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Lipid indexes and parameters of lipid peroxidation during physiological pregnancy

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Abstract

Background: Specific metabolic changes during physiological pregnancy are characterized by hyperlipidemia and increased oxidative stress. However, these specific changes raise the question of their pro-atherogenic potential during pregnancy and their influence on the risk of developing cardiovascular disease (CVD) in women later in life, as well as complications during pregnancy. The aim of this study was to investigate the changes in lipid indexes and parameters of lipid peroxidation in non-complicated pregnancy in order to estimate their course of change and potential relationship during non-complicated pregnancy.

Methods: The study included 43 healthy pregnant women and 38 non-pregnant healthy women, in appropriate ages, as the control group. Lipid parameters and oxidative stress parameters were monitored in a longitudinal study in the first, second and third trimesters, and before delivery during non-complicated pregnancy.

Results: Results have shown that lipid indexes rise during pregnancy. The values were significantly increased when compared to the first trimester in all lipid indices and in comparison with the control group. Thyobarbituric acid reactive substances (TBARS) and lipid hydroperoxides (LOOH) were not changed significantly during physiological pregnancy, but LOOH showed a significantly higher value in the first trimester compared with the control group. Prooxidative-antioxidative balance (PAB) significantly increases as pregnancy progresses.

Conclusions: We observed the changes in lipids, lipid indexes and parameters that indicate oxidative

modification of lipids in physiological pregnancy that may lead to an atherogenic, prooxidant state.

Keywords: hyperlipidemia; lipid indexes; lipid peroxidation; pregnancy.

Introduction

Non-complicated (physiological) pregnancy is a dynamic state accompanied by specific metabolic changes. Among these changes, the most interesting for researchers in the last couple of years were specific lipid profile and oxidative stress status, because of their potential influence on women's health later in life and their influence on cardiovascular disease (CVD) development [1–3]. In addition, these alterations in lipogenesis and oxidative stress status have been linked to perinatal morbidity and mortality, as a popular area for research outcomes [3–7]. Specific altered lipid profile during non-complicated pregnancy is essential for the normal course of pregnancy and fetal development. Nevertheless, these specific changes in lipid parameters raise the question of their pro-atherogenic potential during pregnancy and its influence on the risk for the development of CVD in women later in life, as well as complications during pregnancy, especially preeclampsia, but also gestational diabetes mellitus and intrauterine growth restriction (IUGR). By the end of the third trimester, most healthy pregnant women develop a lipid profile that could be considered highly atherogenic in healthy non-pregnant women [1]. Non-complicated pregnancy is also associated with alterations in the composition and size of low-density lipoprotein (LDL) and high-density lipoprotein (HDL) particles, which become smaller and denser with higher pro-atherogenic potential and decreased atheroprotective potential [6, 7]. Apolipoprotein A-I (apoA-I) and apolipoprotein B (apoB) are considered to be better indicators of pro-atherogenic and atheroprotective lipid components, because of their lower metabolic variations compared to other lipid components [8]. ApoB is an essential structural component of very low-density lipoproteins (VLDLs), intermediate-density lipoproteins (IDLs) and LDL. As each particle in these lipoproteins contains

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apoB, the total number of atherogenic particles can be estimated by measuring the plasma level of this apolipoprotein. The levels of apoA-I in plasma are strongly correlated with HDL-cholesterol (HDL-C) levels and generally with HDL particles with confirmed antiatherogenic effects [9, 10]. The ratio apoB/apoA-I is considered to be the best indicator of the pro-atherogenic and atheroprotective components of lipoprotein particles [8]. Similarly, the atherogenic index of plasma (AIP) is considered a good indicator for the presence of small dense particles [8], so the combination of these indexes provides good information about the characteristics of dyslipidemia.

Non-complicated pregnancy is also characterized by increased oxidative stress. Reactive oxygen species (ROS) and their control by antioxidants are involved in the physiology of the female reproductive system [2]. They are important for the normal course of pregnancy and fetal development. When the balance with the antioxidant system is disturbed, oxidative stress in pregnancy may lead to serious complications, such as preeclampsia, gestational diabetes mellitus, IUGR, miscarriage and preterm birth [2, 11]. Increase in oxidative stress is associated with abnormal lipid profile and may cause oxidative modification of lipids, so the studies which were conducted in complicated pregnancies also showed increased concentrations of lipid peroxides [2, 12, 13]. Altered lipid profile, oxidative stress and inflammation are molecular mediators of endothelial dysfunction development, which leads to preeclampsia and other pregnancy complications [10, 12, 14].

The aim of this study was to investigate serum lipid profile by observing the changes in the ratios between pro-atherogenic and atheroprotective lipid components expressed as lipid indexes, as well as AIP in non-complicated pregnancy. Also, we wanted to evaluate the changes in markers of oxidative stress and markers of lipid oxidative modifications during non-complicated pregnancy because of their crucial role in the development of pregnancy complications.

Materials and methods

For the purpose of a longitudinal study, 60 healthy pregnant Caucasian women were recruited during their regular gynecological check-ups at the Gynecology and Obstetrics Clinic “Narodni Front” in Belgrade, Serbia. The study lasted for 2 years; the blood was sampled toward the end of each trimester and before delivery. A full medical history was taken, including noting the presence of any

systemic disorders before pregnancy, smoking status, alcohol intake, antioxidant supplementation, and family history of CVD and diabetes mellitus. The median age of the subjects was 26 years (range 20–35). The study protocol also included height and weight measurement for body mass index calculation ($BMI = \text{weight [kg]} / \text{squared height [m}^2\text{]}$). Exclusion criteria from the study were overweight before pregnancy, as well as the presence of any chronic disease before pregnancy or intake of regular medication affecting the lipid profile and oxidative stress status, multiple gestation, molar pregnancy, gestational hypertension, gestational diabetes, preeclampsia, the presence of any other complications in pregnancy and preterm delivery. Based on these criteria, 17 pregnant women were excluded from the study, so finally data from 43 pregnant women were fully processed. The control group consisted of 38 healthy women. Exclusion criteria for controls were inflammation, infection, presence of neurological dysfunction, and a history of CVD, renal, hepatic, gastrointestinal, pulmonary, endocrine or oncological disease. The control and pregnancy groups were matched for age. Responses to a standard questionnaire were collected in person by trained interviewers. The whole study was planned according to the ethical standards detailed in the Declaration of Helsinki (as revised in 1983) and according to local institutional guidelines.

Venous blood was drawn from each subject's antecubital vein after nighttime fasting (12 h) into one serum sample tube and one ethylenediaminetetraacetic acid (EDTA) sample tube before centrifugation at $1500 \times g$ for 10 min. Plasma and serum samples were stored at -80°C in aliquots until analysis (1 month after the blood sampling).

Basic biochemical parameters were determined using an Ilab 300 Plus auto-analyzer employing commercial kits (Bioanalytica, Belgrade, Serbia). Hematology parameters were determined using the hematological analyzer Cel-Dyn 1700 (Abbott Diagnostics, Chicago, IL, USA). AIP was calculated according to the following equation: $AIP = \log(\text{triglyceride [TG]} / \text{HDL-C})$, with units for TG and HDL-C in mmol/L [14]. The other lipid indexes were expressed through simple ratios of lipid components: apoB/apoA-I, cholesterol (CHOL)/HDL-C, LDL-C/HDL-C and TG/HDL-C. The concentration of thiobarbituric acid-reactive substances (TBARS) was measured using the molar absorption coefficient of $1.56 \times 10^5 \text{ M}^{-1}$ at 535 nm, as described by Girotti et al. [15]. Concentrations of lipid hydroperoxides (LOOH) were measured in serum by the ferric-xylenol orange method [16]. The prooxidant-antioxidant balance (PAB) was measured using a method described by Alamdari et al. [17], in which 3,3',5,5'-tetramethyl benzidine

and its cation are used as redox indicators participating in two simultaneous reactions.

Statistical analysis

The assessment of the normality of data distribution was done using the Kolmogorov-Smirnov test. Data were shown as the mean value and standard deviation for normally distributed variables and as the geometric mean and the 95th confidence intervals derived from log-normal values. The comparisons of two groups of continuous variables were performed using Student's t-test. A comparison of continuous variables (more than two groups) was performed using the analysis of variance (repeated measures) with *post hoc* Bonferroni correction. All statistical analyses were performed using the MedCalc Software (Ostend, Belgium). All statistical tests were considered significant at the probability level of 0.05.

Results

General biochemical and hematological parameters are shown in Table 1.

As was expected, there was no difference in blood pressure between the investigated groups. All observed changes in biochemical and hematological parameters which were statistically significant between the first trimester and late pregnancy, as well as between the control group of non-pregnant women and the first trimester of pregnancy, were expected (Table 1).

In Table 2, we present the term of delivery and general characteristics of newborns. All 43 pregnancies ran their normal course of pregnancy and outcome, and delivery at expected terms. Also, all babies born were healthy with a high Apgar score (>8) (Table 2).

Total CHOL, TG, LDL-C and HDL-C rose significantly as the pregnancies progressed in comparison with the first trimester (Table 3).

Table 1: Biochemical and hematological parameters during physiological pregnancy.

Parameter	First trimester	Second trimester	Third trimester	38 th Week of gestation	Control group ^a
Week of gestation	12.9±0.65	23.2±0.52	31.7±0.12	37.3±0.12	–
SBP, mmHg	111.7±11.8	109.5±11.0	108.3±8.6	107.8±9.8	118.3±11.8
DBP, mmHg	71.3±8.7	70.2±7.4	69.4±6.5	68.6±7.5	76.3±10.6
Weight gain, %	4.2±4.10	13.6±5.37 ^{b,f}	21.6±6.47 ^{b,g,c,f}	25.2±7.92 ^{b,g,c,f,d,f}	–
WBC, ×10 ⁹	8.1±1.96	9.3±2.05 ^{b,f}	9.7±2.21 ^{b,f}	10.2±5.40 ^{b,f}	5.7±1.29 ^{b,h,c,i,d,i,e,i}
RBC, ×10 ¹²	4.0±0.23	3.7±0.25	3.8±0.25	3.9±0.28	4.42±0.32
Hemoglobin, g/L	124.5±8.49	115.8±8.37	115.0±8.28	118.9±9.42	131.0±8.29
Hematocrit, %	35.6±2.28	33.0±2.30	33.5±2.27	34.5±2.57	39.8±2.83
MCH, pg	30.7±1.36	31.0±1.41	30.3±1.72 ^{c,f}	30.2±2.01 ^{c,f}	29.7±1.69 ^{b,i,c,i}
Platelets, ×10 ⁹	217.7±50.52	236.9±54.18	218.8±50.78	216.0±56.66	210.5±48.82
Total protein, g/L	68.7±10.16	64.2±6.13	63.8±3.20 ^{b,f}	63.7±4.34 ^{b,f}	70.5±3.73 ^{c,i,d,i,e,i}
Glucose, mmol/L	4.3±0.44	4.3±0.48	4.5±0.50	4.3±0.48	4.4±0.45
Urea, mmol/L	3.1±0.68	2.9±0.75	2.6±0.84 ^{b,f}	2.7±0.77 ^{b,f}	4.4±1.09 ^{b,i,c,i,d,i,e,i}
Creatinine, μmol/L	63.6±6.41	62.4±6.51	62.9±8.03	67.9±7.61 ^{b,g,c,g,d,g}	63.5±8.41 ^{e,i}
AST, U/L	17.5±2.97	20.2±7.74	21.7±7.49 ^{b,f}	23.0±12.71 ^{b,f}	18.2±2.55
ALT, U/L	14.4±6.17	19.4±17.00	21.9±21.28	22.5±35.18	17.4±3.12

Data are expressed as mean±SD. ^aSignificantly different from the control group; ^bsignificantly different from the first trimester; ^csignificantly different from the second trimester; ^dsignificantly different from the third trimester; ^esignificantly different from the 38th week of gestation.

^fp<0.05, ^gp<0.001 (Tukey's *post hoc* test), ^hp<0.05 (Student's t-test), ⁱp<0.001 (Student's t-test). ALT, alanine aminotransferase; AST, aspartate aminotransferase; DBP, diastolic blood pressure; MCH, mean corpuscular hemoglobin; RBC, red blood cell; SBP, systolic blood pressure; WBC, white blood cell.

Table 2: Term of delivery and newborn characteristics (expressed as mean value±SD).

Week of gestation at delivery term	Gender of newborn babies M/F	The weight of newborn babies, g	The length of newborn babies, cm	The head circumference of newborn babies, cm	Apgar score of newborn babies at 1 and 5 min
39.5±1.00	22/21	3459.3±426.26	51.6±2.04	35.3±1.03	8.9±1.11/9.7±0.98

SD, standard deviation.

Table 3: Lipid parameters and lipid indexes during physiological pregnancy.

Lipid and lipid indices	First trimester	Second trimester	Third trimester	38 th Week of gestation	Control group
CHOL, mmol/L	4.9 ± 0.79	6.3 ± 0.97 ^{b,g}	6.8 ± 1.05 ^{b,g,c,g}	6.9 ± 1.10 ^{b,g,c,g}	4.5 ± 0.71 ^{b,i,c,i,d,i,e,i}
TG, mmol/L ^a	1.0 (0.95–1.12)	1.6 ^{b,g} (1.49–1.79)	2.3 ^{b,g,c,g} (2.14–2.56)	2.7 ^{b,g,c,g,d,g} (2.54–3.01)	0.8 ^{b,i,c,i,d,i,e,i} (0.71–0.90)
HDL-C, mmol/L	1.9 ± 0.36	2.3 ± 0.50 ^{b,g}	2.1 ± 0.52 ^{c,g}	1.9 ± 0.45 ^{c,g,d,f}	1.5 ± 0.30 ^{b,i,c,i,d,i,e,i}
LDL-C, mmol/L	2.5 ± 0.73	3.2 ± 0.96 ^{b,g}	3.7 ± 1.04 ^{b,g,c,g}	3.6 ± 1.08 ^{b,g,c,f}	2.6 ± 0.66 ^{c,i,d,i,e,h}
Apo-AI, g/L	1.5 ± 0.29	1.7 ± 0.28 ^{b,g}	1.7 ± 0.32 ^{b,g}	1.6 ± 0.30 ^{b,f}	1.5 ± 0.18 ^{c,i,d,i,e,h}
ApoB, g/L	0.6 ± 0.14	0.8 ± 0.15 ^{b,g}	1.0 ± 0.17 ^{b,g,c,g}	1.1 ± 0.18 ^{b,f,g,c,g,d,g}	0.8 ± 0.15 ^{b,i,d,i,e,i}
ApoB/ApoA-I	0.44 ± 0.15	0.50 ± 0.14 ^{b,f}	0.63 ± 0.22 ^{b,g,c,g}	0.70 ± 0.21 ^{b,g,c,g,d,f}	0.50 ± 0.13 ^{a,h,c,i,d,i}
CHOL/HDL-C	2.6 ± 0.64	2.9 ± 0.74 ^{b,f}	3.5 ± 1.19 ^{b,g,c,g}	3.8 ± 1.12 ^{b,g,c,g,d,f}	3.1 ± 0.77 ^{d,i,e,i}
LDL-C/HDL-C	1.3 ± 0.56	1.5 ± 0.67	2.0 ± 0.99 ^{b,g,c,g}	2.0 ± 0.91 ^{b,g,c,g}	1.8 ± 0.66 ^{b,i,c,i,h}
TG/HDL-C	0.6 ± 0.24	0.8 ± 0.27 ^{b,g}	1.3 ± 0.59 ^{b,g,c,g}	1.6 ± 0.72 ^{b,g,c,g,d,g}	0.6 ± 0.46 ^{c,i,d,i,e,i}
AIP	−0.3 ± 0.16	−0.1 ± 0.17 ^{b,g}	0.1 ± 0.20 ^{b,g,c,g}	0.2 ± 0.19 ^{b,g,c,g,d,g}	−0.3 ± 0.23 ^{c,i,d,h,e,i}

Data are expressed as mean ± SD; ^ameans and 95th confidence intervals derived from log-normal values. ^bSignificantly different from 1st trimester; ^csignificantly different from 2nd trimester; ^dsignificantly different from 3rd trimester; ^esignificantly different from 38th week gestation. ^fp < 0.05, ^gp < 0.001 (Tukey's *post hoc* test). ^hp < 0.05 (Student's *t*-test), ⁱp < 0.001 (Student's *t*-test). apoA-I, apolipoprotein A-I; apoB, apolipoprotein B; CHOL, cholesterol; HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density lipoprotein-cholesterol; TG, triglycerides.

HDL-C showed the highest value in the second trimester, but by the end of pregnancy this value declined and in the 38th week of pregnancy it was significantly lower than in the second trimester (Table 3). Lipid indexes that showed relations among lipid parameter growth during pregnancy indicated an increase in pro-atherogenic components of lipid parameters. The values increased significantly when compared to the first trimester in all the lipid indexes. CHOL/HDL-C and LDL-C/HDL-C indexes were significantly lower in the first trimester than in the control group due to an increase in HDL-C and LDL-C compared to total CHOL. As pregnancy progressed, these indices grew and were significantly higher than in the first trimester (Table 3).

ApoB/apoA-I and AIP lipid indexes also increased significantly during physiological pregnancy, indicating an increase in pro-atherogenic components as pregnancy progresses. TBARS is the final product of decomposition of lipid peroxides and represents a late-stage marker of oxidant damage. During pregnancy, these values are mostly unchanged, and statistical analysis showed that

there was no significant difference in the values during pregnancy compared to the start of pregnancy and compared to non-pregnant women (Table 4).

The movement in the values of LOOH during pregnancy was similar, but the values at the beginning of pregnancy were significantly higher than the values in the control group.

PAB showed significantly higher values in the first trimester of pregnancy compared to the values of the control group of non-pregnant women, and also in all the examined periods of pregnancy compared to the first trimester (Table 4).

Discussion

Pregnancy in healthy women is associated with physiological hyperlipidemia that is essential for the normal course of pregnancy and fetal growth and development. However, recent studies have shown that a remarkably altered lipid profile during pregnancy is associated with

Table 4: Oxidative stress parameters during physiological pregnancy.

Parameter	First trimester	Second trimester	Third trimester	38 th Week of gestation	Control group
TBARS, μmol/L	1.0 ± 0.28	1.1 ± 0.30	1.1 ± 0.35	1.0 ± 0.22	0.9 ± 0.42
LOOH, μmol/L	9.5 ± 2.1	9.5 ± 1.80	9.2 ± 2.39	9.4 ± 2.57	7.9 ± 1.84 ^{b,h,c,h,d,h,e,h}
PAB, HK units ^a	107.1	146.0 ^{b,g}	160.6 ^{b,g,c,g}	170.7 ^{b,g,c,g,d,f}	68.6 ^{b,i,c,i,d,i,e,i}
	(102.9–123.3)	(142.5–154.2)	(147.4–170.2)	(155.4–185.3)	(61.4–76.6)

Data are expressed as mean ± SD; ^ameans and the 95th confidence intervals derived from log-normal values. ^bSignificantly different from the first trimester; ^csignificantly different from the second trimester; ^dsignificantly different from the third trimester; ^esignificantly different from the 38th week of gestation. ^fp < 0.05, ^gp < 0.001 (Tukey's *post hoc* test). ^hp < 0.05 (Student's *t*-test), ⁱp < 0.001 (Student's *t*-test). LOOH, lipid hydroperoxides; PAB, prooxidative-antioxidative balance; TBARS, thiobarbituric acid reactive substances.

perinatal morbidity and mortality, so dyslipidemia in pregnancy is placed in the focus of actual investigations [3]. Results of the current study have shown that during non-complicated pregnancy, as it progresses, there is an increase in pro-atherogenic components of the lipid profile (CHOL, TG, LDL-C and apoB), and they reach maximum values in the third trimester (Table 3). These results are in agreement with previous studies which indicate that physiological pregnancy is associated with an increase in lipid components as pregnancy progresses [1, 18, 19]. During the second trimester of non-complicated pregnancy, there is an increase in HDL-C concentrations and this increase, with a slight decline, is maintained to the end of delivery time [1, 7, 18]. The results of the current study have shown the same characteristics in HDL-C alterations during physiological pregnancy (Table 3). This increase in atheroprotective HDL-C concentrations during non-complicated pregnancy could be explained as a compensatory mechanism in specific physiological dyslipidemias of pregnancy.

Because of specific alterations in lipid profile markers during non-complicated pregnancy (increase in both pro-atherogenic and atheroprotective lipid markers), it is considered that atherogenic indexes are better indicators of lipid profile changes [1, 8, 20–22]. Also, results of previous studies have shown that the values of the atherogenic indexes are significantly higher in pregnancies complicated by preeclampsia and gestational diabetes in comparison with the values in uncomplicated pregnancy [1, 4, 6, 21]. Among them, according to recent research, maybe the most interesting are apoB/apoA-I (due to their low metabolic variations, compared with the CHOL and TG) and AIP. It has been shown that AIP is a good indicator for the presence of small, dense LDL and HDL particles in plasma, and also that apoB/apoA-I is the best indicator of the relationship between pro-atherogenic and atheroprotective lipid components [8]. It is believed that the apoB/apoA-I index is an important indicator of dyslipidemia with the consequent effect of endothelial dysfunction. Any value above 0.8 for women is considered high risk for the development of CVD [8]. AIP in excess of 0.5 has been proposed as the cut-off value, indicating atherogenic risk [1].

Research results in our population of healthy pregnant women have shown a significant increase in these indexes during pregnancy, which indicates an increase in the pro-atherogenic components of the lipid profile as pregnancy progresses and their intensification in the third trimester (Table 3).

Jia et al. [22] in their study stated that the indices CHOL/HDL-C and TG/HDL-C were good indicators of the distribution of HDL-C subclasses, and their simultaneous

rise showed the movement of HDL subclasses toward smaller particles, and the weakness of the reverse CHOL transport. Increases in AIP during non-complicated pregnancy (Table 3) also indicate possible changes in LDL particle distribution toward small, dense LDL particles [8]. According to our results, with an increase in the mentioned indices (Table 3), we could speculate that there is a change in the lipoprotein particle composition during non-complicated pregnancy. It is strongly believed that small dense LDL particles contribute to endothelial dysfunction in preeclampsia [1, 6, 19], so we consider it very important to investigate the distribution of LDL and HDL particles in non-complicated pregnancy and especially in high-risk pregnancies during the first trimester of pregnancy as potential markers for the prediction of preeclampsia development.

There is a great body of evidence that pregnancy is a physiological condition exhibiting a high susceptibility to oxidative stress development [23]. Increased oxidative stress leads to oxidative modifications of lipids, and lipid peroxidation is considered the cause of complications in pregnancy, especially in the development of preeclampsia [2, 11, 13, 19, 20]. In our study, during physiological pregnancy without complications, the examined parameters of oxidative stress have shown the following characteristics: LOOH and PAB increased significantly in early pregnancy compared to the value in the control group of non-pregnant women (Table 4). As pregnancy advances, the LOOH values do not change significantly, while PAB increases significantly during the entire period of pregnancy. TBARS values do not change significantly in pregnant women compared to non-pregnant women, neither at the beginning of pregnancy nor during the course of pregnancy as it advances. Studies have shown that inappropriate antioxidant response of the mother to the generation of ROS, and the lipid peroxidation that occurs during pregnancy, with altered lipid profile, could be the basis of pregnancy complications (preeclampsia, IUGR, fetal death, gestational diabetes, preterm delivery, etc.) [24]. These facts suggest potential importance in the determination of these parameters, especially lipid peroxidation parameters, which are elevated in complicated pregnancies. Additionally, our results have shown that LOOH and TBARS during physiological pregnancy were stable, so they might be interesting in correlation with the occurrence of complications. The results have also shown that the PAB value increases significantly during pregnancy and is intensified in the third trimester, indicating that pregnancy is a state of continuous oxidative stress which deepens (Table 4). This result is in agreement with previous studies which have shown that oxidative stress parameters increase

during pregnancy [25]. Taking into consideration the fact that physiological pregnancy is a condition of increased oxidative stress and altered pro-atherogenic lipid profile, it is obvious that these characteristics can lead to the development of atherosclerotic plaques and, consequently, the development of CVD. Similarly, due to an unbalanced and weak adaptive response mechanism during pregnancy, these alterations can lead to complications during pregnancy as confirmed in previous studies [26, 27].

Metabolic changes during physiological non-complicated pregnancy could be a risk factor for the development of CVD later in women's life, as well as for the development of complications in pregnancy. However, these changes during pregnancy in healthy women are under the control of appropriate mechanisms. Accordingly, women with inadequate adaptive response, particularly if they had started pregnancy with inadequate ratios of atheroprotective and pro-atherogenic components, and in the presence of enhanced oxidative modification of lipids, may develop some complications during pregnancy. The findings of the present study suggest a potential role of antioxidant supplementation during pregnancy, especially in subjects with high risk for preeclampsia and IUGR development. Antioxidant use might reduce lipid peroxidation and also improve antioxidant capacity, and possibly prevent or delay the development of pregnancy complications. However, currently available evidence indicates that antioxidative supplementation has little to no effect on relevant outcomes [28, 29] and there are no official recommendations for antioxidant supplementation use in pregnancy. However, the importance of lifestyle and dietary habits during pregnancy is beyond question, and the consumption of a varied and balanced diet is essential to ensure favorable outcomes of pregnancy [30].

Limitations

This study has limitations; first, we used data from a relatively small cohort and further, we did not investigate the underlying mechanisms of dyslipidemia and the development of lipid oxidative modifications in non-complicated pregnancy. Prospective studies with larger samples are needed.

Conclusions

In conclusion, we observed the changes in lipids, lipid indexes and oxidative stress parameters during pregnancy

that may lead to an atherogenic, prooxidant state. Further, we could speculate that it would be important to determine these parameters in early pregnancy or the first trimester, with the aim of predicting pregnancy complications. Finally, the combination of the investigated lipid indices and parameters of oxidative stress could be a possible biochemical algorithm for the prediction of pregnancy complications.

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