# Comparison Of Serum Galectin-13, Aldosterone And Electrolytes ($NA^+$, $K^+$, $CL^-$) In Preeclamptic And Healthy Pregnant Women

**Dr. Sammiya Uraneb[1], Dr. Farhat Bano[2], Dr. Nazish Shahzad Khan[3], Dr. Rehana Mushtaq[4]**

*[1]M.Phil. Scholar, Biochemistry University of health Sciences, Lahore, Pakistan*
*[2]Associate Professor & Head of Biochemistry Department, University of Health Sciences, Lahore, Pakistan*
*[3]Lecturer Biochemistry, University of Health Sciences, Lahore.*
*[4]Obs & Gynae Department, National Medical College and Teaching Hospital, Parsa, Birgunj, Nepal*
*Corresponding author: Dr. Farhat Bano,*
*Associate Professor & Head of Biochemistry Department, University of Health Sciences, Lahore, Pakistan. Email: dr.farhatbano_2000@yahoo.com*

**Key Word**

Preeclampsia, Aldosterone, Galectin-13/ PP13, Electrolytes, sodium, potassium, chloride

**ABSTRACT**

Preeclampsia is recognized as a vascular disorder of pregnancy with poorly developed placenta leading to reduced perfusion and ischemia. Its incidence is increased by 25% during last two decades. Total 108 pregnant women were enrolled in our research divided in two groups. Blood samples were taken at 36-40 weeks of gestation and were processed and stored for galectin-13, aldosterone and electrolytes ($Na^+$, $K^+$, $Cl^-$) measurement. Data was analyzed by SPSS. We observed that Galectin-13 levels were non significantly decreased while aldosterone levels were significantly reduced, the electrolytes, sodium and chloride were found significantly increased, and potassium was significantly decreased. Galectin-13 was found to be positively correlated with aldosterone suggesting potential role of these novel hormones in pathogenesis of preeclampsia. Raised sodium and chloride while reduced potassium have significant role in development of preeclampsia.

## INTRODUCTION

Preeclampsia (PE) affects pregnant ladies causing organ damage and uteroplacental dysfunction. Incidence of preeclampsia varies from 5-10% worldwide, while in Pakistan is 19% (Soomro et al., 2019). Preeclampsia if not treated well in time, may progress into eclampsia, stroke, blindness, thrombocytopenia, HELLP syndrome, renal failure, placental abruption, fetal growth retardation, fetal loss/ abortion, preterm delivery, fetal death. So, researchers are interested in new development like Flt, VEGF, PLGF, endoglin, TGF, endothelin, galectins and we are mainly interested in galectin-13, aldosterone, and electrolytes.

Galectin-13, also known as placental protein-13 (PP13), is glycoprotein, produced and secreted by syncytiotrophoblast (Asma et al., 2021). It has crucial role in placental development, regulation of feto-maternal immunological tolerance and angiogenesis. It is essential for endometrial implantation and maintenance of placentation (Vokalova et al., 2020).

Aldosterone is not only linked to reduced maternal blood pressure, enhanced fetal, placental angiogenesis, and increased maternal plasma volume but it also supports fetal development, placental trophoblast proliferation and placental growth (Mahar et al., 2021). Pregnancy-related hypertension may be the early manifest of the disrupted potassium and sodium transport across the vascular smooth muscle cell membrane, which controls blood pressure (Gamit et al., 2023). In physiological gestation**,** electrolyte balance is maintained in the response of plasma mineralocorticoids like Aldosterone.

Reviewing the recent advances in this syndrome we have design our research having objectives to compare galectin-13, aldosterone and electrolytes in preeclamptic and healthy pregnant women.

## MATERIALS & METHODS

It was cross-sectional comparative study. Samples were collected from DHQ hospital Multan estimation was done in Biochemistry department UHS Lahore.
108 pregnant females were enrolled in current study, divided in two groups, Group-1 includes 54 Preeclamptic women while Group-2 includes 54 Healthy pregnant women.

**Inclusion Criteria** of Preeclamptic Group: Age 20-40 years, Gestational age term (36-40 weeks), Newly diagnosed case, Blood pressure.≥140/90mmHg after 20 weeks of gestation, Proteinuria ≥300 mg/ 24hr urine sample or ≥1+ on dipstick, and that of Control Group: is Age 20-40 years, Gestational age term (36-40 weeks), Blood pressure (≤ 120/ 80 mmHg), Absence of proteinuria.

**Exclusion Criteria** includes severe anemia (< 9g/dl), chronic hypertension, hepatic dysfunction, renal dysfunction, diabetes mellitus, cardiac problems, multiple pregnancies, malignancy, autoimmune diseases.

### Methodology

The blood samples were taken from pregnant women between 36 to 40 weeks gestation after taking written informed consent, and demographic data was recorded on prescribed form. The serum was separated and stored for subsequent biochemical analysis.
Serum Galectin-13/ Placental Protein-13 (PP13) and serum aldosterone levels were estimated by their available ELISA kits while serum electrolytes were measured by using Automated Electrolytes Analyzer.

### Statistical Analysis of Data

SPSS was used to record and access the data. Shapiro-Wilk test was used to check data normality.
For numeric data mean and standard deviation was used. Student t-test was applied in case of quantitative variables. Frequencies and percentages of categorical variables were observed and chi square test was applied for comparison. The value of p (≤ 0.05) was considered statistically significant.

**Table 1: shows demographic parameters of both groups.**

| Parameters | Preeclamptic women Mean ± SD | Healthy Pregnant women Mean ± SD | p-value | % |
|---|---|---|---|---|
| Maternal age | 29.6 ± 5.7 | 28.5 ± 4.9 | 0.480 | 3.8 % Inc. |
| Gestational age | 36.2 ± 1.08 | 36.8 ± 1.2 | 0.064 | 1.6 % Dec. |
| Parity (Primigravida) | 55.6 ± 1.05 | 44.4 ± 1.08 | 0.276 | 25.2 % Inc. |
| Education | 51.9 ± 2.1 | 48.1 ± 1.02 | 0.907 | 7.9 % Inc. |
| Occupation | 54.1 ± 1.02 | 45.9 ± 1.08 | 0.750 | 17.8 % Inc. |
| Socioeconomic status | 48.1 ± 1.04 | 51.9 ± 1.07 | 0.586 | 7.3 % Dec. |
| Body Mass Index | 34.5 ± 3.3 | 34.9 ± 3.6 | 0.864 | 1.2 % Dec. |
| Systolic Blood Pressure | 172.2 ± 13.9 | 115.8 ± 4.3 | <0.001 | 48.7 % Inc. |
| Diastolic Blood Pressure | 109.4 ± 6.2 | 75.9 ± 5.0 | <0.001 | 44.1 % Inc. |
| Proteinuria | 2.3 ± 1.06 | 0 | <0.001 | 100 % Inc. |

**Table 2: shows biochemical parameters of both groups.**

| Parameter | Preeclamptic women Mean ± SD | Healthy Pregnant women Mean ± SD | p-valu | % |
|---|---|---|---|---|
| Galectin-1 | 63.53 ± 33.14 | 76.87 ± 33.08 | 0.145 | 17.3 % Dec. |
| Aldosteron | 31.52 ± 19.9 | 44.53 ± 22.28 | 0.028 | 29.2 % Dec. |
| Sodium | 140.47 ± 3.9 | 134.65 ± 3.69 | < 0.00 | 4.3 % Inc. |
| Chloride | 103.6 ± 1.21 | 102.25 ± 1.62 | 0.001 | 1.3 % Inc. |
| Potassium | 3.3 ± 0.11 | 4.04 ± 0.18 | < 0.00 | 17.5 % Dec. |

**Table 3: Correlation of serum Galectin-13 and Aldosterone levels with serum electrolytes ($Na^+$, $K^+$ and $Cl^-$)**

| | | $Na^+$ | $K^+$ | $Cl^-$ |
|---|---|---|---|---|
| **Galectin-13** | Correlation Coefficient | -0.138 | 0.138 | -0.167 |
| | p-value | 0.321 | 0.318 | 0.229 |
| **Aldosterone** | Correlation Coefficient | -0.057 | 0.298 | -0.199 |
| | p-value | 0.684 | 0.029* | 0.149 |

## RESULTS

### Demographic Parameters of Preeclampsia and Healthy Pregnancy:

Table-1 shows nonsignificant increase in maternal age, primigravida, education in preeclamptic women while nonsignificant decrease was observed in gestational age, low socioeconomic status, BMI, working women in preeclamptic women.
However, significant raised systolic and diastolic blood pressure along with proteinuria were observed in preeclamptic women as compared to healthy pregnant women. (Table 1)

### Biochemical Estimation:

There is nonsignificant decrease in Galectin-13 in preeclamptic women as shown in table 2, p-value 0.145, 17.3% Dec.
There is significant decrease in Aldosterone and potassium in preeclamptic women as shown in table 2, p-value 0.028, and <0.001, 29.2% Dec and 17.5% Dec respectively.
There is significant increase in sodium and chloride in preeclamptic women as shown in table 2, p-value <0.001 and 0.001, 4.3% Inc. and 1.3 % Inc respectively.

## DISCUSSION

Preeclampsia is vascular pathology related to pregnancy in which women develop hypertension with proteinuria after mid-gestation. If not treated at proper time, preeclampsia can lead to deleterious complications like clotting problems, hepato-renal failure, convulsions or even fetal death. Researchers are trying to find out the role of various biochemical parameters like angiogenic factors (plasma protein A, PGF, Galectin-13), anti-angiogenic factors, (soluble fms-like tyrosine-1, asprosine and alebela hormone) in order to manage preeclampsia.
In our research we tried to find out the level of galectin-13, aldosterone and electrolytes sodium (Na), potassium(K) and chloride (Cl) and their correlation in preeclamptic and healthy pregnant women along with the demographic variables (like age, age, parity, BMI, socioeconomic status and education)
Galectin-13/ Placental Protein-13 is necessary for fluid homeostasis, pregnancy adaptation and fetal growth regulation (Jovanović Krivokuća et al., 2021). Low serum galectin-13 levels might be responsible for preeclampsia. The severity of preeclampsia may be correlated with the level of galectin-13 (Pankiewicz et al., 2020). We studied galectin-13 levels in last trimester and found non significant decrease in Galectin-13 levels among preeclamptic women as compared to healthy pregnant women (table-2, 17.3% Dec.).
It is evident that normal level of galectin-13 is necessary for maintenance of normal pregnancy and any disturbance in its level may lead to fatal complications (Chen et al., 2022). In conditions where galectin-13 levels are reduced, the immune system of mother attack almost all of the invading trophoblasts and prevent conversion of maternal spiral arterioles leading to reduced perfusion of placenta, IUGR, and ultimately development of compensatory hypertension and preeclampsia (Menkhorst et al., 2021, Jovanović Krivokuća et al., 2021).
We found that Galectin-13 levels were low in third trimester in patients having preeclampsia as compared to normotensive pregnant ladies. In accordance with our study, many other studies also demonstrated that galectin-13 levels were low among preeclamptic patients in comparison to normotensive pregnant women (Vokalova et al., 2020, Asma et al., 2021, Vasilache et al., 2022). In majority of these studies, galectin-13 levels were measured during first trimester and females having low galectin-13 in first trimester subsequently develop preeclampsia (Sammar et al., 2019, Sammar et al., 2014). While others observed its reduced levels during third trimester (Balogh et al., 2019, Nasser et al., 2020). So, it may be possible that its decreased level interferes with certain processes that are necessary for placental development. However, the results of a small number of researches on the expression of galectin-13 in preeclampsia are inconsistent (Chalova et al., 2018). Our finding

contradicts few of previous studies in which HELLP syndrome and preterm preeclampsia are linked to elevated levels of maternal serum galectin-13 during last trimester (Sammar et al., 2019). The severity of preeclampsia may be correlated with the level of galectin-13. It is evident that circulating galectin-13 level gradually tends to rise in healthy pregnancy towards end of last trimester (Gadde et al., 2018, Vasilache et al., 2022). Administration of synthetic Gal-13 in genetically mutant hypertensive pregnant rats improve hypertensive condition (Drobnjak, 2018). For future we aim to study the level of Gal-13 in each term for better understanding its role in preeclampsia, its management and to avoid complication such as eclampsia.

Another potential useful biomarker for maintaining blood pressure is aldosterone, as we discussed above that high level of Gal-13 might be responsible for hypotensive condition in pregnant women. Role of aldosterone in blood pressure maintenance is well established. Aldosterone, along with Gal-13 may play an important role to control hypertensive and hypotensive conditions in pregnant women. It works together by altering electrolytes concentration and maintain plasma volume.

In our result we found significant decrease in aldosterone levels in preeclamptic women as compared to healthy pregnant women (table-2, 29.2 % Dec.). The synthesis of prorenin (precursor of renin) from corpus luteum decreases in preeclampsia, resulting in reduced concentration of angiotensin II, which has major effect on adrenal gland to release aldosterone (Wiegel et al., 2021). Decrease level of angiotensin is directly related to level of aldosterone. In line with our finding, researchers also mentioned that in preeclampsia aldosterone levels are significantly decreased (Mistry et al., 2022, Mahar et al., 2021). To the contrary, Birukov and Gathiram found that aldosterone levels were not associated with preeclampsia incidence (Birukov et al., 2019, Gathiram and Moodley, 2020).

In PE women reduced aldosterone and reduce prorenin, reduced activity of pro-RAAS, are responsible for reduced plasma, reduced cardiac output, vasoconstriction (Lumbers et al., 2019). Aldosterone is a component of RAAS system. Due to important role of aldosterone in development of placenta, decrease in this novel hormone has certainly correlation with development of preeclampsia. So, decreased aldosterone levels can interfere with angiogenesis and vasculogenesis that leads to disturbance in blood flow, oxidative stress, reduced plasma volume expansion, electrolyte imbalance, hypertension/ preeclampsia, impaired uteroplacental perfusion, intrauterine growth restriction and miscarriage (Gao et al., 2020). It has been discovered that in preeclamptic women circulating aldosterone levels and fetal birthweight are positively correlated (Scaife and Mohaupt, 2017). In preeclampsia-induced mice, the reduced levels of aldosterone are observed leading to impaired development of placenta and fetus (Jena et al., 2020).

Potassium, sodium, and chloride play pivotal role in etiopathogenesis of preeclampsia. The major cause of hypertension is the disturbance in intracellular and extracellular ionic concentrations (Baek and Kim, 2021). In our study we observed the significant increase in sodium and chloride while potassium was significantly reduced (table-2, 4.3 % Inc., 1.3 % Inc. and 17.5% Dec., respectively). This is in accordance to prior studies, that the sodium level was increased and potassium was reduced significantly in preeclamptic women (Gamit et al., 2023, Uddin et al., 2023). While others reported no difference in sodium levels among normotensive and preeclamptic women (Khan et al., 2022). Few researches also reported reduced levels of sodium in preeclamptic women (Fatima et al., 2022).

Demographic variables also play an important role in the development of preeclampsia. We observed nonsignificant increase in maternal age while nonsignificant decrease in gestational age in preeclamptic women as compared to healthy pregnant women (table-1) in accordance with shafi et al (Shafi et al., 2021). In current study we also observed parity in relation to preeclampsia and concluded that preeclampsia risk increases in primigravida up to 25.22% while multigravidity reduces its risk (table-1). Multiparity was significantly associated with low risk of preeclampsia (Maeda et al., 2021). This study revealed statistically nonsignificant association between maternal education and socioeconomic status with preeclampsia. Preeclampsia affects women with lower levels of education more frequently and more severely. Thus, a lack of education and low socioeconomic status are thought to increase the risk of preeclampsia. This outcome was attributed to reduced access to quality health care and poor compliance to treatment and nutrition. This study supports the findings of previous studies, which showed that preeclampsia was more prevalent in mothers with lower levels of education and economic conditions (Khader et al., 2018). So Significant association was found between preeclampsia and level of education of mothers and their socioeconomic conditions (Mattsson et al., 2022).

In present research, we observed BMI of pregnant women preconception and during antenatal weight gain, and concluded that BMI has no effect on incidence of preeclampsia (table-1, 1.2% Dec). Obesity imposes major significant negative effects on pregnancy, directly and indirectly through the associated metabolic dysfunctions

and proinflammatory cytokines responsible for pathophysiological mechanism of preeclampsia and proinflammatory status like endothelial dysfunction (Abraham and Romani, 2022).
Hypernatremia is a major characteristic of preeclampsia and plays a major part in elevation of blood pressure (Kumar et al., 2020). Disturbed electrolyte and aldosterone fail to maintain expansion of plasma volume, blood pressure, placental growth and cause edema and hypertension ultimately developing preeclampsia
Galectin-13 has nonsignificant negative correlation with sodium and chloride while nonsignificant positive correlation with potassium (as shown in table-3). However, aldosterone is significantly corelated with potassium but has nonsignificant correlation with sodium and chloride (as shown in table-3).
Diet with high salt not only raises blood pressure during pregnancy but also neonates of hypertensive mothers are at risk of developing cardiac fibrosis and altered epithelial-mesenchymal transition (Huang et al., 2022). Dietary salt reduction is one of the most effective treatments for high blood pressure (Couch et al., 2021).

## CONCLUSION

- In light of our research, we concluded that the reduced levels of Galectin-13 may be responsible for decreased levels of aldosterone resulting imbalance of electrolytes and water homeostasis, hence leading to high blood pressure, insufficiency of placenta, fetal growth retardation, preeclampsia and eclampsia.
- By giving agonist of Galectin-13 and Aldosterone early in pregnancy, not only electrolytes and water balance is corrected but it might also help in controlling blood pressure, preventing preeclampsia, appropriate uteroplacental growth ultimately resulting healthy mother and her child.
- Also, low salt and healthy diet might help in controlling weight and preventing preeclampsia.

## REFERENCES:

1. Abraham, T. and Romani, A. M. 2022. The relationship between obesity and pre-eclampsia: Incidental risks and identification of potential biomarkers for pre-eclampsia. Cells, 11(9): 1548.
2. Asma, M., Sharmin, F., Begum, F., Begum, M. and Alam, M. M. 2021. Role of Maternal Serum Placental Protein 13 at 11-13 weeks of Pregnancy as a Predictor of Pre-eclampsia. Journal of National Institute of Neurosciences Bangladesh, 7(1): 47-51.
3. Baek, E. J. and Kim, S. 2021. Current understanding of pressure natriuresis. Electrolytes & Blood Pressure: E & BP, 19(2): 38.
4. Balogh, A., Toth, E., Romero, R., Parej, K., Csala, D., Szenasi, N. L., Hajdu, I., Juhasz, K., Kovacs, A. F. and Meiri, H. 2019. Placental galectins are key players in regulating the maternal adaptive immune response. Frontiers in immunology, 101240.
5. Birukov, A., Andersen, L. B., Herse, F., Rakova, N., Kitlen, G., Kyhl, H. B., Golic, M., Haase, N., Kräker, K. and Müller, D. N. 2019. Aldosterone, salt, and potassium intakes as predictors of pregnancy outcome, including preeclampsia. Hypertension, 74(2): 391-398.
6. Chalova, K., Pehlivanov, B., Amaliev, I., Amaliev, G., Ray-Cheva, R. and Ivanovska, M. 2018. Maternal serum concentrations of Corin, endoglin, PP13 and sFlt-1 and their changing with advancement of pregnancy and correlation with Doppler of uterine arteries. Folia Med (Plovdiv), 60(4): 558-64.
7. Chen, M., Shi, J.-L., Zheng, Z.-M., Lin, Z., Li, M.-Q. and Shao, J. 2022. Galectins: Important Regulators in Normal and Pathologic Pregnancies. International Journal of Molecular Sciences, 23(17): 10110.
8. Couch, S. C., Saelens, B. E., Khoury, P. R., Dart, K. B., Hinn, K., Mitsnefes, M. M., Daniels, S. R. and Urbina, E. M. 2021. Dietary approaches to stop hypertension dietary intervention improves blood pressure and vascular health in youth with elevated blood pressure. Hypertension, 77(1): 241-251.
9. Drobnjak, T. 2018. Physiological and pharmacokinetic properties of Placental Protein 13 (PP13) In vivo and in vitro studies in animals.
10. Fatima, I., Bemat Ilyas, D. M. S. and Kausar, A. 2022. Biochemical Profile of Pre-eclampsia–A Case Control Study at Rural Set-up. European Journal of Molecular & Clinical Medicine (EJMCM), 9(01): 2022.
11. Gadde, R., Cd, D. and Sheela, S. 2018. Placental protein 13: An important biological protein in preeclampsia. Journal of circulating biomarkers, 71849454418786159.
12. Gamit, A., Khubchandani, A., Patel, J. and Patel, H. 2023. Comparison of serum calcium, serum magnesium, serum sodium and serum potassium in patients of preeclampsia and normal pregnant

women-a cross-sectional study. National Journal of Physiology, Pharmacy and Pharmacology, 13(2): 278-278.
13. Gao, Q., Li, X., Zhou, X., Liu, B., Tang, J., Li, N., Zhang, M., Lu, X., Xu, Z. and Sun, M. 2020. Pathophysiological Roles and Disorders of Renin-Angiotensin-Aldosterone System and Nitric Oxide During Perinatal Periods. Maternal-Fetal and Neonatal Endocrinology. Elsevier.
14. Gathiram, P. and Moodley, J. 2020. The role of the renin-angiotensin-aldosterone system in preeclampsia: a review. Current Hypertension Reports, 221-9.
15. Huang, M., Li, X., Ren, L., Huang, L., Pan, J., Yao, J., Du, L., Chen, D. and Chen, J. 2022. Maternal high salt-diet increases offspring's blood pressure with dysfunction of NO/PKGI signaling pathway in heart tissue. Gynecology and Obstetrics Clinical Medicine, 2(2): 69-75.
16. Jena, M. K., Sharma, N. R., Petitt, M., Maulik, D. and Nayak, N. R. 2020. Pathogenesis of preeclampsia and therapeutic approaches targeting the placenta. Biomolecules, 10(6): 953.
17. Jovanović Krivokuća, M., Vilotić, A., Nacka-Aleksić, M., Pirković, A., Ćujić, D., Legner, J., Dekanski, D. and Bojić-Trbojević, Ž. 2021. Galectins in early pregnancy and pregnancy-associated pathologies. International Journal of Molecular Sciences, 23(1): 69.
18. Khader, Y. S., Batieha, A., Al-Njadat, R. A. and Hijazi, S. a. S. 2018. Preeclampsia in Jordan: incidence, risk factors, and its associated maternal and neonatal outcomes. The journal of maternal-fetal & neonatal medicine, 31(6): 770-776.
19. Khan, J. A., Ashraf, A., Qureshi, W. A. and Fayaz, F. 2022. Comparison of serum electrolytes with preeclampsia severity: a cross sectional study. International Journal of Research in Medical Sciences, 10(11): 2586.
20. Kumar, H., Prabhu, A. and Sudha, K. 2020. Assessment of Serum Cations in Normal and Preeclampsia Pregnancies: A Cross Sectional Comparative Study. Indian Journal of Public Health Research & Development, 11(5): 484-488.
21. Lumbers, E. R., Delforce, S. J., Arthurs, A. L. and Pringle, K. G. 2019. Causes and consequences of the dysregulated maternal renin-angiotensin system in preeclampsia. Frontiers in endocrinology, 10563.
22. Maeda, Y., Kaneko, K., Ogawa, K., Sago, H. and Murashima, A. 2021. The effect of parity, history of preeclampsia, and pregnancy care on the incidence of subsequent preeclampsia in multiparous women with SLE. Modern Rheumatology, 31(4): 843-848.
23. Mahar, A. S., Abdel-Hakam, F. A., El Hakim, S. F. and El Baky, N. M. 2021. Aldosterone hormone levels in preeclamptic women in comparison with normal pregnancy. The Scientific Journal of Al-Azhar Medical Faculty, Girls, 5(2): 449-455.
24. Mattsson, K., Juárez, S. and Malmqvist, E. 2022. Influence of socio-economic factors and region of birth on the risk of preeclampsia in Sweden. International Journal of Environmental Research and Public Health, 19(7): 4080.
25. Menkhorst, E., Than, N. G., Jeschke, U., Barrientos, G., Szereday, L., Dveksler, G. and Blois, S. M. 2021. Medawar's PostEra: Galectins emerged as key players during fetal-maternal glycoimmune adaptation. Frontiers in Immunology, 125152.
26. Mistry, H. D., Klossner, R., Kallol, S., Lüthi, M. P., Moser, R., Schneider, H., Ontsouka, E. C., Kurlak, L. O., Mohaupt, M. G. and Albrecht, C. 2022. Effects of aldosterone on the human placenta: Insights from placental perfusion studies. Placenta, 12332-40.
27. Nasser, N., Baban, R., Al-Habib, M. and Jameel, R. 2020. The association between urinary placental protein 13 and soluble fms-like tyrosine kinase-1 in preeclamptic women in the third trimester of pregnancy. Baghdad Journal of Biochemistry and Applied Biological Sciences, 1(01): 49-55.
28. Pankiewicz, K., Szczerba, E., Fijalkowska, A., Szamotulska, K., Szewczyk, G., Issat, T. and Maciejewski, T. M. 2020. The association between serum galectin-3 level and its placental production in patients with preeclampsia. Journal of Physiology & Pharmacology, 71(6).
29. Sammar, M., Drobnjak, T., Mandala, M., Gizurarson, S., Huppertz, B. and Meiri, H. 2019. Galectin 13 (PP13) facilitates remodeling and structural stabilization of maternal vessels during pregnancy. International Journal of Molecular Sciences, 20(13): 3192.
30. Sammar, M., Nisamblatt, S., Gonen, R., Huppertz, B., Gizurarson, S., Osol, G. and Meiri, H. 2014. The role of the carbohydrate recognition domain of placental protein 13 (PP13) in pregnancy evaluated with recombinant PP13 and the DelT221 PP13 variant. PloS one, 9(7): e102832.

31. Scaife, P. J. and Mohaupt, M. G. 2017. Salt, aldosterone and extrarenal Na+-sensitive responses in pregnancy. Placenta, 5653-58.
32. Shafi, N., Bano, F. and Uraneb, S. 2021. The role of novel hormone asprosin in insulin resistance during preeclampsia. Pakistan Journal of Pharmaceutical Sciences, 34.
33. Soomro, S., Kumar, R., Lakhan, H. and Shaukat, F. 2019. Risk factors for pre-eclampsia and eclampsia disorders in tertiary care center in Sukkur, Pakistan. Cureus, 11(11).
34. Uddin, S. N., Haque, M., Barek, M. A., Chowdhury, M. N. U., Das, A., Uddin, M. G. and Islam, M. S. 2023. Analysis of serum calcium, sodium, potassium, zinc, and iron in patients with pre-eclampsia in Bangladesh: A case–control study. Health Science Reports, 6(2): e1097.
35. Vasilache, I.-A., Carauleanu, A., Socolov, D., Matasariu, R., Pavaleanu, I. and Nemescu, D. 2022. Predictive performance of first trimester serum galectin-13/PP-13 in preeclampsia screening: A systematic review and meta-analysis. Experimental and Therapeutic Medicine, 23(6): 1-12.
36. Vokalova, L., Balogh, A., Toth, E., Van Breda, S. V., Schäfer, G., Hoesli, I., Lapaire, O., Hahn, S., Than, N. G. and Rossi, S. W. 2020. Placental protein 13 (Galectin-13) polarizes neutrophils toward an immune regulatory phenotype. Frontiers in immunology, 11145.
37. Wiegel, R. E., Karsten, M. J., Reijnders, I. F., Van Rossem, L., Willemsen, S. P., Mulders, A. G., Koning, A. H., Steegers, E. A., Danser, A. J. and Steegers-Theunissen, R. P. 2021. Corpus luteum number and the maternal renin-angiotensin-aldosterone system as determinants of utero-placental (vascular) development: the Rotterdam Periconceptional Cohort. Reproductive Biology and Endocrinology, 191-14.