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Intrapartum Maternal Capillary Blood Glucose in Diabetic Pregnancy and Risk Factors Associated with Neonatal Hypoglycemia

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ABSTRACT

Objectives: To find an association between intrapartum maternal capillary blood glucose in diabetic pregnancy and neonatal hypoglycemia, and find the factors affected by this condition.

Materials and Methods: The study was a retrospective cohort study of 677 cases of diabetic pregnancies, delivered at Hatyai Hospital from October 2016 to September 2019. The primary outcome was to find an association between intrapartum maternal capillary blood glucose in diabetic pregnancy and neonatal hypoglycemia. The secondary outcome was to find factors that may be associated with neonatal hypoglycemia. Multiple logistic regression was used for analysis which quantifies the magnitude of association. Adjusting for covariates was done. The association was expressed as odd ratio and was interpreted as significant at p value < 0.05.

Results: From 677 cases reviewed, pregestational diabetes mellitus was 67 cases (9.90%) and gestational diabetes mellitus was 610 cases (90.10%). Neonatal hypoglycemia was recorded at 64 cases (9.45%). Following analysis, we found that a high level of capillary blood glucose of more than 110 mg/dL during intrapartum periods in diabetic pregnancy was associated with neonatal hypoglycemia (adjusted odds ratio (aOR) 2.46, 95%CI 1.40-4.32, p = 0.002). Cesarean delivery was also associated with this condition (aOR 4.04, 95% CI 2.15-7.55, p < 0.001).

Conclusion: Intrapartum capillary blood glucose levels exceeding 110 mg/dL and cesarean delivery in diabetic pregnancy were associated with neonatal hypoglycemia.

Keywords: blood glucose, diabetes mellitus, hypoglycemia, intrapartum, neonate, pregnancy.

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ความสัมพันธ์ของระดับน้ำตาลปลายนิ้วระยะคลอดในสตรีตั้งครรภ์ที่เป็นเบาหวานและปัจจัยที่เกี่ยวข้องกับการเกิดภาวะน้ำตาลต่ำในทารกแรกเกิด

วรรณิดา นิปกะกุล, รัตน์พร เบญจมานนท์

บทคัดย่อ

วัตถุประสงค์: *ศึกษาความสัมพันธ์ของระดับน้ำตาลปลายนิ้วระยะคลอดในสตรีตั้งครรภ์ที่เป็นเบาหวานกับการเกิดภาวะน้ำตาลต่ำในทารกแรกเกิด และหาปัจจัยที่มีผลต่อภาวะน้ำตาลต่ำในทารกแรกเกิด*

วัสดุและวิธีการ: *เป็นการศึกษาจากเหตุไปผลแบบย้อนหลัง (Retrospective cohort study) ในสตรีตั้งครรภ์ที่มีภาวะเบาหวานที่คลอด ณ โรงพยาบาลหาดใหญ่ ตั้งแต่เดือนตุลาคม พ.ศ.2559 ถึงเดือนกันยายน พ.ศ.2562 จำนวน 677 คน วัตถุประสงค์หลักคือ ความสัมพันธ์ของระดับน้ำตาลปลายนิ้วระยะคลอดในสตรีตั้งครรภ์ที่เป็นเบาหวานกับการเกิดภาวะน้ำตาลต่ำในทารกแรกเกิด วัตถุประสงค์รอง คือ หาปัจจัยที่มีผลต่อภาวะน้ำตาลต่ำในทารกแรกเกิด โดยใช้ multiple logistic regression ประเมินระดับความสัมพันธ์ วิเคราะห์ปรับค่าตัวแปรร่วม แสดงค่าความสัมพันธ์เป็น odd ratio และค่านัยสำคัญกับที่ $p < 0.05$*

ผลการศึกษา: *จากการศึกษาผู้ป่วย 677 คน พบภาวะเบาหวานก่อนการตั้งครรภ์ 67 คน (ร้อยละ 9.90) และเบาหวานที่เกิดจากการตั้งครรภ์ 610 คน (ร้อยละ 90.10) พบภาวะน้ำตาลต่ำในทารกแรกเกิด 64 คน (ร้อยละ 9.45) จากการวิเคราะห์พบว่าภาวะน้ำตาลสูงเกินกว่า 110 มก/ดล ในระยะคลอดในสตรีตั้งครรภ์ที่เป็นเบาหวานมีความสัมพันธ์กับการเกิดภาวะน้ำตาลต่ำในทารกแรกเกิด (adjusted odds ratio (aOR) 2.46, 95%CI 1.40-4.32, $p = 0.002$] และพบว่าการคลอดโดยการผ่าคลอดมีความสัมพันธ์กับการเกิดภาวะน้ำตาลต่ำในทารกแรกเกิด (aOR 4.04, 95% CI 2.15-7.55, $p < 0.001$)*

สรุป: *ระดับน้ำตาลปลายนิ้วระยะคลอดในสตรีตั้งครรภ์ที่เป็นเบาหวานที่ระดับน้ำตาลสูงเกินกว่า 110 มก/ดล และการคลอดโดยการผ่าคลอดสัมพันธ์กับการเกิดภาวะน้ำตาลต่ำในทารกแรกเกิด*

คำสำคัญ: *ระดับน้ำตาล, เบาหวาน, ภาวะน้ำตาลต่ำ, ระยะคลอด, ทารกแรกเกิด, สตรีตั้งครรภ์*

Introduction

Diabetes in pregnancy is divided into pregestational and gestational diabetes. As in the Clinical Practice Guideline for Diabetes 2017[1], treatment of this patient group is aimed to decrease adverse events in pregnant women and deliver healthy newborn without complications.

According to Hatyai Hospital's records, diabetes in pregnancy was found in 3% of all pregnancies delivered from 2017-2018, and increased to 5.1% in 2019. This trend will continue to increase in the future, so it is important for obstetricians to have knowledge of this practice to decrease the number of complications as much as it possible.

Hypoglycemia in the newborn can cause dyspnea, lethargy and seizure. The causes can be due to low newborn birthweight, prematurity, infection, diabetic mother and other reasons[2, 3, 4, 5]. The poor control of blood sugar level in diabetic pregnancy in the intrapartum period is thought to affect hypoglycemia in newborns. As in the American College of Obstetricians and Gynecologists (ACOG) practice bulletin guidelines, controlling blood sugar in the range of 70-110 mg/dL was suggested in pregestational diabetes pregnancy[6]. No suggestion regarding gestational diabetes pregnancy was mentioned[7]. However, there is still limited evidence to support this practice. Many recent studies have produced different results and have stated that controlling of blood sugar level in the intrapartum period did not decrease the hypoglycemia in newborns[8, 9]. Moreover, in some systemic reviews, the association was still inconclusive[10].

The researcher is interested in this subject and aims to discover the association between this condition and assist in the adjustment of the practice inpatient care, prevent complications, and reduce the number of unnecessary operations.

We set the primary objective to find an association between intrapartum maternal capillary blood glucose in diabetic pregnancy and neonatal hypoglycemia. The secondary objective was to find factors that may be associated with neonatal hypoglycemia.

Materials and Methods

A retrospective cohort study was performed by reviewing the electronic medical records of a diabetic pregnancy group between October 2016 and September 2019. This study was approved by the Research Ethics Committee of Hatyai Hospital (REC-HY) (Protocol number 31/2564).

The sample size was calculated using the formula for cohort studies. The total sample size of 641 cases was the minimum requirement. ICD10 of O240-O244 + O80, O81, O82 was used to search patients included in the medical records, with singleton and term pregnancy cases. A Total number of 730 case records were reviewed, while 53 cases (7.26%) of patients with incomplete records and death fetus in utero were excluded. The remaining 677 patient records, including 530 cases in tight control blood sugar group (< 110 mg/dL) and 147 cases in a nontight control blood sugar group (≥ 110 mg/dL) were reviewed intensively and data subsequently extracted. The value of blood sugar ≥ 110 mg/dL, stated as non-tight control blood sugar, was used to compare results with those of the previous study which used the same range of blood sugar[8]. With patients who had several values of blood sugar levels, the final level was used to show the manner of tight control blood sugar, i.e.: if the patient had hyperglycemia and then received insulin therapy or a change of intravenous fluid, and then the blood sugar dropped to < 110 mg/dL, the patient was categorized in the tight control blood sugar group. Maternal hypoglycemia (< 70 mg/dL) was found in a small number of cases, and all case received therapy such as intravenous glucose loading or a changed of fluid solution to increase the amount of glucose form. All cases showed improvement.

Categorization of this patient group also depended on the final value of blood sugar.

Neonatal hypoglycemia was diagnosed using 2011 American Academy of Pediatrics (AAP) guidelines[11]. Neonates with plasma glucose < 40 mg/dL and any symptoms including tachypnea, jitteriness, cyanosis, seizure, apneic episode, weak and highpitched cry, floppiness or lethargy, poor feeding or eyerolling neonates with plasma glucose < 25 mg/dL after birth - 4 hours postdelivery, and neonates with plasma glucose < 35 mg/dL at 4 hours - 24 hours postdelivery were defined as neonatal hypoglycemia. Data on presenting symptoms and specific treatment for these neonates were also collected.

From the data collected, overt diabetes mellitus was the same as pregestational diabetes, which was the diabetes that found before pregnancy or laboratory suspected (HbA1C ≥ 6.5%, fasting blood sugar (FBS) ≥ 126 mg/dL, random plasma glucose ≥ 200 mg/dL). Gestational diabetes mellitus (GDM) was diabetes that arises during pregnancy and does not meet the above criteria. GDMA1 required only dietary or lifestyle adjustments to control the level of blood sugar, while the GDMA2 required medication such as insulin to control blood sugar levels within the targeted range. Pre-pregnancy body mass index (BMI) was classified as Asian population range. Underweight is BMI < 18.5 kg/m^2, normal range BMI is 18.5-22.9 kg/m^2, overweight is BMI 23-24.9 kg/m^2, obese is BMI 25 - 29.9 kg/m^2, and morbid obese is BMI ≥ 30 kg/m^2. Antepartum blood sugar control level was classified as well control patient if ≥ 80% of blood sugar collected was within the targeted range. And classified as partial and poor control if 50-79% and < 50% blood sugar collected was in the targeted range, respectively. Neonatal birthweights were classified as low birthweight if weight < 2,500 grams, normal birthweight if weight 2,500 - 4,000 grams, and fetal macrosomia if weight more than 4,000 grams.

Statistical analyses were performed using STATA (Statacorp, USA) software, version 16SE. Descriptive statistics were used to demonstrate demographic data. Continuous data was presented with mean ± standard deviation (SD). The correlation of two discrete data were analyzed with Chi-squared test and Fisher's exact test as appropriate. The correlation of linear data was analyzed using t-test. Multiple logistic regression was used for analysis, which quantified the magnitude of association between intrapartum maternal capillary blood glucose and neonatal hypoglycemia. Other factors that may be associated with these conditions were also analyzed. For all analyzed results, a p value < 0.05 was considered statistically significant.

Results

Between October 2016 - September 2019, total 25,664 pregnancies delivered at Hatyai Hospital. Of the 677 reviewed cases, pregestational diabetes mellitus was 67 cases (9.90%) and gestational diabetes mellitus was 610 cases (90.10%). Maternal demographic, antenatal and intrapartum characteristics of pregnant women in the study are presented in Table 1.

Non-tight control capillary blood glucose levels in the intrapartum period, which was defined as capillary blood glucose levels at 110 mg% or higher, were found in 147 (21.71%) cases. The remaining 530 cases were in a tight control capillary blood glucose level and calculated as 78.29% of all cases.

Neonatal characteristics were reviewed (Table 2). Hypoglycemia was found in 64 (9.45%) newborns of all births from maternal diabetes. Non-hypoglycemia was found in 613 (90.55%) newborns of all births.

Table 1. Antenatal and intrapartum maternal characteristics (n = 677).

Maternal Characteristics	n (%)
Age (years), mean (SD)	32.98 (5.84)
Age range (years)	
< 20	11 (1.62)
20-24	48 (7.09)
25-29	118 (17.43)
30-34	206 (30.43)
≥ 35	294 (43.43)
Gravidity, Median (IQR)	2 (2-3)
Gravidity	
< 4	519 (76.66)
≥ 4	158 (23.34)
Parity, Median (IQR)	1 (0-2)
Parity	
< 4	642 (94.83)
≥ 4	35 (5.17)
Gestational age at delivery (days), mean (SD)	270.21 (7.84)
Diabetes mellitus	
Pregestational diabetes	67 (9.90)
GDMA1	391 (57.75)
GDMA2	219 (32.35)
Pre-pregnancy BMI (kg/m^2), mean (SD)	28.06 (5.95)
Pregestational BMI classification (kg/m^2)	
Underweight (< 18.5)	21 (3.10)
Normal (18.5 - 22.9)	114 (16.84)
Overweight (23 - 24.9)	84 (12.41)
Obesity (25 -29.9)	230 (33.97)
Morbid obesity (≥ 30)	228 (33.68)
Antepartum insulin use	
No	394 (58.20)
Yes	283 (41.80)
Antepartum blood sugar control level	
Well	372 (54.95)
Partial	187 (27.62)
Poor	118 (17.43)
Intrapartum CBG level (mg%)	
< 110	530 (78.29)
110-140	106 (15.66)
> 140	41 (6.06)
Mean capillary blood glucose (mg%), mean (SD)	95.15 (20.23)
Frequency of intrapartum CBG monitoring	
Baseline determination alone	327 (48.30)
Every hour	105 (15.51)
Every 2 hours	223 (32.94)
Every 4 hours	20 (2.95)
Every 6 hours	2 (0.30)
Intrapartum CBG level	
Tight control	530 (78.29)
Non- tight control	147 (21.71)
Intrapartum insulin use	
No	658 (97.19)
Yes	19 (2.81)
Mode of delivery	
Normal spontaneous delivery	320 (47.27)
Cesarean section	348 (51.40)
Operative vaginal delivery	9 (1.33)

GDMA1: gestational diabetes mellitus class A1, GDMA2: gestational diabetes mellitus class A2, BMI: body mass in-dex, CBG: capillary blood glucose, SD: standard deviation, IQR: interquartile range

Table 2. Neonatal characteristics and outcomes (n = 677).

Neonatal characteristics	n (%)
Sex	
Male	357 (52.73)
Female	320 (47.27)
Birthweight (grams), mean (SD)	3332.26 (498.15)
Birthweight classification	
Low birthweight	22 (3.25)
Normal birthweight	589 (87.00)
Fetal macrosomia	66 (9.75)
CBG, mean (SD)	63.24 (18.73)
Time for CBG sampling	
30 minutes	16 (2.36)
1 hour	643 (94.98)
2 hours	18 (2.66)
Hypoglycemia	
No	613 (90.55)
Yes	64 (9.45)
Presence of hypoglycemic symptoms (n = 64)	
No	19 (29.69)
Yes	45 (70.31)
Specific treatment for hypoglycemic neo-nates (n = 64)	
Feed	43 (67.19)
D10W	15 (23.44)
Increase IV fluid rate	6 (9.37)

CBG: capillary blood glucose, D10W: dextrose 10% in water, SD: standard deviation

Table 3 shows the univariate analysis of factors that may affect intrapartum blood glucose levels in diabetic mothers. There were six factors that significantly affected with $p < 0.05$, types of diabetes, mode of delivery, antepartum insulin used, antepartum blood sugar control level, frequency of intrapartum capillary blood glucose monitoring and intrapartum insulin used.

Table 4 shows the univariate analysis of factors that may affect neonatal hypoglycemia. There were 11 factors that significantly affected this conditions at $p < 0.05$, gravida exceeding 4, mean gestational age, types of diabetes, maternal pre-pregnancy BMI classification, mode of delivery, maternal antepartum insulin used, maternal antepartum blood sugar control level, frequency of intrapartum maternal capillary blood glucose monitoring, maternal intrapartum non-tight control capillary blood glucose level, newborn birthweight classification, and time of newborn capillary blood glucose sampling.

The multiple logistic regression analysis of the association between intrapartum maternal capillary blood glucose levels and neonatal hypoglycemia is shown in Table 5. We found that high levels of capillary blood glucose during intrapartum period exceeding 110 mg/dL in diabetes pregnancy is associated with neonatal hypoglycemia (adjusted odds ratio (aOR) 2.46, 95%CI 1.40-4.32, $p = 0.002$). Mode of delivery was also associated with this condition (aOR 3.05, 95% CI 1.80-5.15, $p < 0.001$). After subgroup analysis was performed, the result showed that cesarean delivery route increases neonatal hypoglycemia compared with spontaneous vaginal delivery (aOR 4.04, 95%CI 2.15-7.55, $p < 0.001$). Other factors were not significantly associated with this condition after using multiple logistic regression.

Table 3. Univariate analysis of factors associated with intrapartum maternal capillary blood glucose level.

Factors	Tight control CBG group n = 530 (%)	Non-tight control CBG group n = 147 (%)	p value
Age range (in years)			0.391†
< 20	7 (1.32)	4 (2.72)	
20 - 24	35 (6.60)	13 (8.84)	
25 - 29	90 (16.98)	28 (19.05)	
30 - 34	168 (31.70)	38 (25.85)	
≥ 35	230 (43.40)	64 (43.54)	
Gravidity			0.242*
< 4	401 (75.66)	118 (80.27)	
≥ 4	129 (24.34)	29 (19.73)	
Parity			0.501*
< 4	501 (94.53)	141 (95.92)	
≥ 4	29 (5.47)	6 (4.08)	
Gestation age at delivery (days), mean (SD)	270.20 (8.12)	270.25 (6.80)	0.938‡
Diabetes mellitus			0.002†
Pregestational diabetes	48 (9.06)	19 (12.93)	
GDMA1	325 (61.32)	66 (44.90)	
GDMA2	157 (29.62)	62 (42.18)	
Pregestational BMI classification (kg/m^2)			0.356†
Underweight (< 18.5)	15 (2.83)	6 (4.08)	
Normal (18.5 - 22.9)	87 (16.42)	27 (18.37)	
Overweight (23 - 24.9)	71 (13.40)	13 (8.84)	
Obesity (25 - 29.9)	174 (32.83)	56 (38.10)	
Morbid obesity (≥ 30)	183 (34.53)	45 (30.61)	
Antepartum insulin use			0.016*
No	327 (61.70)	67 (45.58)	
Yes	203 (38.30)	80 (54.42)	
Antepartum blood sugar control level			0.016*
Well	302 (56.98)	70 (47.62)	
Partial	147 (27.74)	40 (27.21)	
Poor	81 (15.28)	37 (25.17)	
Frequency of intrapartum CBG monitoring			< 0.001†
Baseline determination alone	280 (52.83)	47 (31.97)	
Every hour	68 (12.83)	37 (25.17)	
Every 2 hours	163 (30.75)	60 (40.82)	
Every 4 hours	18 (3.40)	2 (1.36)	
Every 6 hours	1 (0.19)	1 (0.68)	
Intrapartum insulin use			< 0.001†
No	528 (99.62)	130 (88.44)	
Yes	2 (0.38)	17 (11.56)	
Mode of delivery			0.008†
Normal spontaneous delivery	238 (44.91)	82 (55.78)	
Cesarean section	287 (54.15)	61 (41.50)	
Operative vaginal delivery	5 (0.94)	4 (2.72)	
Sex			0.643*
Male	277 (52.26)	80 (54.42)	
Female	253 (47.74)	67 (45.58)	
Birthweight classification			0.519†
Low birthweight	16 (3.02)	6 (4.08)	
Normal birthweight	465 (87.74)	124 (84.35)	
Fetal macrosomia	49 (9.24)	17 (11.56)	

GDMA1: gestational diabetes mellitus class A1, GDMA2: gestational diabetes mellitus class A2, BMI: body mass in-dex, CBG : capillary blood glucose, SD: standard deviation. *Chi-square test, †Fisher's exact test, ‡ t-test

Table 4. Univariate analysis of factors associated with neonatal hypoglycemia.

Factors	Without neonatal hypoglycemia n = 613 (%)	With neonatal hypoglycemia n = 64 (%)	p value
Age range (years)			0.067†
< 20	10 (1.63)	1 (1.56)	
20 - 24	43 (7.01)	5 (7.81)	
25 - 29	104 (16.97)	14 (21.88)	
30 - 34	196 (31.97)	10 (15.63)	
≥ 35	260 (42.41)	34 (53.13)	
Gravidity			0.014*
< 4	462 (75.37)	57 (89.06)	
≥ 4	151 (24.63)	7 (10.94)	
Parity			0.239†
< 4	579 (94.45)	63 (98.44)	
≥ 4	34 (5.55)	1 (1.56)	
Gestational age at delivery (days), mean (SD)	270.45 (8.03)	267.92 (5.27)	0.014‡
Diabetes mellitus			0.002*
Pregestational diabetes	55 (8.97)	12 (18.75)	
GDMA1	366 (59.71)	25 (39.06)	
GDMA2	192 (31.32)	27 (42.19)	
Pregestational BMI classification (kg/m2)			0.005†
Underweight (<18.5)	18 (2.94)	3 (4.69)	
Normal (18.5-22.9)	105 (17.13)	9 (14.06)	
Overweight (23-24.9)	81 (13.21)	3 (4.69)	
Obesity (25-29.9)	215 (35.07)	15 (23.44)	
Morbid obesity (≥30)	194 (31.65)	34 (53.13)	
Antepartum insulin use			0.006*
No	367 (59.87)	27 (42.19)	
Yes	246 (40.13)	37 (57.81)	
Antepartum blood sugar control level			0.004*
Well	349 (56.93)	23 (35.94)	
Partial	160 (26.10)	27 (42.19)	
Poor	104 (16.97)	14 (21.88)	
Frequency of intrapartum CBG monitoring			0.024†
Baseline determination alone	293 (47.80)	34 (53.13)	
Every hour	90 (14.68)	15 (23.44)	
Every 2 hours	209 (34.09)	14 (21.88)	
Every 4 hours	20 (3.26)	0 (0.00)	
Every 6 hours	1 (0.16)	1 (1.56)	
Intrapartum insulin use			0.095†
No	598 (97.55)	60 (93.75)	
Yes	15 (2.45)	4 (6.25)	
Intrapartum CBG level			0.004*
Tight control	489 (79.77)	41 (64.06)	
Non-tight control	124 (20.23)	23 (35.94)	
Mode of delivery			< 0.001†
Normal spontaneous delivery	306 (49.92)	14 (21.88)	
Cesarean section	299 (48.78)	49 (76.56)	
Operative vaginal delivery	8 (1.31)	1 (1.56)	
Sex			0.100*
Male	317 (51.71)	40 (62.50)	
Female	296 (48.29)	24 (37.50)	
Birthweight classification			< 0.001†
Low birthweight	21 (3.43)	1 (1.56)	
Normal birthweight	543 (88.58)	46 (71.88)	
Fetal macrosomia	49 (7.99)	17 (26.56)	
Time for CBG sampling			0.005†
30 minutes	12 (1.96)	4 (6.25)	
1 hour	588 (95.92)	55 (85.94)	
2 hours	13 (2.12)	5 (7.81)	

GDMA1: gestational diabetes mellitus class A1, GDMA2: gestational diabetes mellitus class A2, BMI: body mass in-dex, CBG: capillary blood glucose, SD: standard deviation. * Chi-square test, † Fisher's exact test, ‡ t-test

Table 5. Crude and adjusted logistic regression models of neonatal hypoglycemia and intrapartum maternal capillary blood glucose level.

	Neonatal hypoglycemian					
	Crude			Adjusted		
	OR	95%CI	p value	OR	95%CI	p value
Intrapartum maternal CBG in non-tight control level	2.21	1.28-3.82	0.004	2.46	1.40-4.32	0.002
Mode of delivery	2.91	1.72-4.93	< 0.001	3.05	1.80-5.15	< 0.001
- Normal spontaneous delivery	Reference			Reference		
- Cesarean section	3.58	1.93-6.63	< 0.001	4.04	2.15-7.55	< 0.001
- Operative vaginal delivery	2.73	0.32-23.38	0.359	2.27	0.25-19.96	0.459

CBG: capillary blood glucose, OR: odds ratio, CI: confidence interval

Discussion

The pregnancies delivered at Hatyai Hospital were 25,664 cases between October 2016 - September 2019. To estimate the proportion of diabetic cases, diabetic pregnancies was found 960 cases or 3.74%. Which was lower than that of the United States at 6.5%[12] but higher than the previous study in Thailand which found diabetes in 2.32% of all pregnancies[13]. After dividing the groups of diabetes, pregestational diabetes mellitus was found 82 cases (0.32%) of all pregnancies and gestational diabetes mellitus in 806 cases (3.41%) of all pregnancies. This was lower than that in the USA, which was found 1.5% and 5%, respectively.

Our study population was predominantly gestational diabetes mellitus, especially type A1 which was managed with dietary control. The majority of parturients were obese and morbidly obese. The incidence of intrapartum maternal blood glucose in non-tight control level was 21.71%, similar to that found in other studies[8]. Our study determined the last blood glucose prior to delivery as the controlled level and assumed that high blood sugar level controlled with intravenous fluid solution changed and insulin administration and dropped to lower than 110 mg/dL in the tight control group. Some studies found that duration of hyperglycemic levels, or mean blood sugar during labor, demonstrated the better results[14,15], but our study did not intensively detail this.

The ACOG practice bulletin number 201 recommends monitoring blood glucose levels every hour during labor in pregestational diabetic pregnancy[6]. However, the frequency of glucose monitoring in this institution is no consensual and baseline determination is mostly conducted alone, depending on the individual physician's decision.

Insulin administration was used in the form of regular insulin and continuous intravenous infusion, but with high capillary blood glucose levels exceeding 110 mg/dL, not every case received insulin. This may be related to the differences in individual practices of the physicians. However, in the liberal high level of blood sugar (> 140 mg/dL), every case received intravenous insulin.

The majority of infants were born to diabetic mothers in this institution appear to have weights appropriate for gestational age. Fetal macrosomia was found at 9.75%. This was related to suboptimal antepartum glycemic control and some studies have found this leads to neonatal hypoglycemia[16,17]. However, our study found no association.

The incidence of neonatal hypoglycemia among diabetic parturient in this study was found to be 9.45%, similar to the previous study[2, 8]. We did not find any maternal antepartum characteristics or managements that associated with neonatal hypoglycemia, but in the intrapartum period, we found that intrapartum maternal capillary blood glucose at the non-tight control level and mode of delivery as a cesarean route, were significantly associated with neonatal hypoglycemia.

In the context of maternal hyperglycemia levels, neonatal hypoglycemia is thought to be due to the increase in fetal glucose levels that stimulate the fetal pancreas to synthesize excessive insulin causing fetal

hyperinsulinemia. This can cause diminished hepatic glucose production in neonates. After birth, a fall in plasma glucose concentration, while the insulin level is still high, finally results in neonatal hypoglycemia. Some studies have stated that chronic hyperglycemia or antepartum suboptimal control of blood sugar results in this condition[14,18]. Hyperglycemia in the intrapartum period is considered in the same way, but the results were still inconclusive[10]. The cut-off level to determine hyperglycemia was different in practice. We used a capillary blood glucose level of 110 mg/dL or more to determine high, or as in non-tight control level. Some studies have shown that the percentage of time spent in the hyperglycemic level may affect this[14,15]. Our results supported the association between intrapartum high capillary blood glucose levels of more than 110 mg/dL and neonatal hypoglycemia, but we lack the detail about the time spent. Further studies may be beneficial.

Some studies explored the relationship between cesarean deliveries and the neonatal hypoglycemia[19, 20, 21], and stated that this route of delivery was also found in the higher incidence of neonatal hypoglycemia. Factors were fasting time before surgery and high glycemic load. However, these factors were not detailed in our studies, so further research is recommended.

Compared to the previous study, our study had a larger number of cases and includes more details about the antepartum blood glucose control level[8]. However, with the retrospective study design, our study had limitations, as possible inclusion of confounding factors, selection bias or misclassification bias from data collection. It also did not detail some data, such as indication for cesarean delivery, incidence of shoulder dystocia, fasting time, intravenous fluid during intrapartum period and dosage of insulin. These limitations may be reduced in further studies which include a greater amount of detailed data.

Hypoglycemia in neonate is also influenced by factors such as premature birth, infection, low birth weight, antepartum glyburide used, etc.[2, 3, 4, 5] Some cases had many factors that augment the affected to this condition. Awareness of the potential results and control of intrapartum level of maternal glucose to normal levels is highly recommended.

Conclusion

Intrapartum capillary blood glucose exceeding 110 mg/dL in diabetic pregnancies was associated with neonatal hypoglycemia. Another factor affected this condition was cesarean delivery.

Acknowledgments

This study was approved by the Institutional Review, Hatyai Hospital, Songkla, Thailand.

Potential conflicts of interest

The authors declare no conflicts of interest.

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