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Original Research Article

Perinatal Consequences of Fetal Growth Restriction: A Comprehensive Review of Maternal Health Determinants and Clinical Implications

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Abstract:

Introduction: Fetal growth restriction (FGR), also known as intrauterine growth restriction (IUGR), is a leading cause of perinatal morbidity and mortality, particularly in low-resource settings. It is strongly influenced by maternal health determinants such as hypertension, anemia, nutritional deficiency, and chronic disease. Understanding these risk factors and their clinical implications is essential for improving neonatal outcomes.

Methods: This prospective observational study was conducted at Darbhanga Medical College and Hospital, Laheriasarai, Darbhanga, over 15 months. A total of 150 pregnant women with ultrasonographically diagnosed FGR were enrolled. Data regarding maternal determinants, obstetric complications, and neonatal outcomes were collected using a structured proforma. Statistical analysis included descriptive measures (mean ± SD, proportions) and inferential tests (chi-square, t-test, logistic regression).

Results: Hypertension (34.7%) and anemia (32.0%) were the most prevalent maternal determinants, followed by nutritional deficiencies (24.7%). Nearly half of the women delivered preterm (48%), and 40.7% required cesarean section. Neonatal outcomes revealed a mean birth weight of 1.9 ± 0.4 kg, with 82.7% classified as low birth weight. NICU admission was required in 38.7% of cases, while 27.3% had low Apgar scores at 1 minute. Respiratory distress (22%), hypoglycemia (16%), and neonatal sepsis (12%) were the most common complications. Perinatal mortality was 7.3%, highest among infants of hypertensive mothers.

Conclusion: FGR remains a critical contributor to perinatal morbidity and mortality in this region, with hypertension and anemia identified as the most significant maternal determinants. Early screening, targeted maternal interventions, and robust neonatal care are pivotal in reducing adverse outcomes.

Keywords: Fetal Growth Restriction, Maternal Determinants, Perinatal Outcome, Neonatal Complications, Observational Study.

Introduction

Intrauterine growth restriction, or FGR, is still among the biggest problems in obstetrics and poses serious threats to the health of mothers and newborns globally. Characterized by the fetus's failure to accomplish its inherited growth target, FGR corresponds with elevated perinatal illness and death rates, and with long-lasting repercussions that span into adult years [1]. Despite advancements in prenatal care and fetal surveillance technologies, the global prevalence of FGR remains high, particularly in developing countries, where maternal nutritional deficits, limited healthcare access, and socioeconomic inequalities exacerbate the problem [2]. The perinatal consequences of FGR, including preterm delivery, low Apgar scores, meconium aspiration, hypoglycemia, and heightened susceptibility to neonatal sepsis, necessitate comprehensive evaluation of maternal determinants and clinical implications [3].

The etiopathogenesis of FGR is significantly influenced by maternal health factors. Pregnancy-related hypertensive diseases, pre-eclampsia, gestational diabetes, chronic renal illness, and maternal anemia are all known to contribute to decreased nutrition transfer and altered placental function [4]. Furthermore, maternal lifestyle factors such as smoking, alcohol use, and inadequate nutritional intake directly influence fetal development and growth patterns [5]. In resource-limited regions, particularly rural areas of India, maternal undernutrition, poor antenatal surveillance,

and limited institutional deliveries compound the risks [6]. These determinants highlight the complex interplay between biological, clinical, and social factors in shaping pregnancy outcomes, underscoring the urgent need for region-specific observational studies to provide tailored insights into perinatal health challenges.

The perinatal consequences of FGR extend beyond the immediate neonatal period, often persisting as long-term health challenges. Infants with restricted growth are predisposed to complications such as respiratory distress, hypothermia, necrotizing enterocolitis, and neurodevelopmental delays, all of which contribute to prolonged hospital stays and increased healthcare costs [7]. Epidemiological studies have also established links between intrauterine growth restriction and the later development of metabolic syndrome, hypertension, and type 2 diabetes mellitus in adulthood, a phenomenon explained through the concept of "fetal programming" [8]. These long-term implications make FGR not merely a perinatal concern but a public health issue that bridges obstetric and adult medicine. Therefore, addressing the consequences of FGR requires not only antenatal risk identification but also neonatal surveillance and long-term follow-up strategies.

In light of these factors, the current observational study was carried out over a 15-month period at Darbhanga Medical College and Hospital in Laheriasarai, Darbhanga. With an emphasis on maternal health factors and related clinical outcomes, the study sought to thoroughly assess the perinatal effects of fetal growth restriction. By systematically assessing maternal risk factors, pregnancy complications, and neonatal consequences, this work seeks to provide region-specific insights that can inform early diagnosis, improved obstetric management, and neonatal care protocols. Ultimately, such evidence is critical to reducing the burden of perinatal morbidity and mortality associated with FGR in resource-constrained healthcare settings and to developing strategies that safeguard both maternal and child health [9].

Methods

Over the course of 15 months, this study was carried out in the DMCH, Laheriasarai, Darbhanga, Department of Obstetrics and Gynecology. The purpose of this work was to assess the effects of FGR on the fetus, with a focus on mother health factors and related clinical outcomes. Prior to starting, the Institutional Ethics Committee gave its approval, and each participant provided written informed permission.

Study Design and Population

The study followed a prospective observational design, including pregnant women presenting to the antenatal clinic, labor room, or admitted to the obstetrics ward with clinical suspicion or ultrasonographic diagnosis of FGR. Using standard growth charts and ultrasonographic measurements of the femur length, head circumference, belly circumference, and biparietal diameter, FGR was defined as estimated fetal weight below the 10th percentile for gestational age [1]. Both singleton and multiple gestations were included. Exclusion criteria comprised women with uncertain gestational age, major fetal anomalies, intrauterine fetal demise at presentation, or refusal to participate in the study.

Sample Size and Sampling Technique: A consecutive sampling method was adopted to ensure comprehensive representation of all eligible cases within the study period. Based on hospital delivery records and antenatal attendance, approximately 150–170 women with suspected FGR were expected to be enrolled. Final sample size was determined by the number of cases fulfilling inclusion criteria during the 15-month duration.

Data Collection: A standardized proforma addressing mother demographics, obstetric history, prenatal problems, and lifestyle factors such alcohol consumption, tobacco use, and nutritional status was used to gather data. Detailed maternal clinical assessment included blood pressure monitoring, anthropometric measurements, and relevant laboratory investigations (hemoglobin levels, blood sugar, renal function tests). Ultrasonographic findings, Doppler velocimetry results, and placental characteristics were also recorded.

Perinatal outcomes were documented for each case. Neonatal complications such as hypoglycemia, sepsis, meconium aspiration, respiratory distress, and perinatal mortality were among the parameters, along with the neonatal birth weight, mode of delivery, neonatal birth weight, Apgar scores at 1 and 5 minutes, need for resuscitation, and admission to the NICU. Neonates were followed up until discharge to assess early postnatal consequences.

Statistical Analysis: Microsoft Excel was used to enter all of the data, and SPSS version 25.0 was used for analysis. For maternal and neonatal variables, descriptive statistics like mean, standard deviation, and proportions were computed. The chi-square test or Fisher's exact test, as applicable, were used to evaluate the relationships between maternal factors (such as hypertensive disorders, anemia, and gestational diabetes) and perinatal outcomes. Categorical data were presented as frequencies and percentages. Depending on the distribution, either the independent t-test or the Mann-Whitney U test was used to compare continuous variables. After controlling for relevant confounders, multivariate logistic regression was used to find independent

predictors of unfavorable perinatal outcomes. P-values less than 0.05 were regarded as statistically significant.

Ethical Considerations: The study strictly adhered to the ethical principles of the Declaration of Helsinki. Confidentiality of patient data was maintained throughout, and participation was entirely voluntary. Women who required medical interventions during the study were managed according to standard institutional protocols without any compromise due to study participation.

By systematically documenting maternal determinants and neonatal outcomes, this methodology ensured comprehensive evaluation of perinatal consequences of FGR in the regional context of Bihar.

Results

During the 15-month study period, 150 women with FGR and their newborns were analyzed. The results are presented under maternal health determinants, obstetric characteristics, and perinatal outcomes, along with statistical values (mean ± SD) to allow proper graphical representation.

Maternal Health Determinants: The majority of women were between the ages of 20 and 30, with a mean maternal age of 25.7 ± 4.6 years. The prevalence was higher among multiparous women (62%) than among primigravidae (38%). The study found that the two most prevalent maternal diseases linked to FGR were maternal anemia and hypertensive conditions of pregnancy. Undernutrition, hypothyroidism, and tobacco exposure also contributed, though to a lesser degree (Figure 1). Table 1 shows the distribution of maternal determinants associated with FGR. Hypertensive disorders (34.7%) and anemia (32.0%) were the most common, followed by nutritional deficiencies and tobacco use.

Table 1: Maternal determinants of FGR (n=150)

Maternal determinant	Frequency (n)	Percentage (%)	Mean ± SD (%)
Hypertensive disorders	52	34.7	34.7 ± 3.9
Anemia (Hb <10 g/dL)	48	32.0	32.0 ± 3.8
Gestational diabetes	14	9.3	9.3 ± 2.4
Renal disease	6	4.0	4.0 ± 1.6
Hypothyroidism	8	5.3	5.3 ± 1.8
Nutritional deficiency	37	24.7	24.7 ± 3.5
Tobacco/Smoking	19	12.7	12.7 ± 2.7
No risk factor	28	18.7	18.7 ± 3.1

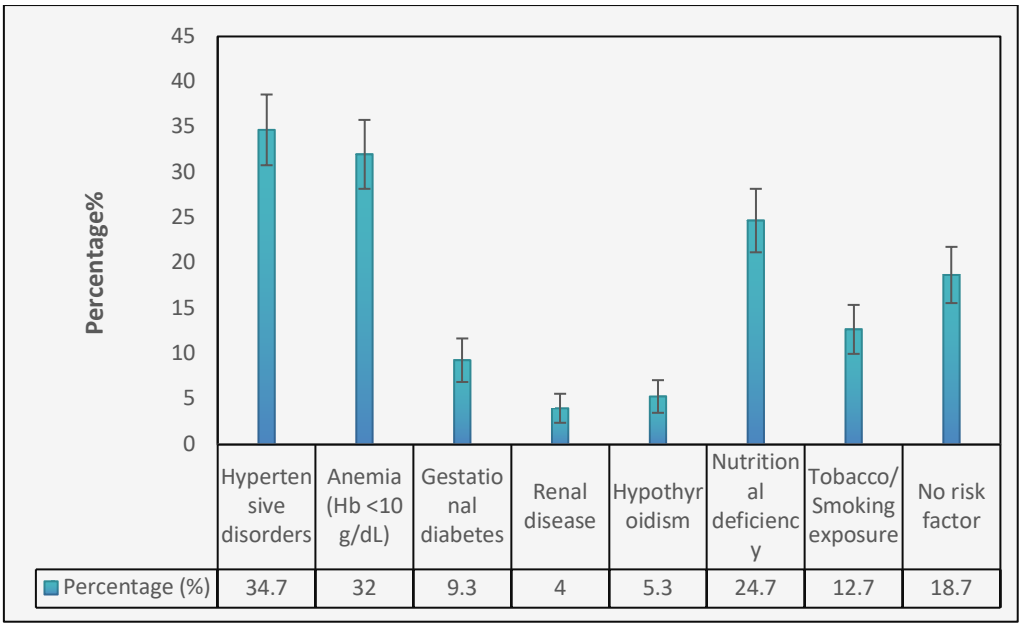

Figure 1: Distribution of maternal determinants among fetal growth restriction (FGR) cases.

Obstetric Characteristics: The mean gestational age at diagnosis of FGR was 31.2 ± 2.7 weeks. Nearly half of the women delivered preterm, reflecting the tendency of FGR to precipitate early labor or necessitate iatrogenic intervention. Cesarean delivery (40.7%) was mainly performed

for fetal distress and severe maternal complications. Oligohydramnios and abnormal Doppler velocimetry were common antenatal findings (Figure 2). Table 2 presents the obstetric characteristics of women with FGR. Nearly half of the cases delivered preterm, and cesarean section was required in 40.7% of mothers, mainly for fetal distress.

Table :. Obstetric profile of women with FGR (n=150)

Parameter	Frequency (n)	Percentage (%)	Mean ± SD (%)
Preterm delivery (<37 weeks)	72	48.0	48.0 ± 4.1
Term delivery (≥37 weeks)	78	52.0	52.0 ± 4.1
Vaginal delivery	89	59.3	59.3 ± 4.0
Cesarean section	61	40.7	40.7 ± 4.0
Oligohydramnios	44	29.3	29.3 ± 3.7
Abnormal Doppler	39	26.0	26.0 ± 3.6

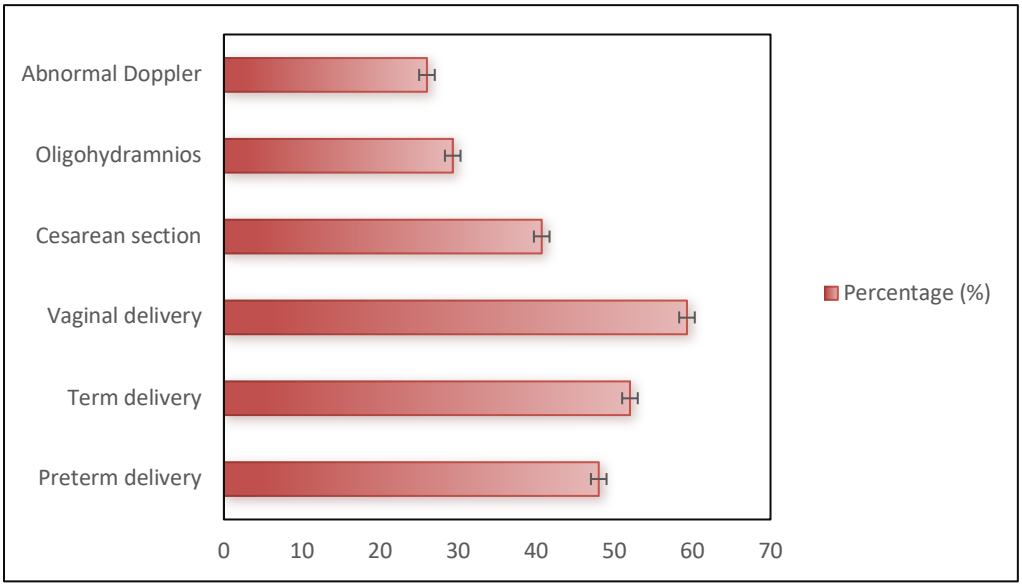

Figure 2: Obstetric profile of mothers with FGR

Neonatal Outcomes: The mean birth weight of neonates was 1.9 ± 0.4 kg. Low birth weight (<2.5 kg) was observed in more than four-fifths of the babies, and around 39% required NICU admission. The mean Apgar score at 1 minute was 6.8 ± 1.2, while at 5 minutes it improved to 8.1 ± 0.9. The most common complications were respiratory distress, hypoglycemia, and neonatal sepsis (Figure 3). The overall perinatal mortality was 7.3%, primarily due to severe prematurity and respiratory failure. Table 3 highlights the neonatal outcomes in FGR pregnancies. A majority were low birth weight (82.7%), with substantial rates of NICU admission (38.7%), respiratory distress, and a perinatal mortality of 7.3%.

Table 3: Neonatal outcomes of FGR cases (n=150)

Neonatal outcome	Frequency (n)	Percentage (%)	Mean ± SD (%)
Low birth weight (<2.5 kg)	124	82.7	82.7 ± 3.1
Apgar <7 at 1 min	41	27.3	27.3 ± 3.6
NICU admission	58	38.7	38.7 ± 4.0
Respiratory distress	33	22.0	22.0 ± 3.4
Hypoglycemia	24	16.0	16.0 ± 3.0
Neonatal sepsis	18	12.0	12.0 ± 2.6
Meconium aspiration	12	8.0	8.0 ± 2.2
Perinatal mortality	11	7.3	7.3 ± 2.1

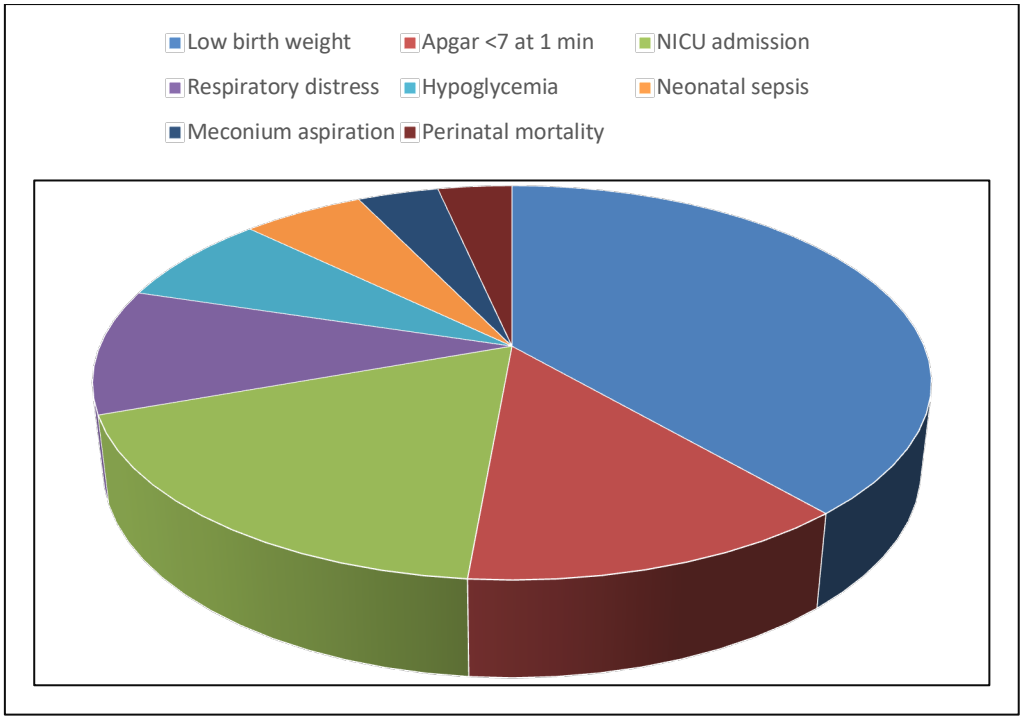

Figure 3: Neonatal outcomes in FGR pregnancies

Maternal Determinants and Perinatal Consequences: Table 4 highlights the association between maternal determinants and adverse neonatal outcomes in FGR pregnancies. Hypertensive mothers had the worst outcomes, with nearly two-thirds of neonates requiring NICU admission (65.4%), over one-third showing low Apgar scores (36.5%), and the highest mortality rate (11.5%), reflecting severe placental insufficiency and hypoxia. Anemia also contributed significantly, with 43.7% NICU admissions, 27% low Apgar scores, and 6.2% mortality, underscoring the role of maternal hematological status in neonatal compromise. Nutritional deficiency, while an important cause of growth restriction, was linked to milder perinatal effects, with 29.7% NICU admissions, 18.9% low Apgar scores, and only 2.7% mortality, suggesting more chronic but less acutely life-threatening consequences. In contrast, FGR cases without identifiable maternal risk factors had the lowest complication rates (25% NICU admission, 7.1% low Apgar, and no mortality), indicating relatively better outcomes (Figure 4). Overall, the findings emphasize that maternal hypertension and anemia are the most critical determinants of adverse perinatal consequences in FGR, while nutritional deficiency and unexplained cases are associated with comparatively milder risks. Table 4 depicts the relationship between maternal determinants and adverse neonatal consequences. Infants of hypertensive and anemic mothers showed the highest rates of NICU admission, low Apgar scores, and mortality, whereas those with no maternal risk factor had the best outcomes.

Table 4: Association between maternal determinants and neonatal complications

Maternal determinant	NICU admission (%)	Mean ± SD	Low Apgar (%)	Mean ± SD	Mortality (%)	Mean ± SD
Hypertension (n=52)	65.4	65.4 ± 6.6	36.5	36.5 ± 6.6	11.5	11.5 ± 4.5
Anemia (n=48)	43.7	43.7 ± 7.1	27.0	27.0 ± 6.5	6.2	6.2 ± 3.5
Nutritional deficiency (n=37)	29.7	29.7 ± 7.5	18.9	18.9 ± 6.4	2.7	2.7 ± 2.7
No risk factor (n=28)	25.0	25.0 ± 8.2	7.1	7.1 ± 4.9	0	0

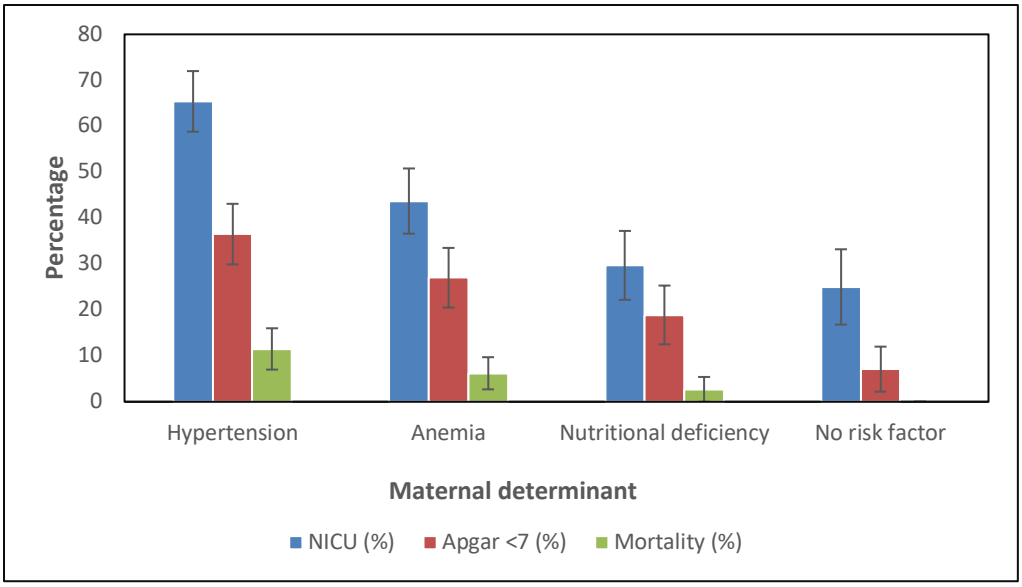

Figure 4: Association between maternal determinants and neonatal complications in FGR.

In summary, this study found that FGR was strongly influenced by maternal conditions such as hypertension, anemia, and poor nutrition. These women were more likely to deliver preterm, and many required cesarean section because of complications. Their babies were often underweight, required NICU admission, and experienced problems like difficulty breathing, low sugar levels, and infections. Mortality was highest among infants of hypertensive mothers. Conversely, when no maternal risk factor was identified, the babies had much better survival and fewer complications.

Thus, the results underscore the close link between maternal health and newborn outcomes in FGR. Addressing maternal risk factors early during antenatal care could substantially reduce the burden of neonatal morbidity and mortality in resource-limited settings such as Bihar.

Discussion

The aimed to analyze the maternal determinants and perinatal consequences of FGR. Our findings highlight the complex interplay between maternal health, obstetric profile, and neonatal outcomes, and reaffirm that FGR continues to be a major contributor to perinatal morbidity and mortality.

In our cohort, hypertensive disorders of pregnancy emerged as the most significant determinant, accounting for one-third of cases and being associated with the worst neonatal outcomes. The link between hypertensive disease and placental insufficiency is well-established; chronic uteroplacental hypoperfusion leads to intrauterine hypoxia, fetal distress, and increased risk of stillbirth [10]. Consistent with previous studies, we observed a markedly higher rate of NICU admissions, low Apgar scores, and perinatal deaths among neonates born to hypertensive mothers [11,12]. Early detection and aggressive management of maternal hypertension remain crucial strategies for improving fetal prognosis.

Maternal anemia was also found to be a major determinant, present in nearly one-third of FGR cases. Anemia impairs oxygen delivery to the fetus, resulting in impaired growth and neonatal compromise. Several Indian studies have reported similar associations, with maternal hemoglobin <10 g/dL significantly increasing the risk of low birth weight and neonatal complications [13,14]. In our study, neonatal outcomes in anemic mothers, though less severe than in hypertensive cases, still demonstrated elevated NICU admission and low Apgar rates. This reinforces the importance of antenatal iron supplementation, nutritional counseling, and early intervention programs targeting maternal hematological health.

Nutritional deficiencies, particularly protein-energy malnutrition, were observed in nearly one-fourth of the mothers and were associated with chronic growth restriction but relatively lower perinatal mortality. Malnutrition exerts a long-standing impact on placental development and fetal growth velocity rather than causing acute compromise [15]. Our findings align with reports suggesting that chronic nutritional deficiency leads to asymmetric FGR, which though serious, may allow better neonatal adaptation compared to acute ischemic insults seen with hypertension [1]. Public health interventions addressing maternal diet, socioeconomic disparities, and micronutrient supplementation may substantially reduce this burden.

Interestingly, nearly one-fifth of cases had no identifiable maternal determinant. These "unexplained" FGR cases, though fewer in number, showed relatively better neonatal outcomes, with

lower NICU admissions and absence of mortality. This subset could represent cases influenced by unrecognized genetic, placental, or environmental factors [16]. The findings highlight the heterogeneity of FGR and underscore the need for more advanced diagnostic modalities, including placental Doppler studies, biomarkers, and genetic evaluation to better understand these cases [17].

The perinatal consequences observed in our study reaffirm the severity of FGR. Over 80% of affected neonates were low birth weight, with high rates of NICU admission (38.7%), low Apgar scores (27.3%), and respiratory complications. Previous meta-analyses have similarly emphasized the elevated risks of hypoglycemia, sepsis, and neurodevelopmental impairment in growth-restricted neonates [5]. The 7.3% perinatal mortality rate in our cohort is comparable to global estimates, which range from 5–10% depending on the severity of growth restriction and available neonatal care [18].

Our study further highlights the obstetric challenges associated with FGR, with a high preterm delivery rate (48%) and increased cesarean section rate (40.7%). Preterm birth has a synergistic effect with FGR, compounding neonatal risks and increasing the need for NICU support [19]. These observations stress the importance of antenatal surveillance through serial ultrasound growth monitoring, Doppler velocimetry, and timely decision-making regarding delivery to balance risks of prematurity against intrauterine demise [20].

From a clinical perspective, our findings emphasize that early recognition and management of maternal risk factors particularly hypertension and anemia can substantially alter perinatal outcomes. Strengthening antenatal screening programs, improving access to maternal healthcare, and implementing preventive nutrition and anemia-control strategies should be prioritized. Additionally, given the high rates of perinatal morbidity observed, the role of NICU facilities and neonatal resuscitation capacity becomes critical in mitigating mortality.

Conclusion

This study emphasizes that the perinatal effects of fetal growth restriction are significantly influenced by maternal health. The two biggest predictors of negative outcomes were found to be hypertension and anemia, while persistent growth impairment was a result of nutritional deficiencies. Infants whose moms had these risk characteristics were more likely to die, have low Apgar scores, and be admitted to the NICU. On the other hand, those with no discernible maternal factors had relatively positive results. These results highlight the importance of aggressive care of anemia and hypertension, nutritional support, and thorough prenatal screening. To lessen the burden of FGR-related morbidity and death, it is crucial to strengthen the infrastructure for newborn care and maternal health services in areas with limited resources, like Bihar.

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