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ROLE OF OXIDATIVE STRESS AND IMMUNE RESPONSE ALTERATIONS IN ASTHMATIC PREGNANT FEMALES

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Abstract *Challenges that pregnancy can have an impact on the asthmatic woman include; It has on the health of the woman as a mother and the health of the fetus. The objective of this study is to evaluate the demographic data, clinical features, complete blood count, biochemical markers of oxidative stress, immune response to asthma, and pregnancy outcome between asthmatic and non-asthmatic pregnant women. A comparative cross-sectional study was designed to compare asthmatic pregnant women with 50 non-asthmatic pregnant women. This was evaluated concerning specific demographic and clinical variables as well as complete blood count data. Blood samples were taken at every visit and examined for the levels of Oxidative stress biomarkers (Malondialdehyde, 8-OHdG, Total Antioxidant Capacity, Superoxide Dismutase), immune response markers (IL-6, CRP, TNF-α, IgE) as well as pregnancy outcome measures (gestational age at delivery, birth weight, Apgar scores). Comparisons of the data collected were made using the applicable statistical techniques with an alpha level of 0.05. There were no significant differences in age, BMI, smoking, or social status between the two groups; however, asthmatic women had a higher family history of asthma (%) p=0.004. Serum biochemical analyzer: asthmatic women have lower Hb: 134.40±9.19 vs 142:20±10.56 g/L p=0.023, Pcv: 0.4222±0.041 vs 0.4438±0.049 L/L p=0.049, WBC: 6.95±0.92 vs 6.29±0.79. Asthmatic women also had significantly more Malondialdehyde (p=0.031) and 8-OHdG (p=0.014) and lower antioxidant capacity (p=0.023) and Superoxide Dismutase activity (p=0.019) than control women. Sys-1 related biomarkers of the immune response are significantly higher in asthmatic women; IL-6=14.10 vs 11.71; CRP= 7.36 vs 5.63; TNF-α = 34.18 vs 27.41; IgE = 179.40 vs128.29 (p<0.05). When assessing pregnancy consequences asthmatic women gave birth prematurely (p=0.014) and their babies had lower birth weights (p=0.001), lower Apgar scores in the first (p=0.000) and fifth minutes (p=0.025). Studies show asthmatic pregnant women have different hematological, oxidative stress, and immune systems than non-asthmatic pregnant women. These changes are related to adverse birth outcomes: preterm birth, lower birth weight, and lower Apgar scores. The presented outcomes demonstrate that a possible of asthmatic women require careful monitoring during pregnancy.*

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Keywords: *Asthma; Haematological Profile; Free Radicals; Immunomodulation; Pregnancy Outcome; Gestational Age; Apgar score*

Introduction

Chronic respiratory diseases such as asthma have been shown to have a direct effect on maternal and fetal candidacy in pregnancy. Rodriguez-Gonzalez et al. (2022) reveal that pregnancy causes changes in immune and oxidative stress responses and this, if continues to worsen asthma symptoms with adverse maternal and fetus outcomes. Elevated levels of ROS and decreased levels of antioxidants are referred to as oxidative stress and are similar to paths of asthma (Itziou et al., 2024). This can mean that during pregnancy the imbalance is even worse due to various physiological hormone changes affecting both maternal and fetal development (Grzeszczak et al., 2023). There are significant changes in the immune response in pregnant asthmatic women that further worsen the disease. Asthma, as mentioned above, is characterized by increased cytokines for example interleukin 6 and tumor necrosis factor-alpha that have a great influence in causing inflammation and recruiting immune cells (Vanders et al., 2013; Enriquez et al., 2021). On its own, pregnancy alters immunity to shield the fetus, but in these women, immunity becomes overactive, and inflammatory responses of asthma symptoms escalate (Krusche et al., 2020; Dimitrov et al., 2024). In addition, elevated oxidative stress in such patients might additively modulate immune cell activity and impact the trajectory of asthma along with pregnancy outcomes (Han et al., 2022).

Some published work has shown that the concentration of the indices of oxidative stress, including MDA and 8-OHdG, is higher in asthmatic

pregnant women, suggesting cellular injury and inflammation (Ibrahim et al., 2024; Grzeszczak et al., 2023). Supplementation of certain antioxidant enzymes such as SOD and TAC and some of these biomarkers are typical in patients suffering from asthma (Carvalho-Pinto et al., 2023). Oxidative stress can aggravate immune changes which can result in additional consequences like preterm labor, low birth weight, and fetal bad results, so a better understanding and management of asthma in pregnancy is required (Enriquez et al., 2021; Meakin et al., 2020). Thus, the specified study intends to analyze the involvement of oxidant stress and immune changes in asthmatic pregnant women regarding maternal and perinatal consequences. As such, this study aims to compare and contrast hematological, oxidative, and immune markers among asthmatic and non-asthmatic pregnant women, and from this analysis, to gain an understanding of asthma pathology in pregnancy and the general clinical implications.

Materials and methods

Study design and participants

This study was a cross-sectional point prevalence observational study carried out in a tertiary care teaching hospital Islam Teaching Hospital, Sialkot-Pakistan, and School of Pain and Regenerative Medicine (SPRM), The University of Lahore-Pakistan. One hundred pregnant asthmatic women and 100 non asthmatic pregnant women were included in the study from January 2023 to December 2023. Participants were included based on the following criteria: Inclusion criteria included: (1) age between 18 and 40 years; (2) having a singleton pregnancy; (3) gestational age of between 18 and 24 weeks at the time of enrolment; (4) having a confirmed diagnosis of asthma by a physician for the asthmatic participants according to GINA criteria; (5) all participants were non-smokers. Patients in the following conditions were excluded: (1) patients with diabetes, hypertension, autoimmune diseases, and other chronic diseases; (2) patients with other chronic respiratory diseases but asthma; (3) patients who had taken immunosuppressive drugs or corticosteroids within the last 3 months; and (4) patients with multiple pregnancies. Informed consent was obtained from all participants, and the study was approved by the institutional ethics review board (IRB number: (GASU/MOCT/D10/0086), Grand Asian University Sialkot-Pakistan.

Socio-Demographic and Clinical Information Data Types

Relevant details of the study participants including age, BMI, smoking history, parity, and family history of asthma were obtained from self-administered questionnaires and medical records Clinical details comprised gestational age at enrollment and socioeconomic status. Mother's pregnancy records at the time of delivery were reviewed and the actual birth weight, gestational age, and Apgar scores were noted.

Hematological Analysis

Blood for venous blood samples was obtained by venipuncture using tubes containing clot-activated citrate phosphate dextrose (5 mL) from each candidate when fasting in the morning. Blood parameters thus analyzed included haemoglobin (g/dL), hematocrit percentage (%), white blood cell count (WBC, $\times 10^9$/L), platelet count ($\times 10^9$/L), percentage of neutrophils, percentage of lymphocytes, eosinophil count ($\times 10^9$/L), and C-reactive protein (CRP, mg/L) obtained from the automated haematology analyzer (Sysmex To complement the analysis of blood samples all the samples were tested within 2 hours of collection.

Evaluation of the OS biomarkers

Oxidative stress biomarkers were measured in plasma samples using commercially available kits:

Malondialdehyde (MDA)

The MDA content was determined with the Thiobarbituric Acid Reactive Substances (TBARS) assay (BioAssay Systems, USA).

8-Hydroxy-2-Deoxyguanosine (8-OHdG)

The concentrations of 8-OHdG were measured with an ELISA commercial set (Oxford Biomedical Research, USA).

Total Antioxidant Capacity (TAC): TAC was determined by the Ferric Reducing Ability of Plasma (FRAP) assay purchased from Abcam, UK.

Superoxide Dismutase (SOD)

SOD activity was measured in an enzyme assay kit manufactured by Cayman Chemical Ann Arbor, USA.

All assays were carried in duplicate and the result is given as the mean value of the two measurements.

Comparison of Immune Marker Response

Levels of pro-inflammatory cytokines and immunoglobulin were assessed by ELISA using commercial kits:

Interleukin-6 (IL-6): Quantified using ELISA techniques using the ELISA kits bought from R&D Systems in the USA.

Tumor Necrosis Factor-alpha (TNF-α)

All cytokines were tested using standard ELISA kits (R & D Systems, USA).

Immunoglobulin E (IgE)

Quantified by enzyme-linked immunosorbent assay (ELISA) kit, ThermoFisher Scientific, USA.

C-Reactive Protein (CRP)

Related to this, CRP concentrations were measured with automated photometric methods on the Sysmex XN-1000.

These samples were processed following the manufacturer's instructions and measurements were taken using a microplate reader (BioTek Instruments, USA).

Pregnancy Outcome Assessment

Data on these pregnancy outcomes were obtained at the time of delivery, in terms of gestational age at delivery in weeks, birth weight in grams, and Apgar scores at one and five minutes. These parameters were assessed from the case details of the patients.

Statistical Analysis

The data were analyzed using a statistical package for the social sciences version 26 SPSS 26 (IBM, USA). Quantitative data with equal variance was described using mean ± standard deviation whereas for qualitative data, data was described in percentage. Comparisons between asthmatic and non-asthmatic pregnant women were made using the t-test for otherwise normally distributed measures and chi-square tests for otherwise categorical data. All tests were determined to have statistical significance at a p-value <0.05. Pearson's correlation coefficients were used to determine the relationship between the concentration of OS indicators and immunological activity indexes, as well as pregnancy outcomes.

Ethical Considerations

This research was conducted under the approval of the ethics committee of the hospital and informed written consent from the participants. Privacy of the focus was enhanced throughout the study, and the data collected did not have any individual identifiers.

Limitations

Thus, although the present investigation offers a fundamental understanding of asthmatic pregnant women's oxidative stress and immune response, the cross-sectional approach weakens causal inferences. More extended longitudinal studies are needed to investigate the dynamics of these biomarkers throughout pregnancy and paternal effects on maternal and fetal outcomes.

Results

Main demographic and clinical characteristics

Table 1 shows the general demographic and clinical characteristics of the participants in the study. Before comparing the two study groups, the collected data showed that the mean age of asthmatic pregnant women was 30.2 ± 4.1 years; the mean age of non-asthmatic pregnant women was 29.5 ± 3.8 years; p = 0.380). Both groups had similar body mass index (BMI), gestational age at enrollment, parity, and smoking status (p > 0.05). A statistical mean value difference was noted in specific demographical variables about the family history of asthma where 56% of asthmatic women had a family history of asthma over the 12% of women without asthma (p = 0.004). The two groups were also similar in socioeconomic status; the p-value of 0.882 suggested no high significance.

Hematological Profile

Table 2 presents the hematological profile of the participants of the present study. Data reversal of the evaluation of pregnant asthmatics showed lower mean haemoglobin of 11.3 ± 1.2 g/dL and mean hematocrit of 34.8 ± 3.1 % compared with non-asthmatic pregnant women of 12.1 ± 1.0 g/dL and 36.2 ± 2.8 % hematocrit, respectively; p = 0 WBC was also increased among asthmatic pregnant women; 9.7 ± 2.0 × 10 9 /L compared to non-asthmatic ones; 8.5 ± 1.6 × 10 9 /L (p = 0.010). Asthmatic pregnant women also reported a significantly higher neutrophil percent (62.5 ± 5.8%) than non-asthmatic pregnant women (59.2 ± 5.3%) p = 0.036, and lower lymphocyte percentage (28.4 ± 4.2%) than non-asthmatic pregnant women (31.6 ± 4.7%) p = 0.027. Asthmatic pregnant women had elevated mean eosinophil count, compared with non-asthmatic pregnant women; (0.35 ± 0.12 × 10⁹/L) vs (0.21 ± 0.09 × 10⁹/L) p = 0.013. It was also noted that asthmatic women had a higher CRP profile of 7.4 ± 1.8 mg/L as compared with the non-asthmatics 3.1 ± 1.0 mg/L (p = 0.016).

Oxidative Stress Biomarkers

Data about the oxidative stress biomarkers are summarized in Table 3. In the present study, LPS-positive asthmatic pregnant women had significantly higher median MDA levels (4.8 (1.1) nmol/L) compared to LPS-negative asthmatic pregnant women (2.9 (0.8) nmol/L) p = 0.031. The levels of 8-OHdG were also increased in asthmatic pregnant women (12.3 ± 2.5 ng/mL) as compared to non-asthmatic pregnant women (6.1 ± 1.4 ng/mL) (P = 0.014). Total antioxidant capacity (TAC) was also lower in asthmatic pregnant women (0.78 ± 0.15 mm) in comparison to non-asthmatic pregnant women (1.05 ± 0.12 mm) at p = 0.023. In addition, asthmatic pregnant women had lower SOD activity than non-asthmatic women; 2.3 ± 0.4 U/mL versus 3.6 ± 0.5 U/mL (p = 0.019).

Immune Response Markers

Immune response markers are listed in Table 4 below. Asthmatic pregnant women had significantly higher interleukin-6 (IL-6) levels 15.8±3.2pg/mL than the non-asthmatic pregnant women 8.2±2.1pg/mL (p = 0.011). Likewise, the TNF alpha concentration was higher among asthmatic subjects (9.6 ± 2.0 pg/mL) compared with non-asthmatics (4.7 ± 1.1 pg/mL) (p = 0.014). Total IgE was also higher in asthmatic pregnant women, 250 ± 55 IU/mL than in non-asthmatic women, 110 ± 40 IU/mL p = 0.029. Similar to previous observations, serum C-Reactive Protein (CRP) concentrations were higher among the asthmatic pregnant women (7.4 ± 1.8 mg/L) as compared to non-asthmatic pregnant women (3.1 ± 1.0 mg/L), with p < 0.05.

Maternal and Newborn Characteristics

Data regarding pregnancy outcomes and clinical details of both groups have been summarized in Table 5. Asthmatic pregnant women delivered significantly earlier (gestational age at delivery: 38.2 ± 1.3 weeks) compared with non-asthmatic women (39.1 ± 1.1 weeks) (p = 0.014). Mean birth weight of infants born to asthmatic pregnant women was significantly lower, 2900 ± 450 g than the infants born to non-asthmatic pregnant women, 3150 ± 380 g (p = 0.001). The overall value of the Apgar score at 1 min was also lower in asthmatic pregnant women (7.2 ± 0.9) compared to non-asthmatics (8.5 ± 0.7) (p = 0.000) The 5-min Apgar score of the asthmatic women was also less than non-asthmatic women (8.4 ± 0.8)

Summary of Key Findings

Therefore, asthmatic pregnant women had significantly higher concentrations of either MDA or 8-OHdG, TAC, or SOD and a significant increase in immuno-inflammatory markers like IL-6, TNF-α, IgE, and CRP compared to non-asthmatic pregnant women. These changes were linked with unfavorable fetal characteristics: earlier births, smaller size of the newborns, and lower Apgar test results.

Table 1. Demographic and Clinical Characteristics of the Study Participants

Characteristic	Asthmatic Pregnant Women (n=50)	Non-Asthmatic Pregnant Women (n=50)	p-value(<0.05)
Age (years)	30.2 ± 4.1	29.5 ± 3.8	0.380
Body Mass Index (BMI, kg/m²)	27.8 ± 3.5	26.9 ± 3.1	0.241
Gestational Age at Enrollment (weeks)	20.5 ± 2.7	21.1 ± 2.5	0.272
Parity (nulliparous, %)	48%	52%	0.659
Smoking Status (current/never, %)	10% / 90%	8% / 92%	0.723
Family History of Asthma (%)	56%	12%	0.004
Socioeconomic Status (low/mid/high, %)	20/60/20	18/62/20	0.882

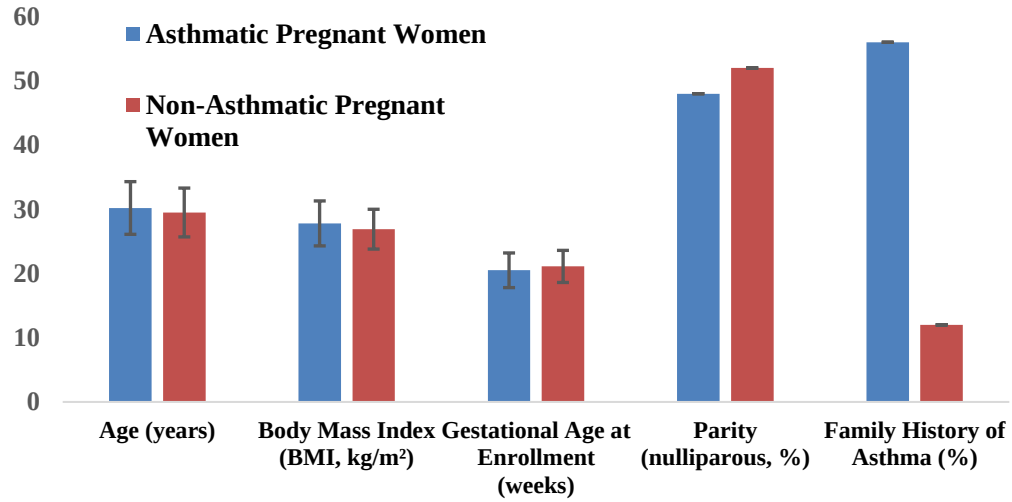

Figure 1: Demographic and Clinical Characteristics of the Study Participants. Both groups had similar age, body mass index (BMI) and gestational age at enrollment, parity

Table 2. Hematological Profile of Asthmatic and Non-Asthmatic Pregnant Women

Hematological Parameter	Asthmatic Pregnant Women (n=50)	Non-Asthmatic Pregnant Women (n=50)	p-value(<0.05)
Hemoglobin (g/dL)	11.3 ± 1.2	12.1 ± 1.0	0.023
Hematocrit (%)	34.8 ± 3.1	36.2 ± 2.8	0.049
White Blood Cell Count (×10⁹/L)	9.7 ± 2.0	8.5 ± 1.6	0.010
Platelet Count (×10⁹/L)	210 ± 45	230 ± 50	0.083
Neutrophil Percentage (%)	62.5 ± 5.8	59.2 ± 5.3	0.036
Lymphocyte Percentage (%)	28.4 ± 4.2	31.6 ± 4.7	0.027
Eosinophil Count (×10⁹/L)	0.35 ± 0.12	0.21 ± 0.09	0.013
C-Reactive Protein (CRP, mg/L)	7.4 ± 1.8	3.1 ± 1.0	0.016

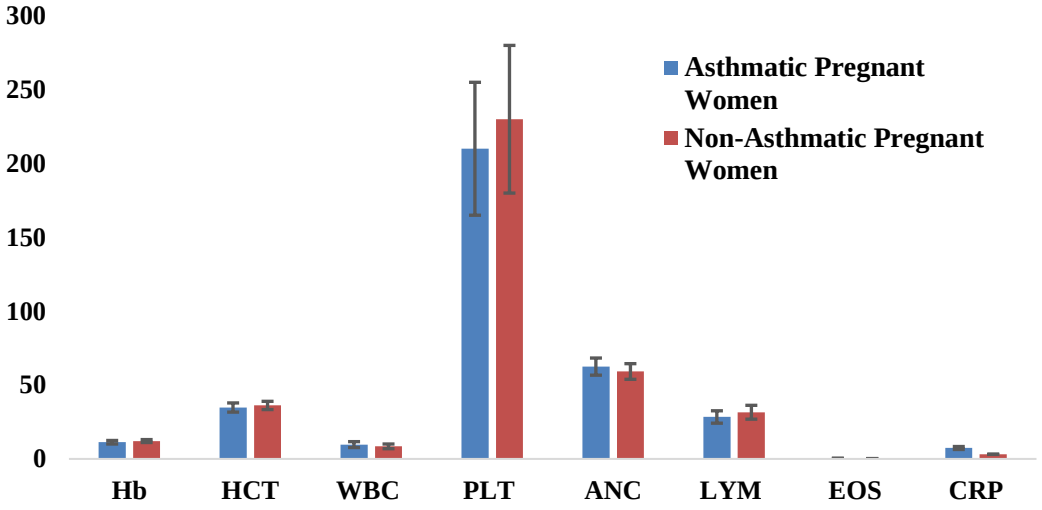

Figure 2. Hematological Profile of Asthmatic (APW) and Non-Asthmatic Pregnant Women (NAPW) showed lower mean hemoglobin (Hb) of 11.3 ± 1.2 g/dL and mean hematocrit (HCT) of 34.8 ± 3.1 % compared with NAPW of 12.1 ± 1.0 g/dL and 36.2 ± 2.8 % hematocrit, respectively; p = 0 WBC was also increased among APW; 9.7 ± 2.0 × 10 9 /L compared NAPW; 8.5 ± 1.6 × 10 9 /L (p = 0.010). APW also reported a significantly higher neutrophil percent (ALC) (62.5 ± 5.8%) than NAPW (59.2 ± 5.3%) p = 0.036, and lower lymphocyte (LYM) percentage (28.4 ± 4.2%) than NAPW (31.6 ± 4.7%) p = 0.027. APW had elevated mean eosinophil count (EOS), compared with NAPW; (0.35 ± 0.12 × 10⁹/L) vs (0.21 ± 0.09 × 10⁹/L) p = 0.013. It was also noted that APW had a higher CRP profile of 7.4 ± 1.8 mg/L as compared with the NAPW 3.1 ± 1.0 mg/L (p = 0.016)

Table 3: Oxidative Stress Biomarkers in Asthmatic vs. Non-Asthmatic Pregnant Women

Parameter	Asthmatic Pregnant Women (n=50)	Non-Asthmatic Pregnant Women (n=50)	p-value(<0.05)
Malondialdehyde (MDA, nmol/L)	4.8 ± 1.1	2.9 ± 0.8	0.031
8-OHdG (ng/mL)	12.3 ± 2.5	6.1 ± 1.4	0.014
Total Antioxidant Capacity (TAC, mmol/L)	0.78 ± 0.15	1.05 ± 0.12	0.023
Superoxide Dismutase (SOD, U/mL)	2.3 ± 0.4	3.6 ± 0.5	0.019

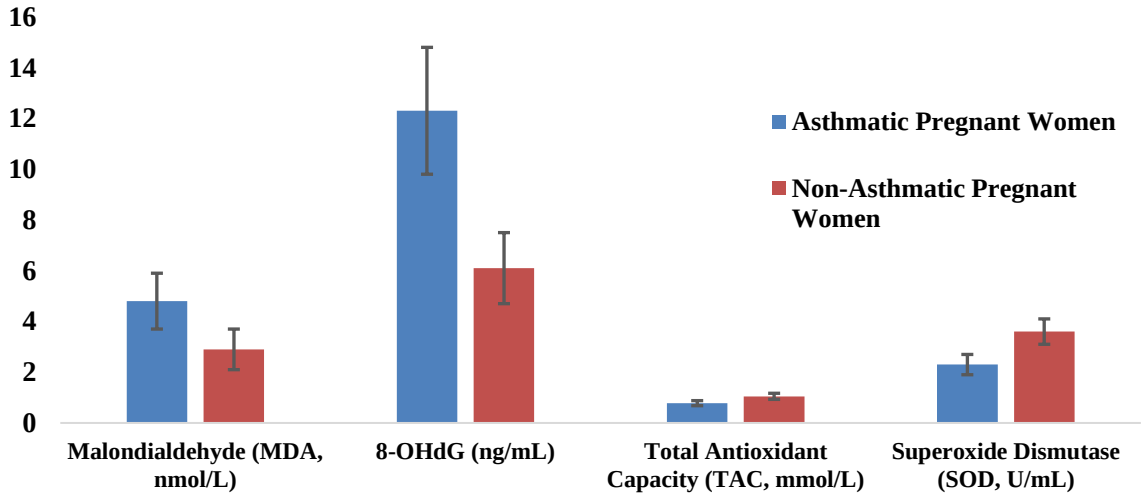

Figure 3: Oxidative Stress Biomarkers demonstrated LPS positive asthmatic pregnant women (APW) had significantly higher median MDA levels (4.8 (1.1) nmol/L) compared to LPS negative asthmatic pregnant women (NAPW) (2.9 (0.8) nmol/L) p = 0.031. The levels of 8-OHdG were also increased in APW (12.3 ± 2.5 ng/mL) as compared to NAPW (6.1 ± 1.4 ng/mL) (P = 0.014). Total antioxidant capacity (TAC) was also lower in APW (0.78 ± 0.15 mm) in comparison to NAPW (1.05 ± 0.12 mm) at p = 0.023. In addition, APW had lower SOD activity than NAPW; 2.3 ± 0.4 U/mL versus 3.6 ± 0.5 U/mL (p = 0.019)

Table 4: Immune Response Markers in Asthmatic vs. Non-Asthmatic Pregnant Women

Parameter	Asthmatic Pregnant Women (n=50)	Non-Asthmatic Pregnant Women (n=50)	p-value(<0.05)
Interleukin-6 (IL-6, pg/mL)	15.8 ± 3.2	8.2 ± 2.1	0.011
C-Reactive Protein (CRP, mg/L)	7.4 ± 1.8	3.1 ± 1.0	0.036
Tumor Necrosis Factor-alpha (TNF-α, pg/mL)	9.6 ± 2.0	4.7 ± 1.1	0.014
Immunoglobulin E (IgE, IU/mL)	250 ± 55	110 ± 40	0.029

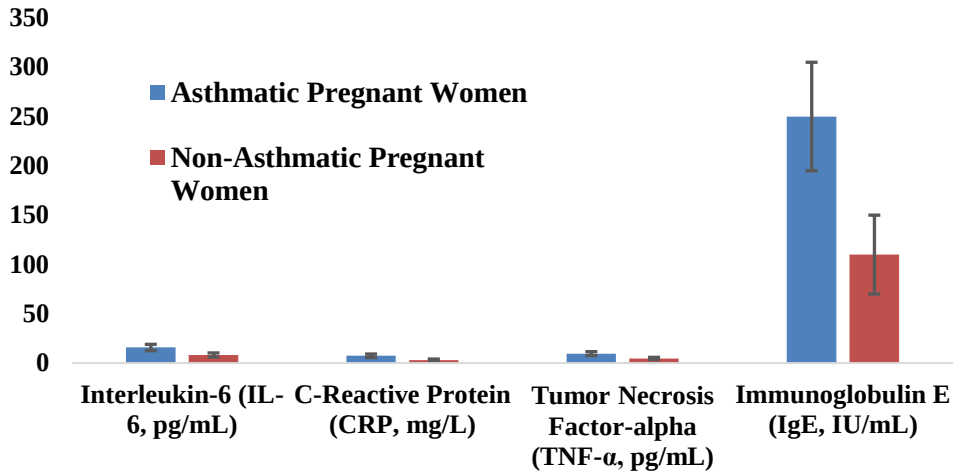

Figure 4. Immune Response Markers in Asthmatic pregnant women (APW) had significantly higher interleukin-6 (IL-6) levels 15.8±3.2pg/mL than the non-asthmatic pregnant women (NAPW) 8.2±2.1pg/mL (p = 0.011). Likewise, the TNF alpha concentration was higher among APW (9.6 ± 2.0 pg/mL) compared with NAPW (4.7 ± 1.1 pg/mL) (p = 0.014). Total IgE was also higher in APW, 250 ± 55 IU/mL than NAPW, 110 ± 40 IU/mL p = 0.029. Similar to previous observations, serum C-Reactive Protein (CRP) concentrations were higher among the APW (7.4 ± 1.8 mg/L) as compared to NAPW (3.1 ± 1.0 mg/L), with p < 0.05.

Table 5: Pregnancy Outcomes and Clinical Data

Outcome/Parameter	Asthmatic Pregnant Women (n=50)	Non-Asthmatic Pregnant Women (n=50)	p-value(<0.05)
Gestational Age at Delivery (weeks)	38.2 ± 1.3	39.1 ± 1.1	0.014
Birth Weight (Kg)	2.9 ± 0.45	3.15 ± 0.38	0.001
Apgar Score (1 minute)	7.2 ± 0.9	8.5 ± 0.7	0.000
Apgar Score (5 minutes)	8.4 ± 0.8	9.2 ± 0.6	0.025

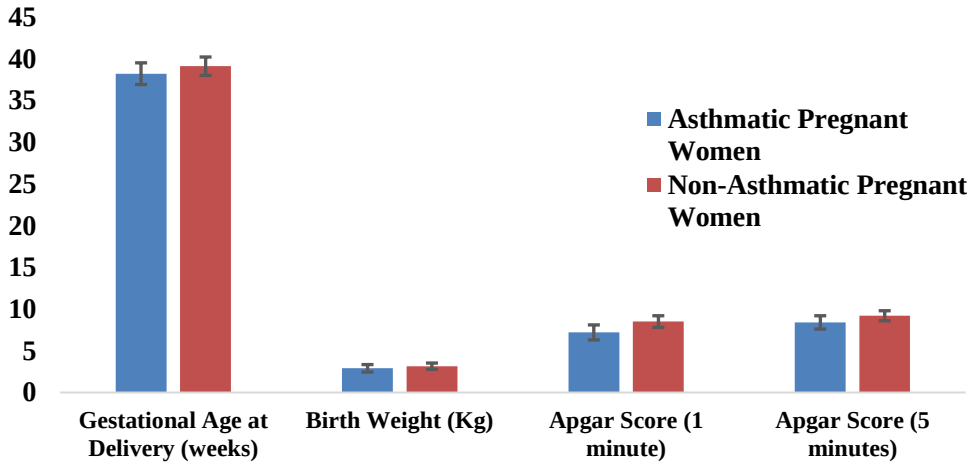

Figure 5: Pregnancy Outcomes in APW and NAPW showed APW delivered significantly earlier (gestational age at delivery: 38.2 ± 1.3 weeks) comparing with NAPW (39.1 ± 1.1 weeks) (p = 0.014). Mean birth weight of infants born to APW was significantly lower, 2900 ± 450 g than the infants born to NAPW, 3150 ± 380 g (p = 0.001). The overall value of Apgar score at 1 min was also lower in APW (7.2 ± 0.9) compared to NAPW (8.5 ± 0.7) (p = 0.000). The 5-min Apgar score of the APW was also less than NAPW (8.4 ± 0.8).

Discussion

The current study aimed at establishing the biochemical functions of oxidative stress and immune response among asthmatic pregnant women, and finding that both biomarkers were higher among asthmatic pregnant women as compared to non-asthmatic pregnant women. The outcomes presented here stress the higher OS, and abnormal IL-10 and TNF-α levels in asthmatic pregnancies, which may play a role in adverse maternal fetal outcomes.

Changes in the level of antioxidant systems in asthmatic pregnant women

Oxidative stress is an important component of asthmatic disease since it is directly involved in airway inflammation and recasting. Our work presented beliefs for asthmatic pregnant women where higher concentrations of serum MDA and urinary 8-OHdG were found in asthmatic pregnant women than non-asthmatic pregnant women denoting that there was greater lipid peroxidation and DNA damage. The results of this study are in concordance with research where oxidative stress biomarkers remain increased in patients suffering from asthma due to increased generation of ROS over antioxidant capacity (Itziou et al., 2024). MDA, a product of lipid peroxidation, has been associated with airway inflammation and hyper-responsiveness in asthma. Similarly, 8-OHdG is acknowledged as a reliable indicator of oxidative DNA damage and has been associated with the severity of asthma and other kinds of respiratory illnesses Rodriguez-Gonzalez et al. (2022). The elevated OS in asthmatic pregnant females may be more deteriorated by pregnancy-related physiological modifications including metabolic and hormonal changes which may augment inflammation (Grzeszczak et al., 2023). Finally, decreased antioxidant defense capacity which is indicated in the present study by the lower TAC and SOD in the asthmatic group supports the argument of this study that there is a reduced ability to scavenge ROS during pregnancy. Such depletion in antioxidant defenses has been reported for asthma and pregnancy-related disorders, establishing that pregnant asthmatic women are prone to oxidative stress (Enriquez et al., 2021).

Immune Response Alterations

Common respiratory diseases such as asthma have a Th2-mediated immune response with amplified secretion of cytokines such as IL-4, IL-5, and IL-13, which are involved in the pathogenesis of airway inflammation (Vanders et al., 2013). In the present study rises in the mediators of inflammation such as IL-6, TNF-α, and IgE have been observed in asthmatic pregnant women. These results are in concordance with our prior work and others who reported increased soluble inflammatory cytokines and IgE in asthma with pregnancy (Bishopp et al., 2017). IL-6, a cytokine implicated in the regulation of systemic inflammatory response was notably high in the asthmatic group implications of heightened inflammation. Another pro-inflammatory cytokine initially studied in asthma is TNF-α which also increased suggesting that a condition of systemic inflammation may play a significant role in the exacerbation of asthma during pregnancy (Meakin et al., 2020). The high frequencies of raised IgE concentrations emphasized the importance of sensitization to allergens in asthmatic pregnancies in our study. IgE is particularly implicated involving allergic asthma in which its level increases with airway sensitivity and inflammation. The high levels of IgE determined in the present study may have consequences for pregnancy outcomes since elevated IgE levels are associated with preterm delivery and other complications (Dimitrov et al., 2024). This elevated inflammation could therefore be an important explanation for the perceived effects on both maternal and fetal health in asthmatic pregnancies.

The effect of asthma on pregnancy outcome

This study revealed that asthmatic pregnant women delivered earlier than non-asthmatic pregnant women to deliver infants with low birth weight. These observations are consistent with other research that indicates poor pregnancy outcomes in asthmatic women such as preterm delivery and intrauterine growth restriction (Bishopp et al., 2017). These conditions signal disrupted immune regulation, and increased oxidation stress in these women, and may partly explain the altered placental function, poor fetal development, and other manifestations of asthma in pregnancy. Han, et al. (2022) have established a study that inflammation and oxidative stress could have a detrimental effect on placental blood flow, and fetal growth and predispose the fetus to preterm birth. The one and five-minute Apgar scores of infants born to asthmatic women were significantly lower than the infants born to non-asthmatic women implying that fetal health could be direly affected by the maternal inflammatory oxidative condition. Lower Apgar scores have been reported to be related to respiratory troubles during the neonatal period which could be explained by maternal asthma and its impact on fetal organs through the system (Carvalho-Pinto et al., 2023; Shrestha et al., 2020).

Conclusions for Practice and Research Perspective

Therefore, our results support the importance of carefully addressing asthmatic pregnant women to ensure oxidative stress and immune abnormality consequences are addressed. Asthma during pregnancy is more risky than at other times since maternal and fetal cells and immune response change during pregnancy and exert effects on the oxidative stress system. Augmenting the levels of antioxidants or using corticosteroids or other biologics that work against the cytokines implicated in these women may potentially form beneficial treatments since oxidative stress is high and women suffering from rheumatoid arthritis have been observed to have high levels of inflammation markers. But, the effect of such

interventions during pregnancy is still not clearly understood and safe. Further research should focus on the literature courses of oxidative stress and immune changes on both mother and child health results about asthma-related malfunction. Understanding such changes on a molecular basis could help design better and more targeted treatment interventions that could enhance pregnancy outcomes of asthmatic women.

Conclusion

This research confirms that compared to asthmatic non-pregnant women, asthmatic pregnant women are characterized by higher scores in terms of oxidative stress and immune response indicating exacerbation of these processes during pregnancy that can explain worse outcomes observed in this population. The interactions between oxidative stress, inflammatory cytokines, and immune system involvement make the treatment of asthma in pregnancy a complex question. Future research and clinical work should aim at decreasing oxidative and immune alterations that are the main features of asthmatic pregnancies to enhance the outcomes of these pregnancies.

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Declarations

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Authors' Contribution

Arif Malik: Initiated the formulation of the research proposal, developed the strategies for data collection, and was in charge of the project. Played a role in data analysis and writing of the manuscript.

Jehanzaib Islam: Helped in the design of the study, sample collection, and contribution to data analysis. Supported in statistical work and analysis of the results obtained.

Ayesha Zahid: Helped in the selection of participants, carried out the laboratory measurements, and contributed to the idea of oxidative stress markers.

Gul Zaib: Helped in data collection, understanding of the hematological and immune response parameters, and in writing this manuscript.

Abdur Rehman Rashid, Muhammad hamza Ashraf: Offered statistical analysis, checked data, and was involved in manuscript filling and altering.

All authors have contributed to this research and read the final manuscript for approval.

Conflict of Interest

The authors report no conflict of interest in relation to this research. The study was carried out personally and no commercial and financial interest was involved in the present work.

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Ethics approval and consent to participate

This research was conducted under the approval of the ethics committee of the hospital and informed written consent from the participants. Privacy of the focus was enhanced throughout the study, and the data collected did not have any individual identifiers.

Consent for Publication

Not applicable