Original Article

Journal of Practical Biochemistry and Biophysics
Volume 1 Number 1, January - June 2016

Estimation of Serum Calcium, Uric acid and Lipid Profile Levels in Women with Normal Pregnancy and Pre-eclampsia in Rohilkhand Region of Uttar Pradesh

Biswajit Das*, Sumeru Samanta, Ayaz K. Mallick*****

Author Affiliation: *Professor, **Assistant Professor, ***Associate Professor, Department of Biochemistry, Rohilkhand Medical College, Bareilly- 243006.

Abstract

Background and Objective: Incidence of preeclampsia in India is reported to be 8-10% of pregnancies. It is a non-convulsive form of hypertensive disorder of pregnancy. The present study has been undertaken to estimate and compare the serum values of calcium, uric acid, triglycerides, total cholesterol HDL-C and LDL-C between l non pregnant healthy women, normotensive pregnant women and pre-eclamptic women. *Materials and Methods:* Study includes 120 women divided into three groups. Estimation of serum calcium, uric acid, triglycerides, total-cholesterol and HDL-C were analyzed by O-Cresolphthalein-Complexone , Modified Trinder Peroxidase, CHOD-PAP and Phosphotungstic acid precipitation method, using Erba Chem-5 plus semi-autoanalyser. *Results:* Mean serum calcium and HDL-C levels were significantly decreased in group-C and group-B in comparison to group-I, $p<0.05$. The mean serum concentration of uric acid in pre-eclamptic pregnant women (group-C) was significantly elevated than normotensive pregnant women (group-B) cases and healthy non-pregnant women (group-A). The mean triglyceride, and LDL-C levels were significantly increased in group-C as compared to group-B, $p<0.05$. But there was no difference in the mean values of total-cholesterol between cases (group-B and group-C) and control (group-A), $p>0.05$. *Conclusion:* Women having pre-eclampsia had low levels of serum calcium, elevated the serum uric acid and disturbed lipid profile. These levels may have cause and effect relationship with these disorders.

Keywords: Pregnancy; Pre-Eclampsia; Calcium; Uric Acid; Lipid Profile; Women.

Introduction

Pre-eclampsia is a non-convulsive form of hypertensive disorder of pregnancy [1]. Incidence of preeclampsia in India is reported to be 8-10% of pregnancies. The diagnosis of pre-eclampsia (International Society for the Study of Hypertension in Pregnancy) is determined by the presence of elevated blood pressure combined with significant proteinuria (≥0.3 g / 24 hours) after the 20th week of gestation in a previously normotensive, non-proteinuric patient [2]. These disorders are associated with adverse prenatal outcomes such as stillbirth, preterm and small for gestational age babies [3,4]. In India majority of the cases of pre-eclampsia are the patients belonged to poor socio-economic class and have not received proper medical attention during their antenatal period [5].

Calcium is one of the most abundant elements in the human body. Deficiency of calcium may lead to tetanic convulsions, bleeding diathesis, capillary haemorrhages, tissue exudation and osteomalacia [6]. Some studies have concluded that the increase in the intracellular calcium causes vasoconstriction, increase in the peripheral resistance and therefore, an increase in the blood pressure [7]. Epidemiological and clinical studies have shown that an inverse

Reprint Request: Biswajit Das, Professor and Head, Department of Biochemistry, Rohilkhand Medical College and Hospital, Bareilly- 243006 Uttar Pradesh, India.
E-mail: biswajitdas1971@gmail.com

relationship exists between calcium intake and development of hypertension in pregnancy [8]. Many trials have been conducted to observe the protective effect of preventive calcium supplementation in pregnant women . A previous review by Hofmyer et al. has shown that calcium supplementation during pregnancy had a significant effect in reducing risk of gestational hypertension and pre-eclampsia [9,10].

Uric acid (2, 6, 8-trihydroxypurine) is the end product of purine metabolism and its elevated level induces endothelial dysfunction and may induce hypertension and vascular disease [11]. An association between elevated serum uric acid levels and preeclampsia was first reported by Slemons and Bogert in 1917 [12]. In women who go on to develop preeclampsia, uric acid concentration is elevated as early as 10 weeks of gestation, at a time much earlier than clinical presentation of the disorder. There are several proposed mechanisms for elevation of uric acid in the pre- eclampsia, such as abnormal renal clearance, increased tissue breakdown, acidosis and a rise in the activity of the xanthine oxidase/ dehydrogenase enzyme [13].

The association of alteration in serum lipid profile in essential hypertension is well documented. Various studies claim that abnormal lipid synthesis leading to increase of thromboxane level and the decrease of prostaglandin levels as well as the imbalance of lipid peroxidase and antioxidants is responsible for pre-eclampsia. There is a positive correlation between serum triglycerides and systolic blood pressure as well as diastolic blood pressure in pre eclampsia cases. Hormonal imbalance leading to altered lipid profile in serum is assumed to be the prime factor in etiopathogenesis of pregnancy - induced hypertension (PIH) [14,15].

In spite of numerous studies; the etiology of pre-eclampsia has not yet been fully elucidated. According to many authors in recent studies observes that the changes in levels of serum calcium, uric acid and lipid profile appear to be of immense value in understanding the pathogenesis of pre-eclampsia. The present study has been undertaken to evaluate and compare the changes in serum levels of calcium, uric acid and lipid profile in healthy non-pregnant women, normal pregnant women and in pre-eclamptic women in Rohilkhand region of Uttar Pradesh.

Materials and Methods

The study was conducted at the Department of Biochemistry, Rohilkhand Medical College and Hospital (RMCH), Bareilly, Uttar Pradesh. The duration of study was 12 months, from March 2015 to February 2016. Total 120 women were recruited for this case control study. They were divided in the following three groups, each group consisting of 40 subjects. *Group A:* Comprised healthy non-pregnant women with age's ranges from 22-35 years taken as controls, *Group B:* comprised of normotensive pregnant women with same age groups, receiving antepartum care at the out patients department and *Group C:* consisted of pre-eclamptic women with similar age groups who were admitted to the Department of Obstetrics and Gynecology, RMCH, Bareilly. All cases were selected by taking a detailed medical history, physical examination and other relative investigations. While selecting the subjects, care was taken that none of them was suffering from diabetes mellitus, cardio-vascular diseases, renal diseases, chronic hypertension, and co-agulation disorders. Before performing the various tests subjects consent had been taken. All the procedures reported here in the study have followed the guidelines approved by the locally appointed ethical committee.

Pre-eclampsia was defined as development of blood pressure > 140/90 mmHg after 20 weeks of gestation and proteinuria of ≥300 mg as confirmed by 24h urine collection in women with no known history of hypertension, renal disease, and endocrine abnormalities and had single pregnancy and had no family history of lipid or carbohydrate disorders (Lampinen et al 2008).

Blood pressures of our selected subjects were measured by standard mercury sphygmomanometer and venous blood samples were collected from antecubital vein after an overnight fasting from all participant's with aseptic precautions. Blood samples were allowed to clot at room temperature and the serum was separated by centrifugation. The estimation of these parameters was carried out within 4-6 hrs. The following tests were done in each sample during the study.

a. Serum Calcium by O-Cresolphthalein-Complexone method [16].
b. serum uric acid by Modified Trinder Peroxidase method [17].
c. Serum Triglycerides was measured by GPO-PAP method [18].
d. Serum Total Cholesterol by CHOD-PAP method [19].
e. HDL-Cholesterol Estimation by Phosphotungstic acid precipitation method [20].
f. Estimation of Serum LDL cholesterol.

Indirect method has been used in accordance with the outline of Freidewald's Formula. (Freidewald W.T. et al 1972).

The value of LDL cholesterol is calculated as

LDL-Cholesterol= Total Cholesterol – [(Triglycerides/5) + (HDL-Cholesterol)]

Statistical Analysis

Data were presented as mean ± SD. A student's unpaired t-test was used for cross sectional comparisons of continuous variables between the 2 groups. The results were considered statistically significant when the probability of the null hypothesis was less than at least 5% ($p < 0.05$).

Results

Of the 40 pre-eclamptic patients 24 were primigravida (60%) and 16 were multigravida (40%). The mean gestational age of pre-eclamptic women in group-C was statistically significant in comparison to normotensive pregnant women in group-B (31.17 ± 4.08 week vs. 33.00 ± 4.37 week) [Table 1, Figure 1.A, B].

From Table 2 and Figure 2 we compared the results of mean systolic, diastolic and mean arterial blood pressure (MAP) of Group-B women with Group-A women and Group-C women with group-B women (Table 2, Figure 2). The mean ± SD systolic, diastolic and mean arterial blood pressure (MAP) of Group-B women were significantly higher than Group-A women (126.0 ± 6.8 vs 120.0 ± 9.3 mm of Hg, 78.1 ± 7.5 vs. 70.8 ± 8.3 mm of Hg and 96.7 ± 5.48 vs. 85.5 ± 6.68 mm of Hg) and Group-C women were significantly higher than Group- B women (174.2 ± 13.1 vs. 126.0 ± 6.8 mm of Hg, 105.4 ± 7.3 vs. 78.1 ± 7.5 mm of Hg and 128.0 ± 6.5 vs. 92.7 ± 5.48 mm of Hg).

Table 3, Figure 3. A & B shows significantly lower mean serum calcium & HDL-C in Group-B and Group-C ($p < 0.05$) compared to Group-A. The mean serum concentration of uric acid in normotensive pregnant women (Group-B) cases was significantly higher in comparison to healthy non-pregnant women (Group-A). But the mean value of serum uric acid in pre-eclamptic pregnant women (Group-C) was significantly elevated than normotensive pregnant women (Group-B) [6.9 ± 0.54 mg/dl vs 5.17

Table 1: Showing gestational weeks and Parity of the study groups

Subjects		Group-B (40)	Group-C (40)	P value
Estimated Gestational weeks	24-28	07(17.5%)	12 (30 %)	
	29-33	15 (37.5 %)	13 (32.5 %)	
	34- 38	18(45 %)	15(37.5 %)	
	Mean ± SD	33.00 ± 4.37	31.17 ± 4.08	Gr. B vs Gr.C $p < 0.05$
Parity	Primi	28 (70%)	24 (60%)	
	Multi	12 (30%)	16 (40%)	

Table 2: Mean systolic, diastolic and mean arterial pressure (MAP) for the three groups of participants.

Blood Pressure (mm of Hg)	Group-A	Group-B	Group-C	P value
Systolic (mean ± SD)	120.0 ± 9.3	126.0 ± 6.8	174.2 ± 13.1	Gr. A vs Gr.B $p < 0.05$, Gr.B vs Gr.C $p < 0.05$
Diastolic (mean ± SD)	70.8 ± 8.3	78.1 ± 7.5	105.4 ± 7.3	Gr. A vs Gr.B $p < 0.05$, Gr.B vs Gr.C $p < 0.05$
Mean arterial pressure (mean ± SD)	85.5 ± 6.67	96.7 ± 5.48	128.0 ± 6.5	Gr. A vs Gr.B $p < 0.05$, Gr.B vs Gr.C $p < 0.05$

Table 3: Showing serum calcium, uric acid & lipid profile values in study groups

Parameters	Group-A (n=40)	Group-B (n=40)	Group-C (n=40)	Statistical relationship of Gr-B & Gr-C with Gr-A
Calcium (mg/dl)	9.60 ± 0.70	8.80 ± 0.65	8.22 ± 0.63	P < 0.05 in Gr-B; P< 0.05 in Gr C
Serum Uric acid (mg/dl)	3.89 ± 0.64	5.18 ± 0.94	7.1± 0.54	p < 0.05 in Gr.B & p < 0.05 in Gr Gr.C
Triglyceride (mg/dl)	174.02 ± 11.2	179.6 ± 14.1	203.22 ± 15.7	P < 0.05 in Gr- B; P > 0.05 in Gr-C
Total Cholesterol (mg/dl)	190.98 ± 13.3	197.48 ± 14.4	195. 74 ± 13.8	P>0 .05 in Gr-B; P > 0.05 in Gr-C
HDL-C (mg/dl)	53.58 ± 4.43	49.22 ± 6.25	47.94 ± 5.7	P <0.05 in Gr-B; P < 0.05 in Gr-C
LDL-C (mg/dl)	102.6 ± 13.8	112.3 ± 17.23	107.09± 16.31	P < .05 in Gr-B; P > 0.05 in Gr. C

± 0.94 mg / dl, $p < 0.05$. Triglyceride mean value was significantly higher ($p < 0.05$) in Group-B cases as compared to Group-A; but non significantly higher ($p > 0.05$) in Group-C in comparison to Group-A. We also observed non significant ($p > 0.05$) difference between mean values of total cholesterol between cases (Group-B and Group-C) and control (Group-A). The mean value of LDL-cholesterol which was highly significant ($p < 0.05$) in Group-B cases and non significant ($p > 0.05$) in Group-C cases in comparison to Group-A cases.

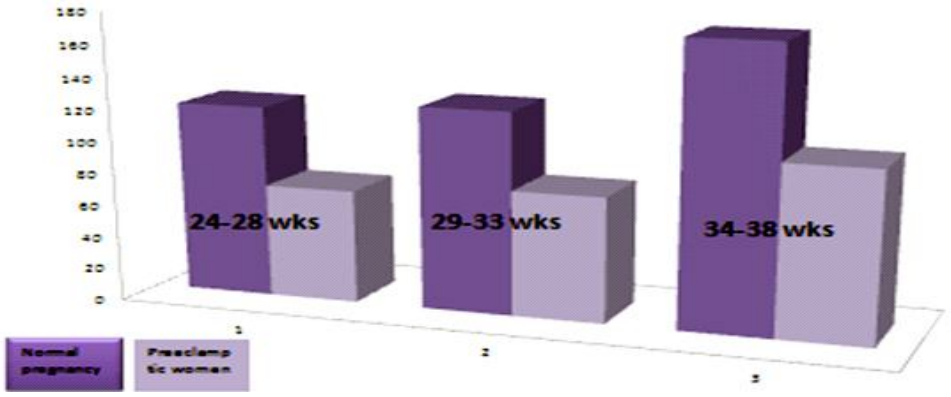

Fig. 1A: Showing number of women in normal pregnancy and pre-eclamptic cases along with gestational weeks

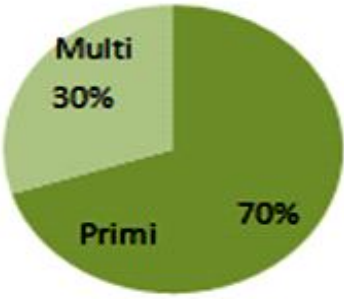

Fig. 1B: Showing number of primi and multi women in normal pregnancy

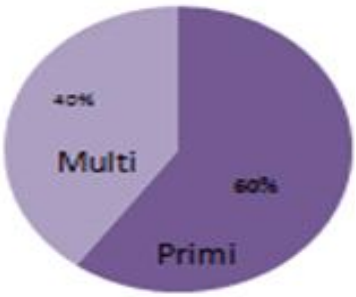

Fig. 1C: Showing number of primi and multi pre-eclamptic women

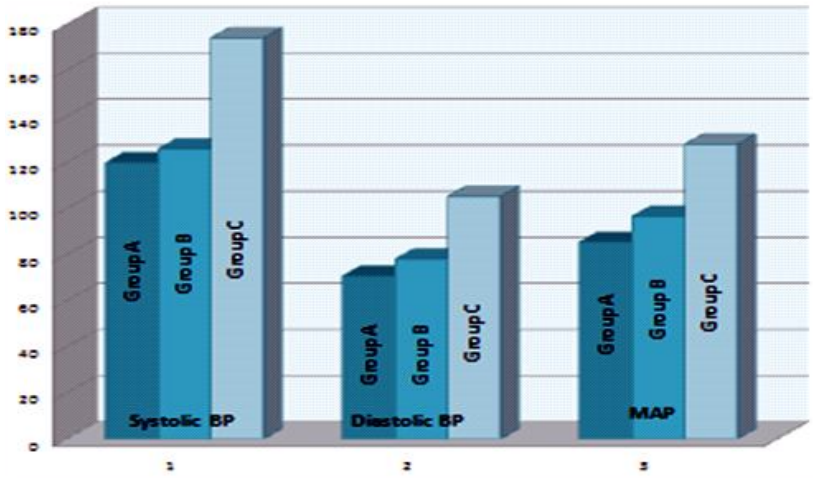

Fig. 2: Showing mean systolic, diastolic and mean arterial pressure (MAP) of three different studied Groups.

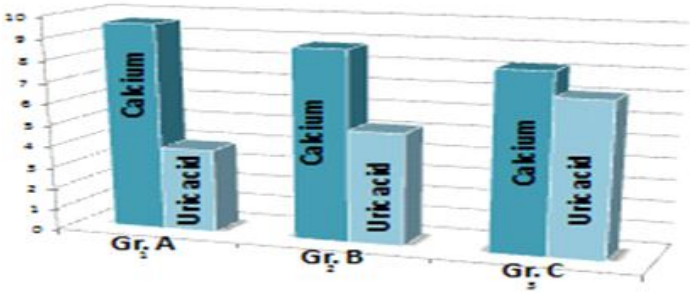

Fig. 3A: Showing serum calcium and uric acid levels in three different Groups.

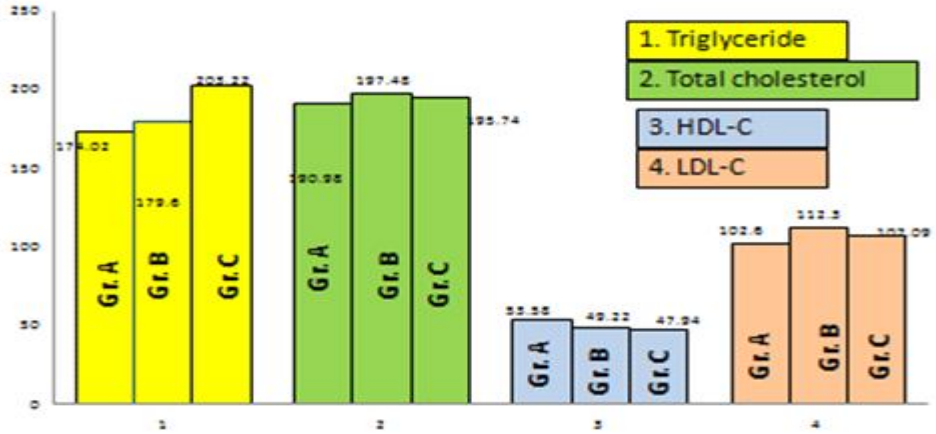

Fig. 3B: Showing serum triglyceride, total cholesterol, HDL-C and LDL-C levels in three different studied Groups.

Discussion

In this study the mean ± SD gestational ages of Group B and group C cases were 33.00 ± 4.37 week and 31.17 ± 4.08 week and also majority of the patients (65%) were primigravida (Table 1). The mean gestational age was highly significant in pre-eclamptic women (Group-C) in comparison to normotensive pregnant women (Group-B) ($p < 0.05$). The mean systolic, diastolic and mean arterial blood pressure (MAP) in pre-eclamptic women (Group-C) was significantly higher than normotensive pregnant women (Group-B) and non-pregnant healthy women (Group-A). These results are in agreement with study of other authors [21,22].

From Table 3 we observed that mean serum calcium value was highly significant between non pregnant healthy women (Gr. A) with pregnant healthy women (Gr. B) and preeclamptic women (Gr. C). This finding matches with previous studies conducted by Idogun E.S. et al. [23], J. Moodley et al. [24], Punthumapol C et al [25]. This result supported the hypothesis that low serum calcium level might be a cause in the development of pre-eclampsia. The effect of serum calcium on changes in blood pressure could be explained by the level of intracellular concentration of calcium[25]. Belizan [26] hypothesized that a low calcium intake results in high parathyroid hormone levels and increased membrane permeability. As a result, calcium is released from the mitochondria and it enters the cytoplasm, thus resulting in increased intracellular free calcium levels and decreased serum calcium levels. The elevation of cytoplasmic calcium levels triggers smooth muscle contraction, thus resulting in vascular constriction and increased blood pressure [27]. In our study majority of the pregnant women in Group-B and Group-C are low socioeconomic status. Socioeconomic status may be correlated with calcium intake. Women from the low income group were more likely to have less than the recommended dietary allowance (RDA) for calcium. However, the present finding was contradictory to some other studies where the mean serum calcium levels in pre-eclamptic women was not different from normal pregnancy [28,29].

The mean serum uric acid levels in the present study significantly lower in Group-A (non-pregnant healthy women) than Group-B (normotensive pregnant women), $p < 0.05$. Our results agree with previous findings of some authors [30,31]. A decreased glomerular filtration rate may contribute to an increased uric acid, but this likely occurs later

in pregnancy closer to the time of pre-eclampsia diagnosis [31]. In the present study, we also found significantly elevated mean serum uric acid level in pre- eclamptic women (Group-C) compared to normotensive pregnant women (Group-B). Similar results were observed by other authors [25,32]. Hyperuricemia is believed to be resulted from decreased renal excretion as a consequence of pre-eclampsia, also results from increased production secondary to tissue ischemia and oxidative stress [32]. Soluble uric acid impairs nitric oxide generation in endothelial cells. Thus hyperuricemia induces endothelial dysfunction and may induce hypertension and vascular disease [32]. But in some authors namely Salako BL et al., Weerasekera DS et al. [33,34] did not find any significant difference in mean serum uric acid levels between pre- eclamptic women and normotensive pregnant women.

The current study we analyzed, the role of lipid parameters in pre-eclampsia cases and found that the patients of Group-C (preeclampsia) have significant difference in serum triglyceride as compare to Group-A (control) subject ($p < 0.05$). In this study the mean ± SD serum triglyceride of Group-C participant was (203.22 ± 15.7) more than the mean ± SD serum triglyceride of Group-A (174.02 ± 11.2) participants. These findings are in agreement with work of many authors [21,35,36]. The principle modulator of this increase in triglyceride is esterogen, as pregnancy is associated with hyperestrogenaemia. Esterogen inhibits the hepatic lipid oxidation so the net effect is increased delivery of free fatty acids into hepatic biosynthesis of endogenous triglycerides which carried by VLDL (Jayanta et al. 2006) [35]. But some authors believed that the increase level of triglycerides in preeclampsia is probably not due to hyperesterogenaemia as the levels of esterogen decreases in pre-eclampsia. Another hypothesis for increase level of triglycerides in pre-eclampsia is that hyper-triglyceridemia is probably a consequence of competition between the substrates chylomicron and very low-density lipoprotein cholesterol for the enzyme lipoprotein lipase. Classically, chylomicron clearance occurs in two sequential steps: (a) Triglyceride hydrolysis by the enzyme lipoprotein lipase, (b) Uptake of the remnant by the liver. Delay in the second step leads to accumulation of remnants in plasma and is generally thought to represent the atherogenic risk of hyper-triglyceridemia. Elevation in triglyceride, found in preeclampsia is likely to be deposited in predisposed vessels, such as uterine spiral arteries and contributes to the endothelial dysfunction, both directly and indirectly through generation of small dense low-density lipoprotein cholesterol (Sattar et al. 1997) [37].

But we could not observe any significant change in maternal serum TC (total cholesterol) level in these studied groups. This finding is similar to previous studies conducted by NAF Islam et al [21], jayanta et al [38], Sattar et al [37]. From Table 3; Figure 3.B we also observed that the increase in HDL-C and decrease in LDL-C levels is due to hyperestrogenaemia. But in preeclampsia, the estrogen level is decreased, so reduced serum HDL-C level and increased serum LDL-C levels were observed. This finding is supported by other authors [21,39].

Conclusion

Analysis of the results of the present works, it is clear that the women who develop pre-eclampsia had low level of maternal total serum calcium, elevation of the serum uric acid level and disturbed lipid profile due to abnormal lipid metabolism. This association may be significant in understanding the pathological processes of pre-eclampsia and may help in developing strategies for prevention and early diagnosis of pre-eclampsia and other .

References

1. Montan S, Sjoberg N, Svenningsen N. Hypertension in pregnancy—fetal and infant outcome: a cohort study. Hyper tens pregnancy. 1987; 6: 337-48.
2. Brown MA, Lindheimer MN, De Swiet M, Van Assche A, Moutquin JM. The classification and diagnosis of the hypertensive disorders of pregnancy: statement from the International Society for the Study of Hypertension in Pregnancy (ISSHP). Hyper tens pregnancy. 2001; 20: 9-24.
3. Habli M, Levine RJ, Qian C, Sibai B. Neonatal outcomes in pregnancies with preeclampsia or gestational hypertension and in normotensive pregnancies that delivered at 35, 36, or 37 weeks of gestation. Am J Obstet Gynecol. 2007; 197(4): 406 e401-407.
4. Ananth CV, Basso O: Impact of pregnancy-induced hypertension on stillbirth and neonatal mortality. Epidemiology. 2010; 21(1): 118-123.
5. Surraya Halimi, Syed Muhammad Ashhad Halimi. Eclampsia and its association with external factors. J Ayub Med Coll Abbottabad. 2010; 22(3).
6. Indumati V et al. Role of serum electrolytes in PIH; Journal of Clinical and Diagnostic Research. 2011 Feb; 5(1): 66-69.
7. Belizan J.M., Villar. J., Repke J. The relationship between calcium intake and pregnancy induced

hypertension: up-to-date evidence. Am. J. Obstet. Gynecol. 1988; 158: 898-902.

8. Ortega RM, Martinez RM, Lopez-Sobaler AM, Andres P, Quintas ME. Influence of calcium intake on gestational hypertension. Ann Nutr Metab. 1999, 43(1): 37-46.
9. Hofmeyr GJ, Duley L, Atallah A. Dietary calcium supplementation for prevention of pre-eclampsia and related problems: a systematic review and commentary. B jog. 2007; 114(8): 933-943.
10. Hofmeyr GJ, Atallah AN, Duley L: Calcium supplementation during pregnancy for preventing hypertensive disorders and related problems. Cochrane Database Syst Rev. 2006; 3: CD001059.
11. Sukonpan K, Phupong V. Serum calcium and serum magnesium in normal and pre-eclamptic pregnancies. Arch Gynecol Obstet. 2005; 273: 12-16.
12. Slemons JM, LJ Bogert: The uric acid content of maternal and fetal blood. J Biol Chem. 1917; 32: 63.
13. Bain bridge SA, Roberts JM. Uric acid as a pathogenic factor in pre- eclampsia. Placenta. 2008; 29: S67-S72.
14. Robson, S.C. Hypertension and renal disease in pregnancy; In: Dew Hurst's Textbook of Obstetrics and Gynecology for postgraduates, Ed. Edmonds, D.K., 6th ed. Blackwell Science Ltd., 1999; New York, p 167- 9.
15. Karl W, Birgit W, Michael M. H et al. Triglyceride Rich Lipoproteins Are Associated with Hypertension in Pre-eclampsia. The Journal of Clinical Endocrinology & Metabolism. 2003; 88(3): 1162-1166.
16. Gindler EM & King J.D. Am J. Clin Pathol. 1972; 58: 376.
17. Kabasakalian P., Kalliney S. and Wescott A. Clin. Chem. 1973; 19: 522.
18. McGOWAN, M. W. ARTISS, J. D. STRANBERG, D. R. ZAK, B. A. Peroxidase coupled method for the colorimetric determination of serum Triglycerides. Clin.Chem. 1983; 29: 538-542.
19. Allian, C.C., L.S.Poon, C.S.Chan, W.S.Richmond and P.C. Fu, Enzymatic determination of total serum cholesterol. Clin.Chem. 1974; 20: 470-475.
20. Burstein M., Scholnic H. R., Morfin R. J. Lipid Res. 1970.
21. NAF Islam et al. Study of serum lipid profile in pre-eclampsia and eclampsia. Faridpur Med. Coll. J. 2010; 5(2): 56-59.
22. Das et al. Evaluation of Serum Calcium and Lipid Profile in Womenwith Pre-eclampsia, Eclampsia and Normal Pregnancy in Rohilkhand region of Uttar Pradesh. NJIRM. 2011 Oct-Dec; 2(4): 15-22.
23. Idogun E.S et al. extra cellular calcium and magnesium in preeclampsia and eclampsia. African journal of reproductive health. 2007; 11(2): 89-94.
24. J. Moodley et. al. Serum calcium ion concentrations in eclampsia. South African Medical research Council, Johannesburg. 1987; 72: 382-385.
25. Punthumapol C et al. J Med Assoc Thai. 2008; 91 (7): 968-973.
26. Belizan J.M., Villar. J., Repke J. The relationship between calcium intake and pregnancy induced hypertension: up-to-date evidence. Am. J. Obstet. Gynecol. 1988; 158: 898-902.
27. Standley CA, Whitty JE, Mason BA, Cotton DB. Serum ionized magnesium levels in normal and pre-eclamptic gestation. Obstet Gynecol. 1997; 89: 24-7.
28. Ingec M, Nazik H, Kadanali S. Urinary calcium excretion in severe pre-eclampsia and eclampsia. Clin Chem Lab Med. 2006; 44: 51-3.
29. Hayder A.H.AL-Biati. Serum Lipid Profile And Uric Acid Concentration During Pregnancy. Diyala Journal of Medicine. 2011 December; 1(2): 90-94.
30. Dehghan, A., van Hoek, M., Sijbrands, E.J., Hofman, A., Witteman, J.C.. High serum uric acid as a novel risk factor for type 2 diabetes. Diabetes Care 2008; 31: 361-2.
31. Williams KP, Galerneau F. The role of serum uric acid as a prognostic indicator of the severity of maternal and fetal complications in hypertensive pregnancies. J Obstet Gynaecol Can. 2002; 24: 628-32.
32. Khosla UM, Zharikov S, Finch JL, Nakagawa T, Roncal C, Mu W, et al. Hyperuricemia induces endothelial dysfunction. Kidney Int. 2005; 67: 1739-42.
33. Salako BL, Odukogbe AT, Olayemi O, Adedapo KS, Aimakhu CO, Alu FE, et al. Serum albumin, creatinine, uric acid and hypertensive disorders of pregnancy. East Afr Med J. 2003; 80: 424-8.
34. Weerasekera DS, Peiris H. The significance of serum uric acid, creatinine and urinary microprotein levels in predicting pre-eclampsia. J Obstet Gynaecol. 2003; 23: 17-9.
35. Powers RW, Evans RW, Majors AK. Plasma homocysteine concentration is increased in preeclampsia and is associated with evidence of endothelial activation. Am J Obstet Gynecol. 1998; 179:1605-1611.
36. Enquobahrie, DA, Williams MA, Butler CL, Miller RS, Luthy DA. Maternal plasma lipid concentrations in early pregnancy and risk of preeclampsia. Am J hypertens. 2004; 17(7): 574-81.
37. Sattar, N., A. bendomir, C. Berry, J. Shepherd, I. Greer and C. J. Packard. Lipoprotein subfraction concentrations in pre-eclampsia: Pathogenic parallels to atherosclerosis. Obstet. Gynecol. 1997; 89: 403-408.
38. Jayanta, D., K.M. Ananda and K.S. Pradip. Study of serum lipid profile in PIH. Indian J. Clin. Biochem. 2006; 21: 165-168.
39. Gratacos E, casals E, Gomez O, et. al. Increased susceptibility to low density lipoprotein oxidation in women with a history of pre-eclampsia. Br J of Obst & Gynae. 2003; 110(4): 400-4.