ORIGINAL ARTICLE

Factors Associated with Cesarean Operations of Gestational Diabetic Mellitus and Diabetes Complications

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Objective: To identify risk factors of cesarean delivery in pregnant women with diabetes mellitus and complications caused by gestational diabetes.

Materials and Methods: A retrospective cohort study was conducted at the Department of Obstetrics and Gynecology, Phatthalung Hospital. The participants consisted of pregnant women who labored at Phatthalung Hospital between 2017 and 2021. The inclusion criteria comprised women who labored from 28 to 42 weeks and had complete medical records. Patients having previous cesarean sections, cesarean section on maternal demand, and twin pregnancy were excluded. The study group was diabetic mellitus pregnant women, while non-diabetic pregnant women was generated by random numbers at ratio of 1:1 as control group. The data collected were demographic data, age, body mass index (BMI), number of gestations, parity, abortion, type of diabetic mellitus, underlying disease, route of delivery, indications for cesarean delivery, and maternal and neonatal outcomes.

Results: Two thousand twelve pregnant women consisted of 1,006 pregnancies with diabetes and 1,006 non-diabetic pregnancies. Pregnant women with diabetes significantly increased the risk of cesarean section 1.42 time (95% CI 1.19 to 1.70, p<0.001). The greatest indication for cesarean section of both groups was cephalopelvic disproportion, but failure for induction of labor and macrosomia were found in the study group more than in the control group. Logistic regression analysis, adjusted for age group, number of gestations, and BMI, showed that pregnancy-induced hypertension and newborn weight of 4,000 g or more were risk factors for cesarean section among diabetic pregnancies. The maternal complications of the study group were preeclampsia, indicated preterm labor, and premature rupture of membranes. The common fetal complications were macrosomia and birth asphyxia.

Conclusion: Risk factors of cesarean section among pregnant women with diabetes included preeclampsia and newborn weight of 4,000 g or more. Gestational diabetes increased significantly the maternal and fetal complications.

Keywords: Gestational diabetic mellitus; Cesarean section; Complications

Received 31 January 2023 | Revised 10 July 2023 | Accepted 13 July 2023

J Med Assoc Thai 2023;106(9):837-42

Website: http://www.jmatonline.com

In 2021, the International Diabetes Federation reviewed an estimated that 21.1 million live births (16.7%) of pregnant women presented with diabetic mellitus and this prevalence is increasing worldwide[1]. The prevalence showing 80.3% involved gestational diabetes mellitus (GDM), 10.6% with overt diabetic mellitus, and 9.1% that consisted of diabetes, including type 1 and type 2, that was first detected in pregnancy. Globally, the prevalence of gestational diabetes among women of the same age group is highest in Southeast Asia. The overall rate is 28% with the highest rate among women aged 45 to 49 years at 42.3%, although fewer pregnancies are observed in this age group. The neonatal complications increased one fourth from pregnancy with hyperglycemia status[1]. When maternal glucose passes through the placenta, it can lead to fetal hyperglycemia with fetal release of insulin, insulin-like growth factors, and growth hormones. These, in turn, can lead to an increase in fetal fat deposition and are associated with macrosomia[2,3]. Following the multidisciplinary team approach for diabetic pregnant women in Phatthalung Hospital used in the last few years, the rate of operative deliveries and other diabetic complications may have changed but there is still limited data. Therefore, the present study aimed to investigate the risk of caesarean section and rate of complications in diabetic pregnancy.

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How to cite this article:

Suwannarat N, Punpuckdeekoon P. Factors Associated with Cesarean Operations of Gestational Diabetic Mellitus and Diabetes Complications. J Med Assoc Thai 2023;106:837-42.

DOI: 10.35755/jmedassocthai.2023.09.13757

Materials and Methods

After ethics approval by the Phatthalung Ethics Committee for Research Involving Human Subjects (No.16/2565), medical records of pregnant women that attended antenatal care and labored at Phatthalung Hospital between 2017 and 2021 were reviewed. The inclusion criteria were those who delivered at gestational age between 28 and 42 and had complete data records. Women, scheduled for an elective cesarean delivery, such as previous cesarean section, maternal demand for cesarean section, and twins were excluded. The present study group consisted of 1,006 pregnant women with gestational diabetes mellitus and overt diabetes mellitus. Random numbers were generated to select 1,006 non-diabetic women to serve as the comparison in a retrospective cohort study. The study group were pregnant women with overt diabetes or those diagnosed as gestational diabetes mellitus by 100-g oral glucose tolerance test (OGTT) according to the Carpenter-Coustan criteria either done after abnormal 50-g glucose challenge test or 1-step 100-g OGTT between 24 and 28 weeks of gestation.

Demographic data including age, body mass index (BMI), number of gestations, parity, and abortion were retrieved. Pregnancy outcomes including route of delivery, indication for cesarean section, maternal complications such as postpartum hemorrhage, pregnancy-induced hypertension, and neonatal outcomes such as birth weight, preterm labor, birth asphyxia, and neonatal death, were also extracted.

Statistical analysis was performed using descriptive statistics, including number, percentage, mean, and standard deviation to describe various characteristics as appropriate. Student t-test, and chi-square, and Mann-Whitney U tests were used to compare various risks of cesarean section and characteristics between groups. Logistic regression analysis was performed to determine independent risk factors for cesarean delivery, adjusted for potential confounders. All statistical analyses were performed using complete cases and Stata/BE, version 17.0 (Stata Corp, College Station, TX, USA). A p-value of less than 0.05 was considered statistically significant.

Results

The characteristic features of 2,012 deliveries were included in the analyses. Table 1 shows the demographics of the study population. The average age was 29 years, ranging between 18 and 46. The mean age of non-diabetic and diabetic pregnant women were 29 and 32 years old, respectively, and the majority group comprised women between 20 and 34 years old. Higher percentage of pregnant women 35 years old or older was found in the diabetic group. Most pregnant women in the control group were first gestation at 38.9%, whereas pregnant women with diabetes were three or more gestation at 41.1%. Pregnant women in the diabetes group had higher BMI and chronic hypertension than women in control the group at 8.8% and 1.4%, respectively.

Table 2 shows maternal outcomes. The research found that pregnant women with diabetes experienced higher rates of gestational hypertension and pre-eclampsia than non-diabetic group. Preeclampsia with severe features was found at 9.54% among

Table 1. Comparison of baseline characteristics between two groups

	Non-GDM (n=1,006) n (%)	GDM (n=1,006) n (%)	p-value
Age (years)			<0.001*
Mean±SD	28.79±5.77	32.12±6.08	
<20	42 (4.2)	21 (2.1)	
20 to 34	799 (79.4)	617 (61.3)	
≥35	165 (16.4)	368 (36.6)	
Gravidity			<0.001*
1	392 (38.9)	306 (30.6)	
2	326 (32.5)	286 (28.3)	
≥3	288 (28.6)	414 (41.1)	
Parity			<0.001*
0	392 (38.9)	306 (30.4)	
1	332 (33.2)	293 (29.0)	
2	169 (16.7)	241 (23.9)	
3	73 (7.3)	99 (9.9)	
≥4	40 (3.9)	67 (6.8)	
Abortion	78 (7.7)	117 (11.6)	
BMI (kg/m^2)			<0.001*
Mean±SD	27.61±4.77	29.9±5.49	
≤25	390 (38.8)	242 (24.1)	
26 to 30	393 (39.1)	372 (37.0)	
31 to 34	154 (15.3)	206 (20.5)	
35 to 39	54 (5.4)	137 (13.5)	
≥40	15 (1.5)	49 (4.9)	
Medical illness			
Chronic hypertension	14 (1.4)	89 (8.8)	<0.001*
Nephrotic syndrome	0 (0.0)	3 (0.29)	0.083
Systemic lupus erythematosus	1 (0.09)	1 (0.09)	1.000
Heart failure	1 (0.09)	3 (0.29)	1.000

GDM=gestational diabetes mellitus; BMI=body mass index; SD=standard deviation

* p<0.05 is considered statistical significance

Table 2. Maternal outcomes

Maternal outcome	Non-GDM (n=1,006); n (%)	GDM (n=1,006); n (%)	Odds ratio (95% CI)	p-value
Pregnancy-induced hypertension				
Gestational hypertension	7 (0.69)	37 (3.67)	5.44 (2.38 to 14.54)	<0.001*
Pre-eclampsia without severe features	9 (0.89)	33 (3.28)	3.75 (1.74 to 8.97)	<0.001*
Pre-eclampsia with severe features	34 (3.37)	96 (9.54)	3.016 (1.99 to 4.64)	<0.001*
Eclampsia/HEELP syndrome	1 (0.09)	1 (0.09)	1 (0.01 to 78.57)	1.000
Preterm labor	88 (8.74)	108 (10.73)	1.25 (0.92 to 1.70)	0.132
Indicated$	24 (27.27)	74 (68.52)	3.24 (2.00 to 5.42)	<0.001*
Spontaneous	64 (72.73)	34 (31.48)	0.51 (0.32 to 0.80)	0.002
Premature rupture of membranes	34 (3.37)	65 (6.46)	1.97 (1.27 to 3.11)	<0.001*
Route of delivery				<0.001*
Normal delivery	559 (55.56)	470 (46.72)	1	
Cesarean section	447 (44.44)	536 (53.28)	1.42 (1.19 to 1.70)	
Indication for cesarean section				
Cephalopelvic disproportion (CPD)	148 (33.11)	137 (25.56)	0.91 (0.71 to 1.18)	0.482
Fetal distress	140 (31.32)	118 (22.01)	0.82 (0.63 to 1.08)	0.142
Failed induction	66 (14.76)	122 (22.76)	1.96 (1.42 to 2.73)	<0.001*
Pre-eclampsia c unfavorable cervix	30 (6.71)	73 (13.62)	2.54 (1.62 to 4.07)	<0.001*
Abnormal presentation	48 (10.74)	52 (9.70)	1.09 (0.71 to 1.66)	0.681
Placenta previa	13 (2.91)	13 (2.43)	0.99 (0.42 to 2.35)	0.999
Macrosomia#	2 (0.45)	21 (3.92)	10.70 (2.60 to 94.3)	0.001*
Postpartum hemorrhage	9 (0.89)	20 (1.98)	2.24 (1.02 to 5.63)	0.039*

GDM=gestational diabetes mellitus; CI=confidence interval

* $p<0.05$ is considered statistical significance

Chi-square test for categorical data

$ Indicated preterm: preeclampsia with severe features, placenta previa with active bleeding; # Estimated fetal weight ≥4,000 gram

pregnant women with diabetes, and 3.37% in the control group.

Preterm labor increased 1.25-fold (95% CI 0.92 to 1.70) among pregnant women with diabetes and a significant higher rate was noted of indicated preterm labor at 68.52%.

Pregnant women in the diabetes group presented a significantly increased risk of cesarean delivery more than non-diabetic pregnancy at 53.28% and 44.44%, respectively (odds ratio 1.42, 95% CI 1.19 to 1.70). Both groups had the same highest cesarean indication due to cephalopelvic disproportion. However, the second most indication were differed with failed induction of labor among pregnant women with diabetes and fetal distress in the comparison group.

The logistic regression analysis of the risk factors for cesarean section among pregnant women with diabetes adjusted for age group, number of gestations, and BMI is shown in Table 3. Preeclampsia with and without severe features increased the risk of cesarean delivery by 11.48 folds (95% CI 6.10 to 21.60) and 3.45 folds (95% CI 1.67 to 7.12), respectively. A significant cesarean section rate was observed among those delivered newborn 4,000 g or more (adjusted odds ratio 1.87, 95% CI 1.36 to 2.56).

Comparison of neonatal outcomes between the two groups is shown in Table 4. Complications such as respiratory distress, neonatal death, birth asphyxia, and neonatal intensive care unit (NICU) admission significantly emerged among pregnant women in the diabetes group. The complications found only among pregnant women with diabetes were shoulder dystocia and neonatal hypoglycemia with four cases and three cases, respectively.

Causes of stillbirth among the non-diabetic group were prolapsed cord in one case, placenta previa with maternal shock in one case and unknown in one case. Causes of stillbirths among the diabetic group had unknown causes with six cases.

Two and five neonatal deaths with various causes were found in non-GDM and GDM groups, respectively.

Fetal anomalies were found similarly in both groups. One newborn with cleft lip and cleft palate was born among pregnant with diabetes. The non-

Table 3. Logistic regression analysis of risk factors for caesarean section in gestational diabetes mellitus women

	Normal labor n (%)	Cesarean section n (%)	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)#	p-value*
Group						
Non-GDM	559 (55.59)	447 (44.44)	1		1	
GDM	470 (46.72)	536 (53.28)	1.42 (1.19 to 1.70)	<0.001*	1.17 (0.97 to 1.41)	0.100
Chronic hypertension	33 (32.0)	70 (68.0)	2.30 (1.50 to 3.51)	<0.001*	1.23 (0.76 to 1.98)	0.382
Gestational hypertension	19 (43.2)	25 (56.8)	1.38 (0.75 to 2.52)	0.293	1.41 (0.76 to 2.60)	0.271
Pre-eclampsia without severe features	10 (23.8)	32 (76.2)	3.41 (1.67 to 6.98)	0.001*	3.45 (1.67 to 7.12)	0.001
Pre-eclampsia with severe features	11 (9.6)	103 (90.4)	12.68 (6.79 to 23.67)	<0.001*	11.48 (6.10 to 21.60)	0.001
Birth weight (g)						
<2,500	67 (32.5)	139 (67.5)	1.32 (0.73 to 2.38)	0.347	1.39 (0.77 to 2.52)	0.269
2,500 to 3,500	764 (56.5)	587 (43.5)	1		1	
3,501 to 3,999	165 (45.8)	195 (54.2)	1.24 (1.03 to 1.50)	0.023	1.11 (0.91 to 1.36)	0.268
≥4,000	33 (34.7)	62 (65.3)	2.34 (1.74 to 3.15)	<0.001*	1.87 (1.36 to 2.56)	0.001

GDM=gestational diabetes mellitus; OR=odds ratio; CI=confidence interval

* p<0.05 is considered statistical significance

Chi-square test for categorical data

Logistic regression analysis: adjusted for age group, number of gestation, and BMI

Table 4. Neonatal outcomes

Neonatal outcomes	Non-GDM (n=1,006) n (%)	GDM (n=1,006) n (%)	p-value
Chromosome abnormality	1 (0.09)	0 (0.00)	1.000
Fetal anomaly	2 (0.19)	1 (0.09)	1.000
Fetal growth restriction	15 (1.49)	11 (1.09)	0.430
Macrosomia	25 (2.48)	70 (6.96)	<0.001*
Neonatal death and stillbirth	5 (0.49)	11 (1.09)	0.132
Shoulder dystocia	0 (0.00)	4 (0.40)	0.125
Apgar score <7 at 5 minutes	12 (1.19)	24 (2.38)	0.044*
Respiratory distress syndrome	15 (1.49)	24 (2.38)	0.143
Sepsis	7 (0.69)	10 (0.99)	0.465
Transient tachypnea of newborn	2 (0.20)	6 (0.60)	0.156
Hypoglycemia	0 (0.00)	3 (0.30)	0.250
NICU admission	15 (1.49)	27 (2.68)	0.060

* p<0.05 is considered statistical significance

Chi-square test or Fisher's exact test for categorical data

diabetic group exhibited one Ebstein anomaly and a trisomy 18 newborn.

Discussion

Correa et al.[4] found that the incidence of gestational diabetes in the United States was higher at all ages. In 2021, studies found that Southeast Asia showed a high prevalence of gestational diabetes, with a high prevalence of 28% compared with that of other racial groups[1,5].

The present study illustrated that woman over 35 years, BMI greater than 30 kg/m², higher parity, and those with chronic hypertension were found more often in the diabetic mellitus group. The result was consistent with the findings of Chu et al.[6].

In this study, maternal and neonatal complications presented by pregnant women in the diabetes group were higher than those in the control group. Preeclampsia was the most common complication associated with diabetes. Preeclampsia with severe features was found more among those with overt diabetic mellitus at 36.6%, followed by gestational diabetes requiring insulin treatment at 10.9%, and those treated by diet control at 5.1%. The data were similar to the research of Weissgerber and Mudd[7] reporting preeclampsia at two to four times higher in overt diabetic mellitus. Previous study found that risk factors increasing the likelihood of preeclampsia consisted of a BMI greater than 27 kg/m², diagnosed with diabetes before 20 weeks of gestation and poor blood sugar control[8,9].

The present study revealed significant increase of preterm births among pregnant women with diabetes, consistent with other studies[10,11]. Those studies indicated that preterm labor was the majority among the diabetic group, while the non-diabetic group had a higher portion of spontaneous preterm, which was mostly related to teenage pregnancy. The cause that indicated preterm births in the present study was mostly because of preeclampsia with severe features.

Fetal birth asphyxia was significantly found among diabetic pregnant women who developed preeclampsia. Furthermore, the eleven stillbirths in

this group were related to unpredicted birth asphyxia despite good blood sugar control during antepartum and intrapartum periods. Prior study[12] reported higher risk of stillbirth in overt diabetes mellitus at three to five times for obese mothers and at two point eight times for poor blood sugar control.

Research showed that pregnant women with a BMI greater than 30 kg/m² and overt diabetes mellitus were major risk factors for macrosomia[13]. In the present study, 33 macrosomias delivered vaginally including 23 in diabetic pregnant women and 10 in non-diabetic women. The four cases of shoulder dystocia occurred in diabetic pregnant women who needed insulin treatment. All newborns weighed between 4,100 to 4,250 g. To reduce this complication, scheduled cesarean section may be offered to diabetic mothers with estimated fetal weight more than 4,000 g.

Pregnant women with diabetes had a higher rate of caesarean section than that of non-diabetic group. Indications for surgery due to failed induction of labor and preeclampsia with unfavorable cervix were about two times compared with the control group. This could partly be the result of a significant two-fold and eight-fold increase in the rate of preeclampsia with severe features and macrosomia among pregnant women with diabetes. The results of the present study agreed with the study of Boriboonhirunsarn and Waiyanikorn[14].

Hedderson et al.[15] reported that preeclampsia and macrosomia were the independent factors of cesarean section among pregnant women with diabetes, after adjusting for age, number of gestations, and BMI.

In Thailand, Phaloprakarn and Tangjitgamol[16] created a risk score for predicting primary cesarean section for gestational diabetic mellitus using risk factors such as number of deliveries, maternal weight, and insulin use for which the calculation proved accurate.

Even when standard guidelines to control blood sugar are used in Phattalung Hospital, macrosomia and cesarean section rate are still significantly higher compared with the non-diabetic group. To reduce the rate of cesarean delivery, other therapies should be added such as preconception counseling and aspirin administration for preeclampsia prophylaxis. Conversely, proper risk assessment for suitable candidates to deliver by cesarean section during antepartum and intrapartum may help diminish serious complications such as shoulder dystocia and birth asphyxia. Results from the present study should assist the researchers to develop a reliable tool for predicting cesarean section in diabetic pregnant women.

The strength of the present study was a large number of diabetic pregnant women over five-year period. However, the limitations include incomplete data retrieval due to a retrospective design. In addition, nearly half of pregnant women in the comparison group delivered by cesarean section. This was partly because many high-risk patients were referred from community hospitals. As a result, a difference of cesarean section rate between the two groups might be underestimated in the study.

Conclusion

Risk factors of cesarean section among pregnant women with diabetes included preeclampsia and newborn weight 4,000 g or more. Gestational diabetes increased significant maternal and fetal complications.

What is already known on this topic study?

Diabetic mellitus in pregnancy increases the risk of cesarean section. The strong risk factors of cesarean delivery in pregnant women with diabetes mellitus are preeclampsia and fetal macrosomia. The maternal and fetal complications in pregnant women with diabetes mellitus are significantly increased.

What does this study add?

The clinicians should consider the proper route of delivery in pregnant women with diabetes mellitus for decrease morbidity and mortality. Preeclampsia and macrosomia should be prevented to decrease the cesarean section rate. In the future, a useful tool for predicting the route of delivery should be developed.

Conflicts of interest

The authors declare no conflict of interest.

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