ISSN- O: 2458 - 868X, ISSN–P: 2458 – 8687
National Library of Medicine - ID: 101731606

International Journal of Medical Science and Innovative Research (*IJMSIR*)
IJMSIR : A Medical Publication Hub
Available Online at: www.ijmsir.com
Volume – 8, Issue – 3, May – 2023 , Page No. : 138 - 146

Relationship between maternal weight gain at term, fetomaternal blood flow parameter and neonatal birth weight – An observational, Indian study

[1]Dr. Sunil Kumar, MBBS, MS Obs and Gyne, Third year Resident, INHS Asvini, Colaba Mumbai.

[2]Dr. Rajesh Sharma, MBBS, MS, Trained in ART, Associate Professor Obs and Gyne INHS Asvini Colaba Mumbai.

Corresponding Author: Dr. Sunil Kumar, MBBS, MS Obs and Gyne, Third year Resident, INHS Asvini, Colaba Mumbai.

Citation this Article: Dr. Sunil Kumar, Dr. Rajesh Sharma, "Relationship between maternal weight gain at term, feto maternal blood flow parameter and neonatal birth weight – An observational, Indian study", IJMSIR- May - 2023, Vol – 8, Issue - 3, P. No. 138 – 146.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Weight gain during pregnancy is a key indicator of maternal and fetal nutrition. Ab normal place ntal vascular development can com pro mise pregnancy out comes. The present study evalua ted the relationship of fetal birth weight with maternal weight gain and place ntal blood flow velocimetry.

Methods: 250 primigravida females booked and delive red at study hospital between January 2021 and June 2022 were enrolled. Baseline and demo graphic details were noted with maternal weight gain during pregnancy. Feto-maternal blood flow para meter was measured at 32 -34 weeks and 36-38 weeks of pregnancy by colour doppler ultrasound. Pearson's correlation test was used to assess cor relation of fetal birth weight with maternal weight gain and umbilical artery (UA) S/D ratio.

Results: Mean age of enrolled females was 25.12±4.29 years, with majority having normal BMI (n=175, 70%). Mean maternal weight gain was 11. 85±2.32 kg (range: 5.9 kg to 16 kg). 188 females (75.2%) had weight gain of 10-15 kg. 210 (84%) females at 32-34 weeks and 238 (95.2%) females at 36-38 weeks had UA S/D ratio of <3. 35 (14%) females gave birth to neonates with birthweight <2.5 kg. 12 (4.8%) neonates were admitted to NICU, with no deaths reported. Correlation between maternal weight gain and fetal birth weight indicated non-significant mild positive correlation (r=0.29, CI: 0.21-0.42, p=0.11). At both 32-34 weeks (r=0.24, CI: -0.16-0.32, p=0.28) and 36-38 weeks (r=-0.28, CI: -0.15-0.38, p=0.18) there was non-significant mild negative correlation between fetal birth weight and UA S/D. 20 females (8%) had hypertension or pre-eclampsia, and all these cases showed S/D ratio >3.

Conclusion: There was a trend showing direct cor relation of fetal birth weight with maternal weight gain, and inverse correlation with UA S/D ratio. Subjects with ideal weight gain during preg nancy had higher chances of uneventful delivery and better obstetric outcomes.

Keywords: Fetal birth weight, Maternal weight gain, Fetomaternal blood flow, Umbilical artery, S/D ratio.

Introduction

A woman's weight normally increases during preg nancy because of the growth of fetal and maternal tissues and fluids. Weight gain during pregnancy, among the import ant indicators of preg nancy maternal nutrition, is also a good measure of intra-uterine fetal nutrition.[1,2] Thus, sub-optimal gestation nal weight gain (GWG) is associated with various adverse pregnancy outcomes. These out comes may include but are not limited to: high birth weight (HBW), low birth weight (LBW), preg nancy-induced hyper tension, gestational diabetes, preterm births, caesarean delivery, and delayed initiation of breast feeding.[3,4] Birth weight is also a known predictor of fetal wellbeing and newborn's future chances of survival and is dependent on maternal health and nutrition during pregnancy.[5] It is also accepted that child growth failure occurs in the critical window of opportunity, from con ception up-to two years of age, and about 50% of the growth failure which occurs by two years of age occurs in uterus.[6] Low birth weight i.e. weight below 2500 grams may indicate that the baby did not remain in the uterus long enough or it did not develop well enough. The incidence of low birth weight (LBW) in India varies between 25-30% and of which 60-65% are because of fetal growth restriction (FGR).[7] Given its prediction of fetal wellbeing, intrauterine malnutrition has more serious and far-reaching consequences, because an insult which occurs during pregnancy permanently affects tissue structure and function.[8] These concerns make the fetal period a critical window of opportunity, and nutriti on intervention during this period and improving birth weight will help break the vicious intergenerational cycle of malnutrition.[6] Evidence from developing countries over time also demonstrates that the incidence of FGR decreases as a country becomes more developed. Some of the adverse factors responsible are maternal malnutriti on, anemia, inadequate prenatal care, drug abuse, birth order, maternal medical problem, e.g., pregnancy induced hyper tension, diabetes mellitus, cardiac diseases, and chronic infections.[9]

Not only below-par weight gain, but even greater weight gain during pregnancy can lead to poor outcomes in both mother and fetus. Weight gain during pregnancy has always been a matter of great concern for most women and obstetricians. This concern exists because gestational weight gain is related to many complications, both maternal and fetus. Macrosomia is a major complication, consisting of cases of infants born weighing more than 4000 gm, regardless of the gestational age.[10] This large weight is associated with complications for both the mother and the child. The most common complications in macrosomic fetuses include: increased risk of intrauterine death, hypertrophic cardio-myopathy, need for intensive care, shoulder dystocia, humeral and clavicle fractures, meconium aspiration, hypo-glycemia, neonatal hyper-bilirubinemia, paralysis of the facial and brachial plexus and obesity in childhood and adulthood.[11] For mothers, the most common complications include: increased risk of cesarean section, cephalo-pelvic disproportion, pro longed labor, soft-tissue lacerations and postpartum hemo rrhage.[12]

Normal placental vascular development ensures a healthy pregnancy outcome, whereas insufficient or abnormal placental vascular development will compromise preg nancy outcomes both mother and the fetus, with com plications that include preeclampsia and intrauterine fetal growth restriction. The functional unit of the placenta is the chorionic villus, which contains the layers of syn-cyto trophoblasts & cytotrophoblasts, villous stromal, and fetal vascular endothelium that separate maternal blood from the fetal circulation.[13] Doppler ultra sonography pro vides non-invasive hemo dy namic monitoring in human pregnancy. It is used to predict adverse perinatal out comes such as fetal growth restriction and preeclampsia. The present study was planned to evaluate the relation ship between maternal weight gain and flow velocimetry, and the impact of these factors on fetal birth weight. This will help in better understanding of the relationship between maternal weight gain and feto-maternal blood flow in Indian population, which can aid the Indian obstetricians in better feto-maternal care.

Methods

A longitudinal and observational study was conducted by Department of Obstetrics and Gynecology at INHS Asvini, Mumbai. 250 consenting primigravida subjects who were booked and delivered at study hospital bet ween January 2021 and June 2022, fulfilling the screening criteria were enrolled in the study. The study was initiated only after institutional ethics committee per mission was obtained. Subjects with multiple gestation or multigravida status, pregnancies booked in 2nd & 3rd trimester, pregnancy after ART procedure, subject with pre-existing medical complication like diabetes mellitus, hypertensive disease, heart disease, renal disease, autoimmune disease, thrombophilia and connective tissue disorders, subject with feeding disorder or subject who have undergone bariatric surgery, preterm delivery and poly-hydramnios cases were all excluded from study.

Assessment of patient parameters

On admission, routine data such as obstetric, menstrual, medical, surgical, personal and family history were noted. Maternal weight, height, and early pregnancy body mass index (BMI) (based on antenatal records) were calculated. BMI is calculated by dividing the body weight in kilograms by height in meters squared, or kg/ m2. Subjects were classified into 4 groups based on their first trimester BMI:

Under weight –BMI < 18.5 Kg/m^2

Normal weight- BMI -18.5-24.9 Kg/m^2

Overweight -BMI-25-29.9 Kg/m^2

Obese – BMI >30 Kg/m^2

Weight gain during pregnancy was calculated by sub tracting pre-pregnancy weight from maternal weight at the time of delivery. In cases where pre-pregnancy weight is not available, weight in first trimester during first visit to antenatal OPD was taken as pre pregnancy weight to calculate the fetal weight gain during pregna ncy.

Height of the subject was measured using a wall mounted meter stick to the nearest 0.1 cm with women standing erect in her bare feet. Weight was measured digitally to the nearest 0.1 kg with the women in light clothing.

Feto-maternal blood flow assessment

Feto-maternal blood flow parameter was measured at 32-34 weeks, and then at 36-38 weeks of pregnancy by using same colour Doppler ultrasound machine. Blood flow is measured in a free loop of umbilical cord and umbilical artery (UA) S/D ratio was calculated for each case when the fetus is in rest. The enrolled subject's labor was monitored until delivery. The birth outcome was studied, and birth weight was noted.

Statistical analysis

Data analysis was done with the help of statistical software SPSS version 25.0. Quantitative data was presented with the help of mean and standard deviation, while descriptive data was evaluated and expressed as numbers and percentages. The maternal and fetal out comes were evaluated and noted. The fetal birth weight and feto-maternal blood flow assessment were correlated with the help of Pearson's correlation coefficient. P value of less than 0.05 was statistically significant.

Results

Demographic and baseline details

The mean age of enrolled females was noted to be 25.12 $\pm$ 4.29 years, with majority being between 21-25 years' age group (58%). The mean BMI was noted to be 24.4 $\pm$ 3.32 kg/m^2, and majority were in the normal BMI range of 18.5 to 24.99 kg/m^2 (n=175, 70%). Table 1 describes the key baseline participant details.

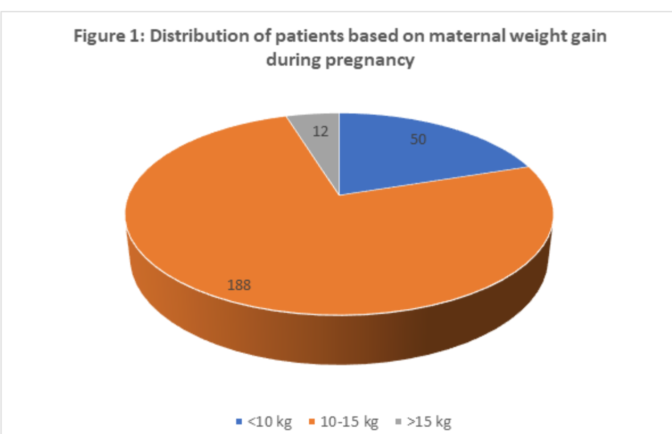
Table 1: Demographic and baseline details of enrolled females (n=250)

Characteristics	Calculated values
Mean age (years)	25.12 ± 4.29
Median age with range (years)	26 (19-31)
Age groups (n with %)	
18-20 years	3 (1.2%)
21-25 years	145 (58%)
26-30 years	100 (40%)
>30 years	2 (0.8%)
Mean BMI (kg/m^2)	24.4 ± 3.32
Median BMI with range (kg/m^2)	23.2 (19.2-34.1)
BMI range (n with %)	
18.5 to 24.99 kg/m^2	175 (70%)
25 to 29.99 kg/m^2	50 (20%)
>30 kg/m^2	25 (10%)

Maternal weight gain during pregnancy

The mean maternal weight gain was noted to be 11.85 ± 2.32 kg, with a median gain of 12.25 kg (range: 5.9 kg to 16 kg). 188 of the enrolled cases (75.2%) were noted to have maternal weight gain of 10-15 kg. (Figure 1)

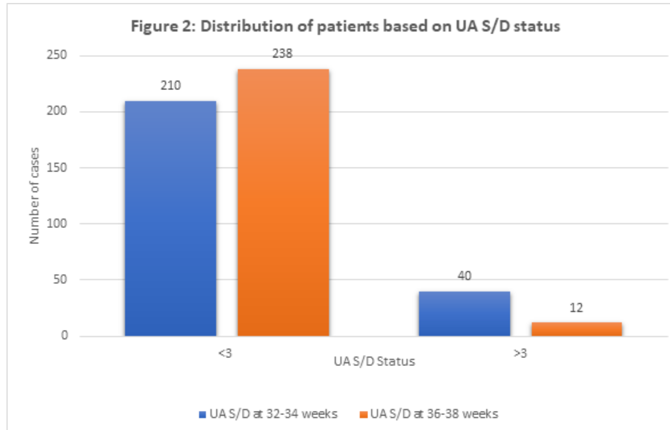
Figure 1:



UA S/D assessment at 32-34 weeks and 36-38 weeks

The mean UA S/D assessment at 32-34 weeks was 2.74 ± 0.58, while it was 2.58 ± 0.13 at 36-38 weeks. The range of UA S/D was 2.2 to 5.5 at 32-34 weeks, while it was 2.3 to 3.1 at 36-38 weeks. 210 (84 %) cases at 32-34 weeks and 238 (95.2%) cases at 36-38 weeks had UA S/D ratio of <3. (Figure 2)

Figure 2:



Maternal and fetal outcomes

210 females (84%) underwent vaginal delivery, 30 (12%) underwent caesarean delivery (22 underwent emergency section and 8 underwent elective section), while 10 (4%) females underwent instru mental delivery. The indications for the emergency section were non-progression of labour (n=16) and fetal distress (n=6). The maternal complications are noted below in figure 3.

Figure 3:

Figure 3: Maternal complications in study (n=250)

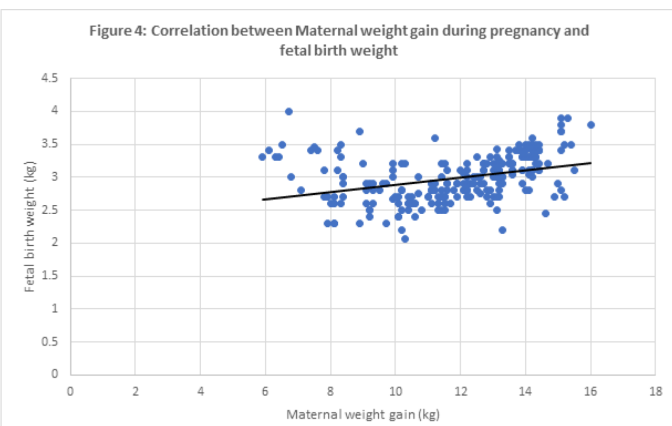
The mean neonatal birth weight was noted to be 2.95 ± 0.37 kg, while the median birth weight was 2.9 kg (range: 2.07 to 4.1 kg). 215 (86%) of the enrolled mothers gave birth to neonates with birthweight ≥2.5 kg, while remaining 35 (14%) had neonates with birthweight <2.5 kg. A total of 12 (4.8%) neonates were admitted to NICU, the indications for which were fetal distress (n=6), low birth weight (n=4) and low APGAR scores (n=2). No incident of neonatal death was noted in study.

The mean maternal weight gain was noted to be lower (9.23 ± 2.21 kg) in the sub-group of patients with neonates having low birth weight in com parison to the subgroup with normal birth weight, which noted a higher mean maternal weight gain (10.27 ± 2.11 kg). However, the difference was not statistically significant (p=0.21).

Correlation of fetal birth weight with maternal weight gain and UA S/D

On calculating the correlation between maternal weight gain and fetal birth weight, the correlation value (r) was noted to be 0.29 (CI: 0.21-0.42). which indicated mild positive correlation between maternal weight gain and neonatal birth weight. However, P value was 0.11, considered NOT significant. (Figure 4)

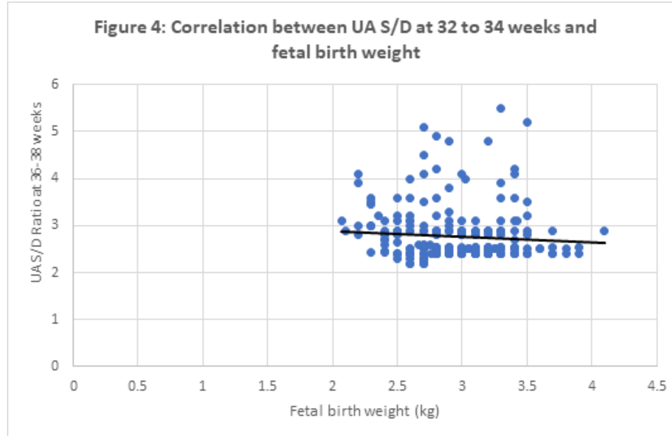
Figure 4:



P=0.11, considered not significant by Pearson's correlation test

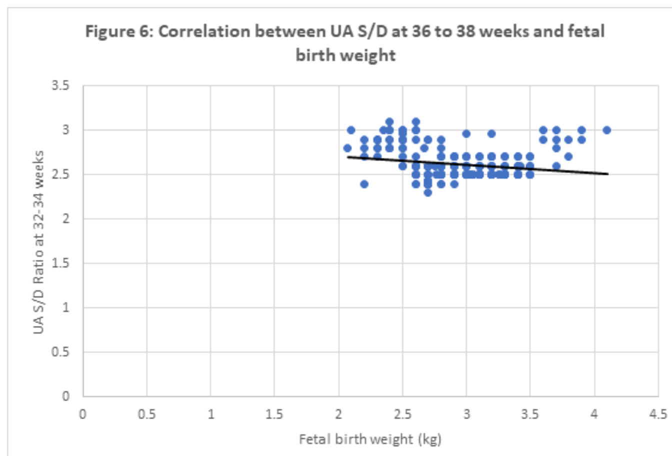
The correlation between fetal birth weight and UA S/D ratio was also evaluated. At 32-34 weeks, the r value was -0.24 (CI: -0.16 to 0.32), while at 36-38 weeks the r value was -0.28 (CI: -0.15 to 0.38) indicating mild negative correlation between fetal birth weight and UA S/D at both time points. P value was >0.05 and not significant at both time points (Figures 5,6).

Figure 5:



P=0.28, considered not significant by Pearson's correlation test.

Figure 6:



P=0.18, considered not significant by Pearson's correlation test

Discussion

Fetus is completely dependent upon the mother for its nutrition. Nutrition from the maternal circulation is transferred to the fetus through placental interference. Insufficient or aberrant placental vascular development will endanger the health of the mother and the baby throughout pregnancy, leading to issues including pre-eclampsia and intrauterine fetal growth limitation. Normal placental vascular development assures a success ful pregnancy result. Doppler ultrasonography is a non-invasive method of hemodynamic monitoring of human pregnancy. It is employed to evaluate both placental and fetal circulation. Additionally, it is utilised to foresee unfavorable prenatal outcomes such hypertension and fetal growth limitation. Doppler examinations of the uterine artery (UtA), umbilical artery (UA), middle cerebral artery (MCA), and ductus venosus are frequently carried out. According to a research, unfavorable peri natal outcomes in the obstetric population may be accu rately predicted by maternal and fetal Doppler blood flow characteristics.[14]

In present study, there was a non-significant positive corr elation noted between maternal weight gain and neonatal birth weight. Gestational weight gain re commendations aim to optimize outcomes for the woman and the infant. In 2009, the Institute of Medicine (IOM) published revised gestational weight gain guidelines that are based on pre preg nancy body mass index (BMI) ranges for underweight, normal weight, overweight, and obese women recommended by the World Health Organization and are independent of age, parity, smoking history, race, and ethnic back ground.[15] The updated IOM recommend ations have met with controversial reactions from some physicians who believe that the weight gain targets are too high, especially for overweight and obese women.

Generally, the hemodynamic changes in pregnancy are usually characterized by declining umbilical artery flow resistance and increased blood flow with advancing gestational age. Doppler ultrasound in the umbilical artery may present some advantages over Non-Stress Test (NST) in predicting adverse fetal outcome. Impaired utero placental blood supply does not necessarily corr elate with permanent fetal hypoxemia,[16] particularly as oxygen supply may be adequate or only slightly reduced during maternal resting, at the time when NSTs are performed. Some fetuses with absence of end-diastolic velocity may therefore present normal NST, since they have normal blood gas values at the time of examination. In these cases, NST may not reflect the severe fetal compromise until a short time before fetal death. Furthermore, during the mid-trimester and early in the third trimester, the value of a non-reactive NST is difficult to determine, since a considerable number of NSTs are expected to be non-reactive due to the relative immaturity of the fetal central nervous system.[17] Doppler ultra sound, a non-invasive method to examine the utero placental circulation, has been proposed as an early screening test for fetal growth restriction.[18] The use of UA Doppler as a fetal testing modality is based on the premise that abnormal placental perfusion is associated with adverse pregnancy outcome. In growth restricted fetuses, Doppler studies of the UA can identify placentas with increased vascular impedance and thus, select a group of high-risk pregnancies in need of increased fetal and maternal surveillance.[19,20] Vergani P et al studied the placental blood flow and fetal outcome and concluded that abnormal Doppler velocimetry of the UA in suspected growth restricted fetuses is statistically correlated with preterm delivery, delivery by cesarean section, admission to the NICU and a final diagnosis of fetal growth restriction.[21] In present study, the umbilical artery doppler study was conducted between 32-34 weeks as well as between 36-38 weeks. The UA S/D ratio was raised at 32-34 weeks in 16% of enrolled females, and in 4.8% at 36-38 weeks. The LBW status was found to be present in 14% neonates. The S/D ratio was calculated for the pregnancy females, and on correlating them with the fetal weight gain, mild negative correlation was noted. This indicated that with higher S/D ratio, there was a trend for lower fetal birth weight. These findings were not statistic ally significant however an indirect trend was noted between umbilical artery SD ratio and fetal birth weight.

There are studies which have evaluated utility of UA Doppler in predicting fetal outcomes. The study conducted by Bonnin et al. investigated the impact of umbilical placental resistance level on fetal growth develop ment. Doppler measurements were conducted in third trimester, just like in our study.[22] The authors had found an inverse correlation between placental resistance index and the birth weight of neonates, which is in alignment to our findings. These findings suggest that umbilical placental resistance level determines fetal growth development and birth weight during pregnancies without placental insufficiency. A recent study published in 2022 by Adi Kamni et al. noted that pregnant women with adverse pregnancy outcomes had significantly higher second trimester mean umbilical systolic/diastolic (S/D) ratio ($p = 0.016$). By the third trimester, the um bilical artery PI was higher in the mothers with associ ated adverse fetal outcomes.[23] These findings go in-line with our study findings which showed negative corre lation between UA S/D ratio and fetal birth weight.

Pregnancies complicated with hypertensive disorders are regarded as high-risk and contri bute to increased mater nal and perinatal morbidity and mortality. The genesis behind abnormal umbilical artery Doppler spectral waveforms in patients with hypertensive dis orders in preg nancy is not unrelated to the significant reduction in maternal utero-placental flow in some of the hypertensive disorders. Reduction in utero-placental blood flow invariably results in deterioration of umbilical artery waveforms.[24] Out of 250 females, 20 females (8%) were noted to have developed hypertension or pre-eclampsia in our study, and all these cases showed S/D ratio >3. In addition, it was found that majority of these females with hypertension or pre-eclampsia had neonates with low birth weight (18/20, 90%). This showed a direct associ ation between hyper tension or pre-eclampsia status, and low neonatal birth weight.

The study had a few limitations. Present study was con ducted at only one study centre, and hence the genera lization of results to whole Indian population needs to be done with caution. In addition, UA S/D ratio was correlated with fetal birth weight, but pulsality index and resistivity index were not focused upon. Multi centric studies with large sample size are required to validate our study findings.

Conclusion

There was a trend showing direct correlation of fetal birth weight with maternal weight gain, and inverse correlation of fetal birth weight with UA S/D ratio. There was direct association noted between hypertension or pre-eclampsia status, and low neonatal birth weight. Subjects with ideal weight gain during pregnancy had higher chances of un eventful delivery and better obstetric outcomes. Weight gain during pregnancy should be individualized and im portance of individual nutrition plan should be emphasis ed during anti-natal follow ups.

References

1. Muthayya S. Maternal nutrition & low birth weight—What is really important? Indian J Med Res. 2009;130(5):600–8.
2. Panahandeh Z. Gestational Weight Gain and Fetal Birth Weight in Rural Regions of Rasht / Iran. 2009; 19 (1): 18–24.
3. Liu Y, Dai W, Dai X. Prepreg Nancy body mass index and gestational weight gain with the outcome of pregnancy: a 13-year study of 292, 568 cases in China. 2012; 905–11.
4. Haugen M, Brantsæter A, Winkvist A, Lissner L, Alexander J, Of tedal B, et al. Associations of pre-preg nancy body mass index and gestational weight gain with

preg nancy outcome and postpartum weight retention: a pro spective observational cohort study. BMC Pregnancy Child birth. 2014; 14(1):201.

5. Lechtig A, Cornale G, Ugaz ME, Arias L. Decrea sing stunting, Anemia, and vitamin A deficiency in Peru: Results of the good start in life program. Food Nutr Bull. 2009;30(1):37–48.

6. Shrimpton R. Maternal nutrition and the inter generation al cycle of growth failure. Matern Nutr inter generation al cycle growth Fail Prog Nutr 6th Rep World Nutr Situat. 2010;62–75.

7. Raman TR, Devgan A, Sood SL, Gupta A, Ravi Chander B. Low Birth Weight Babies: Incidence And Risk Factors. Med J Armed Forces India. 1998; 54 (3): 191-5.

8. Barker DJP. In utero programming of cardiovascular disease. Theriogenology. 2000;53(2):555–74.

9. Hivre SS, Gantra BR. Determinants of low birth weight. A community based prospective cohort study. Indian Pediatr. 1994;31:1221–5.

10. Chen CN, Chen HS, Hsu HC. Maternal Pre-pregnancy Body Mass Index, Gestational Weight Gain, and Risk of Adverse Perinatal Outcomes in Taiwan: A Population-Based Birth Cohort Study. Int J Environ Res Public Health. 2020;17(4):1221.

11. Ukah UV, Bayram pour H, Sabr Y, Razaz N, Chan WS, Lim KI, et al. Association between gestational weight gain and severe adverse birth outcomes in Washington State, US: A population-based retrospective cohort study, 2004-2013. PLoS Med. 2019; 16(12): e1 003 009.

12. Santos S, Voerman E, Amiano P, Barros H, Beilin LJ, Bergstrom A, et al. Impact of maternal body mass index and gestational weight gain on pregnancy compli cations: an individual participant data meta-analysis of Euro pean, North American and Australian cohorts. BJOG. 2019;126 (8):984-95.

13. Wang Y, Zhao S. Vascular Biology of the Placenta. San Rafael (CA): Morgan & Claypool Life Sciences; 2010. Chapter 1, Introduction. Available from: https:// www. ncbi. nlm.nih.gov/books/NBK53251/ Accessed on 15th April 2023.

14. Alfirevic Z, Stampalija T, Gyte GM. Fetal and umbilical Doppler ultrasound in high-risk pregnancies. Cochrane Database Syst Rev. 2010;(1):CD007529.

15. Institute of Medicine. Weight gain during preg nancy: re-examining the guidelines. Washington, DC: 20 09.

16. Nicolaides KH. Bilardo CM. Soothill PW. Campbell S. Absence of end-diastolic frequencies in umbilical artery: a sign of fetal hypoxia and acidosis. Br Med J 1987: 297: 1026-32.

17. Torres PJ, Gratacós E, Alonso PL. Umbilical artery Doppler ultrasound predicts low birth weight and fetal death in hypertensive pregnancies. Acta Obstet Gynecol Scand. 1995;74(5):352-5.

18. Bower S, Schuchter K, Campbell S. Doppler ultra sound screening as part of routine antenatal scanning: prediction of pre-eclampsia and intrauterine growth retardation. Br J Obstet Gynaecol. 1993;100:989–94.

19. Ghosh GS, Gudmundsson S. Uterine and umbilical artery Doppler are comparable in predicting perinatal outcome of growth-restricted fetuses. BJOG 2009; 116 (3): 424–430.

20. Gudmundsson S, Marsa´l K. Blood velocity wave forms in the fetal aorta and umbilical artery as predictors of fetal outcome: a comparison. Am J Perinatol 1991; 8 (1):1–6.

21. Vergani P, Andreotti C, Ron Caglia N, Zani G, Pozzi E, Pezzullo JC, et al. Doppler predictors of adverse neo natal outcome in the growth restricted fetus at 34

weeks' gestation or beyond. Am J Obstet Gynecol 2003; 189 (4):1007–11.

22. Bonnin P, Bailli art O, Kedra W, Ciraru-Vigneron N, Niang E, Savin E, et al. Relationship between birth weight and umbilical Doppler blood flow velocity wave forms during the third trimester of pregnancy. Eur J Med. 1993;2(4):219-22.

23. Adekanmi AJ, Roberts A, Morhason-Bello IO, Adeyinka AO. Utilization of Uterine and Umbilical Artery Doppler in the Second and Third Trimesters to Predict Adverse Pregnancy Outcomes: A Nigerian Exper ience. Womens Health Rep (New Rochelle). 2022; 3 (1): 256-66.

24. Sebire NJ. Umbilical artery Doppler revisited: Patho physiology of changes in intra-uterine growth restriction revealed. Ultrasound Obstet Gynecol 2003;21:419-22.