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Obstetric and neonatal outcomes in the management of twin pregnancies with gestational diabetes using the IADPSG criteria for singleton pregnancies

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Abstract

Background This study evaluates the effectiveness of the International Association of Diabetes and Pregnancy Study Groups (IADPSG) criteria, typically applied to singleton pregnancies, in managing gestational diabetes mellitus (GDM) in twin pregnancies. Focusing on a Chinese cohort, it contrasts the clinical outcomes and complications in twin pregnancies with and without GDM.

Methods We conducted a retrospective cohort study at our hospital from January 2019 to December 2021, including all twin deliveries except those before 28 weeks of gestation, with prior diabetes, or unknown GDM status. GDM was diagnosed using a 75 g oral glucose tolerance test based on the IADPSG criteria, and management involved dietary or insulin interventions. We assessed outcomes such as hypertensive disorders (gestational hypertension, preeclampsia, and eclampsia), membrane rupture, preterm birth, small for gestational age (SGA), large for gestational age (LGA), and neonatal intensive care unit (NICU) admissions.

Results Among 1003 twin pregnancies, 21.7% had GDM, with 11.5% receiving insulin. GDM was associated with older maternal age, higher BMI, and a family history of diabetes. Pregnant women with GDM had lower weekly weight gain (0.44 kg/week vs. 0.58 kg/week, $p < 0.001$) and experienced a higher risk of SGA neonates (aOR = 1.68, 95% CI: 1.06–2.67) and increased NICU admissions (aOR = 1.30, 95% CI: 1.00-1.69) compared to those without GDM. Additionally, dichorionic twins with GDM showed higher risks of SGA and NICU admissions, while monochorionic twins had no significant differences. A U-shaped relationship was identified between weekly weight gain and the rates of SGA and NICU admissions, with the lowest risk observed at a weekly weight gain of 0.75 kg for SGA and 0.57 kg for NICU admissions.

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Conclusions Applying singleton-derived IADPSG criteria to twin pregnancies may mitigate some maternal risks but elevates the risk for SGA neonates, suggesting a need for tailored diagnostic and management strategies for twin pregnancies.

Trial registration Retrospectively registered.

Keywords Gestational diabetes mellitus, Twin pregnancy, Chorionicity, Small-for-gestational-age

Introduction

Gestational diabetes mellitus (GDM) elevates perinatal risks in singleton pregnancies, including preeclampsia (PE), premature rupture of membranes, macrosomia, small for gestational age (SGA), neonatal hypoglycemia, and respiratory distress syndrome (RDS) [1]. Effective management of GDM in singletons is known to mitigate these risks [2]. Conversely, twin pregnancies inherently carry higher risks of GDM and related complications than singletons [3]. However, the extent to which GDM exacerbates perinatal outcomes in twins remains unclear, due to mixed findings in current research. Evidence on the risks associated with GDM in twin pregnancies is contradictory; some studies report increased adverse outcomes [4–8], such as gestational hypertension and PE, while others note minimal associations [9, 10]. These discrepancies are often attributed to variations in study methodologies, including inconsistent diagnostic criteria and missing data on pre-pregnancy body mass index (BMI) and chorionicity.

Diagnostic guidelines for GDM differ widely [11, 12], still predominantly based on studies involving singletons [3]. The appropriateness of applying these singleton-based guidelines to twins has not been substantiated, leading to uncertainties around the benefits of strict glycemic control in such cases [13–15].

This study aimed to evaluate adverse perinatal outcomes between twin pregnancies with GDM diagnosed with the International Association of Diabetes and Pregnancy Study Groups (IADPSG) criteria and those without. It particularly focuses on the differential outcomes in dichorionic versus monochorionic twin pregnancies. By doing so, it contributes to a more nuanced understanding of how existing GDM management protocols may perform when extended to twin scenarios, which may inform future research and adjustments in clinical practice guidelines.

Materials and methods

Study population

This retrospective study encompassed all twin pregnancies delivered at our institution in Eastern China from January 1, 2019, to December 31, 2021. We excluded cases involving singleton pregnancies, delivered at less than 28 weeks of gestation, absent early ultrasound scans for chorionicity or gestational age determination, prior diabetes mellitus, or missing GDM screening results.

Data collection

Data were extracted from the hospital's medical records system, covering maternal demographics, clinical histories, and obstetric-pediatric outcomes. The study included dichorionic (DC) and monochorionic (MC) twins. The MC group was further classified into monochorionic diamniotic (MCDA) and monoamniotic (MCMA) twins. In the case of MCDA twins, they were either naturally MCDA or became MCDA after mid-trimester fetal reduction surgery performed on MCTA pregnancies. Chorionicity was assessed via prenatal ultrasound and confirmed by surgical and pathological reports post-delivery. Gestational age for naturally conceived twins was calculated from the last menstrual period or early ultrasound if discrepancies exceeded five days. For assisted reproduction cases, gestational age was based on the date of embryo implantation.

GDM diagnosis and management

GDM screening was performed using a 75 g oral glucose tolerance test (OGTT), with diagnoses confirmed upon exceeding thresholds of fasting glucose ≥ 5.1 mmol/L, 1-hour postprandial glucose ≥ 10.0 mmol/L, or 2-hour postprandial glucose ≥ 8.5 mmol/L. Management included self-monitored blood glucose, tailored dietary and exercise plans, and, if necessary, insulin therapy based on guidelines from the IADPSG and other standards [1, 16]. All management protocols were uniform across the patient population, overseen by our maternal-fetal medicine team.

Outcomes measured

Outcomes assessed included hypertensive disorders (gestational hypertension, PE, and eclampsia), premature rupture of membranes, preterm delivery, fetal distress, fetal death, and delivery modes. Gestational hypertension was defined as a new development of a blood pressure of ≥ 140/90 mmHg after 20 weeks' gestation without proteinuria, and PE was defined as the onset of a blood pressure of ≥ 140/90 mmHg and proteinuria of ≥ 300 mg/24 h [17]. Neonatal outcomes measured were NICU admission, SGA, LGA [18], birth weight discordance, and conditions like RDS, neonatal hypoglycemia, necrotizing

enterocolitis, infections and jaundice. The intertwin birth weight discordance was calculated using the following formula: (birth weight of the heavier twin − birth weight of the lighter twin) / birth weight of the heavier twin × 100% [19]. A discordant twin pair was defined as having a BWD greater than 25%, based on the NICE guidelines [20], which indicate that BWD exceeding 25%, when combined with other ultrasound findings, is more effective for diagnosing selective intrauterine growth restriction (sIUGR). Outcomes were stratified by chorionicity into monochorionic and dichorionic groups.

Statistical analysis

Descriptive statistics quantified maternal and perinatal data. Group comparisons employed t-tests or Analysis of variance (ANOVAs) for parametric data and Mann-Whitney U tests for non-parametric data. Categorical outcomes were analyzed using Pearson's chi-squared or Fisher's exact tests. Generalized estimating equations (GEE) assessed differences in neonatal outcomes between GDM and non-GDM groups, with marginal standardization to estimate risk differences. All statistical analyses were conducted using SPSS 24.0 and the R programming language, considering p-values <0.05 as statistically significant.

Results

Study population characteristics

We included 1046 women with twin pregnancies, excluding 43 due to our criteria, resulting in 1003 cases included in the analysis. Of these, 773 (77.1%) were dichorionic, and 230 (22.9%) were monochorionic. Among the monochorionic cases, 225 were MCDA, with 223 initially classified as MCDA and 2 converted from MCTA following fetal reduction at 15–16 weeks, while the remaining 5 were MCMA. GDM was diagnosed in 218 women (21.7%) following the IADPSG criteria. These women underwent standardized dietary and exercise interventions, with 25 (11.5%) requiring insulin therapy for inadequate glycemic control (Fig. 1).

Maternal characteristics

Table 1 contrasts maternal characteristics between the GDM and non-GDM groups. Women with GDM were older (average age 33.20 vs. 32.02 years; $p<0.001$) and had higher pre-pregnancy BMI (22.22 vs. 21.40; $p<0.001$). Significant associations were found for previous GDM history (2.3% in GDM vs. 0.3% in non-GDM; $p=0.007$), family diabetes history (13.3% vs. 5.9%; $p<0.001$), and higher local GDM prevalence (51.8% vs. 42.2%; $p=0.011$). Post-diagnosis, the GDM group exhibited significantly lower weekly weight gains (0.44 vs. 0.58 kg/week; $p<0.001$) and total gestational weight gain (GWG) (14.08 vs. 17.13 kg; $p<0.001$).

The impact of GDM on maternal outcomes

Following adjustments for maternal age, pre-pregnancy BMI, early and middle pregnancy BMI gain, history of GDM, family history of type II diabetes, and geographic differences, no significant differences in maternal outcomes were observed in the twin pregnancy GDM group compared to the non-GDM group (Table 2).

Neonatal outcomes

GDM-associated pregnancies showed a higher risk of SGA neonates (7.1% in GDM vs. 4.5% in non-GDM; aOR = 1.68; $p=0.027$) and a trend towards more frequent NICU admissions (49.1% vs. 43.6%, aOR = 1.30; $p=0.051$), but a reduced risk of LGA neonates (3.7% vs. 7.2%, aOR = 0.49; $p=0.014$). Dichorionic (DC) twins with GDM had increased risks of SGA (7.0% vs. 3.8%, aOR = 1.91; $p=0.017$) and NICU admission (44.5% vs. 38.5%, aOR = 1.35; $p=0.046$). The absolute risks for monochorionic twins were similar to those for dichorionic twins, although the statistical significance was not reached likely due to the smaller sample size (Table 3).

We observed no significant differences in neonatal sex ratio or other adverse neonatal outcomes (including prematurity, RDS, neonatal asphyxia, delivery weight discordance, neonatal hypoglycemia, necrotizing enterocolitis, neonatal infection, neonatal jaundice, neonatal malformation, respiratory system diseases, and hyperbilirubinemia), as shown in Appendix Table 1. The number of cases of neonatal deaths is quite limited, with only 1 in the GDM group and 7 in the non-GDM group. Given the small sample size, statistical analysis would not yield meaningful comparisons, and there was no significant difference in neonatal death rates between the two groups. Therefore, we did not include these data in the primary outcome analysis.

Effect of gestational weight gain on outcomes

Analysis revealed a U-shaped relationship between weekly weight gain and rates of SGA and NICU admissions, with the lowest risk at a weekly weight gain of 0.75 kg (SGA) and 0.57 kg (NICU admissions). No such relationship was observed for LGA (Fig. 2).

Discussion

The study's primary objective was to assess how the IADPSG criteria for GDM diagnosis, initially developed for singleton pregnancies, affected key perinatal outcomes in twin pregnancies. We identified a GDM prevalence of 21.7% within our twin pregnancy cohort, which aligns with the higher end of the prevalence spectrum previously reported, ranging from 3.2 to 25.5%. This rate substantiates the findings from a previous retrospective cohort study conducted at our institution. That study documented a threefold increase in gestational diabetes

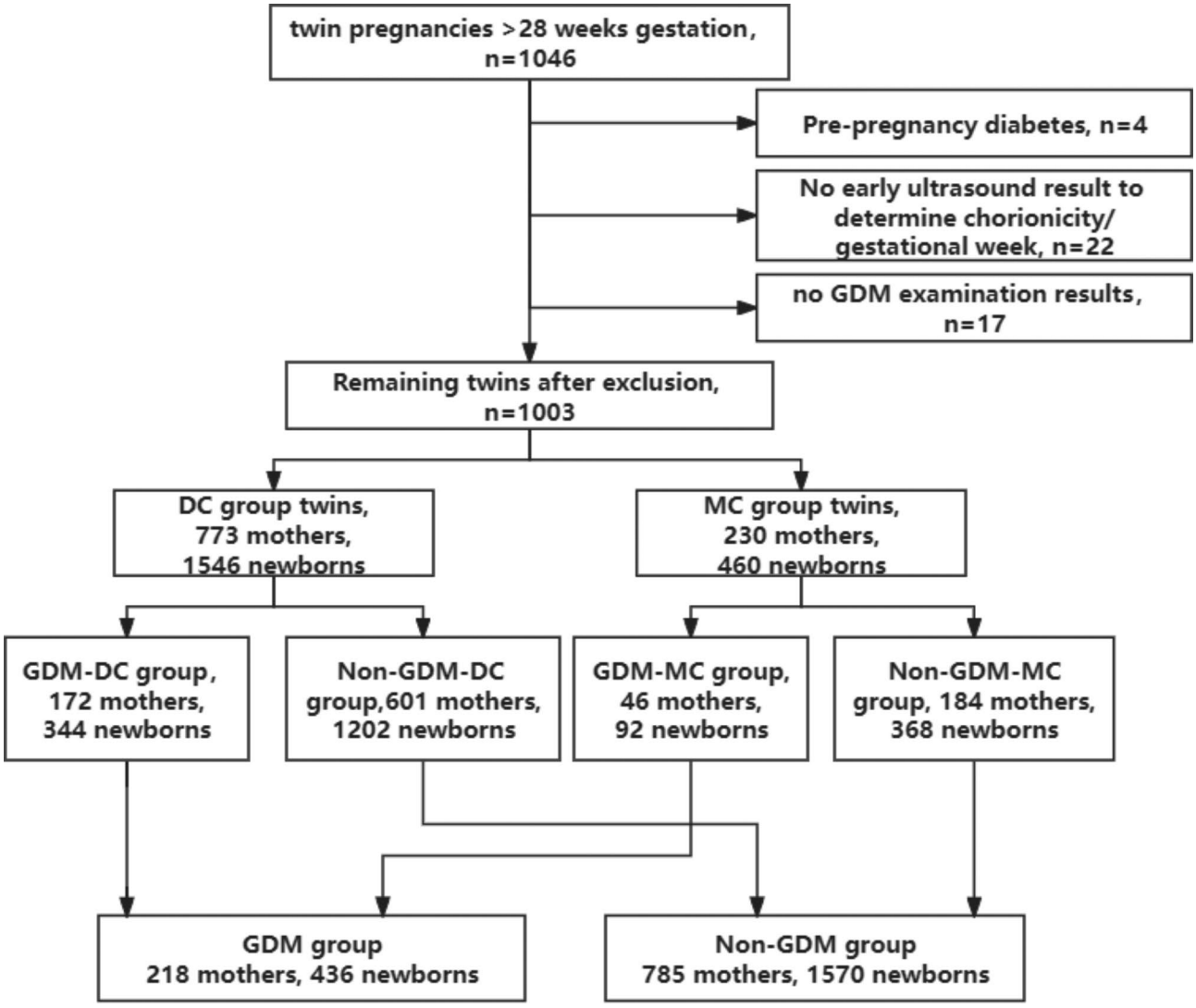

Fig. 1 Flow chart of selection of the study population

mellitus (GDM) incidence following the shift from the conventional two-step diagnostic procedure, which includes an initial 50 g glucose screening test followed by a 100 g diagnostic oral glucose tolerance test according to the Carpenter-Coustan criteria, to the simplified one-step International Association of Diabetes and Pregnancy Study Groups (IADPSG) protocol [21]. Similar trends have been documented in studies of singleton pregnancies [22, 23].

Risk factors for GDM in women with twin pregnancies include advanced maternal age, primiparity, higher pre-pregnancy BMI and assisted reproductive technology(ART) conception [5, 8, 24]. Our study revealed that women with GDM in twin pregnancies were more likely to be aged 35 or older, overweight or obese, and have a personal or family history of diabetes, as well as being registered residents of Shanghai. These findings are consistent with meta analyses focusing on Asian populations [25], emphasizing consistent risk patterns across different studies. Although our data indicated an increased prevalence of GDM among ART-conceived and primigravida, these differences did not reach statistical significance. Furthermore, our analysis showed no significant variation in GDM incidence across different chorionicity of twins, confirming recent findings [26].

Maternal outcomes

The relationship between GDM in twin pregnancies and hypertensive disorders remains a subject of debate. In our study, after controlling for variables such as maternal age and pre-pregnancy BMI, no statistically significant differences were observed in the incidence of hypertension and PE between twin pregnancies affected by GDM and those that were not. This observation aligns with some segments of the literature [8, 26], which report no direct correlation between GDM and hypertensive outcomes,

Table 1 Characteristics of women with twin pregnancies 2019–2021 ($n=1003$)

Characteristics	Non-GDM group ($n=785$)	GDM group ($n=218$)	*p*-value
Maternal age (year)	32.02 ± 3.92	33.20 ± 3.69	0.000
Maternal age ≥ 35 years	201(25.6)	83(38.1)	0.000
Pre-pregnancy BMI (kg/m2)	21.40 ± 3.04	22.22 ± 3.02	0.000
Underweight: BMI < 18.5	78(9.9)	16(7.3)	0.006
Normal weight:18.5 ≤ BMI < 24	593(75.5)	149(68.3)	
Overweight:24 ≤ BMI < 28	88(11.2)	42(19.3)	
Obese: BMI ≥ 28	26(3.3)	11(5.0)	
Multiparity	123(15.7)	28(12.8)	0.294
Assisted Reproductive Technology (ART) pregnancy	489(62.3)	140(64.2)	0.603
Chorionicity (dichorionic)	601(77.8)	172(78.9)	0.524
chronic hypertension	9(1.1)	5(2.3)	0.200
History of GDM	2(0.3)	5(2.3)	0.007
History of polycystic ovary syndrome	20(2.5)	9(4.1)	0.218
Family history of type II diabetes	46(5.9)	29(13.3)	0.000
Geography			0.011
Shanghai	331(42.2)	113(51.8)	
Foreign/expatriate	454(57.8)	105(48.2)	
Educational level			0.405
Master and above	130(16.6)	44(20.2)	
Undergraduate/Specialist	532(67.8)	136(62.4)	
High school and below	123(15.7)	38(17.4)	
Smoking	6(0.8)	1(0.5)	1.000
Early pregnancy			
Ferritin	90.15 ± 68.73	90.3 ± 71.99	0.854
Fasting blood glucose	4.54 ± 0.42	4.64 ± 0.43	0.000
Glycated hemoglobin	5.23 ± 0.29	5.35 ± 0.38	0.000
Middle pregnancy (OGTT)			
Fasting blood glucose	4.16 ± 0.38	4.52 ± 0.53	0.000
1 h after	7.64 ± 1.21	10.18 ± 1.17	0.000
2 h after	6.42 ± 1.04	8.87 ± 1.45	0.000
Glycated hemoglobin	4.96 ± 0.32	5.14 ± 0.42	0.000
Early and middle pregnancy (conception to OGTT) *			
Weight gain (kg)	10.20 ± 4.16	9.20 ± 4.12	0.027
BMI gain (kg/m2)	3.85 ± 1.57	3.53 ± 1.59	0.082
Middle and late pregnancy (OGTT to labor) *			
Weight gain (kg)	6.87 ± 3.38	4.87 ± 3.76	0.000
Weight gain per week (kg/W)	0.58 ± 0.29	0.44 ± 0.47	0.000
BMI gain per week (kg/m2/W)	0.22 ± 0.11	0.17 ± 0.18	0.000
Gestational weight gain (GWG) (kg)	17.13 ± 6.01	14.08 ± 4.94	0.000

while other studies suggest a strong association [10, 27]. Notably, previous research indicates that typical weight gain during pregnancy for Chinese twins ranges from 15 to 21 kg [28], and excessive weight gain is often cited as a contributing factor to hypertensive complications [29, 30].

In contrast to these broader trends, our GDM cohort, managed actively through diet and exercise protocols, gained significantly less weight, an average of only 14.08 kg, compared to the non-GDM group. This moderated weight gain likely played a role in mitigating hypertensive complications traditionally associated with GDM. We postulate that this effective management of weight gain could underlie the absence of increased hypertension and PE rates in our GDM-affected twin pregnancies. This hypothesis is supported by results previously published by our institution [31], indicating that a comprehensive management approach, including specific dietary recommendations, can substantially reduce the risk of gestational hypertension, particularly in twins diagnosed with obesity. Furthermore, the reduction in the incidence of early-onset PE in our cohort may be partly attributed to the proactive use of aspirin in twin pregnancies managed at our hospital, aligning with recent trends towards preventive pharmacological interventions in high-risk populations. This proactive strategy has demonstrated effectiveness in decreasing the prevalence of this severe pregnancy complication, underscoring the value of integrative care strategies in managing complex cases like twin pregnancies with GDM.

Neonatal outcomes

Building upon our findings from maternal outcomes, where strict dietary and exercise regimens were seen to mitigate hypertensive disorders in GDM-affected twin pregnancies, our study further explored the neonatal consequences of these management strategies. Contrary to certain previous studies [26, 32], we observed an increase in neonatal SGA and a decrease in LGA within the GDM group. This trend could be attributed to the notably lower weight gain during pregnancy, particularly after GDM diagnosis, as stringent glycemic and weight control were prioritized. Indeed, meta-analyses suggest that insufficient weight gain in twin pregnancies is linked to increased risks of SGA and low birth weight [29, 33], potentially due to inadequate nutritional intake. The physiological dynamics of twin pregnancies, which include heightened glucose consumption and a higher basal metabolic rate, suggest that some degree of hyperglycemia might be naturally compensatory [8, 26], the greater transient increase in insulin resistance observed in twin pregnancies is merely a physiologic exaggeration rather than a pathology that requires treatment [15]. The recent studies from the American Journal of Obstetrics and Gynecology (AJOG) indicated that while strict glycemic control is associated with reduced LGA incidence, it does not necessarily improve overall neonatal outcomes and may increase SGA prevalence [15, 34]. These findings raise critical questions about the applicability of standard GDM glycemic targets, originally designed for singleton pregnancies, to the unique metabolic requirements of twins. This discrepancy underscores the need for tailored

Table 2 Impact of GDM on maternal outcomes in twin pregnancies ($n=1003$)

maternal outcomes		Non-GDM group ($n=785$)	GDM group ($n=218$)	OR (95%CI)	aOR (95% CI)	*p*-Value Adjusted
hypertensive disorders		170(21.7)	44(20.2)	0.92(0.63,1.33)	0.88(0.60,1.29)	0.515
pre-eclampsia	total	114(14.5)	27(12.4)	0.83(0.53,1.30)	0.84(0.53,1.34)	0.458
	< 37 weeks	100(12.7)	23(10.6)	0.81(0.50,1.31)	0.82(0.50,1.35)	0.442
	< 34 weeks	20(2.5)	4(1.8)	0.72(0.24,2.11)	0.80(0.26,2.45)	0.701
preterm rupture of membranes		114(14.5)	37(17)	1.20(0.80,1.81)	1.26(0.82,1.93)	0.288
preterm delivery	< 37 weeks	496(63.2)	134(61.5)	0.93(0.68,1.27)	0.97(0.70,1.33)	0.836
	< 34 weeks	83(10.6)	29(13.3)	1.30(0.83,2.04)	1.38(0.85,2.24)	0.194
excessive amniotic fluid		15(1.9)	4(1.8)	0.96(0.32,2.92)	1.08(0.33,3.47)	0.902
fetal distress		58(7.4)	20(9.2)	1.27(0.74,2.16)	1.25(0.71,2.19)	0.443
fetal death		7(0.9)	1(0.5)	0.51(0.06,4.19)	0.20(0.01,3.77)	0.280
mode of delivery (Cesarean section)		766(97.6)	212(97.2)	0.88(0.35,2.22)	1.17(0.41,3.36)	0.766
postpartum hemorrhage		32(4.1)	11(5.0)	1.25(0.62,2.52)	1.22(0.59,2.53)	0.591

aOR: Adjusted odds ratio.CI: Confidence interval. AOR was corrected for age, pre-pregnancy BMI, early and middle pregnancy BMI gain, history of GDM, family history of type II diabetes, and geographic differences as covariates with P-values < 0.05 for all models

Table 3 Impact of GDM on neonatal outcomes in twin pregnancies ($n=2006$)

neonatal outcomes	Non-GDM group ($n=1570$)	GDM group ($n=436$)	OR (95% CI)	aOR (95% CI)	*P*-value Adjusted
Total ($n=2006$)					
NICU admission	684(43.6)	214(49.1)	1.25(0.96,1.62)	1.30(1.00,1.69)	0.051
SGA	70(4.5)	31(7.1)	1.64(1.05,2.57)*	1.68(1.06,2.67)*	0.027
LGA	113(7.2)	16(3.7)	0.49(0.28,0.86)*	0.49(0.28,0.87)*	0.014
DC ($n=1546$)					
NICU admission	463(38.5)	153(44.5)	1.31(0.72,2.39)	1.35(1.01,1.81)*	0.046
SGA	45(3.8)	24(7.0)	1.92(1.15,3.23)*	1.91(1.12,3.26)*	0.017
LGA	91(7.6)	16(4.7)	0.60(0.34,1.05)	0.59(0.33,1.04)	0.070
MC ($n=460$)					
NICU admission	221(60.1)	61(66.3)	1.31(0.72,2.39)	1.29(0.70,2.38)	0.408
SGA	25(6.8)	7(7.6)	1.13(0.44,2.91)	1.27(0.48,3.30)	0.631
LGA	22(6.0)	0(0.0)	NA	NA	NA

Generalized estimating equations (GEE) models adjusted for maternal age, pre-pregnancy BMI, early and middle pregnancy BMI gain, history of GDM, family history of type II diabetes, and geographic differences as covariates. *: $P<0.05$

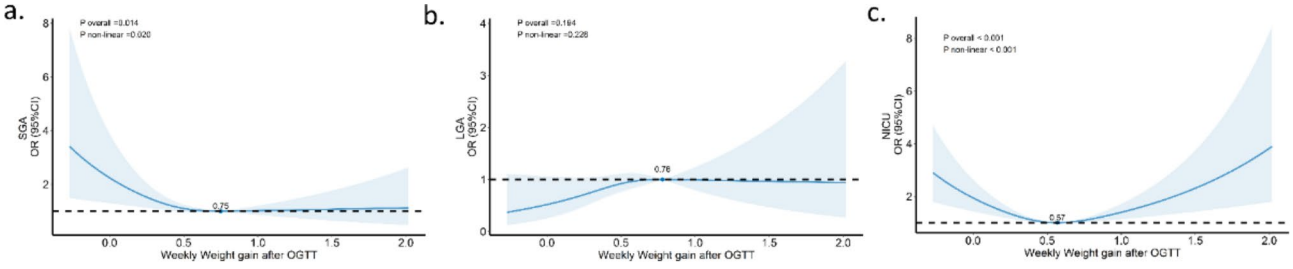

Fig. 2 RCS-curves correlating weekly weight gain after OGTT with neonatal SGA, LGA and NICU admission rates. (**a**) weekly weight gain after OGTT with neonatal SGA, $P<0.05$, $n=2006$. (**b**) weekly weight gain after OGTT with neonatal LGA, $P>0.05$, $n=2006$. (**c**) weekly weight gain after OGTT with neonatal NICU admission rates, $P<0.05$, $n=2006$. The statistics were analyzed with other factors taken into account. Covariates: age, pre-pregnancy BMI, fasting blood glucose and glycated hemoglobin

guidelines that specifically address the dual challenges of managing GDM and optimizing fetal growth in twin pregnancies.

Diagnostic criteria for GDM in twins

In singleton pregnancies, established interventions such as dietary control and insulin therapy are known to benefit both severe and mild cases of GDM, adhering to the National Diabetes Data Group (NDDG) criteria [35]. However, the evidence base concerning the impact of changing diagnostic criteria on maternal and neonatal outcomes in twin pregnancies remains limited. The introduction of the IADPSG criteria has led to increased GDM diagnosis rates, which necessitates an evaluation of cost-effectiveness due to potential increases in healthcare expenditures.

The 2018 guidelines from the American College of Obstetricians and Gynecologists (ACOG) [12] continue to advocate for the two-step diagnostic approach, citing a lack of sufficient evidence to support that a higher diagnosis rate significantly enhances maternal or neonatal outcomes in clinical settings. These guidelines caution against hasty adoption of new criteria without robust national-level research, although they acknowledge that hospitals and organizations may adopt the IADPSG criteria at their discretion.

Our study indicates that applying single-fetus GDM diagnostic criteria to twin pregnancies has resulted in increased GDM diagnosis rates. This heightened detection could lead to potential overdiagnosis and overtreatment, contributing to adverse perinatal outcomes, such as increased incidences of SGA and neonatal intensive care unit (NICU) admissions. These findings underscore the necessity for a tailored approach to diagnosing and managing GDM in twin pregnancies. It is imperative to further investigate and possibly revise the diagnostic criteria specifically for twin pregnancies to avoid the pitfalls of overdiagnosis and ensure optimal perinatal care.

Twin pregnancy weight gain targets

Effective glycemic and weight management in twin pregnancies is essential for reducing risks associated with gestational hypertension and PE [1], though it may increase the likelihood of SGA. This presents a clinical dilemma: balancing weight control with the prevention of adverse perinatal outcomes.

The Institute of Medicine (IOM) guidelines from 2009 recommend a GWG of 16.8–24.5 kg for twins with a normal pre-pregnancy BMI, suggesting variations in these outcomes across different racial groups [36]. For instance, adequate GWG as per IOM standards correlated with increased gestational hypertension risks in Japanese populations [37], while Soichiro Obata proposed lower GWG ranges of 10.3–16.0 kg for twins in Japan, excluding GDM cases [38]. In China, current GWG guidelines are tailored only for singleton pregnancies [39], highlighting the need for specific standards for twins. Studies exploring the application of IOM recommendations to Chinese twins have shown inconsistent results, often neglecting the impact of varying rates of GWG across different pregnancy stages [40–42].

Our research focused on the correlation between weekly weight gain post-OGTT and neonatal outcomes such as SGA, LGA, and NICU admissions. We identified optimal outcomes at a GWG rate of 0.75 kg/week (SGA) and 0.57 kg/week (NICU admissions) during mid-to-late pregnancy (Fig. 2), compared to just 0.44 kg/w in the GDM group, indicating a direct connection between lower weight gain rates and increased SGA/NICU admission risk. These findings underline the importance of establishing specific GWG targets for twin pregnancies in China. Given the limited sample size (436 newborns in the GDM group), expanding this research is essential to confirm these preliminary results and refine GWG recommendations.

Outcomes in dichorionic versus monochorionic twins

Understanding the influence of placental factors is crucial in managing gestational diabetes mellitus (GDM), hypertensive disorders, and fetal growth issues in twin pregnancies. This study examines the perinatal outcomes of GDM in twins categorized by their chorionicity. Our findings indicate that the incidence of GDM is similar across both DC and MC twins, which is consistent with the results reported by Dave et al. [10]. Notably, the neonatal outcomes in the DC twin group mirrored the general twin outcomes, suggesting that GDM increases the likelihood of having a neonate SGA and the risk of NICU admission. A relevant Taiwanese study highlighted that GDM triples the risk of NICU admissions [32], although it did not show a difference in the occurrence of SGA.

Interestingly, in our study, GDM did not lead to a higher incidence of SGA or NICU admissions in the MC twin group, possibly due to the shared placenta, which may dilute the individual impact of GDM typically observed in singletons. This phenomenon suggests that the twin MC group's outcomes might be less affected by the maternal GDM status compared to DC twins, where each fetus has its own placenta.

Furthermore, contrasting findings by Y. Mei indicated that GDM is associated with fewer instances of SGA in monochorionic diamniotic twins [43], which diverges from our observations where no significant differences in weight gain were noted between the GDM and non-GDM groups during pregnancy. Our study, however, had a limited sample size of 460 newborns in the MC group, which may not sufficiently represent broader population dynamics. Expanding the sample size in future research

will be crucial to confirm these preliminary findings and to refine management strategies for this high-risk group.

Advantages and limitations

Our study benefits from several notable strengths, including a robust sample size from a single institution which ensures uniformity in the diagnosis and management of GDM. We specifically focused on twin pregnancies characterized by a high rate of ART usage (up to 62.7%), which provided a unique cohort for examining GDM impacts. Participants showed excellent adherence to prescribed dietary and exercise regimens, enhancing the reliability of treatment outcomes. These factors contributed to the standardized delivery of treatments and allowed us to propose specific weight gain targets tailored for Chinese twin pregnancies, anticipated to improve both obstetric and neonatal outcomes. Additionally, we adjusted for variables such as pre-pregnancy BMI, and weight gain during early and mid-pregnancy, alongside family history, to control for potential confounders. Furthermore, our study's approach of stratifying GDM-affected pregnancies by chorionicity is an aspect that is less commonly addressed in existing literature, providing deeper insights into how GDM impacts different twin types.

Despite these strengths, our study faces certain limitations due to its retrospective design. We analyzed data on weight gain and glucose levels at various stages of pregnancy, but did not comprehensively examine other vital factors like physical activity and detailed glycemic control, which are crucial for understanding the full spectrum of GDM development and management. This omission means we cannot definitively conclude how these factors might influence pregnancy outcomes. Additionally, the study's design did not allow for the tracking of long-term maternal and neonatal health outcomes, which are critical for assessing the enduring impacts of GDM management strategies. Given these gaps, further prospective studies are necessary to validate our findings and refine the guidelines for managing GDM in twin pregnancies. As a next step, we aim to expand our sample size and employ a prospective study design to explore more deeply the diagnostic criteria for GDM in twins and to optimize strategies for glycemic control and weight management.

Conclusions

Our study aimed to evaluate the effectiveness of the IADPSG criteria, originally developed for singleton pregnancies, in managing GDM in twin pregnancies. We found that while these criteria effectively reduce the prevalence of LGA neonates through targeted dietary and pharmacological interventions, they concurrently increase the risk of SGA neonates and potentially elevate NICU admissions. These findings suggest that a tailored approach to managing GDM in twin pregnancies is necessary, incorporating specific diagnostic, glycemic control, and weight management strategies to optimize outcomes for both the mother and neonates. Future research should focus on longitudinal studies to refine these strategies and validate their effectiveness in improving overall perinatal outcomes in twins.

Appendix table 1. Impact of GDM on other neonatal outcomes in twin pregnancies (*n* = 2006)

neonatal outcomes		Non-GDM group (*n* = 1570)	GDM group (*n* = 436)	OR (95% CI)	aOR (95% CI)	*P*-value Adjusted
prematurity	< 37 weeks	992(63.2)	268(61.5)	0.93(0.68,1.27)	0.94(0.69,1.29)	0.712
	< 34 weeks	166(10.6)	58(13.3)	1.30(0.83,2.04)	1.39(0.87,2.21)	0.164
sex(male)		781(49.7)	206(47.2)	0.90(0.71,1.14)	0.87(0.68,1.11)	0.260
RDS		113(7.2)	38(8.7)	1.23(0.76,1.99)	1.31(0.80,2.14)	0.289
neonatal asphyxia		47(3.0)	20(4.6)	1.56(0.80,3.05)	1.93(0.97,3.87)	0.063
delivery weight discordance > 25%		100(6.4)	30(6.9)	1.09(0.60,1.97)	1.07(0.58,1.98)	0.836
hypoglycemia		57(3.6)	17(3.9)	1.08(0.60,1.94)	1.04(0.58,1.88)	0.887
necrotizing enterocolitis		60(3.8)	16(3.7)	0.96(0.51,1.79)	1.00(0.53,1.87)	0.995
neonatal infection		55(3.5)	16(3.7)	1.05(0.57,1.92)	1.25(0.70,2.31)	0.472
neonatal jaundice		321(20.4)	90(20.6)	1.01(0.73,1.41)	098(0.70,1.38)	0.912
neonatal malformation		20(1.3)	10(2.3)	1.82(0.75,4.44)	1.86(0.75,4.58)	0.178
respiratory system diseases		269(17.1)	84(19.3)	1.15(0.83,1.61)	1.20(0.86,1.69)	0.281
hyperbilirubinemia		55(3.5)	22(5.0)	1.46(0.85,2.54)	1.63(0.94,2.85)	0.084

Generalized estimating equations (GEE)models adjusted for maternal age, pre-pregnancy BMI, early and middle pregnancy BMI gain, history of GDM, family history of type II diabetes, and geographic differences as covariates. *: $P < 0.05$

Abbreviations

ANOVA	Analysis of variance
aOR	adjusted odds ratio
ART	Assisted reproductive technology
BMI	Body mass index
CI	Confidence interval
DC	Dichorionic
GDM	Gestational diabetes mellitus
GEE	General estimated equation
GWG	Gestational weight gain
IADPSG	International Association of Diabetes and Pregnancy Study Groups
IOM	Institute of Medicine
LGA	Large for gestational age
MC	Monochorionic
NICU	Neonatal intensive care unit
OGTT	Oral glucose tolerance test
RDS	Respiratory distress syndrome
SGA	Small for gestational age

Author contributions

Jue Ma: The conception, design of the work, writing-original draft; Dongjian Yang: Analysis of the data; Juanxiu Lv: Methodology; Shujing Liu: Data curation; Li Gao: Supervision; Yan Bi: Substantively revised the work; Yanlin Wang: The conception & design of the work, funding acquisition.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The institutional review board approved the study (approval reference number: GKLW-A-2024-023-01). Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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