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Neonatal complication of caesarean sections at tertiary center: Siriraj hospital, Bangkok, Thailand

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Abstract

To study the complications of newborns related to caesarean sections, through a review of indications and details of complications occurring in newborns. This was a retrospective and descriptive study. A search of hospital records identified 3500 cases that underwent caesarean sections during 2017–2018. Newborn complications arising from the caesarean sections, and other relevant details were recorded. Neonatal complications were 49.23% (1723/3500). Bruises (a region of injured tissue or skin in which blood capillaries have been ruptured) (11.65%), jaundice (18.29%) and hypoglycaemia (11.91%) were the most common complications of the neonates. In summary, foetal complications were jaundice, transient tachypnea, hypoglycaemia and bruises. As the rate of caesarean sections continues to increase and is difficult to control, unnecessary caesarean section should be reduced and obstetricians must be well trained in performing caesarean sections to reduce neonatal complications. *(Afr J Reprod Health 2022; 26[9]: 118-132).*

Keywords: Caesarean section; neonatal complication

Résumé

Étudier les complications des nouveau-nés liées aux césariennes, à travers une revue des indications et des détails des complications survenant chez les nouveau-nés. Il s'agissait d'une étude rétrospective et descriptive. Une recherche dans les dossiers hospitaliers a identifié 3500 cas ayant subi une césarienne en 2017-2018. Les complications néonatales résultant des césariennes et d'autres détails pertinents ont été enregistrés. Les complications néonatales étaient de 49,23 % (1723/3500). Les ecchymoses (une région du tissu lésé ou de la peau dans laquelle les capillaires sanguins ont été rompus) (11,65 %), la jaunisse (18,29 %) et l'hypoglycémie (11,91 %) étaient les complications les plus courantes chez les nouveau-nés. En résumé, les complications fœtales étaient l'ictère, la tachypnée transitoire, l'hypoglycémie et les ecchymoses. Comme le taux de césariennes continue d'augmenter et est difficile à contrôler, les césariennes inutiles doivent être réduites et les obstétriciens doivent être bien formés à la pratique des césariennes afin de réduire les complications néonatales. *(Afr J Reprod Health 2022; 26[9]: 118-132).*

Mots-clés: Césarienne; complication néonatale

Introduction

Indicated caesarean section is an important operation that saves the lives of mothers and newborns. Indications for caesarean section include antepartum haemorrhage, foetal distress, breech presentation in a first pregnancy, and related maternal medical complications[1]. The rate of caesarean sections has been increasing markedly around the world for more than 30 years. The ideal rate of caesarean sections specified by the World Health Organization (WHO) is only 10%–15%[2].

On the other hand, caesarean rates increased worldwide in 2015 at an estimated rate of 21.1% (95% uncertainty interval 19.9–22.4)[3]. The rates varied greatly by region. For example, in Latin America and the Caribbean, caesarean rates were as high as 44.3%[1], whereas in low-income countries in Western and Central Africa, the rates were only 4.1%[3]. At the Faculty of Medicine of Siriraj Hospital, Mahidol University, Thailand, the rate of caesarean section was alarming, having risen to 48.86% in 2017[4]. Caesarean rates in high-income countries were 5 times higher than those in low- and

middle-income countries. They were mainly related to educated families, private facilities, and the low obstetric risks of mothers and newborns[3].

Maternal and neonatal mortality rates in middle- and low-income countries were reported to be 10 to 20 times higher than those in high-income countries[5,6]. The causes of mortality and neonatal deaths were asphyxia, infection and prematurity[7]. Interestingly, birth asphyxia was usually caused by difficulties in labour, including obstructed labour[7], which occurs most frequently in low- and middle-income countries. Maternal mortality in low- and middle-income countries was due to haemorrhage, hypertensive diseases and infections[8]. Caesarean section is an intervention that can reduce maternal and neonatal mortality.

The study of Goldenburg *et al*.[9] showed that the highest maternal and neonatal mortality occurs during delivery. A United Nations review of strategies to reduce maternal and neonatal mortality rates confirmed that caesarean section is one of the prompt interventions that can be undertaken to save maternal and neonatal lives[10]. Our study aimed to investigate the complications of mothers and newborns arising from caesarean sections through a review of indications and details of complications that occurred in mothers and newborns at Siriraj Hospital.

Methods

This retrospective study was conducted in the statistical unit of the Department of Obstetrics and Gynecology of the Faculty of Medicine, Siriraj Hospital. Before starting this research, its protocol was approved by the Ethics Committee of the Faculty of Medicine Siriraj Hospital (Si 060/2020) and registered in the Thai Clinical Trials Registry (TCTR 20200127001). The authors thank the Faculty of Medicine Siriraj Hospital, Mahidol University, for its financial support ([IO] R016333027).

The main objective of this study was to investigate the complication of newborns from caesarean sections. Based on the researcher's experience, operators is the main relevant to the caesarean complications. It is estimated that the complication occurring from staffs and residents were approximately 2% and 4%, respectively. When given 2-sided type I error = 0.05, 90% power, n1 (staff), n2 (resident) were equal to 1530 which calculated by nQuery Advisor program. This study is retrospective chart review therefore the investigators estimated that a total of 3100 sample sizes were collected. The retrospective charts of the mid-year 2017-2018 with a sample size of approximately 3500 cases were retrieved.

Data related to all pregnant women who underwent caesarean sections during 2017–2018 were collected from hospital records. A total of 3500 cases were identified. Neonatal weight, APGAR scores, and neonatal complications occurring after the caesarean section. The primary outcome was the complications of neonates arising from the caesarean sections at Siriraj Hospital. Secondary outcomes were relevant adverse outcomes of newborns.

Statistical analysis

Demographic data were summarised using descriptive statistics. Categorical data are presented as numbers and percentages, and continuous data are presented as means ± standard deviations, or as medians and ranges. Statistical analyses were performed using PASW Statistics for Windows (version 18.0; SPSS Inc., Chicago, IL, USA). Baseline data (qualitative parameters, and maternal and infant complications arising from caesarean section) were compared using the chi-squared test and Fisher's exact test. For quantitative variables, the Mann–Whitney U test was used for a univariate analysis, and multiple logistic regression was used for a multivariate analysis. The factors with $P< 0.2$ were used to adjust the outcomes in a multivariate analysis.

Results

Neonatal complications were 49.23% (1723/3500; Table 1). Bruises (11.65%), jaundice (18.29%) and hypoglycaemia (11.91%) were the most common complications of the neonates (Table 1).

Pregnancy with gestational diabetes mellitus was significantly related to neonatal jaundice, hypoglycaemia and transient tachypnea of the

Table 1: Neonatal complications from caesarean sections (can have more than 1 complication)

Neonatal complications	All 1st and/or 2nd (n=3500)	All (n=3615)	1st neonatal (n=3500)	2nd neonatal (n=115)
All neonatal complications	**1723 (49.23%)**	**1723 (47.66%)**	**1706 (48.74%)**	**82 (71.30%)**
Birth injury				
Cephalohaematoma	19 (0.54%)	19 (0.53%)	19 (0.54%)	-
Caput succedaneum	71 (2.03%)	71 (1.96%)	71 (2.03%)	-
Other	671 (19.17%)	671 (18.56%)	665 (19.00%)	6 (5.22%)
• Bruises	408 (11.65%)	408 (11.65%)	405 (11.57%)	6 (5.22%)
• Forceps marks	182 (5.2%)	182 (5.2%)	179 (5.11%)	-
• Abrasions	50 (1.4%)	50 (1.4%)	50 (1.4%)	-
• Sharp wound	14 (0.4%)	14 (0.4%)	14 (0.4%)	-
• Subgaleal hematoma	10 (0.28%)	10 (0.28%)	10 (0.28%)	-
• Subconjunctival haemorrhage	4 (0.11%)	4 (0.11%)	4 (0.11%)	-
• Laceration wound	2 (0.06%)	2 (0.06%)	2 (0.06%)	-
• Hip dislocation	1 (0.03%)			
Jaundice	640 (18.29%)	1 (0.03%)	1 (0.03%)	-
Birth asphyxia	251 (7.17%)	640 (17.70%)		
Mild or moderate	73 (2.09%)		614 (17.54%)	51 (44.35%)
Severe	417 (11.91%)	251 (6.94%)	244 (6.97%)	14 (12.17%)
Hypoglycaemia	14 (0.40%)	73 (2.02%)	71 (2.03%)	3 (2.61%)
Hypocalcaemia	446 (12.74%)	417 (11.54%)	401 (11.46%)	37 (32.17%)
Transient tachypnea of the newborn		14 (0.39%)	14 (0.40%)	-
Persistent tachypnea of the newborn	28 (0.80%)	446 (12.34%)	432 (12.34%)	30 (26.09%)
Respiratory distress syndrome	46 (1.31%)	28 (0.77%)		
Pneumonia		46 (1.27%)	28 (0.80%)	2 (1.74%)
Sepsis	36 (1.03%)	36 (1.00%)	46 (1.31%)	2 (1.74%)
Other	62 (1.77%)		36 (1.03%)	5 (4.35%)
	68 (1.94%)	62 (1.72%)		3 (2.61%)
		68 (1.88%)	58 (1.66%)	
			65 (1.86%)	-

newborns (Table 2). Surgeons older than 50 years and pregnant women with pre-eclampsia were significantly related to all birth injuries (Table 3). Forceps marks were significantly related to a surgeon age of ≥ 50 years, an operation duration of ≥ 60 minutes, a breech presentation, previous caesarean section and pre-eclampsia (Table 4).

The main neonatal complications were from fetal injuries and neonatal respiratory complications. Bruising (11.65%; 408/3500) and neonatal jaundice (18.29%; 640/3500) were the most common neonatal complications. Neonatal jaundice and hypoglycaemia after the caesarean sections were significantly related to a breech presentation and low birth weight (Table 5). Both transient tachypnea and persistent tachypnea of the newborn were significantly related to a surgeon age of ≥ 50 years (transient tachypnea: AOR = 0.67; 95% CI, 0.45–0.99; *P* = 0.045; and persistent tachypnea: AOR = 5.80; 95% CI, 1.51–22.21; *P* = 0.010; Table 10). They were also significantly related to National Institute of Child Health and Human Development criteria for Categories II and III (transient tachypnea: AOR = 1.47; 95% CI, 1.08–2.0; *P* = 0.015; and persistent tachypnea: AOR = 4.24; 95% CI, 1.36–13.20; *P* = 0.013; Table 6).

Cesarean section with indications of breech presentation maternal hypertension was significantly related to respiratory complication. Persistent tachypnea of the newborn was significantly related to breech presentation (AOR = 6.63; 95% CI, 2.33–18.84; *P* < 0.001; Table 6). Furthermore, transient tachypnea and persistent tachypnea had a significant relationship with low

Table 2: Mothers with underlying diseases of diabetes mellitus and hypertension and complications from caesarean sections

Neonatal Complications	**All (N=3500) 1723 (49.23%)**	**Maternal diseases during pregnancy Gestational diabetes (GDM) n (%)**				***P* value**
		No (n=2971)	**GDMA1 (n=434)**	**GDMA2 (n=55)**	**Pre-existing diabetes mellitus (n=40)**	
		1408 (47.39%)	**248 (57.14%)**	**37 (67.27%)**	**30 (75.00%)**	**<0.001**
Birth injury						
Cephalohaematoma	19 (0.54%)	17 (0.57%)	1 (0.23%)	1 (1.82%)	-	0.410
Caput succedaneum	71 (2.03%)	64 (2.15%)	5 (1.15%)	2 (3.64%)	-	0.267
Others	671 (19.17%)	560 (18.85%)	92 (21.20%)	11 (20.00%)	8 (20.00%)	0.711
Jaundice	640 (18.29%)	516 (17.37%)	92 (21.20%)	17 (30.91%)	15 (37.50%)	<0.001
Birth asphyxia						
Mild or moderate	251 (7.17%)	207 (6.97%)	37 (8.53%)	3 (5.45%)	4 (10.00%)	0.548
Severe	73 (2.09%)	59 (1.99%)	8 (1.84%)	3 (5.45%)	3 (7.50%)	0.037
Hypoglycaemia	417 (11.91%)	294 (9.90%)	88 (20.28%)	20 (36.36%)	15 (37.50%)	<0.001
Hypocalcaemia	14 (0.40%)	13 (0.44%)	1 (0.23%)	-	-	0.804
Transient tachypnea of the newborn	446 (12.74%)	364 (12.25%)	64 (14.75%)	13 (23.64%)	5 (12.50%)	0.052
Persistent tachypnea of the newborn	28 (0.80%)	24 (0.81%)	3 (0.69%)	-	1 (2.50%)	0.494
Respiratory distress syndrome	46 (1.31%)	42 (1.41%)	2 (0.46%)	1 (1.82%)	1 (2.50%)	0.316
Pneumonia	36 (1.03%)	30 (1.01%)	3 (0.69%)	2 (3.64%)	1 (2.50%)	0.145
Sepsis	62 (1.77%)	51 (1.72%)	8 (1.84%)	1 (1.82%)	2 (5.00%)	0.412
Other	68 (1.94%)	57 (1.92%)	8 (1.84%)	2 (3.64%)	1 (2.50%)	0.863
Neonatal Complications	**All (N=3500)**	**Hypertension (HT) n (%)**				
	1723 (49.23%)	**No (n=3314)**	**Gestational HT/transient (n=61)**	**Mild to severe pre-eclampsia (n=15)**	**Pre-existing HT (n=110)**	***P* value**
		1603 (48.37%)	**37 (60.66%)**	**14 (93.33%)**	**69 (62.73%)**	**<0.001**
Birth injury						
Cephalohaematoma	19 (0.54%)	18 (0.54%)	1 (1.64%)	-	-	0.348
Caput succedaneum	71 (2.03%)	69 (2.08%)	2 (3.28%)	-	-	0.308
Other	671 (19.17%)	625 (18.86%)	12 (19.67%)	8 (53.33%)	26 (23.64%)	0.005
Jaundice	640 (18.29%)	586 (17.68%)	21 (34.43%)	6 (40.00%)	27 (24.55%)	0.001

Birth asphyxia						
Mild or moderate	251 (7.17%)	227 (6.85%)	7 (11.48%)	-	17 (15.45%)	0.006
Severe	73 (2.09%)	64 (1.93%)	3 (4.92%)	3 (20.00%)	3 (2.73%)	0.001
Hypoglycaemia	417 (11.91%)	376 (11.35%)	10 (16.39%)	6 (40.00%)	25 (22.73%)	<0.001
Hypocalcaemia	14 (0.40%)	13 (0.39%)	-	1 (6.67%)	-	0.069
Transient tachypnea of the newborn	446 (12.74%)	410 (12.37%)	11 (18.03%)	4 (26.67%)	21 (19.09%)	0.036
Persistent tachypnea of the newborn	28 (0.80%)	24 (0.72%)	1 (1.64%)	1 (6.67%)	2 (1.82%)	0.065
Respiratory distress syndrome	46 (1.31%)	42 (1.27%)	2 (3.28%)	1 (6.67%)	1 (0.91%)	0.148
Pneumonia	36 (1.03%)	32 (0.97%)	1 (1.64%)	1 (6.67%)	2 (1.82%)	0.149
Sepsis	62 (1.77%)	54 (1.63%)	4 (6.56%)	1 (6.67%)	3 (2.73%)	0.051
Other	68 (1.94%)	64 (1.93%)	-	-	4 (3.64%)	0.317

Table 3: Factors associated with all birth injuries (n=738) of neonates underwent caesarean section

All birth injuries (n=738) **Factors**	**Unadjusted odds ratio (95% CI)**	***P* value**	**Adjusted odds ratio (95% CI)**	***P* value**
Surgeon age (years)				
Resident and Fellow	1.00	-	1.00	-
30– <40	0.72 (0.41–1.26)	0.250	0.70 (0.39–1.27)	0.239
40– <50	0.97 (0.78–1.20)	0.771	0.91 (0.71–1.16)	0.439
≥50	1.23 (0.97–1.57)	0.094	1.31 (1.01–1.72)	0.047
Time of caesarean: night	1.09 (0.92–1.28)	0.320	1.03 (0.85–1.25)	0.740
Duration of operation: ≥60 minutes	1.12 (0.92–1.36)	0.287	1.19 (0.97–1.47)	0.101
Maternal underlying disease	1.02 (0.81–1.30)	0.856	0.99 (0.76–1.29)	0.931
Breech presentation	0.97 (0.75–1.27)	0.893	1.02 (0.75–1.37)	0.923
National Institute of Child Health and Human Development Categories II and III	1.09 (0.87–1.38)	0.472	1.10 (0.85–1.43)	0.470
Premature rupture of membranes	1.15 (0.87–1.52)	0.339	1.19 (0.88–1.60)	0.272
Previous uterine operation	1.05 (0.50–2.22)	0.891	0.96 (0.43–2.14)	0.911
No medical indications: maternal request	1.12 (0.82–1.52)	0.519	1.16 (0.81–1.67)	0.409
No medical indications: hypertension	1.16 (0.91–1.47)	0.250	1.03 (0.73–1.46)	0.871
Previous injuries				
None	1.00	-	-	-
Not in labour	0.84 (0.67–1.05)	0.127	1.18 (0.82–1.70)	0.385
In labour	0.86 (0.69–1.07)	0.186	1.23 (0.87–1.74)	0.242
Prolonged infertility	1.05 (0.66–1.66)	0.848	0.90 (0.53–1.54)	0.705
Maternal weight (kilograms)	1.01 (1.01–1.02)	0.001	1.011 (1.004–1.004)	0.002
Birthweight (grams)				
Normal (2500–4000)	1.00	-	-	-
Low (>1500–2499)	0.78 (0.60–0.99)	0.046	0.76 (0.57–1.01)	0.059
High (>4000)	0.90 (0.54–1.50)	0.695	0.81 (0.48–1.38)	0.447
GDM				
Not present	1.00	-	-	-
GDMA1	1.07 (0.84–1.37)	0.572	1.04 (0.80–1.34)	0.791
GDMA2	1.05 (0.55–2.01)	0.873	0.80 (0.40–1.60)	0.523
Pre-existing DM	0.94 (0.43–2.06)	0.885	0.75 (0.31–1.78)	0.511
Hypertension				
Not present	1.00	-	-	-
GHT/transient HT	1.13 (0.62–2.07)	0.685	0.98 (0.48–1.98)	0.947
Mild to severe PE	4.35 (1.57–12.03)	0.005	5.47 (1.77–16.91)	0.003
Pre-existing HT	1.18 (0.75–1.84)	0.475	1.14 (0.63–2.06)	0.658

birthweight (transient tachypnea: AOR = 2.43; 95% CI, 1.284–3.20; $P < 0.001$; and persistent tachypnea: AOR = 7.28; 95% CI, 2.59–20.50; $P < 0.001$; Table 6). Neonatal birth asphyxia was significantly related to a surgeon age of ≥ 40 years; an operation duration of < 60 minutes (AOR = 1.76; 95% CI, 1.30– 2.37; $P < 0.001$); breech presentation; National Institute of Child Health and Human Development criteria for Categories II and III (AOR = 4.24; 95% CI, 1.36–13.20; $P = 0.013$); placenta previa; maternal hypertension (AOR = 2.39; 95% CI, 1.60–3.57; $P < 0.001$); and low neonatal birth weight (AOR = 7.28; 95% CI, 2.59–20.50; $P < 0.001$; Table 6).

Discussion

In our study, neonatal complications were found in almost half of the deliveries (49.23%; 1723/3500). Birth injuries accounted for one-fifth of the total injuries. Most were minor, especially bruises (a region of injured tissue or skin in which blood capillaries have been ruptured), which may reflect operator skill in removing a foetus from the uterine cavity. An earlier study showed that foetal injuries

Table 4: Factors associated with birth injuries: bruises, forceps marks and abrasions (n=408)

Factors	Bruises (n=408)				Forceps marks (n=182)				Abrasions (n=50)			
	Unadjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Unadjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Unadjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value
Surgeon age (years)												
Resident and Fellow	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
30– <40	0.72 (0.34–1.50)	0.376	0.75 (0.35–1.57)	0.441	1.03 (0.37–2.87)	0.950	0.86 (0.26–2.84)	0.803	0.62 (0.09–4.57)	0.640	0.72 (0.10–5.45)	0.753
40– <50	1.15 (0.88–1.49)	0.314	1.10 (0.81–1.48)	0.549	1.36 (0.91–2.02)	0.130	1.01 (0.63–1.61)	0.978	0.55 (0.23–1.31)	0.177	0.67 (0.25–1.80)	0.425
≥50	0.99 (0.72–1.38)	0.976	0.97 (0.68–1.39)	0.873	2.86 (1.98–4.13)	<0.001	2.84 (1.86–4.33)	<0.001	0.42 (0.13–1.35)	0.144	0.66 (0.19–2.52)	0.509
Time of caesarean: night	0.98 (0.80–1.20)	0.874	0.90 (0.71–1.15)	0.416	0.72 (0.53–0.97)	0.033	0.97 (0.66–1.43)	0.887	1.55 (0.88–2.73)	0.153	1.28 (0.66–2.49)	0.461
Duration of operation (min): ≥60	0.93 (0.72–1.20)	0.606	0.97 (0.73–1.27)	0.806	1.76 (1.27–2.43)	0.001	1.63 (1.13–2.36)	0.009	0.71 (0.33–1.51)	0.393	0.89 (0.40–1.97)	0.773
Underlying disease	1.16 (0.87–1.55)	0.318	1.18 (0.85–1.62)	0.324	1.01 (0.66–1.56)	0.956	0.66 (0.39–1.13)	0.131	0.70 (0.28–1.78)	0.540	0.87 (0.33–2.30)	0.779
Breech	1.43 (1.06–1.94)	0.021	1.36 (0.96–1.94)	0.082	0.04 (0.01–0.31)	<0.001	0.07 (0.01–0.49)	0.008	4.09 (2.24–7.48)	<0.001	4.07 (1.96–8.43)	<0.001
National Institute of Child Health and Human Development Categories II and III	0.83 (0.60–1.13)	0.254	0.86 (0.60–1.22)	0.392	0.38 (0.21–0.71)	0.002	0.55 (0.28–1.09)	0.089	1.56 (0.77–3.14)	0.215	1.49 (0.66–3.36)	0.337
Premature rupture of membranes	1.20 (0.85–1.69)	0.350	1.19 (0.81–1.73)	0.375	0.53 (0.27–1.05)	0.078	0.69 (0.33–1.48)	0.343	2.02 (0.94–4.35)	0.075	1.77 (0.75–7.15)	0.190
Previous uterine operation	1.05 (0.41–2.70)	0.809	1.05 (0.40–2.76)	0.924	1.45 (0.44–4.73)	0.471	1.04 (0.23–4.75)	0.957	-	-	-	-
No medical indications: maternal request	1.26 (0.87–1.83)	0.259	1.19 (0.77–1.84)	0.443	1.77 (1.10–2.84)	0.020	1.65 (0.91–2.99)	0.097	0.26 (0.04–1.92)	0.260	0.60 (0.07–4.87)	0.631

Factors	Bruises (n=408)				Forceps marks (n=182)				Abrasions (n=50)			
	Unadjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Unadjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Unadjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value
No medical indications: hypertension	1.15 (0.84–1.56)	0.416	1.01 (0.64–1.58)	0.973	1.07 (0.69–1.68)	0.814	0.64 (0.28–1.43)	0.277	1.64 (0.79–3.39)	0.185	2.38 (0.99–5.71)	0.053
Previous									1.00	-	-	-
No	1.00	-	1.00	-	1.00	-	1.00	-	0.72 (0.32–1.61)	0.421	1.35 (0.39–4.73)	0.639
Not in labour	0.81 (0.60–1.09)	0.165	1.04 (0.65–1.66)	0.876	1.83 (1.26–2.66)	0.001	2.49 (1.15–5.40)	0.021	0.46 (0.18–1.17)	0.101	0.60 (0.16–2.22)	0.445
In labour	0.88 (0.67–1.16)	0.374	1.26 (0.81–1.95)	0.303	1.67 (1.15–2.41)	0.006	2.63 (1.24–5.58)	0.012				
Prolonged infertility	1.51 (0.90–2.52)	0.130	1.29 (0.72–2.33)	0.395	1.05 (0.46–2.43)	0.903	0.61 (0.21–1.77)	0.362				
Maternal weight (kilograms)	1.01 (0.99–1.01	0.211	1.01 (0.99–1.01)	0.251	1.03 (1.02–1.04)	<0.001	1.03 (1.02–1.04)	<0.001	- 0.99 (0.96–1.01)	- 0.342	- 0.99 (0.97–1.02)	- 0.541
Birthweight (grams)												
Normal (2500–4000)	1.00	-	-	-	1.00	-	1.00	-	1.00	-	1.00	-
Low (>1500–2499)	0.98 (0.72–1.32)	0.885	0.88 (0.62–1.24)	0.455	0.43 (0.24–0.78)	0.005	0.73 (0.38–1.41)	0.350	1.38 (0.66–2.85)	0.393	0.71 (0.30–1.68)	0.434
High (>4000)	1.09 (0.59–2.03)	0.772	1.09 (0.58–2.04)	0.788	0.93 (0.37–2.32)	0.874	0.79 (0.31–2.03)	0.618	0.77 (0.10–5.64)	0.794	N/A	0.997
GDM												
Not present	1.00	-	-	-	1.00	-	-	-	-	-	-	-
GDMA1	1.09 (0.80–1.47)	0.601	1.04 (0.75–1.43)	0.835	1.77 (1.21–2.61)	0.004	1.52 (0.99–2.33)	0.054				
GDMA2	0.94 (0.40–2.20)	0.878	0.89 (0.37–2.16)	0.802	1.59 (0.57–4.45)	0.381	1.01 (0.33–3.06)	0.997				
Pre-existing DM	0.85 (0.30–2.40)	0.757	0.55 (0.16–1.86)	0.332	1.64 (0.50–5.38)	0.415	1.55 (0.41–5.93)	0.522				
Hypertension (HT)												
Not present	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	-	-
GHT/transient	1.33 (0.65–2.72)	0.437	1.23 (0.52–2.90)	0.636	0.65 (0.16–2.67)	0.547	0.79 (0.15–4.02)	0.773	N/A	0.997	N/A	0.997
HT	1.92 (0.54–6.83)	0.314	2.16 (0.55–8.48)	0.268	4.77 (1.33–	0.016	12.92 (2.7–	0.001	10.47 (2.3–	0.002	6.22 (1.06–	0.044
Mild to severe PE	1.12 (0.63–1.98)	0.699	1.07 (0.51–2.25)	0.865	17.07)	0.007	62.18)	0.025	47.66)	0.996	36.63)	0.996
Pre-existing HT					2.34 (1.26–4.34)		3.31 (1.16–9.44)		N/A		N/A	

Table 5: Factors associated with neonatal jaundice and hypoglycaemia following a caesarean section

Factors	Neonatal jaundice				Factors	Hypoglycaemia			
	Unadjusted odds ratio (95% CI)	***P* value**	**Adjusted odds ratio (95% CI)**	***P* value**		**Unadjusted odds ratio (95% CI)**	***P* value**	**Adjusted odds ratio (95% CI)**	***P* value**
Surgeon age (years)					Surgeon age (years)				
Resident and Fellow	1.00	-	1.00	-	Resident and Fellow	1.00	-	1.00	-
30– -<40	1.30 (0.80–2.12)	0.294	1.37 (0.79–2.39)	0.265	30– <40	1.04 (0.57–1.89)	0.903	0.89 (0.44–1.79)	0.740
40– <50	0.82 (0.64–1.03)	0.088	1.08 (0.82–1.43)	0.595	40– <50	0.64 (0.48–0.86)	0.003	0.66 (0.45–0.95)	0.026
≥50	0.82 (0.62–1.09)	0.166	1.17 (0.85–1.62)	0.344	≥50	0.53 (0.37–0.78)	0.001	0.74 (0.47–1.15)	0.177
Time of caesarean: night	1.35 (1.14–1.61)	0.001	1.05 (0.85–1.29)	0.684	Time of caesarean: night	1.02 (0.83–1.25)	0.001	1.35 (1.04–1.73)	0.022
Duration of operation ≥60 minutes	1.14 (0.93–1.40)	0.211	1.16 (0.92–1.47)	0.208	Duration of operation (min) ≥60 minutes	1.17 (0.92–1.49)	0.209	1.12 (0.84–1.50)	0.442
Underlying disease	1.10 (0.86–1.41)	0.447	0.88 (0.65–1.19)	0.400	Underlying disease	1.28 (0.97–1.69)	0.086	0.85 (0.58–1.24)	0.402
Breech presentation	2.32 (1.83–2.94)	<0.001	1.87 (1.40–2.50)	<0.001	Breech presentation	2.36 (1.80–3.09)	<0.001	1.70 (1.21–2.39)	0.002
National Institute of Child Health and Human Development Categories II and III	1.27 (1.01–1.61)	0.044	1.32 (0.99–1.75)	0.054	National Institute of Child Health and Human Development Categories II and III	1.59 (1.22–2.07)	0.044	1.72 (1.23–2.40)	0.002
Premature rupture of membranes	2.12 (1.64–2.76)	<0.001	1.71 (1.27–2.31)	<0.001	Premature rupture of membranes	1.59 (1.16–2.19)	0.004	1.26 (0.86–1.84)	0.229
Previous uterine operation	1.87 (0.95–3.68)	0.072	1.71 (0.78–3.77)	0.182	Oligohydramnios	2.98 (1.89–4.70)	<0.001	1.80 (1.03–3.15)	0.040
					Obesity	1.29 (0.99–1.68)	0.063	1.00 (0.63–1.59)	0.999
No medical indications: maternal request	0.52 (0.35–0.79)	0.002	0.75 (0.46–1.21)	0.237	No medical indications: hypertension	2.40 (1.86–3.11)	<0.001	1.39 (0.94–2.07)	0.103
					Placenta				
					No	1.00	-	1.00	-
No medical indications: hypertension	2.22 (1.77–2.80)	<0.001	1.60 (1.14–2.24)	0.007	Marginalis	2.31 (1.09–4.91)	0.029	1.94 (0.79–4.78)	0.151
					Totalis	2.71 (1.59–4.62)	<0.001	1.63 (0.81–3.27)	0.169
Previous					Previous				
No	1.00	-	1.00	-	No	1.00	-	1.00	-

Factors	**Neonatal jaundice**				**Factors**	**Hypoglycaemia**			
	Unadjusted odds ratio (95% CI)	***P* value**	**Adjusted odds ratio (95% CI)**	***P* value**		**Unadjusted odds ratio (95% CI)**	***P* value**	**Adjusted odds ratio (95% CI)**	***P* value**
Not in labour	0.59 (0.45–0.77)	<0.001	1.01 (0.67–1.55)	0.947	Not in labour	0.63 (0.46–0.87)	0.005	0.67 (0.41–1.09)	0.105
In labour	1.26 (1.02–1.56)	0.031	1.84 (1.27–2.65)	0.001	In labour	1.07 (0.83–1.39)	0.584	1.15 (0.76–1.74)	0.514
Maternal weight (kilograms)	1.01 (0.99–1.01)	0.404	1.00 (0.99–1.01)	0.188	Maternal weight (kilograms)	1.01 (0.99–1.01)	0.159	0.99 (0.98–1.01)	0.881
Birthweight (grams)					Birthweight (grams)				
Normal (2500–4000)	1.00	-	1.00	-	Normal (2500–4000)	1.00	-	1.00	-
Low (>1500–2499)	6.47 (5.26–7.97)	<0.001	4.72 (3.72–6.00)	<0.001	Low (>1500–2499)	8.25 (6.53–10.41)	<0.001	7.17 (5.42–9.48)	<0.001
High (>4000)	1.13 (0.64–2.02)	0.671	1.03 (0.56–1.86)	0.935	High (>4000)	7.55 (4.85–11.76)	<0.001	8.07 (4.99–13.06)	<0.001
Gestational diabetes mellitus (GDM)					Gestational diabetes mellitus (GDM)				
Not present	1.00	-	1.00	-	Not present				
GDMA1	1.28 (0.99–1.64)	0.052	1.21 (0.92–1.61)	0.180	GDMA1	1.00	-	1.00	-
GDMA2	2.13 (1.19–3.80)	0.011	2.21 (1.16–4.20)	0.016	GDMA2	2.32 (1.78–3.01)	<0.001	2.66 (1.95–3.63)	<0.001
Pre-existing DM	2.86 (1.50–5.45)	0.001	2.17 (0.99–4.74)	0.053	Pre-existing DM	5.20 (2.97–9.13)	<0.001	5.24 (2.67–10.27)	<0.001
Hypertension						5.46 (2.85–10.48)	<0.001	5.58 (2.43–12.81)	<0.001
Not present	1.00	-	1.00	-	Hypertension				
GHT/transient HT	2.44 (1.43–4.18)	0.001	1.13 (0.58–2.20)	0.729	Not present	1.00	-	1.00	-
Mild to severe PE	3.10 (1.10–8.75)	0.032	0.82 (0.25–2.73)	0.750	GHT/transient HT	1.53 (0.77–3.04)	0.223	0.76 (0.33–1.79)	0.536
Pre-existing HT	1.51 (0.97–2.36)	0.067	0.64 (0.34–1.20)	0.163	Mild to severe PE	5.21 (1.84–14.72)	0.002	2.20 (0.63–7.63)	0.214
					Pre-existing HT	2.30 (1.45–3.64)	<0.001	1.09 (0.55–2.20)	0.797

Table 6: Factors associated with transient tachypnea of the newborn, persistent tachypnea of the newborn and asphyxia following a caesarean section

Factors	Transient tachypnea of the newborn				Persistent tachypnea of the newborn				Factors	Asphyxia			
	Unadjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Unadjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value		Unadjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value
Surgeon age (years)									Surgeon age (years)				
Resident and Fellow	1.00	-	1.00	-	1.00	-	1.00	-	Resident and Fellow	1.00	-	1.00	-
30– <40	0.79 (0.42–1.49)	0.463	0.77 (0.39–1.52)	0.443	5.76 (1.91–17.38)	0.002	7.68 (1.60–36.79)	0.011	30– <40	1.23 (0.68–224)	0.494	1.21 (0.59–2.48)	0.609
40– <50	0.61 (0.46–0.82)	0.001	0.63 (0.45–0.88)	0.008	0.41 (0.09–1.77)	0.233	1.21 (0.24–6.12)	0.816	40– <50	0.37 (0.25–0.55)	<0.001	0.44 (0.28–0.69)	<0.001
≥50	0.57 (0.40–0.82)	0.002	0.67 (0.45–0.99)	0.045	1.25 (0.42–3.70)	0.691	5.80 (1.51–22.21)	0.010	≥50	0.19 (0.10–0.36)	<0.001	0.29 (0.14–0.60)	1 0.001
Duration of operation (minutes)									Duration of operation (minutes)				
<60	1.00	-	1.00	-	1.00	-	1.00	-	<60	1.00	-	-	-
≥60	1.63 (1.30–2.03)	<0.001	1.51 (1.15–1.97)	0.003	1.25 (0.53–2.94)	0.616	0.94 (0.27–3.30)	0.922	≥60	1.61 (1.25–2.08)	<0.001	1.85 (1.37–2.51)	<0.001
Underlying disease	1.26 (0.96–1.66)	0.094	1.15 (0.85–1.55)	0.353	1.74 (0.70–4.32)	0.231	1.07 (0.31–3.66)	0.912	Underlying disease	1.01 (0.72–1.40)	0.990	0.80 (0.51–1.25)	0.320
Breech presentation	1.77 (1.34–2.34)	<0.001	1.33 (0.96–1.85)	0.089	7.52 (3.55–15.92)	<0.001	6.63 (2.33–18.84)	<0.001	Breech presentation	4.79 (3.67–6.25)	<0.001	4.09 (2.94–5.68)	<0.001
National Institute of Child Health and Human Development Categories II and III	1.42 (1.09–1.85)	0.009	1.48 (1.09–2.01)	0.013	2.08 (0.88–4.91)	0.096	4.14 (1.31–13.06)	0.015	National Institute of Child Health and Human Development Categories II and III	2.33 (1.78–3.06)	0.044	2.44 (1.74–3.41)	<0.001
Oligohydramnios	1.28 (0.99–1.66)	0.059	1.13 (0.75–1.70)	0.572	0.92 (0.32–2.65)	0.873	1.98 (0.29–13.52)	0.488	Oligohydramnios	2.15 (1.26–3.68)	0.005	1.18 (0.61–2.29)	0.624
No medical indications: hypertension	1.73 (1.32–2.26)	<0.001	1.19 (0.87–1.64)	0.279	3.56 (1.60–7.92)	0.002	3.77 (1.19–11.99)	0.024	Prolapsed cord	12.47 (3.33–46.68)	<0.001	14.85 (3.49–63.26)	<0.001
Placenta									Placenta				
No	1.00	-	1.00	-	-	-	-	-	No	1.00	-	1.00	-
Marginalis	1.81 (0.83–3.97)	0.137	1.62 (0.67–3.91)	0.284					Marginalis	2.71 (1.23–5.94)	0.013	3.23 (1.26–8.25)	0.014
Totalis	1.97 (1.12–3.47)	0.018	1.41 (0.73–2.73)	0.310					Totalis	2.71 (2.33–6.71)	<0.001	3.26 (1.62–6.58)	0.001
Previous caesarean section									No medical indications: hypertension	2.89 (2.19–3.80)	<0.001	2.26 (1.51–3.38)	<0.001
No	1.00	-	1.00	-	1.00	-	1.00	-					
Not in labour	0.76 (0.56–1.02)	0.068	0.83 (0.54–1.28)	0.391	-	-	-	-					

Factors	Transient tachypnea of the newborn				Persistent tachypnea of the newborn				Factors	Asphyxia			
	Unadjusted odds ratio (95% CI)	***P* value**	**Adjusted odds ratio (95% CI)**	***P* value**	**Unadjusted odds ratio (95% CI)**	***P* value**	**Adjusted odds ratio (95% CI)**	***P* value**		**Unadjusted odds ratio (95% CI)**	***P* value**	**Adjusted odds ratio (95% CI)**	***P* value**
In labour	1.22 (0.95–1.56)	0.120	1.11 (0.75–1.64)	0.607	0.61 (0.26–1.45)	0.265	1.55 (0.26–9.20)	0.632					
Maternal weight (kilograms)	1.01 (0.99–1.02)	0.062	1.01 (0.99–1.02)	0.515	0.99 (0.95–1.02)	0.522	0.96 (0.90–1.02)	0.166	Maternal weight (kilograms)	1.01 (0.99–1.01)	0.282	1.01 (0.99–1.02)	0.121
Birthweight (grams)									Birthweight (grams)				
Normal (2500–4000)	1.00	-	1.00	-	1.00	-	1.00	-	Normal (2500–4000)	1.00	-	-	-
Low (>1500–2499)	2.98 (2.36–3.78)	<0.001	2.43 (1.84–3.21)	<0.001	19.02 (8.04–45.00)	<0.001	7.17 (2.51–20.44)	<0.001	Low (>1500–2499)	5.57 (4.34–7.14)	<0.001	3.22 (2.36–4.40)	<0.001
High (>4000)	1.87 (1.09–3.21)	0.022	1.57 (0.89–2.77)	0.120	-	-	-	-	High (>4000)	0.82 (0.33–2.04)	0.666	0.71 (0.28–1.85)	0.485
									GDM				
									Not present	1.00	-	1.00	-
									GDMA1	1.18 (0.85–1.65)	0.327	1.13 (0.76–1.69)	0.545
									GDMA2	1.25 (0.53–2.95)	0.609	0.97 (0.38–2.48)	0.951
									Pre-existing DM	2.17 (0.95–4.94)	0.066	1.18 (0.42–3.34)	0.758
Time from incision to delivery									Hypertension				
									Not present	1.00	-	1.00	-
1–4									GHT/transient	1.80 (0.88–3.69)	0.109	0.74 (0.31–1.77)	0.497
5–10	1.00	-	1.00	-	1.00	-	1.00	-	HT				
>10	0.94 (0.69–1.27)	0.669	0.91 (0.65–1.28)	0.592	0.48 (0.17–1.37)	0.171	0.64 (0.18–2.32)	0.497	Mild to severe PE	2.60 (0.73–9.26)	0.141	0.46 (0.09–2.23)	0.333
	1.08 (0.77–1.51)	0.656	0.92 (0.62–1.37)	0.684	1.03 (0.36–2.98)	0.958	1.81 (0.39–8.38)	0.448					
									Pre-existing HT	2.31 (1.40–3.80)	0.001	0.91 (0.43–1.92)	0.802

during caesarean section were only 1.1%; they were related to the indication for caesarean section, the duration from the skin incision to delivery, and the type of uterine incision[11]. In contrast, foetal injuries predominated in our study, with neonatal jaundice and birth asphyxia being the second and third most common complications.

Many studies have shown that being overweight before pregnancy and gaining weight during pregnancy were associated with higher risks of maternal and neonatal complications and caesarean section[12,13]. Our study found that maternal weight gain and caesarean section were significantly related to postnatal hypoglycaemia and transient tachypnea of the newborn. According to our study, neonatal complications were commonly found in mothers with gestational diabetes. However, hypertension in the women in our study was only significantly related to neonatal complications.

Our study showed that all birth injuries (especially forceps marks and foetal abrasions) were related to a surgeon age of ≥ 50 years, maternal weight, a breech presentation, and a previous caesarean section. We found that physicians aged ≥ 50 years tended to use forceps to aid foetal delivery, which significantly resulted in forceps marks on the newborns. Furthermore, operation times longer than 60 minutes were significantly associated with the use of forceps. The presentation of a foetal breech was also related to the presence of more forceps marks and abrasions. Additionally, a previous caesarean section was associated with more birth injuries, especially forceps marks. We were able to classify birth injuries as directly attributable to the skills of the operator and the indications for the caesarean section. Techniques for breech assistance during caesarean sections could be revised in medical training centres to prevent foetal injuries. Caesarean sections with breech or transverse presentations are more complicated than cephalic presentations[14]. Surgical skill and experience are needed to manipulate the presenting part and the rest of the foetal body out of the uterine cavity without injury. The serious complication related to caesarean section was hip dislocation, which was found in only 1 of 3500 cases. Although only 1 case was identified, operative skills must be revised to improve all maternal and foetal outcomes.

The main point of neonatal complications associated with caesarean section should result from surgical techniques of fetal delivering. Bruises (11.65%) and forceps marks were the most common neonatal complications. Both were possibly caused by the techniques used to remove the foetus from the uterine cavity. The level of difficulty in removing a foetus during a caesarean section is related to the skill and experience of the operator. Currently, there is not enough evidence to support specific delivery methods. However, some studies have shown that maternal and foetal trauma can be reduced by using certain techniques to deliver a foetus in cases of cephalopelvic disproportion with deep engagement of the foetal head[15,16].

Jaundice and transient tachypnea were the second and third most common complications of the neonates. Several studies reported that the delivery route was not related to neonatal jaundice[17,18]. In contrast, the study by Lee and Choi found that neonatal jaundice was more common in neonates born by vaginal delivery than in those delivered by caesarean section[19]. In our study, neonatal bruising and jaundice were the most common neonatal complications. Neonates with bruises are more likely to have jaundice. This is because when blood leaks out of a blood vessel, resulting in black and blue skin, the healing of the bruises is related to high levels of bilirubin and the development of jaundice[20].

Major complications from caesarean section can be reduced by proper teaching planning and training programme of the caesarean section techniques for physicians. The techniques of proper deliver the fetus from uterine cavity according to variety of fetal lie or fetal presentation must well-trained. Unnecessary caesarean section must be also controlled in order to reduce caesarean section rate.

Conclusions

Most of the complications of the newborns were bruising, jaundice, transient tachypnea and hypoglycaemia. The complications of the neonates

could result from the surgical techniques used and the removal of the baby from the uterine cavity.

Author contributions

Saifon Chawanpaiboon contributed to the conception and design of the research; the acquisition, analysis and interpretation of data; the drafting and critical revision of the manuscript; and the approval of the final manuscript.
Vitaya Titapant contributed to the conception and design of the research, revision of the manuscript, and approval of the final manuscript.
Julaporn Pooliam contributed to the analysis and interpretation of data, critical revision of the manuscript, and approval of the final manuscript.

Conflicts of interest

The authors have each completed the International Committee of Medical Journal Editors' Form for Uniform Disclosure of Potential Conflicts of Interest. All authors have nothing to disclose. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee (Si 060/2020) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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