ORIGINAL ARTICLE

Serum pentraxin 3 concentration in patients with type 2 diabetes and nonalcoholic fatty liver disease

Aleksandra Trojak[1*], Małgorzata Waluś-Miarka[1,2*], Maria Kapusta[3], Przemysław Miarka[2,4], Ewa Kawalec[1], Barbara Idzior-Waluś[1,2], Maciej T. Małecki[1,2]

1 Department of Metabolic Diseases, Jagiellonian University Medical College, Kraków, Poland
2 Department of Metabolic Diseases, University Hospital, Kraków, Poland
3 Department of Biochemistry, Jagiellonian University Medical College, Kraków, Poland
4 Department of Nephrology, Jagiellonian University Medical College, Kraków, Poland

KEY WORDS

diabetes mellitus type 2, nonalcoholic fatty liver disease, pentraxin 3

ABSTRACT

INTRODUCTION Nonalcoholic fatty liver disease (NAFLD) is common in patients with type 2 diabetes (T2D). Pentraxin 3 (PTX3), a marker of inflammation, is a cardiovascular risk factor.

OBJECTIVES We examined clinical and biochemical factors associated with serum PTX3 concentrations in patients with T2D with and without NAFLD.

PATIENTS AND METHODS Serum material was obtained from 116 patients with T2D (mean age, 59.1 years), including 79 patients with NAFLD.

RESULTS Median (interquartile range) PTX3 level was 4.264 (2.293) ng/ml in patients with and 3.773 (3.223) ng/ml in patients without NAFLD ($P = 0.93$). In the whole group, PTX3 level was associated with total cholesterol, low-density lipoprotein cholesterol (LDL-C), apolipoprotein (apo) B100, apo C3, triglyceride (TG) concentrations, and waist circumference after adjustment for age and gender. As indicated by partial regression coefficient b, increase of independent variable LDL-C by 1 mmol/l was associated with the rise of PTX3 by 1.2017 ng/ml, increase of apo B100 by 1 mg/dl with the rise of PTX3 by 1.0051 ng/ml, and increase of apo C3 by 1 μg/dl with the rise of PTX3 by 1.0012 ng/ml. In patients with T2D with NAFLD, total cholesterol, LDL-C, TG, apo C3, and apo B100 were associated with PTX3. Associations of PTX3 with apolipoproteins were observed only in the NAFLD group.

CONCLUSIONS Reported associations of PTX3 level add new insight into possible mechanisms of its atherogenic actions.

Correspondence to:
Małgorzata Waluś-Miarka, MD, PhD, Department of Metabolic Diseases, Jagiellonian University Medical College, ul. Kopernika 15, 31-507 Kraków, Poland, phone: +48 12 424 83 00, email: m.walus-miarka@uj.edu.pl
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*AT and MW-M contributed equally to this work.

INTRODUCTION Nonalcoholic fatty liver disease (NAFLD) is one of the most common causes of chronic liver injury in numerous countries around the world. NAFLD is present in up to 50% to 80% of patients with type 2 diabetes (T2D). NAFLD is associated with insulin resistance, central obesity, hypertension, and atherogenic dyslipidemia, including hypercholesterolemia, hypertriglyceridemia, postprandial lipemia, low serum high-density lipoprotein cholesterol (HDL-C) concentrations, and HDL dysfunction.[1-4]

It has been shown that the clinical burden of NAFLD is not confined only to liver-related morbidity and mortality. It is a multisystem disease, affecting extrahepatic organs and regulatory pathways.[5] NAFLD, according to epidemiological data, is a risk factor for cardiovascular events as well as risk factor of diabetic microangiopathy, including chronic kidney disease.[5-8]

Pentraxin 3 (PTX3) is an acute-phase reactant and an essential component of innate immunity. PTX3 shares structural and functional homology with C-reactive protein and is a member of the long pentraxin superfamily, which are soluble proteins induced by various inflammatory stimuli. PTX3 activates the complement system, binds microbial surfaces and apoptotic cells, and aids in their clearance.[9] PTX3 is produced at the site of inflammation by macrophages, dendritic cells, neutrophils, fibroblasts, chondrocytes endothelial

cells and adipocytes, and smooth muscle cells.[9] Its production is induced by interleukin 1, tumor necrosis factor α, oxidized low-density lipoprotein, and microbial moieties.[9,10] PTX3 interacts with ancestral domains conserved in innate immunity, hemostasis, and extracellular matrix and exerts functions related to antimicrobial resistance and tissue repair.[11]

PTX3, a marker of inflammation, is independently associated with the risk of vascular events.[12-14] There are data indicating that PTX3 also has anti-inflammatory and cardioprotective properties.[15] Plasma PTX3 level is, according to some data, a marker for nonalcoholic steatohepatitis and severity of liver fibrosis.[16]

In this study we aimed to determine factors associated with serum PTX3 concentrations in patients with T2D with and without NAFLD.

PATIENTS AND METHODS

A total of 116 consecutive patients (mean age, 59.1 years) with T2D from the outpatient diabetic clinic were included in the study. T2D was diagnosed at least 2 years before inclusion to the study. Patients with acute or chronic inflammatory processes and devastating diseases were excluded. Medical history was taken from all patients and they were asked about alcohol consumption. Persons who defined themselves as alcohol drinkers or those who drank more than 30 g of ethanol daily (or equivalent) for men and 20 g for women were excluded from the study. Patients with autoimmunological, metabolic, or viral liver disease were excluded from participation in the study. All patients answered a standardized questionnaire, and in each patient the following analyses were performed: anthropometric measurements, fasting serum lipids, apolipoproteins (apos), liver enzymes, creatinine, glucose, and glycated hemoglobin A_{1c} (HbA_{1c}). Waist circumference was measured midway between the lowest lateral border of the ribs and the uppermost lateral iliac crest. Body weight was measured in light clothing and with shoes on.

Fasting serum lipids concentrations were determined by enzymatic methods using Roche reagents (Roche Diagnostics, Mannheim, Germany) and HbA_{1c}, by high-pressure liquid chromatography. Cytokeratin 18 fragment – a marker of NAFLD – PTX3, as well as apo C3, B100, and B48 were determined by enzyme-linked immunosorbent assays (cytokeratin 18, Peviva AB, Bromma, Sweden; PTX3, Cloud-Clone Corp., Houston, Texas, United States; apo C3, Abnova Co., Taipei City, Taiwan; apo B100, Cloud-Clone Corp.; and apo B48, Shibayagi Co., Gunma, Japan). Apo A1 was determined by the immunoturbidimetric method (Aptec Diagnostics NV, Sint-Niklaas, Belgium). NAFLD was diagnosed by ultrasonography, which has a sensitivity and specificity up to 95% for the detection of liver steatosis. Ultrasonographic measurements were performed by 2 experienced radiologists who were blinded to the clinical presentations and laboratory finding of the patients. The characteristic sonographic findings for NAFLD including bright hepatic echoes, increased hepatorenal echogenicity, vascular blurring of the portal or hepatic vein were evaluated.[17,18]

Written informed consent was obtained from each patient included in the study. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki and was approved by the Ethics Committee of Jagiellonian University Medical College (decision no. 122.6120.173.2015; date: June 26, 2015).

Statistical analysis

The *t* test and Mann–Whitney test were used for a comparison of selected variables between the groups of patients with and without NAFLD. Statistical analysis included calculations of means (SD) for normally distributed variables and medians (interquartile range [IQR]) for not normally distributed variables and calculations of the Pearson and Spearman rank correlation coefficients. Regression analysis for each variable, with PTX3 as a dependent variable, was performed after logarithmic transformation of PTX3 because of a large skewness of its distribution. The independent variables in regression analysis were: body mass index (BMI), waist / hip ratio (WHR), serum concentration of total cholesterol (TC), TG, HDL-C, low-density lipoprotein cholesterol (LDL-C), glucose, creatinine, activity of alanine and asparagine aminotransferases, γ-glutamyltranspeptidase. The analysis adjusted for age and sex was performed in the whole study group and in the subgroups that were divided according to NAFLD.

RESULTS

We examined 116 patients with T2D, and 79 of them had NAFLD. In the whole group, 86.2% of patients had arterial hypertension, 68.7%, hyperlipidemia, and 36.2%, coronary heart disease. In the NAFLD group, 91.1% had arterial hypertension, 82.2%, hyperlipidemia, and 39.2%, coronary heart disease. Clinical characteristics and laboratory data for the whole study group and subgroups (with and without NAFLD) are shown in TABLE 1. Patients with T2D and NAFLD were younger ($P = 0.01$), had lower HDL-C concentrations ($P = 0.02$), higher values of transaminases and γ-glutamyltranspeptidase (as expected, although still within normal limits), and higher waist circumference ($P < 0.05$). We did not observe differences in serum apolipoprotein concentrations or glycemic control between patients with and without NAFLD (TABLE 1).

Concentrations of PTX3 in the whole group of patients correlated positively with serum concentrations of lipids and apolipoprotein: TC ($r = 0.46$; $P < 0.001$), LDL-C ($r = 0.36$; $P < 0.001$), TG ($r = 0.42$; $P < 0.001$), apo C3 ($r = 0.29$; $P = 0.002$), apo B100 ($r = 0.31$; $P < 0.001$), glucose ($r = 0.21$; $P = 0.04$) levels, and BMI ($r = 0.20$; $P = 0.03$) (TABLE 2). Interestingly, in the NAFLD group, serum PTX3 correlated with TC ($r = 0.47$; $P < 0.001$) and LDL-C ($r = 0.39$; $P = 0.001$), TG ($r = 0.39$; $P < 0.001$), apo C3 ($r = 0.43$; $P < 0.001$), apo B100 ($r = 0.34$; $P = 0.002$), while in patients with T2D and without NAFLD it

TABLE 1 Characteristic of selected variables in patients with type 2 diabetes according to nonalcoholic fatty liver disease

Parameter	Total (n = 116)			Nonalcoholic fatty liver disease						*P* value
				Present (n = 79)			Absent (n = 37)			
	n	X/Me[a]	SD/IQR	n	X/Me[a]	SD/IQR	n	X/Me[a]	SD/IQR	
Age, y	116	59.1	11.07	79	57.3	10.6	37	62.9	11.21	0.01
Diabetes duration, y[a]	114	9	10	78	8	9	36	9	11	0.44
HbA_{1c}, %	87	8.6	2.3	62	8.54	2.19	25	8.8	2.64	0.64
TC, mmol/l	106	4.72	1.36	76	4.59	1.25	30	5.03	1.58	0.14
TG, mmol/l[a]	106	1.8	1	76	1.9	1.2	30	1.6	1.0	0.19
HDL-C mmol/l	106	1.14	0.3	76	1.09	0.25	30	1.26	0.36	0.02
LDL-C, mmol/l	98	2.6	1.16	69	2.49	1.04	29	2.89	1.38	0.12
AST, U/l[a]	109	25	15	76	25.5	20	33	20	10	0.01
ALT, U/l[a]	110	28.5	24	77	31	29	33	22	14	0.001
GGTP, U/l[a]	106	29	23	74	32	41	32	24	12.5	0.001
Glucose, mmol/l[a]	91	7	3	59	7.2	3.2	32	6.9	3.2	0.53
Creatinine, µmol/l[a]	108	76	22	76	76.5	19	32	74.5	25	0.79
Uric acid, µmol/l	103	346.8	94.95	69	353.4	98.47	34	333.3	87.22	0.31
Bilirubin, mg/dl	95	11.44	4.82	67	11.78	4.89	28	10.63	4.65	0.29
Apo C3 µg/ml[a]	115	223.8	122.9	79	243.7	123.6	36	208.2	131	0.06
Waist circumference, cm	113	109.1	13.1	78	110.8	11.97	35	105.3	14.82	0.04
WHR	112	0.99	0.0756	77	0.998	0.0761	35	0.973	0.0727	0.11
BMI, kg/m^2	116	32.74	5.788	79	33.44	5.12	37	31.23	6.842	0.09
CK-18, U/l[a]	116	197.1	189.2	79	206.4	201.4	37	181.9	103.9	0.08
PTX3, ng/ml[a]	116	4.11	2.44	79	4.26	2.29	37	3.77	3.22	0.93
Apo B48, ng/ml[a]	115	3766	3234	78	3459.5	3105	37	4529	3959	0.3
Apo B100, mg/dl	116	88.84	25.79	79	87.8	26.93	37	91.06	23.35	0.53
Apo A1, mg/dl	116	141.56	28.77	79	140.29	28.53	37	144.26	29.49	0.5

a Nonnormally distributed variable – median (Me) and interquartile range (IQR) are presented. Comparison of distributions (Me), Mann–Whitney test; in other cases comparisons of the means were made using *t* test.

Abbreviations: ALT, alanine transaminase; apo, apolipoprotein; AST, aspartate transaminase; BMI, body mass index; CK-18, cytokeratin 18 fragment; GGTP, γ-glutamyltranspeptidase; HbA_{1c}, glycated hemoglobin A_{1c}; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; PTX3, pentraxin 3; TC, total cholesterol; TG, triglycerides; WHR, waist-to-hip ratio; X, mean

was correlated with TC (r = 0.46; P = 0.01), TG (r = 0.50; P = 0.004), waist circumference (r = 0.38; P = 0.02), and BMI (r = 0.42; P = 0.009) (TABLE 2).

TABLE 3 presents partial regression coefficients and partial correlation coefficients between selected variables and logPTX3, after adjustment for age and sex in the whole study group. PTX3 level was associated with the concentrations of TC, LDL-C, apo B100, apo C3, and TG and waist circumference. As indicated by partial regression coefficient b, change of independent variable LDL-C was associated with the greatest change of PTX3, while smaller associations were observed also with TC and TG. An increase of TC, LDL-C, and TG by 1 mmol/l was associated with an increase of PTX3 by 1.1959 ng/ml, 1.2017 ng/ml, and 1.1405 ng/ml respectively. An increase of apo B100 by 1 mg/dl was associated with an increase of PTX3 by 1.0051 ng/ml, and of apo C3 by 1 µg/dl with PTX3 by 1.0012 ng/ml.

Similar results were observed in patients with T2D and NAFLD as in the whole group (TABLE 3). Total cholesterol, LDL-C, TG, apo C3, and apo B100, after adjustment for age and sex, were associated with PTX3. An increase by 1 mmol/l of TC, LDL-C, and TG was related with an increase of PTX3 by 1.1822 ng/ml, 1.1779 ng/ml, and 1.1293 ng/ml respectively. An increase of apo C3 by 1 µg/dl and apo B100 by 1 mg/dl was related with an increase of PTX3 by 1.0014 ng/ml and 1.0051 ng/ml, respectively.

In patients without NAFLD, associations between PTX3 and TC and LDL-C were found, and a positive association with waist circumference was observed. An increase of waist circumference by 1 cm in these patients was associated with an increase of PTX3 by 1.0144 ng/ml.

DISCUSSION The results of this study indicate that PTX3, an inflammation marker, in patients with T2D is associated with TC, LDL-C, apo B100, apo C3, TG, glucose levels and BMI in the whole study group of patients with T2D.

We did not observe differences in concentrations of PTX-3 between patients with and without NAFLD, as observed in patients with and without liver fibrosis[16]; however, we did not perform liver biopsy. In our study, patients with T2D and

TABLE 2 Spearman correlation coefficients of selected variables and serum pentraxin 3 concentrations in patients with type 2 diabetes according to nonalcoholic fatty liver disease

Parameter	Total (n = 116)			Nonalcoholic fatty liver disease					
				Present (n = 79)			Absent (n = 37)		
	n	r_S	*P* value	n	r_S	*P* value	n	r_S	*P* value
Age, y	116	−0.05	0.629	79	−0.09	0.44	37	0.01	0.93
Diabetes duration, y	114	0.01	0.932	78	0.03	0.77	36	−0.04	0.81
HbA_{1c}, %	87	0.12	0.285	62	0.17	0.17	25	−0.01	0.97
TC, mmol/l	106	0.46	<0.001	76	0.47	<0.001	30	0.46	0.01
TG, mmol/l	106	0.42	<0.001	76	0.39	<0.001	30	0.50	0.004
HDL-C mmol/l	106	−0.09	0.34	76	−0.12	0.3	30	−0.07	0.7
LDL-C, mmol/l	98	0.36	<0.001	69	0.39	0.001	29	0.34	0.07
AST, U/l	109	0.00	0.96	76	0.04	0.71	33	−0.14	0.42
ALT, U/l	110	−0.09	0.34	77	−0.10	0.36	33	−0.17	0.35
GGTP, U/l	106	−0.01	0.94	74	−0.01	0.95	32	−0.03	0.87
Glucose, mmol/l[a]	91	0.21	0.04	59	0.24	0.07	32	0.18	0.33
Creatinine, µmol/l[a]	108	0.06	0.52	76	0.07	0.55	32	0.08	0.67
Uric acid, µmol/l	103	0.10	0.29	69	0.11	0.37	34	0.08	0.66
Bilirubin, mg/dl	95	−0.19	0.05	67	−0.17	0.16	28	−0.27	0.16
Apo C3, µg/ml[a]	115	0.29	0.002	79	0.43	<0.001	36	−0.04	0.81
Waist circumference, cm	113	0.16	0.08	78	0.07	0.54	35	0.38	0.02
WHR	112	0.04	0.6394	77	0.03	0.80	35	0.01	0.93
BMI, kg/m^2	116	0.20	0.03	79	0.08	0.48	37	0.42	0.009
CK-18, U/l	116	0.05	0.592	79	0.04	0.7	37	0.08	0.65
Apo B48, ng/ml	115	0.16	0.086	78	0.16	0.17	37	0.22	0.18
Apo B100, mg/dl	116	0.31	<0.001	79	0.34	0.0023	37	0.23	0.16
Apo A1, mg/dl	116	0.16	0.083	79	0.07	0.5281	37	0.29	0.07

Abbreviations: see **TABLE 1**

NAFLD were younger and had lower HDL-C and higher waist circumference than patients without fatty liver disease. Lallukka et al[19] found that the presence of NAFLD predicts the risk of T2D independently of age, which might explain the younger age of patients with NAFLD in our study as they might have had T2D earlier than patients without NAFLD.[19] Lower HDL-C concentrations in patients with NAFLD were also observed by some authors, for example DeFilippis et al,[20] but not by others, for example Bril et al.[21] Patients with NAFLD had higher activity of liver enzymes (as expected, although still within normal limits), than patients without the disease. Interestingly, we did not find any differences in other lipid or apolipoprotein concentrations or glucose control between groups assessed by HbA_{1c} level.

Serum PTX3 levels correlated with TC and TG levels in all patients regardless of the presence of NAFLD. In the whole study group and in patients with NAFLD, the correlations between PTX3 and strong cardiovascular lipid risk factors, that is, LDL-C, apo B100, and apo C3, were observed. Apo B100 is a marker of atherogenic lipoproteins of hepatic origin – very LDL, LDL, and small dense LDL – and a strong cardiovascular risk factor. Positive associations between PTX3 and LDL-C were observed by Hydzik et al[22] in patients with different stages of CAD. There are data indicating that exposure of arterial vascular smooth muscle cells to modified LDL in vitro markedly increased PTX3 expression.[23] However, contrary to our findings, inverse correlations between LDL-C and PTX3 were observed in women with gestational diabetes[24] and in insulin-resistant patients from the Health 2000 Survey.[13] In this study in insulin-resistant patients, PTX3 concentration variations were attributed to variations in LDL--C. Also negative association between PTX3 and LDL-C and apo B100, marker of all atherogenic lipoproteins, was observed by Morishita et al[25] in 163 Japanese patients with stable angina pectoris.

Data from several studies indicate that there is an association between apo B and the presence of NAFLD. In a study by Wang et al,[26] elevated serum apo B levels independently predicted an increased risk for incident NAFLD in Chinese population.[26] The association of NAFLD with apo B dyslipoproteinemias was confirmed by Nass et al[27] in the Lifelines Cohort Study. Associations between apo B and PTX3, found in our patients with NAFLD are in line with these data.

Positive association between PTX3 and apo C3 is of importance, especially in the light of its function in lipid metabolism and in increasing atherosclerosis risk. Apo C3 is now recognized as the key

TABLE 3 Partial regression coefficients and partial correlation coefficients between selected variables and logPTX3 in the whole study group with type 2 diabetes and according to presence of nonalcoholic fatty liver disease, after adjustment for age and sex

Parameter	Total (n = 116)				Nonalcoholic fatty liver disease							
					Present (n = 79)				Absent (n = 37)			
	b*	*r*	R^2	*P* value	b*	*r*	R^2	*P* value	b*	*r*	R^2	*P* value
TC, mmol/l	0.4982	0.07	0.24	<0.001	0.4889	0.47	0.07	<0.001	0.4790	0.49	0.13	0.0087
LDL-C, mmol/l	0.4312	0.43	0.08	<0.001	0.3968	0.38	0.09	0.0014	0.4527	0.47	0.08	0.0136
HDL-C, mmol/l	−0.0686	−0.07	0.06	0.4920	−0.1121	−0.11	0.05	0.3510	−0.0722	−0.08	0.02	0.6954
TG, mmol/l	0.3395	0.34	0.05	<0.001	0.3852	0.38	0.06	<0.001	0.2662	0.28	0.05	0.1472
HbA_{1c}, %	0.0831	0.08	0.03	0.4483	0.1940	0.19	0.03	0.1428	−0.0419	−0.05	0.04	0.8320
Glucose, mmol/l	0.1518	0.16	0.01	0.1450	0.1796	0.18	0.07	0.1931	0.1725	0.18	0.01	0.3296
AST, U/l	0.0131	0.01	0.11	0.8976	0.0249	0.02	0.11	0.8422	−0.0114	−0.02	0.11	0.9383
ALT, U/l	−0.0845	−0.08	0.17	0.4184	−0.1046	−0.10	0.15	0.4087	−0.0390	−0.04	0.21	0.8398
GGTP, U/l	0.0450	0.04	0.10	0.6616	0.0920	0.09	0.07	0.4577	−0.0109	−0.01	0.14	0.9541
Creatinine, µmol/l	0.1713	0.16	0.15	0.1001	0.2089	0.20	0.12	0.0922	0.1605	0.14	0.34	0.4604
WHR	0.1236	0.10	0.37	0.3001	0.0559	0.04	0.49	0.7343	0.1083	0.11	0.20	0.5594
BMI, kg/m^2	0.1487	0.15	0.04	0.1143	0.0856	0.08	0.04	0.4662	0.2470	0.26	0.06	0.1306
Apo C3, µg/ml	0.2702	0.27	0.06	0.0041	0.4303	0.42	0.04	<0.001	0.0749	0.08	0.15	0.6743
Waist circumference, cm	0.2019	0.20	0.04	0.0335	0.0807	0.08	0.06	0.4992	0.3562	0.37	0.09	0.0342
CK-18, U/l	0.0584	0.06	0.10	0.5499	0.0856	0.08	0.09	0.4785	−0.0362	−0.04	0.18	0.8394
Apo B48, ng/ml	0.1756	0.18	0.02	0.0597	0.1848	0.18	0.03	0.1148	0.1149	0.12	0.02	0.4804
Apo B100, mg/dl	0.2678	0.27	0.01	0.0035	0.3261	0.32	0.05	0.0046	0.1873	0.20	0.01	0.2436
Apo A1, mg/dl	0.1339	0.14	0.001	0.1475	0.0988	0.10	0.004	0.3915	0.1677	0.18	0.004	0.2958

b* – standardized partial regression coefficient; *r* – partial correlation coefficient; R^2 – partial determination coefficient

Abbreviations: see **TABLE 1**

inhibitor of lipoprotein lipase and hepatic lipase and it also enhances synthesis and secretion of very LDL from the liver, thus leading to severe hypertriglyceridemia. Apo C3 is an atherogenic protein found on HDL, very LDL, and LDL and confers increased cardiovascular risk.[28] There are also data from genetic gain-of-function apo C3 mutations and clinical studies with apo C3 inhibition indicating that this apo is associated with incident cardiovascular disease.[29,30] Besides its effects on lipid and lipoprotein metabolism, apo C3 is directly involved in stimulation of vascular inflammatory processes. There are data indicating that apo C3 directly provokes proinflammatory responses in vascular cells, including monocytes and endothelial cells.[31,32]

The findings on association between circulating levels of PTX3 and measures of adiposity are inconsistent: some studies have found positive, whereas other have demonstrated inverse associations.[33-35] In our patients with T2D without NAFLD, positive association between PTX3 and waist circumference and BMI was found, while, interestingly, in patients with NAFLD such association did not occur. Alberti et al[36] found that PTX3 expression tended to be higher in obese patients than in those with normal weight only in visceral adipose tissue and correlated with LDL / HDL ratio in the multivariate analysis.[36] In the MESA (Multi-Ethnic Study of Atherosclerosis) study, PTX3 was positively associated with age, obesity, insulin, systolic blood pressure, C-reactive protein, and carotid intima media thickness.[37] The discrepancies in association between PTX3 and obesity indices could be due to differences in body fat mass and fat tissue distribution.

In our group, we did not observe any associations between PTX3 and diabetes control, assessed by HbA_{1c} levels, in line with data presented by Takashi et al.[38]

Recent observations have led some authors to postulate that an increase in PTX3 levels should be regarded as an attempt to counterbalance the overactivation of the proinflammatory cascade induced by interleukin 1, tumor necrosis factor α, oxidized low-density lipoprotein, and microbial moieties, rather than as a harmful response.[39-41] PTX3 provides an anti-inflammatory property to downregulate the production of proinflammatory cytokines, playing multiple roles in the development of atherothrombotic plaque.[39-41] Based on data from the available literature, it seems that PTX3 acts as a crossroad between pro- and anti-inflammatory pathways as an modulatory molecule, influencing inflammatory response and tissue remodeling.[12]

The associations between PTX3 and apo B and apo C3 in patients with T2D are of value in understanding the role of inflammation in NAFLD and vascular disease. The SUMMIT VIP (Surrogate Markers for Micro- and Macrovascular Hard Endpoints for Innovative Diabetes Tools – Vascular

Imaging Prediction) study demonstrated that markers of inflammation, including PTX3, as well as markers of endothelial stress reflect cardiovascular risk in patients with T2D with manifest macroangiopathy, whereas conventional risk factors were not associated with cardiovascular events in these patients.[42]

Treatment of lipid disorders in patients with NAFLD could be of value in reducing cardiovascular risk as well as preventing liver disease progression, as suggested by expert panels.[43,44]

The limitations of this study include a relatively small number of examined patients in the group without NAFLD and lack of confirmation of NAFLD diagnosis by liver biopsy.

In conclusion, PTX3, a marker of cardiovascular risk and inflammation in patients with T2D is associated with TC, TG, LDL-C, apo B, and apo C3. Associations with LDL-C and apos persist only in NAFLD patients. The results of our study could be of value in understanding the parameters influencing PTX3 in patients with T2D and, therefore, in personalized treatment.

ARTICLE INFORMATION

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CONTRIBUTION STATEMENT AT, MW-M, and BI-W contributed to study design. EK and BI-W contributed to statistical analysis. BI-W, MW-M, AT, PM, MTM, and MK contributed to data interpretation. BI-W, MW-M, and MTM contributed to final revision of the manuscript.

CONFLICT OF INTEREST None declared.

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