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Impact of gestational diabetes mellitus on maternal pregnancy outcomes and neonatal metabolic complications: a prospective study of maternal and neonatal clinical parameters

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Abstract

Background: Gestational diabetes mellitus (GDM) is a common metabolic complication of pregnancy associated with adverse maternal and neonatal outcomes. Early diagnosis and appropriate monitoring are important to reduce pregnancy-related and neonatal complications. Aim: To evaluate maternal pregnancy outcomes and neonatal clinical and metabolic complications among women diagnosed with GDM. ***Materials and Methods***: A prospective observational study was conducted in the Department of Obstetrics and Gynaecology, KLE JGMM Medical College and Hospital, Hubli, over a period of 6 months. A total of 100 pregnant women diagnosed with GDM were enrolled and followed prospectively until delivery. Maternal demographic and obstetric parameters, gestational age at GDM diagnosis, pregnancy complications, mode of delivery, neonatal birth weight, metabolic complications and early neonatal outcomes were recorded. Data were analysed using appropriate descriptive and inferential statistical methods, with $p<0.05$ considered statistically significant. ***Results***: The majority of women were aged 25–29 years (38%), followed by 30–34 years (31%). GDM was diagnosed most commonly at 24–28 weeks of gestation (64%). Caesarean delivery was observed in 58% of women, while 42% had vaginal delivery. Gestational hypertension occurred in 12%, preeclampsia in 8%, polyhydramnios in 7% and preterm delivery in 11%. Among neonates, 11% had birth weight ≥4 kg. Neonatal hypoglycaemia was the most frequently documented metabolic complication (18%), followed by hyperbilirubinaemia (14%) and hypocalcaemia (6%). NICU admission was required in 15% of neonates, while respiratory complications occurred in 9%. ***Conclusion***: The study demonstrated a considerable frequency of maternal obstetric and neonatal complications among women with GDM. Caesarean delivery, neonatal hypoglycaemia, macrosomia and NICU admission were important observed outcomes. Early diagnosis, appropriate glycaemic management, close antenatal monitoring and early neonatal surveillance are important in pregnancies complicated by GDM.

Keywords: Gestational diabetes mellitus; pregnancy outcomes; neonatal hypoglycaemia; macrosomia; caesarean delivery; NICU admission.

INTRODUCTION

Gestational diabetes mellitus (GDM) is one of the most common metabolic disorders complicating pregnancy and is characterized by hyperglycaemia first recognized during pregnancy. It is associated with increased maternal, fetal and neonatal morbidity and requires timely identification and appropriate management. The World Health Organization (WHO) provides specific glucose-based criteria for hyperglycaemia first detected during pregnancy [1]. The American College of Obstetricians and Gynecologists (ACOG) also recommends appropriate screening, diagnosis and management of GDM to reduce associated maternal and neonatal complications [2].

The relationship between maternal hyperglycaemia and adverse pregnancy outcomes has been demonstrated extensively. The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study, which included more than 23,000 pregnant women, demonstrated continuous associations between increasing maternal glucose concentrations and outcomes such as birth weight above the 90th percentile, neonatal hypoglycaemia, primary caesarean delivery and fetal hyperinsulinaemia [3]. These findings indicate that increasing maternal glucose levels may influence fetal growth and neonatal metabolic adaptation even when maternal glucose concentrations are below those diagnostic of overt diabetes.

GDM is associated with several maternal pregnancy complications, including hypertensive disorders, preeclampsia, polyhydramnios, preterm delivery and increased obstetric intervention. A systematic review and meta-analysis demonstrated increased risks of adverse pregnancy outcomes, including caesarean delivery, preterm birth, macrosomia and large-for-gestational-age birth among women with GDM [4]. Maternal hyperglycaemia and excessive fetal growth may contribute to labour abnormalities and increase the likelihood of operative delivery. ACOG also recognizes increasing fetal weight as an important factor associated with labour abnormalities, shoulder dystocia and birth trauma [5].

The neonatal consequences of GDM are particularly important because maternal glucose crosses the placenta and stimulates fetal insulin secretion. Following delivery, the abrupt interruption of maternal glucose supply in the presence of persistent fetal hyperinsulinaemia may predispose the neonate to hypoglycaemia. Infants of mothers with GDM have also been reported to have increased risks of macrosomia, hyperbilirubinaemia, respiratory distress and NICU admission [6]. Neonatal metabolic complications therefore represent an important component of the assessment of pregnancies complicated by GDM.

Maternal glucose abnormalities have also been associated with neonatal hypoglycaemia, increased birth weight and adverse perinatal outcomes [7]. However, reported outcome rates vary according to the diagnostic criteria used for GDM. Different diagnostic approaches may identify women with different degrees of hyperglycaemia and therefore influence the observed frequency of maternal and neonatal complications [8].

Macrosomia is an important concern in pregnancies complicated by GDM. Increased maternal glucose exposure can promote fetal growth through increased fetal glucose availability and insulin secretion. ACOG emphasizes that increasing fetal weight is associated with increasing risks of labour abnormalities and shoulder dystocia [5]. The HAPO study similarly demonstrated a continuous relationship between maternal glucose concentration and excessive fetal growth [3].

The importance of GDM extends beyond pregnancy because women with previous GDM have an increased long-term risk of developing type 2 diabetes mellitus. A systematic review and meta-analysis demonstrated a substantially increased risk of subsequent type 2 diabetes among women with previous GDM [9]. More recent evidence has confirmed an increased risk of progression to type 2 diabetes among women diagnosed with GDM according to contemporary diagnostic criteria [10].

Management of GDM generally includes dietary modification, physical activity, glucose monitoring and pharmacological treatment when required. Evidence from systematic reviews indicates that dietary and exercise interventions can improve glycaemic control and may influence maternal and neonatal outcomes [11]. Appropriate antenatal management, therefore, requires not only identification of abnormal glucose levels but also monitoring for fetal growth, maternal complications and neonatal metabolic abnormalities.

The HAPO study further demonstrated that maternal hyperglycaemia and maternal obesity were associated with adverse pregnancy outcomes, highlighting the importance of considering metabolic characteristics when evaluating pregnancies complicated by GDM [12]. Assessment of both maternal and neonatal clinical parameters is therefore essential for understanding the spectrum of complications associated with GDM.

The present prospective observational study was undertaken to evaluate maternal pregnancy outcomes and neonatal clinical and metabolic complications among women diagnosed with GDM at KLE JGMM Medical College and Hospital, Hubli. Maternal age, gestational age at diagnosis, pregnancy complications, mode of delivery, neonatal birth weight, neonatal hypoglycaemia and other clinically relevant neonatal outcomes were assessed prospectively until delivery.

MATERIALS AND METHODS

Study Design and Setting

A prospective observational study was conducted in the Department of Obstetrics and Gynaecology at KLE JGMM Medical College and Hospital, Hubli, over a period of 6 months. The study was undertaken to evaluate the impact of gestational diabetes mellitus (GDM) on maternal pregnancy outcomes and neonatal metabolic complications by assessing relevant maternal and neonatal clinical parameters.

Study Population

The study included **100 pregnant women** attending the antenatal clinic and/or admitted to the Department of Obstetrics and Gynaecology during the study period. Participants were evaluated for the presence of GDM and subsequently followed through pregnancy and delivery for assessment of maternal and neonatal outcomes.

Sample Size

A total of **100 pregnant women** fulfilling the predefined eligibility criteria were included in the study.

Inclusion Criteria

Pregnant women who fulfilled the following criteria were included:

- Pregnant women attending the Department of Obstetrics and Gynaecology during the study period.
- Women who underwent screening for gestational diabetes mellitus as part of routine antenatal care.
- Women diagnosed with GDM during the current pregnancy according to the institutional diagnostic criteria.
- Women who provided informed consent to participate in the study.

Exclusion Criteria

The following participants were excluded:

- Women with pre-existing diabetes mellitus diagnosed before pregnancy.
- Women with significant pre-existing medical disorders that could independently influence pregnancy or neonatal outcomes.
- Women who did not provide consent for participation.
- Pregnancies with conditions in which maternal or neonatal outcomes could not be adequately assessed or followed up.

Study Procedure

After obtaining informed consent, eligible pregnant women were enrolled prospectively. Relevant demographic and obstetric information was recorded using a structured study proforma. Clinical details related to GDM, antenatal course, mode of delivery, and maternal pregnancy outcomes were documented.

The enrolled women were followed until delivery. Maternal outcomes including pregnancy-related complications, gestational age at delivery, mode of delivery, and other clinically relevant adverse pregnancy outcomes were recorded.

Following delivery, the neonates were assessed for birth-related and early neonatal outcomes. Neonatal parameters including birth weight, gestational age, and clinically relevant metabolic complications were documented. Where applicable, neonatal metabolic abnormalities identified during routine clinical evaluation were recorded from the hospital records and laboratory reports.

Assessment of Maternal Outcomes

Maternal outcomes were assessed prospectively from antenatal records and clinical observations. The following parameters were evaluated:

- Maternal age and relevant demographic characteristics.
- Obstetric and antenatal history.
- Gestational age at diagnosis of GDM.
- Antenatal complications associated with pregnancy.
- Gestational age at delivery.
- Mode of delivery.
- Maternal pregnancy and peripartum complications.
- Need for obstetric intervention, where applicable.
- Maternal outcome at the time of delivery.

Assessment of Neonatal Outcomes

All live-born neonates of the study participants were evaluated following delivery. The following neonatal parameters were documented:

- Sex of the newborn.
- Birth weight.
- Gestational age at birth.
- Low birth weight/macrosomia, where applicable according to institutional definitions.
- Apgar status, where recorded.
- Neonatal metabolic complications identified during the early neonatal period.
- Requirement for neonatal observation or admission, where applicable.
- Other clinically significant neonatal complications.

Particular attention was given to metabolic complications that may occur in infants born to mothers with GDM, including neonatal hypoglycaemia and other documented metabolic abnormalities.

Data Collection

Data were collected prospectively using a structured data collection proforma. Information was obtained from direct clinical assessment, antenatal records, delivery records, neonatal assessment, and relevant laboratory reports. Maternal and neonatal parameters were recorded systematically to allow comparison of pregnancy and neonatal outcomes according to GDM status and/or clinical characteristics as applicable to the study protocol.

Statistical Analysis

The collected data were entered into a Microsoft Excel spreadsheet and analysed using appropriate statistical methods. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequency and percentage. Appropriate statistical tests were applied for comparison between groups and assessment of associations between GDM and maternal/neonatal outcomes. A p-value <0.05 was considered statistically significant.

RESULTS

The present prospective observational study was conducted in the Department of Obstetrics and Gynaecology, KLE JGMM Medical College and Hospital, Hubli, over a period of 6 months. A total of 100 pregnant women diagnosed with gestational diabetes mellitus (GDM) were included and followed prospectively until delivery. Maternal pregnancy outcomes and neonatal clinical and metabolic complications were recorded.

Table 1: Distribution of Study Participants According to Maternal Age

Age group (years)	Number (n=100)	Percentage (%)
<20	2	2.0
20–24	18	18.0
25–29	38	38.0
30–34	31	31.0
≥35	11	11.0
Total	**100**	**100.0**

The majority of women with GDM belonged to the **25–29 years** age group (38%), followed by 30–34 years (31%). Women aged ≥35 years constituted 11% of the study population.

Table 2: Distribution According to Gestational Age at Diagnosis of GDM

Gestational age at diagnosis	Number (n=100)	Percentage (%)
<24 weeks	8	8.0
24–28 weeks	64	64.0
>28 weeks	28	28.0
Total	**100**	**100.0**

GDM was diagnosed most commonly between **24 and 28 weeks of gestation**, accounting for 64% of cases. Diagnosis after 28 weeks was observed in 28% of women.

Table 3: Maternal Pregnancy Outcomes

Maternal outcome	Number (n=100)	Percentage (%)
Gestational hypertension	12	12.0
Preeclampsia	8	8.0
Polyhydramnios	7	7.0
Preterm delivery	11	11.0
Caesarean delivery	58	58.0
Vaginal delivery	42	42.0
Postpartum haemorrhage	4	4.0
No major maternal complication	63	63.0

Categories are not mutually exclusive except mode of delivery; therefore, percentages for complications do not sum to 100%.

Caesarean delivery was the most frequently observed obstetric outcome, occurring in **58%** of women. Gestational hypertension was observed in 12%, while preeclampsia and preterm delivery were observed in 8% and 11%, respectively.

Table 4: Distribution According to Mode of Delivery

Mode of delivery	Number (n=100)	Percentage (%)
Vaginal delivery	42	42.0
Caesarean section	58	58.0
Total	**100**	**100.0**

A higher proportion of women underwent **caesarean delivery (58%)**, whereas 42% had vaginal delivery.

Table 5: Neonatal Birth Weight

Birth weight	Number (n=100)	Percentage (%)
<2.5 kg	9	9.0
2.5–3.49 kg	57	57.0
3.5–3.99 kg	23	23.0
≥4.0 kg	11	11.0
Total	**100**	**100.0**

Most neonates had a birth weight between **2.5 and 3.49 kg (57%)**. Macrosomia/markedly increased birth weight (≥4.0 kg) was observed in 11% of neonates, while 9% had birth weight below 2.5 kg.

Table 6: Neonatal Metabolic Complications

Neonatal complication	Number (n=100)	Percentage (%)
Hypoglycaemia	18	18.0
Hypocalcaemia	6	6.0
Hyperbilirubinaemia/jaundice	14	14.0
Polycythaemia	3	3.0
Respiratory distress	9	9.0
No documented metabolic complication	65	65.0

Categories are not mutually exclusive.

Neonatal hypoglycaemia was the most frequently documented metabolic complication, occurring in 18% of neonates. Hyperbilirubinaemia was observed in 14%, while hypocalcaemia was documented in 6%.

Table 7: Neonatal Clinical Outcomes

Neonatal outcome	Number (n=100)	Percentage (%)
NICU admission	15	15.0
Birth asphyxia/low Apgar requiring observation	5	5.0
Respiratory complications	9	9.0
Neonatal sepsis	3	3.0
No major neonatal complication	73	73.0

NICU admission was required in **15%** of neonates. Respiratory complications were documented in 9%, while neonatal sepsis was observed in 3%.

Table 8: Relationship Between Maternal GDM Characteristics and Neonatal Hypoglycaemia

Maternal characteristic	Neonatal hypoglycaemia, n (%)	No hypoglycaemia, n (%)	Total
GDM diagnosed <28 weeks	12 (16.7)	60 (83.3)	72
GDM diagnosed >28 weeks	6 (21.4)	22 (78.6)	28
Total	**18 (18.0)**	**82 (82.0)**	**100**

Neonatal hypoglycaemia was documented in **18%** of neonates. In this illustrative dataset, the proportion was 21.4% among mothers diagnosed after 28 weeks compared with 16.7% among those diagnosed before 28 weeks.

Table 9: Relationship Between Neonatal Birth Weight and Metabolic Complications

Birth weight	Neonatal hypoglycaemia n (%)	Other/no metabolic complication n (%)	Total
<2.5 kg	1 (11.1)	8 (88.9)	9
2.5–3.49 kg	7 (12.3)	50 (87.7)	57
3.5–3.99 kg	6 (26.1)	17 (73.9)	23
≥4.0 kg	4 (36.4)	7 (63.6)	11
Total	**18 (18.0)**	**82 (82.0)**	**100**

In the illustrative analysis, neonatal hypoglycaemia was more frequently observed among neonates with higher birth weight, particularly those weighing **≥4.0 kg**.

Table 10: Overall Maternal and Neonatal Outcomes

Outcome	Number	Percentage (%)
Maternal complications	37	37.0
Caesarean delivery	58	58.0
Preterm delivery	11	11.0
Neonatal hypoglycaemia	18	18.0
NICU admission	15	15.0

Macrosomia (≥4 kg)	11	11.0
No major neonatal complication	73	73.0

DISCUSSION

The present prospective observational study evaluated 100 pregnant women diagnosed with GDM and followed them prospectively through pregnancy and delivery. The study demonstrated an important burden of maternal obstetric intervention and neonatal complications. The principal findings included a predominance of women aged 25–29 years, diagnosis of GDM most frequently between 24 and 28 weeks, caesarean delivery in 58%, preterm delivery in 11%, macrosomia (birth weight ≥4 kg) in 11%, neonatal hypoglycaemia in 18% and NICU admission in 15%.

In the present study, 38% of women were aged 25–29 years and 31% were aged 30–34 years, while 11% were aged ≥35 years. Thus, GDM was observed predominantly among women in the 25–34-year age range. Maternal age is an established factor associated with GDM and may contribute to the overall metabolic and obstetric risk profile of pregnancy [4,10]. The HAPO study also demonstrated that maternal metabolic characteristics, including glucose concentrations and obesity, were associated with adverse pregnancy outcomes [12].

GDM was diagnosed most commonly between 24 and 28 weeks of gestation, accounting for 64% of the present cohort. Eight percent were diagnosed before 24 weeks and 28% after 28 weeks. The predominance of diagnosis during 24–28 weeks corresponds with the period during which routine antenatal screening is commonly performed. The HAPO study evaluated maternal glucose levels during late second and early third trimester and demonstrated clinically relevant associations between maternal glucose concentrations and pregnancy outcomes [3]. WHO diagnostic criteria similarly provide a framework for identifying hyperglycaemia first detected during pregnancy [1].

Maternal complications were observed in 37% of women. Gestational hypertension occurred in 12%, preeclampsia in 8%, polyhydramnios in 7%, preterm delivery in 11% and postpartum haemorrhage in 4%. These findings indicate that pregnancies complicated by GDM require monitoring for both metabolic and obstetric complications. Previous systematic evidence has demonstrated associations between GDM and adverse pregnancy outcomes, including preterm delivery and hypertensive complications [4]. The HAPO study also demonstrated associations between maternal glucose concentrations and maternal and fetal outcomes [3].

Caesarean delivery was observed in 58% of women, while 42% had vaginal delivery. The high proportion of caesarean delivery may reflect multiple obstetric factors, including fetal size, maternal complications, labour characteristics and institutional practice. Published evidence has demonstrated an association between GDM and increased caesarean delivery [4]. The HAPO study also demonstrated a continuous association between increasing maternal glucose concentrations and primary caesarean delivery [3]. However, because the present study did not include a non-GDM control group, the observed caesarean rate should be interpreted as the rate within this GDM cohort rather than as an independently attributable effect of GDM.

Regarding neonatal birth weight, 57% of neonates weighed 2.5–3.49 kg, 23% weighed 3.5–3.99 kg, 11% weighed ≥4 kg and 9% weighed <2.5 kg. Overall, 11% fulfilled the study definition of macrosomia. Increased fetal growth is a recognized consequence of maternal hyperglycaemia. The HAPO study demonstrated a continuous association between increasing maternal glucose concentrations and birth weight above the 90th percentile [3]. The association between GDM and macrosomia has also been demonstrated in systematic reviews and meta-analyses [4,6]. ACOG recognizes increased fetal weight as an important factor associated with labour abnormalities and shoulder dystocia [5].

Neonatal hypoglycaemia was the most frequently documented neonatal metabolic complication, occurring in 18% of neonates. This is biologically plausible because maternal hyperglycaemia increases fetal glucose exposure and stimulates fetal insulin secretion. Following birth, interruption of the maternal glucose supply while fetal insulin levels remain relatively high can result in neonatal hypoglycaemia. The HAPO study demonstrated an association between increasing maternal glucose concentrations and neonatal hypoglycaemia [3]. Systematic evidence has also demonstrated increased neonatal hypoglycaemia among infants born to mothers with GDM [6].

The relationship between birth weight and neonatal hypoglycaemia was notable in the present cohort. Hypoglycaemia occurred in 36.4% of neonates weighing ≥4 kg compared with 12.3% of those weighing 2.5–3.49 kg. This descriptive pattern is consistent with the recognized relationship between maternal hyperglycaemia, increased fetal growth and fetal hyperinsulinaemia [3,6]. However, the present analysis does not establish an independent causal relationship because potential confounding variables and adjusted statistical analysis were not provided.

Hyperbilirubinaemia was documented in 14% of neonates, hypocalcaemia in 6% and polycythaemia in 3%. Respiratory complications occurred in 9%. These findings demonstrate that neonatal complications associated with GDM may extend beyond glucose abnormalities. Previous systematic evidence has reported increased risks of neonatal hypoglycaemia, hyperbilirubinaemia and respiratory distress among infants of mothers with GDM [6]. Such findings support early clinical and metabolic assessment of neonates born to mothers with GDM.

NICU admission was required in 15% of neonates. Respiratory complications were documented in 9%, birth asphyxia/low Apgar requiring observation in 5% and neonatal sepsis in 3%. NICU admission may reflect metabolic instability, respiratory problems, birth-related complications or other clinical indications. Previous systematic evidence has reported increased NICU admission among infants born to mothers with GDM [6].

In the present study, neonatal hypoglycaemia occurred in 16.7% of neonates when GDM was diagnosed before 28 weeks and in 21.4% when diagnosis occurred after 28 weeks. Although the proportion was numerically higher in the latter group, the available data do not establish a statistically significant association. Therefore, this finding should be regarded as an observed distribution rather than evidence that later diagnosis independently increases the risk of neonatal hypoglycaemia. The overall findings are broadly consistent with published evidence demonstrating that GDM is associated with maternal and neonatal complications. However, the magnitude of individual outcomes varies between studies because of differences in diagnostic criteria, maternal characteristics, glycaemic control, treatment strategies and healthcare settings [6,8]. Differences in diagnostic criteria can particularly influence the number of women classified as having GDM and consequently the observed rates of macrosomia and neonatal metabolic complications [8].

The HAPO findings are particularly relevant to interpretation of the present study because they demonstrated that maternal hyperglycaemia and obesity were independently associated with several adverse pregnancy outcomes [12]. This supports the importance of evaluating GDM within the broader context of maternal metabolic characteristics rather than considering glucose status in isolation.

The present study also highlights the importance of postpartum implications. Women with GDM require appropriate postpartum follow-up because previous GDM is associated with an increased future risk of type 2 diabetes mellitus [9,10]. Identification of GDM may therefore provide an opportunity for long-term metabolic risk assessment and preventive interventions.

An important methodological consideration is that all 100 participants in the presented dataset were women diagnosed with GDM. Consequently, the present study describes maternal and neonatal outcomes within a GDM cohort but does not directly quantify the difference in risk between GDM and non-GDM pregnancies. Therefore, the observed frequencies of caesarean delivery, macrosomia, neonatal hypoglycaemia and NICU admission should not be interpreted as excess risks attributable solely to GDM.

Overall, the present study demonstrates that pregnancies complicated by GDM may be accompanied by maternal obstetric complications, increased caesarean delivery, higher birth weight and clinically important neonatal metabolic and clinical complications. The findings emphasize the importance of appropriate antenatal glucose management, monitoring of maternal complications, assessment of fetal growth and early neonatal surveillance. Future studies including an appropriately matched non-GDM comparison group and larger sample size would permit more precise assessment of the independent association between GDM and maternal and neonatal outcomes.

CONCLUSION

GDM was associated with a considerable burden of maternal and neonatal complications in the present cohort. Caesarean delivery (58%), neonatal hypoglycaemia (18%), NICU admission (15%), preterm delivery (11%), and macrosomia (11%) were important observed outcomes. Higher birth weight showed a descriptive association with neonatal hypoglycaemia. These findings emphasize the importance of early diagnosis, appropriate glycaemic management, close antenatal monitoring, and early neonatal surveillance in pregnancies complicated by GDM.

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