Effect of Gravidity on Biochemical Parameters in Normotensive and Hypertensive 3rd Trimester Pregnant Women

Abstract

Pregnancy is a period in which a woman carries one or more foetus in her uterus. It is typically divided into three trimesters based on gestational age which is measured in weeks and months. Gravidity is referred to the number of times a woman has been pregnant. Pregnancy is accompanied with several changes in metabolism and biochemical levels of the system in pregnant women, some of which too certain extent may pose the health risks in those with existing health conditions such as high blood pressure. The study of this changes becomes necessary to determine and arrest this risks should they exist during pregnancy.

Aim

The study was aimed at evaluating the effects of gravidity on biochemical markers in normotensive and hypertensive 3rd trimester pregnant women.

Materials and Methods

At Rivers State University Teaching Hospital, a cross-sectional study was undertaken on 100 women. The consenting patients who met the inclusion criteria were randomly assigned to one of two groups: normotensive (50 normotensive pregnant women in their second trimester) or hypertensive (50 hypertensive pregnant women in their second trimester) (HPW2T). The subjects in each group were subsequently split into three categories depending on gravidity: primigravida (one pregnancy), multigravida (two or more), and grand multigravida (five or more).

For the assessment of TC, TG, HDL, and LDL, fasting blood samples were taken using the venepuncture technique.

AIP, CR-I, CR-II, AC, and APoB/APoA1) biochemical indices were computed quantitatively. At a $p<0.05$, the data was examined using ANOVA and the Tukey comparison test.

Result

There was no significant difference in the biochemical parameters between the gravidity groups in the normotensive group, $p<0.05$. The hypertensive group had a similar result.

Conclusion

In a study conducted at Rivers State University Teaching Hospital, gravidity had no influence on biochemical markers in normotensive and hypertensive pregnant women in the third trimester.

Key Word : Gravidity, pregnancy, cardiovascular marker, hypertensive women, diabetes mellitus

Introduction

Pregnancy is a period in which a woman carries one or more foetus in her uterus (womb). (Huda *et al.,* 2009). It is typically divided into three trimesters based on gestational age which is measured in weeks and months. Gravidity is referred to the number of times a woman has been pregnant. (Huda *et al.,* 2009).

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 (Garduno-Alanís *et al*., 2015). 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 (Wild *et al*., 2015). 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 nonpregnant women (Garduno-Alanís *et al*., 2015). 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 (Ogura *et al*., 2002). Apolipoprotein A-I (apoAI) 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 (Kaneva *et al*., 2015). 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 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 (Kim *et al*., 2007). The ratio apoB/apoA-I is considered to be the best indicator of the pro-atherogenic and atheroprotective components of lipoprotein particles (Kaneva *et al*., 2015). 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 (Al-Gubory *et* al., 2010). 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 (Macekova *et al*., 2010). 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 (Clausen *et al*., 2001). Altered lipid profile, oxidative stress and inflammation are molecular mediators of endothelial dysfunction development, which leads to preeclampsia and other pregnancy complications (Sánchez-Aranguren *et al*., 2014).

Hypercholesterolemia and hyperlipidemia are strongly associated with CVD as they promote atherosclerosis, a precursor to myocardial infarction, stroke, and peripheral vascular disease (Boullart *et* al., 2012). Lipid profile including total cholesterol (TC), high density cholesterol (HDL) and triglycerides (TG) serves as a screening tool for dyslipidemia and the risk of CVD. Using these values low density lipoprotein (LDL) and total cholesterol/ HDL ratio (TC/HDL) are calculated.

HDL and its major protein ApolipoproteinA1 (ApoA1) are recognized as independent protective factors against coronary heart disease (Gordon *et al*., 1977), while elevated Apolipoprotein B (ApoB), LDL and TG are associated with a higher risk of atherosis and cardiovascular disease (Murphy & Woollard, 2010). Triglycerides are a commonly measured component of lipid profiles for cardiovascular risk assessment (Goldberg *et al*., 2011). Raised triglycerides are strongly associated with future risk of diabetes as well as cardiovascular disease (Kannel *et al*., 1981) with elevated TG suggested as an explanation for residual cardiovascular risk even after statin therapy (Wierzbicki *et al*., 2012). Limited study on the effect of gravidity on biochemical parameters in hypertensive pregnant women as compared to normotensives in their 3rd trimester necessitates this study.

Materials and Methods

Study Design

Women totalling 100 took part in the cross-sectional study, which comprised both pregnant and non-pregnant women. According to the clinical history in their clinical folder, 50 of the participants were normotensive and the other 50 were hypertensive. Both groups (normotensive and hypertensive) had three subgroups depending on gravidity (number of pregnancies): primigravida (number of pregnancies=1), multigravida (number of pregnancies>1), and grand multigravida (number of pregnancies≥5). The primigravida subgroup contained 15 participants, the multigravida group had 27 participants, and the grand multigravida group comprised 8 participants in the normotensive group. The primigravida subgroup comprised 21 participants, the multigravida group had 25 participants, and the grand multigravida group contained four participants in the hypertensive group. In Rivers State University Teaching Hospital, their artheriogenic characteristics were tested individually to see if gravidity had an effect on biochemical markers in 3rd trimester pregnant women.

Study Area

The experiment was conducted at the Rivers State University Teaching Hospital (previously known as Braithwaite Memorial Specialist Hospital) in Port Harcourt, which is Rivers state capital.

Study Population

The population of interest is pregnant women in their third trimester, who are further subdivided into two groups: normotensive third trimester pregnant women and hypertensive third trimester pregnant women.

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Eligibility criteria

This study included all apparently healthy pregnant women and hypertensive pregnant women, including those on medication, who were for the first time prenatal care attendant during their current pregnancy. Exclusion criteria covered a recent history of blood transfusion, surgery, or inability to offer informed permission.

Method of Selection

Subjects who qualified for the inclusion criteria and issued their agreement to participate in the study were chosen using a simple random procedure proposed by some researchers in a study on pregnant mothers (Catherine et al., 2021; Faith et al., 2021).

Method of Sample Collection

Total cholesterol (TC), triglyceride (TG), high density lipoprotein (HDL), and low density lipoprotein (LDL) were measured in fasting blood samples taken by venepuncture (LDL). Blood was carefully emptied into plain vacutainer tubes, allowed to clot, then centrifuged for 10 minutes at 1500rpm. The serum was separated and kept at -4°C until it was time for the analysis (Oladapo-Akinfolarin et al., 2017; Oladapo- Akinfolarin et al., 2018).

Laboratory methods

Serum Total Cholesterol Determination

With an enzymatic technique, total cholesterol was quantified (Allain et al., 1974).

Procedure

At the end of enzymatic hydrolysis and oxidation, cholesterol is measured. In the presence of phenol and peroxidase, hydrogen peroxide and 4-aminoantipyrine produce the indicator quinoneimine. The amount of colour generated is proportional to the serum cholesterol levels.

Principle

Requirements for the assay were taken into account. Distilled water was used to zero the device.

1ml of cholesterol reagent was pipetted into clean dry test tubes labelled blank, standard, and tests, followed by 10µl of distilled water, standard, and sample. It was thoroughly mixed by tilting the bottoms of the tubes, then incubated at 37°C for 5 minutes on a waterbath. In a spectrophotometer set to 540nm wavelength, the absorption of the standard and test samples was compared to the blank.

Determination of High-Density Lipoprotein (HDL) Cholesterol in Serum

HDL-C was quantified using an enzymatic technique (Tietz, 1987)

Principle

By adding phosphotungstic acid in the presence of magnesium ions, low density lipoprotein (LDL and VLDL) and chylomicron fractions can be quantitatively precipitated.

Following centrifugation, an enzymatic technique is used to quantify the cholesterol concentration in the HDL fraction that remains in the supernatant.

Procedure

The blood samples were centrifuged for five minutes at 12,000 rpm after being put into tubes. The serum was separated and organized into control, standard, and sample tubes. 200µl of precipitating reagent (R) and 20µl of sample were placed in the test tubes, 20ul of standard in the standard tube, and distilled water in the blank tube. By tilting the bottoms of the tubes, it was adequately mixed and allowed to stand for 10 minutes at room temperature. The tubes were spun at 12,000 rpm for 2 minutes.

The clear supernatant was then removed and the HDL cholesterol level was measured.

Serum Triglycerides Determination

The enzymatic approach is used to quantify triglycerides (Fraser and Hearne, 1981).

Principle

After hydrolysis by enzyme and oxidation with lipases, measurement for triglycerides is taken. Under the catalytic effect of peroxidase, a quinoneimine is generated by combining hydrogen peroxide, 4-aminophenazone, and 4-chlorophenol. The amount of color generated in the sample is related to the concentration of triglycerides.

Procedure

The experiment circumstances were taken into account. Pure water was used to zero the instrument. As a blank, standard, and test, 1ml of triglyceride reagent was applied to the tubes. The tubes were filled with 10 l of standard and sample, mixed, and incubated at 370C for 5 minutes. The absorbance of samples was measured against a blank using a 1cm light path (cuvette) at 505 nm wavelength.

Low-Density Cholesterol Measurement (LDL-C)

Friedewald's equation was used in the determination of LDL cholesterol (Friedwald et al., 1972).

LDL – Cholesterol = Total Cholesterol – (TG/2.2) – HDL

The following standard formulas were used to determine the atherogenic index and lipid ratios:

AIP = Log (TG/ HDL-C): Reference Range = Low risk (-0.3 – 0.1), Moderate risk (0.1 – 0.24), High risk (>0.24) (World Health Organization (WHO), 2014)

CRI-1 = TC/HDL-C: Reference Range = Low risk (< 1-3), Moderate risk (3-5), High risk (>5) (WHO, 2014).

CRI-II = LDL-C /HDL-C: Reference Range =Low risk (< 1-3), Moderate risk (3- 5), High risk (> 5) (WHO, 2014).

AC = TC – HDL-C/ HDL-C: (Reference >3.0) (WHO, 2014)

Apo B/ Apo A1: Reference range = (low risk 0.30, moderate risk 0.6 and high risk 0.8) (WHO, 2014).

Statistical analysis

GraphPad Prism Version 8.0.2.263 was used to analyze the data collected throughout the investigation. The mean and standard deviation were used to represent the data. The one-way analysis of variance (ANOVA) was used to compare the means (ANOVA). At $p<0.05$, the Tukey comparison test was employed to ensure that there were significant differences between the groups.

Result

Effect of Gravidity on Biochemical Parameters in Normotensives 3rd Trimester

Tables 1.0 (a) and 1.0 (b) show the effect of gravidity on LDL and apo B in Normotensive pregnant women at 3rd trimester. Gravidity showed that LDL was significantly higher in grand multigravida of pregnant women at 3rd trimester compared with primigravida and mutigravida of pregnant women at 3rd trimester ($p=0.0174$). Apo B was significantly higher in grand multigravida of pregnant women

at 3rd trimester compared with primigravida and mutigravida of pregnant women at 3rd trimester (p=0.0473). There was no significance using post Hoc for the two parameters.

Table 1.0 (a): Effect of Gravidity on Biochemical Parameters in Normotensives 3rd Trimester

Parameters	**Normotensive Women**			***P*-value**	**F-value**
	Primigravida (1) **n = 21**	**Multigravida(>1)** **n = 22**	**Grand Multigravida (≥ 5)** **n = 7**		
TC(mmol/l)	4.53 ± 0.43	4.85 ± 0.53	4.87 ± 0.43	0.0688	2.8340
TG (mmol/l)	1.39 ± 0.34	1.47 ± 0.30	1.43 ± 0.25	0.6602	0.4190
HDL(mmol/l)	0.89 ± 0.26	1.01 ± 0.15	0.87 ± 0.13	0.0954	2.4710
LDL (mmol/l)	3.05 ± 0.15	3.20 ± 0.34	3.37 ± 0.24	0.0174	4.4250
APoA1 (mg/dl)	340.90 ± 34.34	358.90 ± 33.51	370.90 ± 14.86	0.0622	2.9490
APoB (mg/dl)	140.30 ± 30.71	158.20 ± 28.20	172.00 ± 43.19	0.0473	3.2590
CRP(mg/L)	4.67 ± 1.30	5.96 ± 2.32	5.14 ± 1.64	0.0831	2.6240
VLDL (mmol/l)	0.63 ± 0.15	0.67 ± 0.14	0.65 ± 0.11	0.6602	0.4190
UA (mg/dl)	4.88 ± 0.99	4.88 ± 0.71	4.93 ± 0.42	0.9888	0.0113

Table 1.0 (b): The ANOVA Post – Hoc Findings Using Turkey Multiple Comparison Test for Effect of Gravidity on Biochemical parameters (Normotensive 3rd Trimester)

Parameters	**Primagravida vs.**	**Primagravida vs**	**Multigravida vs**

	Multigravida	Grand multigravida	Grand Multigravida
TC(mmol/l)	0.0818	0.2394	0.9942
TG (mmol/l)	0.6334	0.9468	0.9430
HDL(mmol/l)	0.1204	0.9855	0.2648
LDL (mmol/l)	0.1640	0.0181	0.2773
APoA1 (mg/dl)	0.1686	0.0927	0.6676
APoB (mg/dl)	0.1617	0.0659	0.5782
CRP(mg/L)	0.0690	0.8311	0.5700
VLDL (mmol/l)	0.6334	0.9468	0.9430
UA (mg/dl)	0.9997	0.9882	0.9905

Effect of Gravidity on Biochemical Parameters in Hypertensive 3rd Trimester

Tables 2.0 (a) and 2.0 (b) represents the effect of gravidity on biochemical parameters (TC, TG, HDL, LDL, UA, CRP, VLDL, APO A1, and APO B) in hypertensive pregnant women at 3rd trimester. Gravidity showed no significant effect on all the biochemical parameters in Hypertensive pregnant women at 3rd trimester ($p<0.05$).

Table 2.0 (a): Effect of Gravidity on Biochemical Parameters in Hypertensive 3rd Trimester

Parameters		**Hypertensive Women**		***P*-value**	**F-value**
	Primigravida (1) **n = 20**	**Multigravida(>1)** **n=16**	**Grand Multigravida (≥ 5)** **n = 14**		
TC(mmol/l)	4.98 ± 0.46	4.81 ± 0.44	4.89 ± 0.45	0.5438	0.6171
TG (mmol/l)	1.53 ± 0.37	1.43 ± 0.27	1.65 ± 0.38	0.2101	1.6130
HDL(mmol/l)	0.94 ± 0.27	0.93 ± 0.11	0.99 ± 0.17	0.6342	0.4599

LDL (mmol/l)	3.37 ± 0.28	3.23 ± 0.33	3.17 ± 0.25	0.1200	2.2180
APoA1 (mg/dl)	382.00 ± 21.10	380.30 ± 17.60	375.70 ± 21.58	0.6670	0.4085
APoB (mg/dl)	140.50 ± 17.21	136.40 ± 10.01	135.90 ± 17.04	0.6152	0.4908
CRP(mg/L)	7.90 ± 2.32	7.62 ± 2.18	8.06 ± 2.39	0.8639	0.1468
VLDL (mmol/l)	0.70 ± 0.17	0.65 ± 0.12	0.75 ± 0.17	0.2101	0.6130
UA (mg/dl)	4.53 ± 0.38	4.83 ± 0.40	4.72 ± 0.39	0.0815	2.6460

Table 2.0 (b): The ANOVA Post – Hoc Findings Using Turkey Multiple Comparison Test for Effect of Gravidity on Biochemical parameters (Hypertensive 3rd Trimester)

Parameters	**Primagravida vs. Multigravida**	**Primagravida vs Grand multigravida**	**Multigravida vs Grand Multigravida**
TC(mmol/l)	0.5144	0.8447	0.8779
TG (mmol/l)	0.6339	0.5768	0.1819
HDL(mmol/l)	0.9735	0.7357	0.6332
LDL (mmol/l)	0.2999	0.1289	0.8678
APoA1 (mg/dl)	0.9639	0.6471	0.8133
APoB (mg/dl)	0.7079	0.6588	0.9940
CRP(mg/L)	0.9292	0.9770	0.8568
VLDL (mmol/l)	0.6339	0.5768	0.1819
UA (mg/dl)	0.0736	0.3471	0.7510

Discussion

This study analysed Total Cholesterol (TC), triglyceride (TG), High Density Lipoprotein (HDL), Apolipoprotein A1 and B (ApoA1) (ApoB), Low Density Lipoprotein (LDL), Very Low Density Lipoprotein (VLDL) and Uric Acid (UA).

All lipids and apolipoproteins have been shown to be significantly elevated in pregnancy, the most prominent change being a 2.7-fold increase in triglycerides in the third trimester (Rymer *et al*., 2002). As pregnancy progresses, lipids levels steadily increase during the pregnancy with a noticeable increase in the third trimester (Wiznitzer *et al*., 2009). This lipid metabolism throughout pregnancy allows for proper nutrients for the fetus.

Gravidity showed that LDL was significantly higher in grand multigravida of pregnant women at 3rd trimester compared with primigravida and mutigravida of pregnant women at 3rd trimester ($p=0.0174$). this suggests that the more the number of pregnancy, the higher the LDL concentration in Normotensive pregnant women in their 3rd trimester. This is capable of predisposing these pregnant women to CVD. The result also showed that Apo B which is an essential structural component of very low-density lipoproteins (VLDLs), intermediate-density lipoproteins (IDLs) and LDL was significantly higher in grand multigravida of normotensive pregnant women at 3rd trimester compared with primigravida and mutigravida of normotensivepregnant women at 3rd trimester ($p=0.0473$). This also indicates that as the number of pregnancy increases, the ApoB concentration also increase significantly from primigravida to multigravida and Grand multigravida in normotensive pregnant women in their 3rd trimester. This also predisposes these pregnant women to CVD. The result also showed that there was no significance difference when comparing the different gravidity age among themselves using post Hoc. There was also no significant difference in other biochemical parameters such as TC, TG, HDL, ApoA1, CRP, VLDL and UA in normotensive pregnant women at 3rd trimester.

Gravidity showed no significant effect on all the biochemical parameters in Hypertensive pregnant women at 3rd trimester ($p<0.05$). This suggests that gravidity has no effect on the biochemical parameters of hypertensive pregnant women in their 3rd trimester.

This work disagrees with Enquobahrie *et al*. (2004) that there was a significant rise in LDL concentration in the hypertensive women than in normal pregnant women. But in this study the rise in LDL was seen in normotensive rather than hypertensive women. This work agrees with Enquobahrie (2009) and Clausen (2001) that there was no significant difference in mean total cholesterol concentration in the hypertensive group when compared with that in normal pregnant group. The findings of Tam *et al*. (2018) recorded that maternal serum uric acid concentration was a good prognostic factor for monitoring, and prognosis of fetal/neonatal outcomes in women with preeclampsia/eclampsia. They also observed a relationship between high uric acid level and the risk of preterm birth, low Apgar index, and neonatal death, but not fetal death, but there was no effect of gravidity on uric acid concentration recorded in both the normotensive and hypertensive group in this study, therefore this study is not in consonance with their work. The difference observed in this study from other works is probably the age gestation. Most study focused on first and second trimester while this present study focused on third trimester pregnancy.

This study agree in part with Timur *et al.* (2016). In their work on the Apolipoprotein levels in women with preeclampsia, they found out that Apo B and Apo B / Apo A1 were significantly

increased in normotensives, but Apo A1 was significantly decreased and advocated that Apo A1 and Apo B/Apo A1 ratio be useful markers in patients with preeclampsia. However, encouraged further research to confirm the findings.

Conclusion

At the end of this study conducted at Rivers State University Teaching Hospital, a discovery showing that gravidity had no influence on biochemical markers in normotensive and hypertensive pregnant women in the third trimester was made.

Ethical Clearance and Consent

The Ethics Committee of the Rivers State Ministry of Health provided ethical clearance.

Before being authorized to participate in the study, all eligible subjects signed an informed consent form

References

Al-Gubory, K., Fowler. P.A. & Garrel, C. (2010). The roles of cellular reactive oxygen species, oxidative stress and antioxidants in pregnancy outcomes. *Cell Biology*, 42,1634–50.

Boullart, A.C.I., de-Graaf, J., Stalenhoef, A.F. (2012). Serum triglycerides and risk of cardiovascular disease. *Biochemistry and Biophysics Acta*. 1821(5),867–75.

Clausen, T., Đurovic, S. & Henriksen, T. (2001). Dyslipidemia in early second trimester is mainly a feature of women with early onset preeclampsia. *British Journal of Obstetrics and Gyneacology*, 108,1081–7.

Dashty, M., Motazacker, M.M., Levels, J., de-Vries, M., Mahmoudi, M. & Peppelenbosch, M.P. (2014). Proteome of human plasma very low-density lipoprotein and low-density lipoprotein exhibits a link with coagulation and lipid metabolism. *Thrombosis and Haemostasis*, 23(111),518–30.

Enquobaline, D.A., Williams, M.A., Butler, C.L., Frederick, J.D., Muller, R.S. & Luthy, D. (2004). Maternal Plasma Lipid Concentrations in Early Pregnancy and Risk of Preeclampsia.*American Journal Hypertension, 17, 574 – 581.*

Garduno-Alanís, A., Vázquez-de, Anda, G., Valdés-Ramos, R., Talavera, J.O., Herrera-Villalobos, J.E. & Huitrón-Bravo, G.G. (2015). Predictors of hyperlipidemia during the first half of pregnancy in Mexican women. *Nutrition and Hospitality*, 31,508–13.

Gordon, T., Castelli, W.P., Hjortland, M.C., Kannel, W.B. & Dawber, T.R. (1977). High density lipoprotein as a protective factor against coronary heart disease. The Framingham Study. *American Journal of Medicine*, 62(5),707–14.11.

Goldberg, I.J., Eckel, R.H. & McPherson, R. (2011). Triglycerides and heart disease: still a hypothesis? *Arteriosclerosis, Thrombosis and Vasculature*, 31(8),1716–25.

Huda, M.M., Leung, T.M., Zhou, L., & Abu- Merhi, S. (2009). Regulating intestinal function to reduce Atherogenic Lipoproteins.*Clinical Lipidology. 8(4), 481-490.*

Kaneva, A.M., Potolitsyna,, N.N., Bojko, E.R. & Odland, J. (2015). The Apolipoprotein B/Apolipoprotein A-I ratio as a potential marker of plasma atherogenicity. *Disease Markers*, 2015,591454.

Kannel, W.B., Gordon, T. & Castelli, W.P. (1981). Role of lipids and lipoprotein fractions in atherogenesis: the Framingham study. *Progcress in Lipid Research*, 20,339–48.

Kim, Y.j., Park, H., Lee, H.Y., Ahn, Y., Ha, E.H. & Suh, S.H. (2007). Paraoxonase gene polymorphism, serum lipid, and oxidized low-density lipoprotein in preeclampsia. *European Journal of Obstetrics and Gynecology*, 133,47–52.

Macekova, D., Kovac, G., Hinst, J., Illek, B., Pereckova, J., Baraskova, Z. (2010). Lipid peroxidation and biochemical parameters in maternal pre-delivery and post-delivery plasma. *Biologia*, 65,170–4.

Murphy, A.J. & Woollard, K.J. (2010). High-density lipoprotein: a potent inhibitor of inflammation. *Clinical Experiment in Pharmacology and Physiology*, 37(7),710–8.

Ogura, K., Miyatake, T., Fukui, O., Nakamura, T., Kameda, T., & Yoshino, G. (2002). Low-density lipoprotein particle diameter in normal pregnancy and preeclampsia. *Journal of Atherosclererosis and Thrombosis*, 9,42–7.

Rymer, J., Constable, S., Lumb, P. & Crook, M. (2002). Serum lipoprotein (a) and apolipoproteins during pregnancy and postpartum in normal women. *Journal of Obstetrics and Gynaecology.* 22(3),256–9.

Tam, M., Lelong, H., Nguyennam, L., Phan, D.D., Lehuy, V.Q. and Nguyen A. (2018).Maternal Serum Uric Acid Concentration and Pregnancy Outcomes in Women with Preeclampsia/Eclampsia.*International Journal of Gynecology and Obstetrics, 144, 1.*

Timur, H., Daglar, H.K., Kara, O., Kirbas, A., Inal, H.A., Turkmen, G.G., Yilmaz, Z., Elmas, B. and Uygur, D. (2016).A Study of Serum Apo A1 and Apo B -100 Levels in Women with Preeclampsia.*Pregnancy Hypertension, 6 (2), 121 – 125*.

Wild, R., Weedin, E.A. & Wilson, D. (2015). Dyslipidemia in pregnancy. *Cardiology and Clinicals*, 33,209–15.

Wierzbicki, A.S., Clarke, R.E., Viljoen, A. & Mikhailidis, D.P. (2012). Triglycerides: a case for treatment? Current Opinion on Cardiology. 27(4),398–404.

Wiznitzer, A., Mayer, A., Novack, V., Sheiner, E., Gilutz, H. & Malhotra, A. (2009). Association of lipid levels during gestation with preeclampsia and gestational diabetes mellitus: a population-based study. *American Journal of Obstetrics and Gynecology*, 201(5),482 1–4828