Original Research Article

Levels of Oxidative Stress Marker Malondialdehyde and Some Lipid Fractions in Women Diagnosed with Pre-eclampsia in a Rural Hospital in South East Nigeria

ABSTRACT

BACKGROUND: In recent times, there has been an increasing prevalence in the incidence of pre-eclampsia globally, but there are conflicting reports on the relationship between malondialdehyde and pre-eclampsia. The disturbance in the metabolism of antioxidant and excess lipid peroxidation may be a contributing factor in the development of preeclampsia.

AIM: This was done to compare the serum MDA status and some lipid fractions in women with preeclampsia and normal pregnancy in a rural hospital of Imo State Nigeria.

METHOD: This was a cross sectional study of 50 preeclampsia and 50 normotensive pregnant women attending the Dept. of Medicine and Antenatal clinic of specialist Hospital Umuguma, Owerri Imo State. The study protocol was reviewed and the ethical committee and participants gave their consent.

RESULT: The mean MDA value was significantly higher in the preeclampsia group against the control ($P<0.05$). In the lipid fraction, TG, VLDL-C, LDL were higher in preeclamptic patients when compared to the controls ($P<0.05$). The HDL-C was lower in preeclamptic subjects when compared with the control ($P<0.05$). There was no significant difference in the level of the Total Cholesterols between the group ($P>0.05$).

CONCLUSION: The study showed significant increase in lipid per oxidation and altered lipid metabolism in pregnant women with preeclampsia and buttress the failure of compensatory antioxidant functions in pregnant women with the disorder.

Key words: preeclampsia, lipid peroxidation, malondialdehyde.

Introduction

The exact cause of pre-eclampsia, often referred to as a disease of theories, remains unknown. However, the placenta play's a major role in the pathophysiology of pre-eclampsia, and it has long been referred to as a placental condition, (1) in normal pregnancy major alterations occur in the spiral arteries to allow increased blood supply to the intervillous space in order to meet the needs of the feto-placental unit during the later stages of pregnancy. Pre-eclampsia is characterized by failure of spiral artery remodeling (2), a phenomenon associated with incomplete endovascular trophoblast invasion in early pregnancy (3). That results in a dramatic reduction in blood flow into the intervillous space (2,3). Although, the placenta is necessary for pre-eclampsia, poor placentation is not the cause of pre-eclampsia, but rather an important predisposing factor (1,4). Other pregnancies such as those complicated by intrauterine growth restriction and a subgroup of pattern deliveries are also associated with abnormal placentation but do not develop pre-eclampsia (5,6). This paradox has led to the hypothesis that pre-eclampsia is a two stage disorder, with reduced placental perfusion representing stage one (1,7), while stage two refers to the multi-systemic disorder or maternal syndrome produced in response to reduced placental perfusion (8) that is influenced by genetic or environmental maternal constitutional factors. Endothelial activation appears to be central to the pathophysiological changes associated with pre-eclampsia (9,10,11) with circulating markers of endothelial activation increased in pre-eclampsia (12).

The question remains as to the nature of the link between poor placentation and endothelial activation for which a number of theories have been put forward (13 10,1,14). Some studies suggest that hypoxia resulting from inadequate perfusion upregulates SFT+1, a VEGF and PIGF antagonist, leading to a damaged maternal endothelium and restriction of placental growth.(13,15) It has been proposed that an unknown factor excreted from the placenta is central to the pathogenesis of pre-eclampsia with candidates for this unknown factor including placental debris, apoptotic fragments, lipid peroxidation products and other reactive oxygen species, all of which are able to induce maternal oxidative stress directly or indirectly (16,1,7). Many of the predisposing factors for preeclampsia are also known risk factors for atherosclerosis. Indeed, pre-eclampsia has been suggested to associated with altered athrogenic lipid pattern, with increased plasma Triacylglycerol concentration and decreased HDL-cholesterol concentration evident before clinical manifestations of the disease (17,18,19). Reactive oxygen species degrade polyunsaturated lipids, forming malondialdehyde (20). The compound is a reactive aldehyde

which is one of the many reactive electrophile species that can cause toxic stress in cells and form covalent protein adducts referred to as advanced lipid-oxidation end-product (ALE), in analogy to advanced gylcation end-product (AGE), (21). Malondialdehyde (MDA), which is a product of lipid peroxidation, has been reported to be increased in certain disease conditions including preeclampsia (11,22) which could lead to oxidative stress. The production of this aldehyde serves as a biomarker to measure the level of oxidative stress in a subject (21). Malondialdehyde reacts with deoxyadenosine and deoxyguanosine in DNA, forming DNA adducts, the primary one being M1G, which is mutagenic (23). The guanidine group of arginine residues condenses with malondialdehyde to give 2-amino antipyrine. Malondialdehyde is highly reactive and potentially mutagenic. It has been found in heated edible oils such sunflower and palm oil (24).

In this current study we looked at the level of this oxidative maker and some lipid fractions in preeclampsia and normotensive pregnant women in a rural hospital in Nigeria.

MATERIALS AND METHOD

Study design

This was a cross-sectional randomized study designed to investigate the levels Malondialdehyde and some lipid fractions in pre-eclampsia and normotensive pregnant women.

Study area

This study was carried out in Department of Chemical Pathology, Nnamdi Azikiwe University Nnewi Campus, located within the South-Eastern part of Nigeria. The climate of the area is tropical with mean daily temperature of 29±50°C for most of the year. The annual rainfall is between 217 and 240cm with distinct wet and dry season.

Study population

The study population involves pregnant women attending the Department of Medicine and Antenatal care of Specialist Hospital, Umuguma, Owerri Imo State, Nigeria. Calculated sample size for each group (n) was 50 using the formula n = 2Z2PQ/d2 using 95% confidence interval with 0.05 precision. A prevalence of 1.7% of preeclampsia in Nnewi a neighboring town to Owerri as reported by Mbachu et al(25) was employed. A total of 100 pregnant women were therefore recruited into the study who fulfill the inclusion criteria (comprising 50 pre-eclampsia and 50 normotensive group) informed consent was obtained from each of the subjects after the study was explained to them.

Exclusion criteria

These include lactating mothers, smoking, diabetic and alcoholic individuals, women with acute and chronic illness or taking any other medications that could potentially affect level of the measured parameters were also excluded.

Blood sample collection

5mls of blood was drawn from the cubital vein using a sterile needle and syringe into an appropriate tube. The samples in plain tubes were allowed to clot undisturbed and serum were separated by centrifugation for 10mins at 4,000rpm and stored at -20°C until time of analysis.

Biochemical/laboratory analysis

All reagents used were of analytical grade (AR). Serum MDA was determined using albro et al(26) methodology. Fasting lipid profile was assessed using commercially available kits (Randox), serum total cholesterol and high density lipoprotein HDLc, was determined by cholesterol oxidase method Allain *et al* (27), serum triglyceride by glycerol kinase method of Tinder (28) and LDLc was calculated using Friedwald formula Friedwald (29). Quality control was ensured in the analysis of the samples by the use of commercially prepared samples. The same sensitivity and specificity were maintained.

Statistical analysis

Data collected was analyzed using the Statistical Package for Social Sciences (SPSS) software for windows version 20.0. Proportions were compared with Pearson Chi-square for categorical variables while means were compared using students t-test. Data were presented using tables. Values were set at 95% confidence level, a P-value of <0.05 was considered to be significant.

RESULTS

The maternal anthropometric parameters were compared in **table 1.** The Mean age was 25 years, mean gestational age was 35 weeks, mean BMI was 25kgm^2 and mean HBC g/l was 10.0 in preeclamptic and controls which were not statistically significant. ($p>0.05$) In preeclamptic the mean systolic BP was 147.04±5.9mmHg while in controls mean systolic BP was 115.96±4.9mmHg. In preeclamptic mean diastolic BP was 96.96±6.54mmHg while in controls mean diastolic BP was 80.04±9.87mm Hg. Mean Systolic and diastolic BP were statistically significantly higher in preeclamptic when compared to controls ($p<0.05$).

In **table 1** Mean cholesterol levels were within reference range in preeclamptic and controls (4.34 mmol/l±3.62 versus 4.51mmol/l±3.4) and were not statistically significant ($p>0.05$). The Mean HDL-C, levels were (0.95mmol/l±3.85 versus 1.32mmol/l±2.7) statistically significantly lower in preeclamptic when compared to normal controls ($p<0.05$). The Mean LDL-C levels

were (3.5mmol/l±15.1 versus 2.45mmol/l±8.9) statistically significantly higher in preeclamptic when compared to normal controls ($p<0.05$). Mean triglycerides levels were (2.90mmol/l±0.46 versus 1.33±3.8) statistically significantly higher in preeclamptic when compared to normal controls ($p<0.05$). The mean VLDL-C levels were (1.31mmol/l±0.09 versus 0.60mmol/l±0.98) statistically significant higher in preeclamptic when compared to the normotensive controls. The mean MDA was elevated in preeclamptic subjects when compared to the normotensive controls (3.19nmol±0.25 versus 1.15nmol±0.076) which was statistically significant ($p<0.05$).

Table 1

Comparison of maternal anthropometric characteristics between pre-eclampsia and normotensive pregnant women

Parameter	Preeclampsia(n=50)	Control(n=50)	t-test	P-value
Age(yrs.)	25.0±1.64	25.5±1.70	-1.497	P>0.05
Gestational age (week) at sampling	35.23±1.64	34.64±0.95	5.289	p>0.05
Gravida in (%) primi multi	 34(52.4) 16(28)	 28(40) 22(35)	 _ _	 _ _
BMI(kg/m2)	25.45±1.66	25.94±1.77	-1.427	P>0.05
SBP(mmHg)	147.04±5.9	115.96±4.9	28.66	P<0.05
DBP(mmHg)	96.96±6.54	80.04±9.87	10.11	P<0.05
HBC(g/dl)	10.05±0.58	10.33±0.48	-2.63	P>0.05
Proteinuria primi multi	 2+(34) 3+(16)	 0 0	 _ _	 _ _

BMI: Body mass index; **HBC**: Haemoglobin Concentration; **SBP:** Systolic Blood Pressure; **DBP:** Diastolic Blood Pressure; Values are mean ± standard deviation, $P<0.05$, n= total number of patients.

Anthropometric parameters

Table 1 shows the clinical data on the pre-eclamptic women and healthy controls. The mean Age, BMI and HBC, of all preeclampsia patients was not statistically significantly different from those of control subjects ($p>0.05$). There was a statistical significance difference ($p<0.05$) between the Systolic and Diastolic Blood Pressures of the Test and the Control group. The mean maternal and gestational ages of the subjects and controls were similar. Subjects had different gravida distribution and had nearly equal proteinuria.

Table 2

Comparison of serum concentration of MDA and some lipid fractions in preeclamptic and normotensive pregnant women

Parameter	Preeclampsia(n=50)	Control(n=50)	p-value
MDA(nmol/ml)	3.19±0.25	1.15±0.076	P<0.05
T-CHOL(mmol/l)	4.34±3.62	4.51±3.4	P>0.05
TG(mmol/l)	2.90±0.46	1.33±3.8	P<0.05
LDL-C(mmol/l)	3.5±2.1	2.45±3.9	P<005
VLDL-C(mmol/l)	1.31±0.09	0.60±0.98	P<0.05
HDL-C(mmol/l)	0.95±3.85	1.32±2.7	P<0.05

Biochemical/Laboratory Parameters

Table 2 shows the mean ±SD value of serum MDA and some lipid fraction. Serum MDA were significantly lower ($p<0.05$) in preeclampsia groups in comparison to the control group. The level of serum triglyceride, low density lipoprotein, very low density lipoprotein was significantly lower ($p<0.05$) in normotensive pregnant women when compared to that of pre-eclampsia women. The level of High density cholesterol was significantly lower ($p<0.05$) in pre-eclampsia women when compared to the normotensive pregnant women. There was no statistical difference in the total cholesterol of preeclampsia and normotensive pregnant women ($p>0.05$).

Discussion

Lipid per-oxidation can be defined as the oxidative deterioration of lipids containing a number of carbon-carbon bonds (7,30,14). In pre-eclampsia, oxidative stress is believed to result from

increased formation of lipid peroxides, reactive oxygen species and superoxide anion radicals, leading to an imbalance in production between per-oxidant and antioxidant defenses. These consequently result in endothelial dysfunction, platelet and neutrophil activation, with altered lipid synthesis toward a decreased in prostaglandin and thromboxane A_2 ratio (10). The resulting imbalance in prostaglandin cascade, leads to enhanced multi systemic vasospasm phenomenon in the kidneys, brain, uterus and placenta (13,16). The results obtained from this study showed mean systolic blood pressure of 147.04±5.9mmHg and a Diastolic blood pressure of 96.96±6.54mmHg in preeclampsia patients in contrast to a systolic blood pressure of 115.96±4.9mmHg and a diastolic blood pressure of 80.04±9.87mmHg in control subjects. This confirms an earlier investigation by Gifford et al. (31) who reported a systolic blood pressure of 140mmHg and a diastolic blood pressure of 90mmHg. The slight difference in Gifford et al. (31) results and the value obtained in this study may be due to racial differences. The implication of this is that pathogenesis and development of complication may be more sever in preeclampsia patients in our environment compared to Caucasians.

Studies has shown that women with greater body mass index (BMI) in pregnancy are more likely to become hypertensive than those with lower BMI (32), but the comparable body mass index (BMI) observed this present study ruled out the influence of the parameter (i.e. body mass index) on the aetiology or severity of preeclampsia in pregnant women.

The observation of some lipid fractions of preeclamptic subjects in our study shows significantly higher serum concentrations of triglycerides, LDL-C, VLDL-C and lower serum concentrations of HDL-C. This indicates a risk factor in the development of preeclampsia. It has been suggested that hypertriglyceridemia is a risk factor for preeclampsia. Increased triglyceride levels seem to elevate the risk of placental vascular disorders,(33) which leads to the development of endothelial dysfunction, atherosclerosis and thrombosis.(34) The development of atherosclerosis in the placental spiral arteries of preeclamptic women indicates that elevated levels of triglycerides are involved in this disorder.(35) From literatures, the principle modulator of this hypertriglyceridemia is estrogen as pregnancy is associated with hyperoestrogenaemia.(2,36) Estrogen induces hepatic biosynthesis of endogenous triglycerides, which is carried by VLDL. This process may be modulated by hyperinsulinism in pregnancy.(37) Hypertriglyceridemia may be associated with hypercoagulability.(38) Furthermore, hypertriglyceridemia has been

suggested to be involved in the pathogenesis of hypertensive disorders during pregnancy.(17,18,19)

The findings from this study showed increased lipid peroxidation indicating altered levels of antioxidant status in preeclamptic women. These are consistent with the conclusions from studies in other population beyond Nigeria. (11,20,39). Although some other studies had reported no significant difference in the levels of lipid peroxidation between gestational age matched cases and controls. Striking patterns noticed in this study are relatively higher MDA levels in pre-eclamptic patients and low levels in control groups. The mean MDA in the preeclamptic patients and normotensive pregnant control in this study were 3.19±0.25 and 1.15±0.076 respectively. These values are much lower than the reports from other regions of the world, as reported by Howlader et al, (40) and Begun, (41). However, the findings in this study are similar and in consonant to that of Nnodim et al, (20) and Ilechukwu et al. (9) in south east Nigeria population. Which they reported values of 3.91nmol, 1.68nmol and 2.83±0.9nmol, 1.96±0.63nmol respectively. Also Adetunji et al, (42) reported values of 2.96±0.75 and 1.23±0.12nmol/ml in their patient at Ladoke Akintola University (LAUTECH) Teaching Hospital, Osogbo, Nigeria. Furthermore this result is similar to that of Patil et al, (43) and Gohil et al (11) in India. However, this study was in contrast with the studies of Guptha et al. (44) in which they find no significant difference between preeclamptics and normotensive pregnant controls.

Conclusion

This study demonstrated significant increase in lipid membrane damage activities (lipid peroxidation), as evidence by rise of serum MDA in preeclamptic women. The study also buttresses the point that Preeclamptic women have altered lipid profile courtesy of abnormal lipid metabolism. Elevated triglyceride levels and it delayed clearance coupled with high blood pressure has been shown to play a role in the development of this disorder. The early detection of these abnormalities might help early diagnosis and management of pre eclampsia. We recommend the assessment of these parameters in both the primi and multi gravida women for early detection of altered metabolism, diagnosis and prevention of this disorder.

References

1. Redman C.W and Sargent I.L. Pre-eclampsia as an Inflammatory Response in Pre-eclampsia, Lancet (2003b), Pp. 101-112.
2. Brosens JA, Robertson WB and Dixon HG. The Role of Spiral Arteries in the Pathogensis of Pre-eclampsia, Obstetrics and Gynecology Annual (2004) 1-177-191.
3. Pijnenborg R, Luyton C, Vercruysse L and Van Assche F.A. Attachment and Differentiation Invitro of Trophoblast from Normal and Pre-eclamptic Human Placentas. American Journal of Obstetrics and Gynecology 2008 372, 934-799.
4. Sibai B.M, Dekk G and Kupfermine M. Pre-eclampsia. Lancet. American Journal of Obstetrics and Gynecology 2005; 365, 785-799.
5. Khong T.Y, De Wolf F, Robertism W.B and Brosans. Inadequate Maternal Vascular Response to Placentation in Pregnancies Complicated by Pre-eclampsia and by Small-for-Gestational Age Infants. British Journal of Obstetrics and Gynecology 1986; 93, 1049-1059.
6. Arias F, Rodriquez L, Rayne SC and Kraus FT. Maternal Placental Vasculopathy and Infaction: Two Distinct Subgroups among Patients with Preterm Labour and Preterm Ruptured Membranes. American Journal of Obstetrics and Gynecology, 1993; 168, 585-591.
7. Redman C.W and Sargent I.L. Pre-eclampsia as an Inflammatory Response. In Pre-eclampsia. Lancet 2003b; Pp. 101-112.
8. Ness R.B and Roberts. Heterogeneous Causes Constituting the Single Syndrome of Pre-eclampsia: a Hypothesis and its Implication. American Journal of Obstetrics and Gynecology 2004; 175, 1365-1370.
9. Ilechukwu OU, Onuegbu JA, Olisekodiaka JM, Obi-Ezeani CN. Evaluation of Plasma Selenium, Zinc and Malondialdehyde Levels in Newly Diagnosed Preeclamptic Women at a Teaching Hospital. Ulutas Med J. 2021; 7(2):8691 DOI: 10.5455/umj.20210422011242.
10. Roberts J.M and Copper D.W (2001), Pathogenesis and Genetics of Pre-eclampsia, Lancet 357, 53-56.
11. Gohil JT, Patel PK, ;Gupta P. Evaluation of oxidative stress and antioxidant defence in subject of Preeclampsia. J Obstet Gynaecol. 2012;61:638-640

12. Taylor R.N, DeGroot C, Chi Y.K and LIM K.H. Circulating Factors as Markers and Mediators of Endothelial Cell Dysfunction in Pre-eclampsia. Seminars in Reproductive Endocrinology 2005; 16, 17-31.
13. Magee LA, Helewa M, Pey E, von Dadelszen P. The hypertensive disorder of pregnancy. Best Pract Res Clin Obstet Gynecol. 2015;29:643-657.
14. Levine R.J and Karumanchi S.A. Circulating Angiogenic Factors in Pre-eclampsia. Clinical Obstetrics and Gynecology 2005; 48, 372-386.
15. American College of Obstetricians and Gynaecologists. Hypertension in Pregnancy. Task Force on Hypertension and Pregnancy. 2013;1122-1133.
16. Oladape O, Adetoro O, Ekele B, Chama C, Etok S, Aboyeji A, Gulmezoglu A. When getting there is not enough: A nationwide cross section study of 998 maternal deaths and 1451 near-misses in public tertiary hospital in a low income country. Int J Obstet Gynecol. 2015;10:10528-13458.
17. Potter J.M, Nestel P.J. The Hyperlipdiemia of Pregnancy in Normal and Complicated Pregnancies. American Journal of Obstetrics and Gynecology 1979; 133, 165-170.
18. Hubal C.A, McLaughlin M.K, Evans R.W, Hauth B.A, Sims C.J and Roberts J.M. Fasting Serum Triglycerides, Free Fatty Acids and Malondialdehyde are increased in Pre-eclampsia, are Positively co-related and Decrease within 48hours Postpartum. American Journal of Obstetrics and Gynecology 1996; 174, 975-982.
19. Satter N. The Potential Role of Dyslipidemia. In Pre-eclampsia, Lancet 2003; Pp. 147-157.
20. Nnodim J, Ihim A, Uduji HI. Alterations in antioxidant Enzyme and Malondialdehyde status in preeclampsia. Asian Pac J Trop Biomed. 2012;5750-5752.
21. Toescu V, Nuttall SL, Martin U, Nightingale P, Kendall MJ, Brydon P, et al. Changes in plasma lipids and markers of oxidative stress in normal pregnancy and pregnancy complicated by diabetes. Clin Sci 2004; 106(1):938.
22. Adiga U, D'Souza V, Kamath A, Mangalore N. Antioxidant activity and lipid peroxidation in preeclampsia. J Clin Med. 2007; 70:435-458
23. Ling Yu, Dong Li, Qin-ping et al. High Levels of Activin A Detected in Preeclamptic Placenta Induce Trophoblast Cell Apoptosis by Promoting Nodal Signaling. The Journal of Clinical Endocrinology & Metabolism. 2012;97(8):E1370-9.

24. Aminuddin NA, Sutan R and Mahdy ZA (2021) Role of Palm Oil Vitamin E in Preventing Pre-eclampsia: A Secondary Analysis of a Randomized Clinical Trial Following ISSHP Reclassification. Front. Med. 7:596405. doi: 10.3389/fmed.2020.596405.
25. Mbachu I, Udigwe GO, Okafor CI, Umeonunihu OS, Ezeama C, Eleje GU. The pattern and obstetric outcome of hypertensive disorders of pregnancy in Nnewi, Nigeria. Niger J Med 2013; 22(2):117–22 PMID: 23829122.
26. Albro P.W. Corbett J.T., and Schroeder E.T., (1986). Aplication of the Thiobarbituric acid to the measurement of lipid per oxidation products in "microscopes" Journal of Chemical and Biological Interactions 86:185-194.
27. Allen CC, Poon LS, Chan CS, Richmond W, Fu PC. (1974). Enzymatic determination of total Serum Cholesterol. Clinical chemistry. 20:470-475.
28. Trinder P (1969). Determination of Glucose in Blood Using Glucose Oxidase with an Alternative Oxygen Acceptor. Annals of clinical biochemistry. 6-24
29. Friedwald WT, Levy RI, Fredrickson DS (1972). Estimation of the concentration of low density lipoprotein cholesterol in plasma without use of the preparative ultracentrifuge. Clinical Chemistry. 18 (6):499-502.
30. Rice-Evans C. and burdon R, (1993). Prognosis of lipid. Research. 32:71-110
31. Gifford R.W, August P.A, Cunningham G, Green L.A, Lindheimer M.D, McNellis D, Roberts J.M, Sibai B.M, and Taler S.J.(2000). Report of the national high blood pressure, education program working group on high blood pressure in pregnancy. American Journal of Obstst. And Gynecology. 183;1-22.
32. Pipkin F.B, (2001). Risk factors for preeclampsia. N. Engl. Journal Med. 344:925-6.
33. Ziaei S, Bonab KM, Kazemnejad A. Serum lipid levels at 28-32 weeks gestation and hypertensive disorders. Hypertens Pregnancy. 2006;25(1):310.
34. Gofman J, Delalla O, Glazier F, et al. The serum lipoprotein transport system in health, metabolic disorders, atherosclerosis and coronary heart disease. J Clin Lipidol. 2007;1(2):104-41.
35. Becker H, Berle P, Wallé A et al. Influence of late gestation and early puerperium on lipid and carbohydrate metabolism in normal females. Acta Endocrinol (Copenh). 1971;67(3):570-6.

36. Atherosclerosis, American Association of Clinical Endocrinologists Task Force for Management of Dyslipidemia and Prevention of. American Association of Clinical Endocrinologists' Guidelines for Management of Dyslipidemia and Prevention of Atherosclerosis. Endocrine Practise. 2012;18(Suppl.1).
37. Adegoke OA, Iyare EE and Gbenebitse SO. Fasting plasma glucose and cholesterol levels in pregnant Nigerian women. Niger Postgrad Med J. 2003;10(1):32-6.
38. Kokia, E., Barkai, G., Reichman et al. Maternal serum lipid profile in pregnancies complicated by hypertensive disorders. J. Perinat. Med. 1990;18(6):473-8.
39. Bayhan G. Atamer Y, and Atamer A, 'significance of changes in lipid peroxides and antioxidant enzymes activities in pregnant women with preeclampsia and eclampsia". Clinical and Experimental Obstetrics and Gynecology. 27:142-146.
40. Howlader, Z.H, Kabir Y, Kahn T.A, Islam R, Begum F, and Huffman F.G,(2007) ' plasma lipid profile, lipid peroxidation and antioxidant status in preeclampsia and umcomplicated pregnancies in Bangladish' Journal of Medical science, 7(8)1276-1282.
41. Begum R.(2011), 'lipid peroxidation and antioxidant status in preeclamsia". Journal of Enam. Medical college. 1(2):56-59.
42. Adetunji O.A, and Dolapo P.O,(2013), Comparison of lipid peroxidation and antioxidant activities in preeclampsia and normal pregnancies in Nigerian population. International Journal of Clinical Medicine, vol 4 No(5) 3139-5.
43. Patil SB, Kodiwadmath MV, Kadiwadmath SM. Role of lipid peroxidation and enzymatic antioxidants in pregnancy induced hypertension. Clin Exp Obstet Gynaecol. 2007;34:239-241.
44. Guphta A, Kant S, Gupta SK, Prakash S, Kalaivani M, Pandav CS, et al. Serum FRAP levels and preeclampsia among pregnant women in a rural community of Northern India. J Clin Diag Res. 2016;102:12-15.