

Impact of Glycemic Control in Gestational Diabetes Mellitus on Neonatal Complications: A Prospective Cohort Study from a Tertiary Care Center in Gujarat

Hitendrasinh Balvantsinh Jadeja¹, Taxashil H. Jadeja², Ruchi Pandya³

¹Assistant Professor, Government Medical College, Bhavnagar, Gujarat, India

²MBBS, NHL Medical College, Ahmedabad, Gujarat, India

³Consultant Pathologist, Unipath Speciality Laboratory, Ahmedabad, Gujarat, India

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Corresponding author: Dr. Hitendrasinh Balvantsinh Jadeja

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Abstract

Background: Gestational diabetes mellitus (GDM) poses significant risks to both maternal and fetal health, particularly when glycemic levels remain uncontrolled. In India, where the prevalence of GDM is rising rapidly—estimated at 10-14% in urban areas—neonatal complications such as hypoglycemia, macrosomia, and respiratory distress syndrome (RDS) are common concerns. This study aimed to evaluate how varying degrees of glycemic control influence neonatal outcomes in a resource-constrained tertiary setting, addressing a gap in localized evidence for targeted interventions.

Material and Methods: We conducted a prospective cohort study over one-year at Gujarat in a Tertiary care Medical College and Hospital, involving 150 pregnant women diagnosed with GDM via the International Association of Diabetes and Pregnancy Study Groups (IADPSG) criteria. Participants were categorized into good (n=85) and poor (n=65) glycemic control groups based on mean fasting plasma glucose <95 mg/dL, 2-hour postprandial <140 mg/dL, and HbA1c <6.5%. Ethical approval was obtained from the institutional review board, with informed consent from all. Neonatal outcomes assessed included macrosomia, hypoglycemia, RDS, hyperbilirubinemia, and NICU admissions. Data were analyzed using chi-square tests, t-tests, and multivariate logistic regression, with $p < 0.05$ considered significant.

Results: Maternal age and parity were comparable between groups (28.2 ± 4.1 vs. 29.1 ± 4.3 years; $p = 0.32$). Poor control was linked to higher HbA1c ($6.8 \pm 0.7\%$ vs. $5.6 \pm 0.5\%$; $p < 0.001$). Neonatal macrosomia occurred in 14% of good control vs. 43% of poor ($p < 0.001$), hypoglycemia in 9% vs. 34% ($p < 0.001$), RDS in 5% vs. 20% ($p = 0.002$), hyperbilirubinemia in 18% vs. 38% ($p = 0.005$), and NICU admissions in 8% vs. 28% ($p < 0.001$). Multivariate analysis confirmed poor control as an independent predictor of overall complications (OR 4.2, 95% CI 2.1-8.4; $p < 0.001$).

Conclusion: Tight glycemic control in GDM significantly mitigates neonatal risks, underscoring the need for vigilant monitoring and multidisciplinary care in Indian tertiary centers. These findings advocate for routine HbA1c tracking and early insulin initiation to optimize outcomes, potentially reducing healthcare burdens in high-prevalence regions like Gujarat.

Keywords: Gestational Diabetes Mellitus, Glycemic Control, Neonatal Complications, Macrosomia, Hypoglycemia, Tertiary Care, India.

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Introduction

Gestational diabetes mellitus (GDM) represents a common metabolic disorder complicating 5-15% of pregnancies worldwide, with India bearing a disproportionately high burden due to genetic predisposition and urbanization. It arises from insulin resistance exacerbated by placental hormones, leading to hyperglycemia that can adversely affect fetal development. In Gujarat, rapid lifestyle shifts have amplified GDM incidence, mirroring national trends where urban

women face up to 17% prevalence. Untreated or poorly managed GDM not only heightens maternal risks like preeclampsia but also predisposes neonates to immediate threats such as macrosomia and hypoglycemia. Early detection through oral glucose tolerance testing remains crucial, yet adherence to management protocols varies across socioeconomic strata. [1] The pathophysiology of GDM involves fetal hyperinsulinemia in response to maternal glucose excess, fostering accelerated

growth and organ immaturity. Neonatal complications stem from this imbalance, including respiratory distress from surfactant deficiency and metabolic derangements like polycythemia. [2] International cohorts have linked suboptimal control to a 1.5-fold rise in adverse events, while Indian data from southern states report NICU stays in 12-20% of cases. In western India, however, such patterns are underexplored, with local audits suggesting higher insulin needs amid dietary challenges. [3,4] This study is justified by the paucity of prospective data from Gujarat's tertiary setups, where patient diversity and resource limits influence outcomes. By stratifying glycemic control, we aim to quantify its direct impact on neonatal morbidity, informing tailored guidelines. Such evidence could bolster public health strategies, reducing long-term pediatric burdens in a diabetes-prone population.

Material and Methods

This prospective cohort investigation spanned one year, at the Department of Obstetrics and Gynecology, at a tertiary care teaching Hospital serving urban and rural Gujarat populations. We enrolled 150 consecutive pregnant women aged 18-40 years diagnosed with GDM using the IADPSG criteria: fasting plasma glucose ≥ 92 mg/dL, 1-hour post-glucose ≥ 180 mg/dL, or 2-hour ≥ 153 mg/dL following a 75g oral load between 24-28 weeks gestation. Management followed American Diabetes Association guidelines, emphasizing diet, exercise, and insulin if targets unmet. Ethical clearance was secured from the Institutional Ethics Committee, adhering to Helsinki Declaration principles. Written informed consent was obtained, ensuring confidentiality and voluntary withdrawal options. Inclusion criteria encompassed singleton pregnancies with confirmed GDM, regular antenatal follow-up, and willingness for neonatal assessment. Exclusion applied to pre-existing diabetes, multiple gestations, major fetal anomalies on ultrasound, or chronic maternal conditions like hypertension or renal disease that could confound outcomes. Participants underwent baseline anthropometry, including body mass index (BMI) calculation, and serial glycemic monitoring via self-glucometers. HbA1c was assayed at diagnosis and 36 weeks using high-performance liquid chromatography. Good control was defined as $\geq 80\%$ of readings meeting targets (fasting < 95

mg/dL, postprandial < 140 mg/dL) and HbA1c $< 6.5\%$; poor control otherwise. This yielded 85 in the good group and 65 in poor, with no losses to follow-up due to telephonic reminders and community outreach. Neonatal data were collected within 72 hours post-delivery by pediatricians blinded to maternal status. Outcomes included birth weight for macrosomia (> 4 kg), cord blood glucose for hypoglycemia (< 45 mg/dL), clinical/radiologic criteria for RDS, serum bilirubin for hyperbilirubinemia (> 15 mg/dL), and NICU duration. Statistical analysis used SPSS version 25. Continuous variables were compared via independent t-tests or Mann-Whitney U, categorical via chi-square test. Multivariate logistic regression adjusted for confounders like maternal age, BMI, and parity, reporting odds ratios (OR) with 95% confidence intervals (CI). Sample size was powered at 80% to detect a 20% difference in complications ($\alpha = 0.05$), based on pilot data. $P < 0.05$ signified significance, with no multiplicity adjustments needed.

Results

Over the study period, 150 women with GDM were analyzed, with baseline characteristics showing no significant intergroup differences in age (28.2 ± 4.1 vs. 29.1 ± 4.3 years; $p = 0.32$), parity (1.4 ± 0.8 vs. 1.6 ± 0.9 ; $p = 0.21$), or BMI (26.3 ± 4.2 vs. 27.1 ± 4.5 kg/m²; $p = 0.18$). Gestational age at diagnosis averaged 26.4 weeks, and insulin initiation occurred in 62% overall, higher in the poor control group (78% vs. 48%; $p < 0.001$). Mean HbA1c at 36 weeks was markedly elevated in poor control ($6.8 \pm 0.7\%$ vs. $5.6 \pm 0.5\%$; $p < 0.001$), reflecting sustained hyperglycemia. Neonatal outcomes revealed a clear gradient favoring good control. Macrosomia affected 12 of 85 (14.1%) in good vs. 28 of 65 (43.1%) in poor ($p < 0.001$), while hypoglycemia struck 8 (9.4%) vs. 22 (33.8%; $p < 0.001$). RDS incidence was 4 (4.7%) vs. 13 (20.0%; $p = 0.002$), hyperbilirubinemia 15 (17.6%) vs. 25 (38.5%; $p = 0.005$), and NICU admissions 7 (8.2%) vs. 18 (27.7%; $p < 0.001$). Overall complication rate was 19 of 85 (22.4%) in good control compared to 40 of 65 (61.5%) in poor ($p < 0.001$), with mean NICU stay longer in the latter (2.1 ± 1.2 vs. 4.3 ± 2.1 days; $p = 0.003$). No perinatal deaths occurred. Multivariate analysis affirmed poor control as the strongest predictor, alongside BMI. Details are presented in Tables:

Table 1: Baseline Maternal Characteristics

Characteristic	Good Control (n=85)	Poor Control (n=65)	p-value
Age (years), mean $\pm$ SD	28.2 ± 4.1	29.1 ± 4.3	0.32
BMI (kg/m ²), mean $\pm$ SD	26.3 ± 4.2	27.1 ± 4.5	0.18
Parity, mean $\pm$ SD	1.4 ± 0.8	1.6 ± 0.9	0.21
Gestational age at diagnosis (weeks)	26.3 ± 1.2	26.5 ± 1.4	0.45
Insulin use, n (%)	41 (48.2)	51 (78.5)	< 0.001

Table 2: Glycemic Control Parameters

Parameter	Good Control (n=85)	Poor Control (n=65)	p-value
Mean fasting glucose (mg/dL)	88.4 ± 6.2	112.3 ± 8.1	<0.001
Mean 2-h PP glucose (mg/dL)	118.7 ± 9.4	156.2 ± 12.3	<0.001
HbA1c at 36 weeks (%)	5.6 ± 0.5	6.8 ± 0.7	<0.001
% Targets met	87.2 ± 4.1	62.5 ± 5.3	<0.001

Table 3: Neonatal Outcomes by Glycemic Control Group

Outcome	Good Control (n=85), n (%)	Poor Control (n=65), n (%)	p-value
Macrosomia (>4 kg)	12 (14.1)	28 (43.1)	<0.001
Hypoglycemia (<45 mg/dL)	8 (9.4)	22 (33.8)	<0.001
RDS	4 (4.7)	13 (20.0)	0.002
Hyperbilirubinemia	15 (17.6)	25 (38.5)	0.005
NICU Admission	7 (8.2)	18 (27.7)	<0.001
Overall Complications	19 (22.4)	40 (61.5)	<0.001

Table 4: Multivariate Logistic Regression for Neonatal Complications

Predictor	OR	95% CI	p-value
Poor Glycemic Control	4.2	2.1-8.4	<0.001
Maternal BMI (>25)	2.1	1.1-4.0	0.02
Nulliparity	1.3	0.7-2.5	0.38
Gestational Age <37 week	1.8	0.9-3.6	0.09

Discussion

Gestational diabetes mellitus continues to challenge obstetric care, particularly in developing contexts like India, where socioeconomic factors interplay with metabolic vulnerabilities to amplify neonatal risks. Our findings align with global patterns, demonstrating that suboptimal glycemic management escalates immediate perinatal threats, from metabolic instability to respiratory compromise. In a diverse cohort reflective of Gujarat's demographics, the stark divergence in outcomes - 22% overall complications in well-controlled cases versus 62% in poorly managed - highlights the modifiable nature of these burdens. This underscores the imperative for integrated care models emphasizing self-monitoring and pharmacological escalation, potentially averting long-term sequelae like childhood obesity. [5]

Focusing on macrosomia, our poor control group exhibited a 43% incidence, threefold higher than the 14% in good control, echoing the fetal hyperinsulinism driven by maternal hyperglycemia. This mirrors a large U.S. cohort of over 26,000 GDM pregnancies, where suboptimal trajectories yielded a 1.42 adjusted relative risk (aRR) for large-for-gestational-age births compared to optimal paths. Locally, a southern Indian retrospective analysis of 60 GDM cases reported 51.7% macrosomic neonates overall, attributing it to delayed diagnosis in rural settings—similar to our 27% BMI >25 prevalence complicating control. Unlike the U.S. study's emphasis on longitudinal glucometer data, our reliance on HbA1c captured cumulative exposure, revealing OR 4.2 for complications. These parallels affirm that early

insulin, used in 78% of our poor group, curbs excess growth, though cultural dietary hurdles in Gujarat warrant region-specific nutrition counseling. [6,7]

Neonatal hypoglycemia, at 34% in poor versus 9% in good control, emerged as a sentinel event, often necessitating prompt glucose infusions. This aligns with a Chinese prospective study of 236 GDM mothers, where overall hypoglycemia hit 17.8%, surging with non-conforming control and linking to immune deficits via elevated inflammatory markers. In India, a Puducherry cohort of 139 GDM women noted 4.5% hypoglycemia, but stratified analysis showed 37% complications in suboptimal cases versus 6% optimal—paralleling our p<0.001 gradient and emphasizing post-delivery surveillance. Our lower baseline rate may reflect Gujarat's higher antenatal literacy, yet the 3.6-fold risk in poor control highlights feeding delays as a modifiable factor, contrasting the Chinese focus on prolactin. Integrating point-of-care testing could bridge this, reducing NICU escalations seen in 28% of our at-risk neonates. [8]

Respiratory distress syndrome prevalence doubled from 5% in good to 20% in poor control, likely from delayed lung maturation amid fetal hyperglycemia. This resonates with a meta-analysis associating GDM with heightened NRDS odds, though control specifics were unstratified. [9] Domestically, a Bangalore tertiary study over one year reported RDS in 11% of GDM neonates, akin to our findings but without control differentiation—our data extend this by quantifying the 4.3-fold risk (p=0.002), bolstered by multivariate adjustments for prematurity (9% overall). Unlike the meta's

broad GDM lens, our trajectory-informed approach suggests antenatal corticosteroids for poor controllers, potentially halving our observed 13 cases and aligning with international calls for third-trimester HbA1c thresholds below 6%. [10]

Hyperbilirubinemia, affecting 38% in poor versus 18% in good control, stemmed from polycythemia and hemolysis, prolonging hospital stays. An international review tied this to GDM's oxidative stress, with rates up to 25% in uncontrolled cohorts, though not isolated. [11] In parallel, the Puducherry study captured hyperbilirubinemia within broader 37% suboptimal complications, mirroring our 2.2-fold elevation ($p=0.005$) and linking to jaundice phototherapy needs in 22% of cases. Our Gujarat-specific insight reveals BMI as a confounder (OR 2.1), absent in prior Indian works, urging holistic preconception counseling to mitigate enterohepatic recirculation exacerbated by macrosomia. [12]

NICU admissions, at 28% in poor control, encapsulated multifaceted morbidities, with stays averaging 4.3 days. This tracks the U.S. trajectory analysis' 1.33 aRR for suboptimal paths, emphasizing resource strain in large cohorts. Echoing a Kerala retrospective of 180 cases with 12% IBN rates, our higher threshold reflects Gujarat's referral bias, yet the 3.4-fold risk ($p<0.001$) underscores insulin's protective role, used less in good controllers. Diverging from Kerala's rural focus, our urban data highlight telemedicine's potential to sustain 87% target adherence, curbing admissions and aligning with global pushes for virtual monitoring. [13] Study limitations include single-center design, potentially limiting generalizability beyond Gujarat, and reliance on self-reported glucometers without continuous sensors. Selection bias toward adherent patients may underestimate community risks, warranting multicenter validation.

Conclusion

Our study illuminates the profound influence of glycemic control on neonatal fates in GDM, with poor management heralding a cascade of avoidable complications—from macrosomia's mechanical perils to hypoglycemia's metabolic tremors. By stratifying 150 cases, we discerned a compelling risk gradient, where HbA1c thresholds below 6.5% halved adverse events, showing yet extending prior Indian and global evidence with localized nuance. Tight control not only decreases NICU burdens but fosters resilient starts for offspring in diabetes-endemic regions. Clinically, this mandates proactive insulin protocols and BMI-tailored diets, potentially reshaping antenatal paradigms. Policymakers should prioritize screening equity, curbing Gujarat's rising GDM tide. Future trials might explore long-term neurodevelopmental links, but for now, vigilant stewardship promises

healthier generations. Ultimately, empowering mothers through education bridges metabolic gaps, turning GDM from a threat into a manageable interlude.

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