Academy, University of Gothenburg, Gothenburg S-41346, Sweden.
E-mail: Lennart.jacobsson@gu.se

Received 31 January 2024; Accepted 1 August 2024

DOI: https://doi.org/10.1080/03009742.2024.2388404

analysis has demonstrated a significant decrease in TC and LDL-C over the 5 years before RA diagnosis compared to controls who did not develop RA, although this was not confirmed in a Dutch cohort of subjects with seropositive arthralgia who were later diagnosed with RA (8, 9). The inverse association between TC and its subfractions results in a U-shaped association between TC and CVD risk in RA with intermediate/high disease activity ('RA lipid paradox'), where this group of RA patients has an increased risk of CVD, despite low TC. This U-shaped association is attenuated when lower disease activity is achieved through effective disease-modifying anti-rheumatic drug (DMARD) therapy (4, 7). Several mechanisms in RA for this inverse association between systemic inflammation and cholesterol levels have been proposed, including elevated uptake through increased expression of LDL-C receptors in the liver, an uptake that is enhanced by production of local cytokines such as interleukin-6 and tumour necrosis factor-α (TNF-α) (7). In addition, systemic inflammation may decrease LDL-C through oxidation, resulting in a product that is more easily internalized in atherosclerotic plaques, and by leading to the production of pro-inflammatory HDL-C (7).

In axSpA, the association with CVD tends to be slightly weaker than in RA (3), although axSpA has been shown to be a risk factor for both subclinical atherosclerosis (10) and CVD events (4). In addition, subclinical atherosclerosis and abnormality in CVD risk factors, including dyslipidaemia, has recently been shown to be of a similar degree in RA and ankylosing spondylitis [which corresponds to radiographic axial spondyloarthritis (r-axSpA)] (11). There is, however, only sparse information supporting the presence of the 'lipid paradox' in established axSpA (12) and a lack of knowledge with regard to earlier phases of axSpA.

The aims of the present study were thus to assess the associations between the degree of inflammation and levels of TC, apolipoprotein A1 (ApoA1, as a marker of HDL-C), and apolipoprotein B (ApoB, as a marker of LDL-C) in patients with early-diagnosed axSpA. Inflammation was assessed biochemically, clinically, and on magnetic resonance imaging (MRI) of the sacroiliac joints (SIJ).

Method

Study population and covariates

For the purpose of the present analysis, the baseline data from the Swedish part of the SPondyloArthritis Caught Early (SPACE) cohort included until June 2020 were used. The SPACE cohort is an international, observational cohort, recruiting patients aged >16 years with chronic back pain of a short duration (≥3 months, but ≤2 years), with an age at onset <45 years, seen in the outpatient clinical care of 14 participating centres in four countries. Patients were not eligible for the study if they had another painful condition not related to axSpA that could interfere with the evaluation of the disease or an inability to comply with protocol requirements. In Sweden, eight centres have included 92 patients.

Patients were assessed according to a structured protocol (13). The baseline evaluation included clinical and laboratory assessment, questionnaires with self-reported comorbidities (e.g. diabetes, hypertension), and MRI and X-rays of the SIJ and spine. Non-fasting blood samples were obtained, and laboratory tests, including serum level of C-reactive protein (s-CRP) and blood lipids (TC, LDL-C, HDL-C, ApoA1, and ApoB), were performed according to standard procedures at each centre. Radiographs and MRI images were independently scored by three trained central readers, blinded to clinical data and to the results of other modalities. Inflammation on the MRI of SIJ according to the Assessment of SpondyloArthritis international Society (ASAS) definition was assessed centrally, defined by agreement between at least two out of three readers (14, 15).

Patients were included in the current analyses if they had been given a diagnosis of axSpA by the examining rheumatologist with a level of confidence ≥6 on a 0–10 scale, based on all the available information from the baseline evaluation, including imaging, or if they fulfilled the ASAS classification criteria for axSpA (16–18). In addition, they should have available baseline analysis of TC, ApoA1, and ApoB (only available in 64 out of 92 of the Swedish patients). In a proportion of patients, HDL-C and LDL-C levels were also measured. Relevant clinical variables reflecting disease activity [Ankylosing Spondylitis Disease Activity Score (ASDAS), Bath Ankylosing Spondylitis Disease Activity Index (BASDAI), s-CRP, ASDAS-CRP] and possible confounders, determined a priori [age, sex, body mass index (BMI), hypertension, diabetes, current smoking] were included in the analyses.

Ethics

The Swedish part of the SPACE study protocol was approved by the regional research ethics committee in Lund, Sweden (reference number 2010/653). All participants provided written informed consent according to the Declaration of Helsinki.

Statistical analysis

Descriptive data are expressed as mean ± sd, median (interquartile range), or number (percentage). In addition, categorical cut-offs were made for LDL-C according to target values for patients at high (<2.6 mmol/L) and moderate/low risk (<3.0 mmol/L) of CVD (19). In

line with this, categorical cut-offs were made for ApoB according to levels for patients at high (0.8 g/L) and low/moderate risk (1.0 g/L) of CVD (19). Initially, the associations between blood lipids (TC, ApoA1, ApoB) and CRP, clinical disease activity indices (BASDAI, ASDAS-CRP), MRI inflammation on SIJ, and traditional risk factors for CVD (sex, age, BMI, smoking) were assessed bivariately using Spearman's rank correlation. The association between blood lipids and CRP was further assessed in a number of multivariable linear regression models: (i) adjusting for age and sex; (ii) adjusting for age, sex, and one other covariate at a time (BMI, smoking, BASDAI, sacroiliitis on MRI of SIJ); and (iii) adjusting simultaneously for a priori determined possible confounders (age, sex, BASDAI, current smoking). A p-value < 0.05 was considered significant. The assumptions applying to linear regression models were checked and statistically tested, and none was violated.

Results

Of the 92 patients included in the Swedish SPACE cohort, 64 had available data on TC, ApoA1, and ApoB. The mean ± sd duration since onset of back pain was 12.8 ± 6.3 months and the mean age was 27.6 ± 6.7 years. Most patients were male (60%) and human leucocyte antigen (HLA)-B27 positive (78%), with varying occurrence of phenotypical features known to be associated with axSpA (Table 1).

Of those with available LDL-C, 36% had levels that were above the recommended level for patients with low/moderate CVD risk, and in line with this, ApoB was above the cut-off of 1.0 g/L in 23% (Table 1).

When the association between lipids and CRP, disease activity, and traditional risk factors for CVD was assessed, the serum levels of CRP correlated weakly and inversely with TC (rho = −0.31, p = 0.02), with a similar tendency for both ApoA1 (rho = −0.23, p = 0.07) and ApoB (rho = −0.21, p = 0.10). Correlations were weaker with clinical disease activity (BASDAI) and absent for inflammation of the SIJ on MRI (Table 2). In the linear regression model adjusting for age and sex, CRP levels were significantly and inversely associated with both TC and ApoA1 levels, with a tendency for a similar association with ApoB (Table 3). Adjusting for age, sex, and one other covariate at a time resulted in overall similar estimates, with only slightly attenuated p-levels, especially when adjusting for BASDAI and inflammation on MRI of the SIJ according to the ASAS definition (14) (Table 3).

In the multivariable model adjusting simultaneously for age, sex, BASDAI, and smoking, CRP was, in a similar fashion, inversely associated with TC and ApoB (p = 0.048), with a similar tendency for ApoA1 (Table 3).

Excluding the few patients (n = 8) treated with conventional synthetic DMARDs, TNF inhibitors, or glucocorticoids resulted in similar estimates, with significant (p = 0.048) inverse associations between CRP and TC and ApoB in the multivariable model (Supplementary Table 1).

Blood lipid and CRP levels were similar in subgroups stratified by HLA-B27 status.

Comparison of the patients who were excluded from the analyses (n = 28) because of missing values for apolipoproteins and TC to those who were included showed overall similar distributions for age, sex, and other baseline characteristics (Supplementary Table 2).

Discussion

In the present study, we demonstrate an inverse association in patients with early-diagnosed axSpA between blood lipid levels and systemic inflammation, reflected by the serum level of CRP. This finding appeared to be independent of possible confounders and specifically valid for biochemical systemic inflammation, whereas no significant association was found between blood lipids and BASDAI (largely based on patient-reported outcome) or inflammation on the MRI of SIJ.

Our findings are in line with what has, in particular, been shown previously for RA (7), but also, to some extent, for patients with established axSpA (r-axSpA) (12). Our findings support that the inverse correlation between lipid status and systemic inflammation is a general phenomenon in patients with rheumatic diseases and not restricted to patients with RA.

It is important to consider that the patients in the present study had, at baseline, already received treatment in accordance with the Swedish and international treatment recommendations, with the majority (80%) being treated with non-steroidal anti-inflammatory drugs and a proportion (13%) having already received treatment with DMARDs or glucocorticosteroids. Our analyses could not address the extent to which effective DMARD treatment may ameliorate the associations between systemic inflammation and blood lipids (as seen in RA) in early axSpA (5, 6). On the other hand, the fact that a moderate inverse association between lipids and CRP was present in this young patient group early in the disease course and a substantial proportion had relatively high LDL-C levels (compared to treatment targets for patients at moderate/low and high risk for CVD) suggests that this may be of long-term clinical relevance.

Some limitations should be acknowledged. First, our sample size is modest and may not be completely representative of patients seen in other settings, which may hamper generalizability. On the other hand, there are no previous publications on the subject in early axSpA. Secondly, it would have been advantageous if we had measured oxidized LDL-C and subtypes of HDL-C more

Table 1. Baseline characteristics of the 64 patients with early axial spondyloarthritis (axSpA) from the Swedish part of the SPondyloArthritis Caught Early (SPACE) cohort included in the present study.

Characteristic	Value
Demographics	
Male sex	38 (59)
Age (years)	27.6 ± 6.7
Clinical characteristics	
Duration of back pain (months)	12.8 ± 6.3
HLA-B27 positive	50 (78)
Inflammatory back pain	61 (95)
Peripheral arthritis (history of)	10 (16)
Dactylitis (history of)	6 (9)
Heel enthesitis (history of)	15 (23)
Psoriasis (history of)	10 (16)
Uveitis (history of)	7 (11)
IBD (history of)	3 (5)
Family history of axSpA, reactive arthritis, uveitis, psoriasis, or IBD	28 (44)
Response to NSAID	44 (69)
Elevated CRP (≥ 5 mg/L)	33 (52)
Blood lipids	
TC (mmol/L)	4.3 ± 1.0
HDL-C (mmol/L)	1.46 ± 1.08
ApoA1 g(/L)	1.41 ± 0.26
LDL-C (n = 44)	2.71 ± 0.77
LDL-C < 2.6 mmol /L	18/44 (41)
LDL-C 2.6–2.99 mmol /L	10/44 (23)
LDL-C ≥ 3.0 mmol /L	16/44 (36)
ApoB* (g/L)	0.84 ± 0.22
ApoB < 0.8 g/L	30 (47)
ApoB 0.8–0.99 g/L	19 (30)
ApoB ≥ 1.0 g/L	15 (23)
Traditional risk factors for CVD	
BMI (kg/m^2)	23.9 ± 3.5
BMI ≥ 30 kg/m^2	2 (3)
Current smoker	6 (9)
Hypertension*	3 (5)
Diabetes*	1 (2)
Measures of disease activity	
BASDAI	4.17 ± 2.28
CRP (mg/L)	3.25 (1.00, 7.60)
ASDAS-CRP	2.39 ± 1.06
Imaging	
Sacroiliitis on X-rays (NY criteria)	4/35 (11)
Sacroiliitis on MRI	24/47 (51)
Current treatment for axSpA	
NSAID	51 (80)
Other anti-inflammatory treatment:	8 (13)
csDMARD/bDMARD	3 (5)
TNFi	5 (8)
Glucocorticosteroids	1 (2)

Data are shown as n (%), mean ± sd, or median (interquartile range).
*Based on self-reported diagnoses.
HLA, human leucocyte antigen; IBD, inflammatory bowel disease; NSAID, non-steroidal anti-inflammatory drug; CRP, C-reactive protein; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; ApoA1, apolipoprotein A1; LDL-C, low-density lipoprotein cholesterol; ApoB, apolipoprotein B; BMI, body mass index; CVD, cardiovascular disease; BASDAI, Bath Ankylosing Spondylitis Disease Activity Index; ASDAS, Ankylosing Spondylitis Disease Activity Score; NY, New York; MRI, magnetic resonance imaging; csDMARD, conventional synthetic disease-modifying anti-rheumatic drug; bDMARD, biological disease-modifying anti-rheumatic drug; TNFi, tumour necrosis factor inhibitor.

specifically to better understand the mechanisms behind our observations. Thirdly, our sample was too small to evaluate any impact of effective anti-inflammatory treatment on the reported associations.

Table 2. Associations between total cholesterol (TC), apolipoprotein A1 (ApoA1), and apolipoprotein B (ApoB) and C-reactive protein (CRP) levels, clinical disease activity indices, and traditional risk factors for cardiovascular disease, expressed as Spearman's correlation coefficients.

	TC rho (p)	ApoA1 rho (p)	ApoB rho (p)
Sex (male = 1, female = 2)	–0.02 (0.90)	0.46 (0.0002)	–0.07 (0.57)
Age	0.36 (0.005)	0.12 (0.33)	0.20 (0.13)
BMI	0.02 (0.86)	–0.09 (0.48)	0.19 (0.12)
Current smoker (yes = 1, no = 2)	0.13 (0.33)	–0.008 (0.96)	0.28 (0.04)
BASDAI	–0.22 (0.10)	0.01 (0.94)	–0.05 (0.73)
ASDAS-CRP	–0.31 (0.021)	–0.05 (0.714)	–0.12 (0.362)
CRP	–0.31 (0.02)	–0.23 (0.07)	–0.21 (0.10)
Sacroiliitis on MRI (ASAS criteria)	0.003 (0.98)	–0.06 (0.64)	–0.02 (0.89)

BMI, body mass index; BASDAI, Bath Ankylosing Spondylitis Disease Activity Index; ASDAS, Ankylosing Spondylitis Disease Activity Score; MRI, magnetic resonance imaging; ASAS, Assessment of SpondyloArthritis international Society.

Table 3. Multivariable linear regression models assessing the association between total cholesterol (TC), apolipoprotein A1 (ApoA1), and apolipoprotein B (ApoB) and C-reactive protein (CRP) after adjusting for relevant covariates.

	TC		ApoA1		ApoB	
Covariate adjusted for:	B (se)	p	B (se)	p	B (se)	p
Age and sex	–0.0351 (0.0157)	0.029	–0.0072 (0.0034)	0.026	–0.0064 (0.0031)	0.044
BMI* (per unit)	–0.0354 (0.0161)	0.032	–0.0073 (0.0035)	0.039	–0.0066 (0.0031)	0.036
Present smoker* (yes vs no)	–0.0393 (0.0170)	0.025	–0.0077 (0.0034)	0.028	–0.0071 (0.0032)	0.033
BASDAI* (per unit)	–0.0296 (0.0166)	0.080	–0.0060 (0.0033)	0.075	–0.0059 (0.0035)	0.092
Sacroiliitis on MRI (ASAS criteria)* (yes vs no)	–0.0289 (0.0166)	0.088	–0.0082 (0.0034)	0.020	–0.0057 (0.0032)	0.078
BASDAI and current smoking†	–0.0336 (0.0169)	0.048	–0.0065 (0.0034)	0.065	–0.0069 (0.0034)	0.048

*Adjusted for age and sex and the respective covariate.
†Adjusted for age, sex, BASDAI, and current smoking status.
BMI, body mass index; BASDAI, Bath Ankylosing Spondylitis Disease Activity Index; ASDAS, Ankylosing Spondylitis Disease Activity Score; MRI, magnetic resonance imaging; ASAS, Assessment of SpondyloArthritis international Society.

Conclusion

Our findings indicate that the 'lipid paradox', with an inverse association between systemic inflammation and cholesterol fractions, is present in early axSpA. These patterns must be taken into account, as already stated in the European Alliance of Associations for Rheumatology (formerly the European League Against Rheumatism) (EULAR) recommendations (5), when including lipids in the evaluation of CVD risk. The extent to which these associations are ameliorated with better anti-inflammatory treatment needs to be examined in longitudinal studies.

Disclosure statement

LJ has received lecture and consulting fees from Pfizer, Novartis, Eli-Lily, and Janssen. FG has received grants and/or consulting fees from AbbVie, ASAS, BMS, Galapagos, Janssen, Lilly, Novartis, Pfizer, and UCB. CT has received personal fees from AbbVie, Boehringer-Ingelheim, Nordic Drugs, Novartis, Pfizer, and Roche, outside the submitted work. SE has received consulting fees from Amgen, Jansen, Novartis, and UCB Pharma, and grants from UCB Pharma. The remaining authors have no potential conflicts of interest to declare.

Funding

Funding for this research was received from the Swedish Rheumatism Association [Grant no: R-153187].

Supplementary material

Supplemental data for this article can be accessed online at https://doi.org/10.1080/03009742.2024.2388404.

ORCID

FA van Gaalen http://orcid.org/0000-0001-8448-7407

S Exarchou http://orcid.org/0000-0002-9261-7192

References

1. Atar D, Jukema JW, Molemans B, Taub PR, Goto S, Mach F, et al. New cardiovascular prevention guidelines: how to optimally manage dyslipidaemia and cardiovascular risk in 2021 in patients needing secondary prevention? Atherosclerosis 2021;319:51–61.
2. Arnett DK, Blumenthal RS, Albert MA, Buroker AB, Goldberger ZD, Hahn EJ, et al. ACC/AHA guideline on the primary prevention of cardiovascular disease: a report of the American

College of Cardiology/American Heart Association task force on clinical practice guidelines. Circulation 2019;140:e596–e646.
3. Eriksson JK, Jacobsson L, Bengtsson K, Askling J. Is ankylosing spondylitis a risk factor for cardiovascular disease, and how do these risks compare with those in rheumatoid arthritis? Ann Rheum Dis 2017;76:364–70.
4. Bengtsson K, Forsblad-d'Elia H, Lie E, Klingberg E, Dehlin M, Exarchou S, et al. Are ankylosing spondylitis, psoriatic arthritis and undifferentiated spondyloarthritis associated with an increased risk of cardiovascular events? A prospective nationwide population-based cohort study. Arthritis Res Ther 2017;19:102.
5. Agca R, Heslinga SC, Rollefstad S, Heslinga M, McInnes IB, Peters MJ, et al. EULAR recommendations for cardiovascular disease risk management in patients with rheumatoid arthritis and other forms of inflammatory joint disorders: 2015/2016 update. Ann Rheum Dis 2017;76:17–28.
6. Jacobsson L, Lindgarde F, Manthorpe R, Akesson B. Correlation of fatty acid composition of adipose tissue lipids and serum phosphatidylcholine and serum concentrations of micronutrients with disease duration in rheumatoid arthritis. Ann Rheum Dis 1990;49:901–5.
7. Behl T, Kaur I, Sehgal A, Zengin G, Brisc C, Brisc MC, et al. The lipid paradox as a metabolic checkpoint and its therapeutic significance in ameliorating the associated cardiovascular risks in rheumatoid arthritis patients. Int J Mol Sci 2020;21:9505.
8. Myasoedova E, Crowson CS, Kremers HM, Fitz-Gibbon PD, Therneau TM, Gabriel SE. Total cholesterol and LDL levels decrease before rheumatoid arthritis. Ann Rheum Dis 2010;69:1310–14.
9. Raadsen R, Dijkshoorn B, van Boheemen L, Ten Boekel E, van Kuijk AWR, Nurmohamed MT. Lipid profile and NT-proBNP changes from pre-clinical to established rheumatoid arthritis: a 12 years follow-up explorative study. Joint Bone Spine 2024;91:105683.
10. Toussirot E. The risk of cardiovascular diseases in axial spondyloarthritis. Current Insights Front Med (Lausanne) 2021;8:782150.
11. Fohse FK, Rollefstad S, Ikdahl E, Wibetoe G, Sexton J, Hisdal J, et al. Degree of arterial stiffness is comparable across inflammatory joint disease entities. Scand J Rheumatol 2022;51:186–95.
12. Atzeni F, Nucera V, Galloway J, Zoltan S, Nurmohamed M. Cardiovascular risk in ankylosing spondylitis and the effect of anti-TNF drugs: a narrative review. Expert Opin Biol Ther 2020;20:517–24.
13. van den Berg R, de Hooge M, van Gaalen F, Reijnierse M, Huizinga T, van der Heijde D. Percentage of patients with spondyloarthritis in patients referred because of chronic back pain and performance of classification criteria: experience from the SPondyloArthritis Caught Early (SPACE) cohort. Rheumatology (Oxford) 2013;52:1492–9.
14. Rudwaleit M, Jurik AG, Hermann KG, Landewe R, van der Heijde D, Baraliakos X, et al. Defining active sacroiliitis on magnetic resonance imaging (MRI) for classification of axial spondyloarthritis: a consensual approach by the ASAS/OMERACT MRI group. Ann Rheum Dis 2009;68:1520–7.
15. Lambert RG, Bakker PA, van der Heijde D, Weber U, Rudwaleit M, Hermann KG, et al. Defining active sacroiliitis on MRI for classification of axial spondyloarthritis: update by the ASAS MRI working group. Ann Rheum Dis 2016;75:1958–63.
16. Sieper J, Rudwaleit M, Baraliakos X, Brandt J, Braun J, Burgos-Vargas R, et al. The Assessment of SpondyloArthritis international Society (ASAS) handbook: a guide to assess spondyloarthritis. Ann Rheum Dis 2009;68:ii1–44.
17. Rudwaleit M, Landewe R, van der Heijde D, Listing J, Brandt J, Braun J, et al. The development of Assessment of SpondyloArthritis international socIety classification criteria for axial spondyloarthritis (Part I): classification of paper patients by expert opinion including uncertainty appraisal. Ann Rheum Dis 2009;68:770–6.
18. Rudwaleit M, van der Heijde D, Landewe R, Listing J, Akkoc N, Brandt J, et al. The development of Assessment of SpondyloArthritis international Society classification criteria for axial spondyloarthritis (Part II): validation and final selection. Ann Rheum Dis 2009;68:777–83.
19. Visseren FLJ, Mach F, Smulders YM, Carballo D, Koskinas KC, Back M, et al. ESC guidelines on cardiovascular disease prevention in clinical practice. Eur Heart J 2021;42:3227–337.