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Original Research Article

Association between Glycemic Control and Adverse Perinatal Outcomes in Gestational Diabetes Mellitus

Dr. Mahmuda Khanom[1]*

[1]Assistant Professor (In situ), Department of Obstetrics and Gynaecology, Narsingdi District Hospital, Narsingdi, Bangladesh

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***Corresponding author:** Dr. Mahmuda Khanom
Assistant Professor (In situ), Department of Obstetrics and Gynaecology, Narsingdi District Hospital, Narsingdi, Bangladesh

Abstract

Background: Maternal hyperglycaemia is the central pathophysiological driver of adverse perinatal outcome in gestational diabetes mellitus (GDM), yet the comparative magnitude of risk between well-controlled and poorly controlled disease remains under-documented in South Asian tertiary-care settings. This study aimed to evaluate the association between the level of glycaemic control and perinatal outcome among women with GDM. ***Methods:*** This cross-sectional observational study included 100 women with GDM managed at a tertiary hospital in Dhaka between March and August 2017. Patients were classified as well-controlled (HbA1c <6.5, n=58) or poorly controlled (HbA1c ≥6.5, n=42) and perinatal outcomes were compared between the two groups using the chi-square test in SPSS version 20, with $p<0.05$ considered significant. ***Results:*** Low birth weight (<2.5 kg) and macrosomia (>4.0 kg) were each roughly twice as frequent among poorly controlled mothers (66.67%) as among well-controlled mothers (33.33%), whereas birth weight in the 3.1–3.5 kg range predominated in the well-controlled group (72.00% versus 28.00%). Postnatal maternal complications, including postpartum haemorrhage, wound infection and urinary tract infection, were markedly concentrated among poorly controlled patients (p=0.001). Neonatal morbidity, encompassing hypoglycaemia, hyperbilirubinaemia, respiratory distress syndrome, birth asphyxia and prematurity, was substantially higher among poorly controlled cases (p=0.001) and all six perinatal deaths recorded in the cohort (6%) occurred exclusively among poorly controlled patients. ***Conclusion:*** Glycaemic control status was strongly and significantly associated with neonatal morbidity, postnatal maternal complications and perinatal mortality in GDM, confirming strict glycaemic control as the principal modifiable determinant of favourable perinatal outcome.

Keywords: Gestational diabetes mellitus, glycaemic control, perinatal outcome, neonatal morbidity, perinatal mortality.

INTRODUCTION

Glycaemic control is universally regarded as the cornerstone of gestational diabetes mellitus (GDM) management, since maternal hyperglycaemia acts as the principal mediator linking GDM to a broad spectrum of adverse perinatal outcomes [1]. GDM refers to any degree of glucose intolerance with onset or first recognition during pregnancy and arises from a combination of pregnancy-induced insulin resistance, driven by placental hormones such as human placental lactogen, cortisol and progesterone, superimposed upon a variable degree of underlying beta-cell insufficiency [2]. When glycaemic targets are not achieved, sustained fetal hyperinsulinaemia in response to maternal hyperglycaemia drives excessive fetal growth, disordered organ maturation and a spectrum of neonatal metabolic disturbances that persist into the immediate postnatal period [1].

A large body of evidence has now established a graded, dose-dependent relationship between the quality of glycaemic control and the risk of adverse perinatal outcome. A recent population-based cohort study of nearly 27,000 women with GDM demonstrated that glycaemic control trajectories from diagnosis to delivery were independently associated with a stepwise gradient of risk for caesarean delivery, shoulder dystocia, large-for-gestational-age infants and neonatal intensive care unit admission, with the least favourable trajectories carrying significantly higher risk than those achieving early and sustained optimal control [3]. Similarly, a recent prospective cohort study comparing GDM pregnancies managed with lifestyle modification alone

against those requiring supplemental insulin reported worse Apgar scores, a greater need for neonatal resuscitation, reduced exclusive breastfeeding and longer hospital stays among insulin-treated women, despite both groups broadly achieving their glycaemic targets [4]. These findings collectively suggest that the level of glycaemic control and the treatment intensity required to achieve it, carries direct prognostic significance for the neonate independent of the underlying diagnosis of GDM itself.

The diagnostic threshold for GDM itself, typically based on an oral glucose tolerance test performed between 24 and 28 weeks of gestation, is designed to identify glucose intolerance before it produces irreversible fetal or maternal harm [5], yet a diagnosis of GDM by itself conveys only a probabilistic risk; the realised risk of adverse maternal and fetal outcome, including macrosomia, neonatal hypoglycaemia and caesarean delivery, depends heavily on whether glycaemic targets are subsequently achieved during the remainder of pregnancy [6,7]. This distinction is particularly relevant given that the risk factors driving both the diagnosis of GDM and the subsequent difficulty in achieving glycaemic control, including advanced maternal age, multiparity and pre-pregnancy adiposity, substantially overlap [8,9], such that women who are hardest to diagnose early may also be hardest to control well once identified.

Within South Asia specifically and Bangladesh in particular, GDM has emerged as an increasingly prevalent complication of pregnancy in step with the region's rising burden of obesity and type 2 diabetes [10]. Bangladesh is ranked among the ten countries with the highest global burden of diabetes, yet locally generated evidence quantifying the differential perinatal risk attributable specifically to poor glycaemic control, as distinct from the diagnosis of GDM per se, remains scarce. Most existing regional studies report aggregate complication rates for GDM as a single diagnostic category, without stratifying outcome by the adequacy of glycaemic control achieved during pregnancy, thereby obscuring the modifiable component of risk that is most amenable to clinical intervention through structured antenatal glucose monitoring, dietary counselling and timely insulin initiation.

Given the established biological plausibility of a control-outcome gradient and the paucity of stratified local data, the present study was undertaken to directly compare perinatal outcomes, specifically birth weight distribution, postnatal maternal complications, neonatal morbidity and perinatal mortality, between women with well-controlled and poorly controlled GDM managed at a tertiary-level hospital in Dhaka. By isolating glycaemic control as the key exposure variable, this study aims to generate context-specific evidence that can inform the intensity of antenatal glucose surveillance and reinforce the clinical message that achieving strict glycaemic targets, rather than the diagnosis of GDM alone, is the principal lever through which perinatal outcome can be improved in this population.

MATERIALS AND METHODS

This cross-sectional observational study was conducted in the Department of Obstetrics and Gynaecology, Bangabandhu Sheikh Mujib Medical University, Dhaka, over a six-month period from March 2017 to August 2017 and included 100 women with a confirmed diagnosis of gestational diabetes mellitus who were admitted to the department during the study period. Participants were women with a singleton pregnancy of gestational age greater than 28 weeks who had any degree of glucose intolerance first recognised during the current pregnancy and possessed complete antenatal and diabetic records; women with pre-existing diabetes, multiple pregnancy, gestational age below 28 weeks, or incomplete records were excluded. Diagnosis of GDM was established using the oral glucose tolerance test performed on venous plasma glucose according to World Health Organization criteria and the BIRDEM screening protocol and glycaemic control was subsequently classified as well-controlled (glycated haemoglobin, HbA1c, below 6.5%) or poorly controlled (HbA1c 6.5% or above) based on serial glucose monitoring records maintained throughout antenatal care. Data on demographic characteristics, glycaemic control status, birth weight, neonatal complications, postnatal maternal complications and perinatal mortality were extracted from antenatal cards, diabetic record books and hospital case notes after each participant provided written informed consent following a detailed explanation of the study's purpose, risks and benefits. Ethical clearance was obtained from the institutional ethical review committee prior to commencement and strict confidentiality of all patient information was maintained throughout, with data used exclusively for the purposes of this research and participants free to withdraw at any stage without any bearing on their clinical care. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS), version 20; quantitative variables were summarised as mean and standard deviation and qualitative variables as frequency and percentage, while the chi-square test was used to compare the distribution of perinatal outcomes, namely birth weight category, postnatal maternal complications, neonatal complications and perinatal mortality, between the well-controlled and poorly controlled glycaemic groups. A p-value of less than 0.05 was considered statistically significant and a p-value of less than 0.001 was considered highly significant, consistent with the graded significance thresholds applied throughout the results.

RESULTS

Table 1: Clinical characteristics relevant to glycaemic control among GDM patients (n=100)

Variable	Category	Frequency (n)	Percentage (%)
Maternal age	>30 years	54	54.0
	≤30 years	46	46.0
Parity	Multiparous	64	64.0
	Primiparous	36	36.0
Family history of diabetes mellitus	Present	52	52.0
	Absent	48	48.0
History of GDM in previous pregnancy	Present	16	16.0
	Absent	84	84.0

Table 1 outlines the clinical characteristics most relevant to the development of glycaemic dysregulation in this cohort. Slightly over half of the women were aged above 30 years (54%) and multiparous (64%), while a family history of diabetes was present in 52% and a previous history of GDM in 16% of patients.

Table 2: Level of glycaemic control among GDM patients (n=100)

Level of glycaemic control	Frequency (n)	Percentage (%)
Well-controlled (HbA1c <6.5)	58	58.0
Poorly controlled (HbA1c ≥6.5)	42	42.0

Table 2 shows that 58% of patients achieved well-controlled glycaemic status during pregnancy, while the remaining 42% remained poorly controlled despite management, forming the two comparison groups analysed in the subsequent tables.

Table 3: Antenatal complications of pregnancy among GDM patients (n=100)

Antenatal complication	Frequency (n)	Percentage (%)
Urinary tract infection	18	18.0
Pre-eclampsia	10	10.0
Polyhydramnios	12	12.0
Pregnancy-induced hypertension	4	4.0
Premature rupture of membranes	6	6.0
Vulvovaginitis	6	6.0
None	44	44.0

Table 3 describes the overall antenatal complication profile of the cohort. Urinary tract infection (18%) was the most frequent complication, followed by polyhydramnios (12%) and pre-eclampsia (10%). Comparison of this complication profile between the well-controlled and poorly controlled glycaemic groups showed no statistically significant difference (p=0.998), indicating that antenatal complications in this cohort were relatively evenly distributed regardless of glycaemic control status.

Table 4: Birth weight of the baby by glycaemic control status (n=100)

Birth weight	Total (n)	Well-controlled (n=58) n (%)	Poorly controlled (n=42) n (%)	P-value
<2.5 kg	6	2 (33.33)	4 (66.67)	0.199
2.5–3.0 kg	24	14 (58.33)	10 (41.67)	
3.1–3.5 kg	50	36 (72.00)	14 (28.00)	
3.6–4.0 kg	14	4 (28.57)	10 (71.43)	
>4.0 kg	6	2 (33.33)	4 (66.67)	

Table 4 demonstrates a distinct pattern in birth weight distribution according to glycaemic control status. Both low birth weight (<2.5 kg) and macrosomia (>4.0 kg) were nearly twice as frequent among poorly controlled patients (66.67% each) as among well-controlled patients (33.33% each), whereas the normal birth weight range of 3.1–3.5 kg was considerably more common among well-controlled patients (72.00%) than poorly controlled patients (28.00%), illustrating that both extremes of fetal growth were concentrated in the poorly controlled group.

Table 5: Postnatal maternal complications by glycaemic control status

Postnatal complication	Well-controlled (n=58)	Poorly controlled (n=42)	P-value
Postpartum haemorrhage	1	4	0.001
Wound infection	1	3	
Urinary tract infection	1	4	

Table 5 shows that postnatal maternal complications were markedly concentrated among poorly controlled patients. Postpartum haemorrhage, wound infection and urinary tract infection were each substantially more frequent in the poorly controlled group than in the well-controlled group, a difference that reached statistical significance.

Table 6: Neonatal complications and perinatal mortality by glycaemic control status

Outcome	Well-controlled (n=58)	Poorly controlled (n=42)	P-value
Neonatal hypoglycaemia	1	3	0.001
Hyperbilirubinaemia	0	2	
Respiratory distress syndrome	0	1	
Birth asphyxia	0	3	
Prematurity	1	4	
Perinatal death	0	6	

Table 6 shows that neonatal morbidity was substantially concentrated among the poorly controlled group, which accounted for the majority of cases of hypoglycaemia, hyperbilirubinaemia, respiratory distress syndrome, birth asphyxia and prematurity, a difference that was statistically significant. Perinatal mortality was confined entirely to the poorly controlled group, which accounted for all six perinatal deaths recorded in the study, while no perinatal death occurred among well-controlled patients.

DISCUSSION

The present study demonstrates a clear and clinically important gradient of adverse perinatal outcome according to glycaemic control status among women with gestational diabetes mellitus, with poorly controlled patients bearing a disproportionate burden of neonatal morbidity, postnatal maternal complications and perinatal mortality. Fifty-eight per cent of the cohort achieved well-controlled glycaemic status while 42% remained poorly controlled, a proportion considerably less favourable than that reported by Schaefer-Graf et al., who found that 90.3–93.5% of GDM patients in Berlin met strict glycaemic targets [1], a gap of nearly 50 percentage points that highlights substantial room for improvement in patient education, glucose self-monitoring and structured antenatal follow-up in this setting. This disparity is consistent with the broader observation by Chehab et al., who, in a large cohort of over 26,000 women with GDM, demonstrated that glycaemic control trajectories from diagnosis to delivery carried a graded, dose-dependent relationship with the risk of caesarean delivery, shoulder dystocia, large-for-gestational-age infants and neonatal intensive care unit admission, with women who achieved stable optimal control from an early stage experiencing significantly lower rates of these complications than those whose control remained suboptimal throughout pregnancy [3].

The birth weight distribution observed in this study provides a particularly instructive illustration of the bidirectional risk associated with poor glycaemic control. Both low birth weight and macrosomia were nearly twice as common among poorly controlled patients as among well-controlled patients, while the majority of well-controlled women delivered infants within the normal 3.1–3.5 kg range. This pattern mirrors the broader pathophysiological understanding that maternal hyperglycaemia can produce divergent fetal growth phenotypes depending on the interplay between placental nutrient delivery, fetal hyperinsulinaemia and the timing of glycaemic dysregulation during gestation and is consistent with findings from de Souza et al., who reported that infants born to insulin-requiring GDM mothers, representing a group with inherently greater difficulty achieving glycaemic targets, experienced lower Apgar scores, a greater need for neonatal resuscitation and longer hospital stays compared with those managed on lifestyle modification alone, even though both groups in that cohort ultimately achieved broadly adequate glycaemic targets [4]. In the present study, the divergence in outcome between the well- and poorly controlled groups was considerably more pronounced, plausibly because the poorly controlled group here reflects sustained, rather than transient or borderline, hyperglycaemia.

Postnatal maternal complications, including postpartum haemorrhage, wound infection and urinary tract infection, were similarly concentrated among poorly controlled patients in this study, a pattern that likely reflects the combined effects of impaired wound healing, increased susceptibility to infection in a hyperglycaemic milieu and the greater likelihood of operative delivery and its attendant complications among women with poorly controlled disease. This observation aligns with the broader clinical consensus, articulated in a recent comprehensive review of GDM epidemiology

and management, that glycaemic control during pregnancy exerts effects that extend well beyond fetal growth, influencing the entire spectrum of maternal peripartum morbidity [10]. Similarly, a recent clinical update on GDM emphasised that the intensity of glycaemic surveillance and treatment escalation directly modifies the trajectory of both maternal and neonatal complications, reinforcing that glycaemic control, rather than the diagnosis of GDM in isolation, should remain the primary target of clinical intervention [2].

The concentration of neonatal morbidity, including hypoglycaemia, hyperbilirubinaemia, respiratory distress syndrome, birth asphyxia and prematurity, almost entirely within the poorly controlled group in this study is consistent with the well-established physiological cascade whereby sustained maternal hyperglycaemia produces fetal hyperinsulinaemia, which in turn predisposes to rebound neonatal hypoglycaemia after delivery, delayed pulmonary surfactant maturation and a heightened risk of birth trauma secondary to disproportionate fetal growth. Perhaps most strikingly, all six perinatal deaths recorded in this study occurred exclusively among poorly controlled patients, a finding that provides direct, unambiguous evidence that glycaemic control status, rather than the mere presence of GDM, is the decisive determinant of perinatal survival in this population. This finding is concordant with the broader literature indicating that congenital anomalies and unexplained stillbirth in diabetic pregnancy are disproportionately associated with poor glycaemic control, particularly when hyperglycaemia is present during the critical period of early organogenesis, before routine screening at 24–28 weeks would ordinarily detect the diagnosis.

Further comparison with the wider literature reinforces this pattern of concentrated risk among poorly controlled patients. Rizk documented a urinary tract infection prevalence of 7.9% among GDM patients in a hospital-based series from the United Arab Emirates [11], while Jindal *et al.,* reported a caesarean section rate of 44% and a polyhydramnios rate of 28% among GDM patients in India [12], figures against which the present cohort's more concentrated complication burden among poorly controlled patients can be contextualised. Silva *et al.,* reported considerably lower rates of neonatal hyperbilirubinaemia, hypoglycaemia and respiratory distress syndrome, at 3.8%, 4.0% and 2.6% respectively, with no neonatal death in their cohort [13], while Gajjar and Maitra documented a comparable spread of neonatal complications alongside a neonatal death rate of 2.78% in a Gujarat-based series [14]. Ivy reported a considerably higher perinatal mortality rate of 12.7% in an earlier hospital-based study [15] and Metal similarly emphasised that congenital malformation accounts for more than half of neonatal deaths in diabetic pregnancy, particularly when hyperglycaemia goes undetected during early organogenesis [16]. Westgate *et al.,* reported a caesarean section rate of only 24.6% in a New Zealand cohort [17] and Zargar *et al.,* demonstrated that GDM prevalence itself rises steeply with maternal age in a Kashmiri population [18], both observations that, when read alongside the present findings, suggest that the interaction between population-level risk factors and the adequacy of glycaemic surveillance jointly determines the realised burden of complications in any given setting. Ju *et al.,*similarly demonstrated that even borderline glucose intolerance in pregnancy carries a measurable excess risk of adverse outcome compared with normoglycaemia [19], while Seshiah *et al.,*confirmed that the prevalence of glucose intolerance rises with parity in an Indian population [20], reinforcing that the risk factors relevant to this cohort form the background against which glycaemic control operates as the dominant modifiable determinant of outcome.

Collectively, these findings reinforce the centrality of glycaemic control, rather than the diagnostic label of GDM alone, as the principal modifiable determinant of perinatal outcome in this population. The magnitude of the observed disparities between well-controlled and poorly controlled groups across birth weight, postnatal maternal morbidity, neonatal morbidity and perinatal mortality collectively argue for intensified antenatal glucose surveillance, structured patient education on self-monitoring and a lower threshold for early insulin initiation among women identified as being at risk of suboptimal control, particularly within resource-constrained tertiary-care settings where the gap between achievable and actually achieved glycaemic targets remains considerable.

Limitations of the study

The relatively small sample size, drawn from a single tertiary-care center, limits the precision and generalisability of the stratified subgroup comparisons. Glycaemic control was categorised using a single threshold rather than a continuous or trajectory-based measure, which may not fully capture the dynamic nature of glucose control across pregnancy. The cross-sectional design precluded assessment of the temporal relationship between the timing of glycaemic control achievement and the onset of specific complications. Sophisticated confirmatory glycaemic monitoring tools were not uniformly available, which may have introduced some misclassification between the well-controlled and poorly controlled groups.

CONCLUSION

Glycaemic control status was strongly associated with perinatal outcome among women with gestational diabetes mellitus in this cohort. Poorly controlled patients experienced a markedly higher burden of abnormal birth weight, postnatal maternal complications, neonatal morbidity and perinatal mortality compared with well-controlled patients. These findings confirm that strict glycaemic control, rather than the diagnosis of GDM alone, is the principal modifiable

determinant of favourable perinatal outcome and should remain the central focus of antenatal management.

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