

# Timing of elective Caesarean section at term on neonatal morbidities

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**Objective:** To compare the incidence of neonatal morbidities with elective Caesarean sections at different weeks of gestation in Hong Kong.

**Methods:** Medical records of all women with an elective Caesarean section performed at gestational age  $\geq 37$  weeks in Queen Elizabeth Hospital, Hong Kong, between 1 January 2016 and 31 December 2018 were retrospectively reviewed. Adverse neonatal outcomes collected included respiratory distress syndrome, transient tachypnoea, persistent pulmonary hypertension, sepsis, and neonatal intensive care unit admission.

**Results:** A total of 1576 records were analysed. Overall, 74.68% of babies were delivered at 38 weeks' gestation. The most common adverse neonatal outcome was transient tachypnoea (6.66%), followed by neonatal intensive care unit admission (5.90%), respiratory distress syndrome (5.26%), and sepsis (4.69%). Compared with babies born at 39 weeks' gestation, those born at 37 weeks' gestation were at increased risk of respiratory distress syndrome (odds ratio [OR]=5.348,  $p=0.024$ ), neonatal intensive care unit admission (OR=3.938,  $p=0.027$ ), a composite respiratory outcome (OR=3.402,  $p=0.007$ ), and an overall composite outcome (OR=3.397,  $p=0.002$ ).

**Conclusion:** Elective Caesarean delivery at 37 weeks' gestation is associated with higher risks of respiratory distress syndrome and neonatal intensive care unit admission, compared with elective Caesarean delivery at 39 weeks' gestation.

**Keywords:** *Cesarean section; Infant, newborn; Intensive care units, neonatal; Neonatal sepsis; Respiratory distress syndrome, newborn*

## Introduction

According to the World Health Organization, a Caesarean section rate of  $>10\%$  at the population level is not associated with reductions in maternal and newborn mortality rates<sup>1</sup>. In Hong Kong, the overall Caesarean section rate is around 30% to 40%. In the most recent audit in Hong Kong in 2014, the Caesarean section rate increased from 30.4% in 2004 to 42.1% in 2009 and decreased to 37.3% in 2014; 60% of Caesarean sections were elective<sup>2</sup>. The most common indication for Caesarean section was a previous uterine scar (32.3%), followed by social reasons (15.1%) and fetal malpresentation or abnormal lie (9.2%)<sup>2</sup>.

The incidence of neonatal morbidities, especially respiratory complications, significantly increased following Caesarean section, compared with vaginal delivery. In a meta-analysis of 16 studies with 327 272 neonates born by vaginal delivery and 55 246 neonates born by elective Caesarean section, the risk of neonatal respiratory morbidity increased by 95% in those delivered by elective Caesarean section<sup>3</sup>. In a study in the United States, elective repeated Caesarean delivery before 39 weeks was associated with respiratory and other adverse neonatal outcomes such as newborn sepsis, transient hypoglycaemia, and neonatal intensive care unit admission<sup>4</sup>. In a multicentre

retrospective cohort study in Lebanon, Caesarean delivery before 39 weeks' gestation was associated with respiratory and other adverse neonatal outcomes, and delaying birth by 1 to 2 weeks (until 39 weeks) could prevent 64% to 77% of adverse respiratory outcomes<sup>5</sup>. In a prospective cohort study in Iran, compared with Caesarean section after 39 weeks' gestation, Caesarean section at 38 to 39 weeks was associated with a higher rate of transient tachypnoea of the newborn (adjusted odds ratio [OR]=2.91,  $p=0.032$ ) and neonatal intensive care unit admission (adjusted OR=2.59,  $p=0.02$ )<sup>6</sup>. Therefore, the National Institute for Health and Care Excellence<sup>7</sup>, the Royal College of Obstetricians and Gynaecologists<sup>8</sup>, the American College of Obstetricians and Gynecologists<sup>9</sup>, and the Royal Australian and New Zealand College of Obstetricians and Gynaecologists<sup>10</sup> all recommend against routinely performing elective Caesarean sections before 39 weeks because of the increased risk of respiratory morbidity in the newborn.

In a retrospective study in Hong Kong in 2012, a significantly increased risk of transient tachypnoea was found for babies delivered by elective Caesarean section

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at 37 and 38 weeks<sup>11</sup>, which may be due to differences in the timing of lung maturation between Chinese and non-Chinese babies. This aim of this study was to investigate associations between gestational age and neonatal outcomes in term babies born by elective Caesarean section in Hong Kong.

## Materials and methods

Medical records of all women with an elective Caesarean section performed at gestational age  $\geq 37$  weeks in Queen Elizabeth Hospital, Hong Kong, between 1 January 2016 and 31 December 2018 were retrieved from the Clinical Management System and Obstetric Specialty Clinical Information System and retrospectively reviewed. Those with multiple pregnancies, major fetal congenital abnormality, gestational diabetes mellitus, known diabetes mellitus, intrauterine death, preterm delivery, small-for-gestational-age foetus or intrauterine growth restriction were excluded. Maternal characteristics retrieved included parity, age, ethnicity, gestation, antenatal risk factors, and indication for Caesarean section. The gestational age was determined according to the last menstrual period and early ultrasound at 11 to 14 weeks' gestation. However, if the date of the last menstrual period was unknown, or if the gestational age determined by early ultrasound was inconsistent with that calculated by the last menstrual period by  $>1$  week, then the gestational age was adjusted according to the early ultrasound. Diagnosis of neonatal morbidities was made by paediatricians after clinical assessment, blood tests, and radiological examinations. Neonatal characteristics (sex and birth weight) and outcomes (respiratory distress syndrome, transient tachypnoea, persistent pulmonary hypertension, sepsis, and neonatal intensive care unit admission) were collected. A composite respiratory outcome for newborns included the first three outcomes, whereas an overall composite outcome included all five outcomes.

Data analysis was performed using SPSS (Windows version 24.0; IBM Corp, Armonk [NY], US). Descriptive analyses were used for the frequency and distribution of data for categorical variables. For all analyses, 39 weeks' gestation was used as the reference because it is the recommended gestational age for Caesarean section delivery. Logistic regression analyses were used to determine the risk of neonatal outcomes, the composite respiratory outcome, and an overall composite outcome in relation to the gestational week of delivery. Odds ratio with 95% confidence intervals were calculated after adjusting for confounders such as ethnicity to determine associations between gestational week of delivery and neonatal

morbidities. A p value of  $<0.05$  was considered statistically significant.

## Results

Of 2204 patients who underwent an elective Caesarean section during the study period, 628 were excluded because they did not meet the eligibility criteria and the remaining 1576 were included in the analysis (Table 1). The mean maternal age was 33.44 years; 72.4% of patients were multiparous; 90.23% of patients were Chinese; and 60.53% of patients had a previous Caesarean section. Most (74.68%) of elective Caesarean sections were performed at 38 completed weeks' gestation.

The most common adverse neonatal outcome was transient tachypnoea ( $n=105$ , 6.66%), followed by neonatal intensive care unit admission ( $n=93$ , 5.90%), respiratory distress syndrome ( $n=83$ , 5.26%), and sepsis ( $n=74$ , 4.69%) [Table 2].

**Table 1. Maternal, pregnancy, and neonatal characteristics of participants with elective Caesarean sections**

Characteristic	No. (%) of participants (n=1576)
Maternal age, y	
<18	1 (0.06)
18-35	948 (60.15)
$\geq 35$	627 (39.78)
Parity	
Primipara	435 (27.60)
Multipara	1141 (72.40)
Ethnicity	
Chinese	1422 (90.23)
Non-Chinese	154 (9.77)
Baby sex	
Male	822 (52.16)
Female	754 (47.84)
Birth weight, g	
<2500	37 (2.35)
2500-4000	1517 (96.26)
$>4000$	22 (1.40)
Gestational age, wk	
37	271 (17.20)
38	1177 (74.68)
39	97 (6.15)
40	22 (1.40)
$\geq 41$	9 (0.57)

Compared with babies born at 39 weeks' gestation, babies born at 37 weeks' gestation were at increased risk of respiratory distress syndrome (OR=5.348,  $p=0.024$ ), neonatal intensive care unit admission (OR=3.938,  $p=0.027$ ), the composite respiratory outcome (OR=3.402,  $p=0.007$ ), and the overall composite outcome (OR=3.397,  $p=0.002$ ) [Table 3]. Compared with babies born at 39 weeks' gestation, babies born at 38 weeks' gestation and 40 weeks' gestation were also at increased risks but not significantly, except for the overall composite outcome in babies born at 40 weeks' gestation ( $p=0.018$ ).

## Discussion

In the present study, the risks of respiratory distress syndrome and neonatal intensive care unit admission significantly increased in babies born at 37 weeks'

gestation, compared with 39 weeks' gestation. Similarly, in a retrospective cohort study in the Netherlands, the risks of neonatal mortality and morbidity increased in babies born before 39 weeks, compared with at 39 weeks<sup>12</sup>. In a multicentre study in Lebanon, Caesarean delivery prior to 39 weeks was associated with respiratory and other adverse neonatal outcomes<sup>5</sup>. In a retrospective cohort study in Turkey, babies born at 37 weeks to 37 weeks plus 6 days of gestation had a higher rate of respiratory distress syndrome<sup>13</sup>. In the United States, the Consortium on Safe Labor reported that the risk of developing respiratory distress syndrome was threefold greater at 37 weeks than at 39 to 40 weeks of gestation<sup>14</sup>.

In the present study, the incidence of adverse neonatal outcomes was also higher (but not significantly) in

**Table 2. Incidence of adverse neonatal outcomes at different gestation age**

Adverse neonatal outcome	No. (%) of neonates				
	37 weeks' gestation (n=271)	38 weeks' gestation (n=1177)	39 weeks' gestation (n=97)	40 weeks' gestation (n=22)	≥41 weeks' gestation (n=9)
Respiratory distress syndrome	27 (9.96)	53 (4.50)	2 (2.06)	1 (4.55)	0
Transient tachypnoea	26 (9.59)	72 (6.12)	4 (4.12)	3 (13.64)	0
Persistent pulmonary hypertension	0	1 (0.08)	0	0	0
Sepsis	14 (5.17)	54 (4.59)	3 (3.09)	3 (13.64)	0
Neonatal intensive care unit admission	30 (11.07)	59 (5.01)	3 (3.09)	1 (4.55)	0
Composite respiratory outcomes	49 (18.08)	123 (10.45)	6 (6.19)	4 (18.18)	0
Overall composite outcomes	63 (23.25)	172 (14.61)	8 (8.25)	6 (27.27)	0

**Table 3. Comparison of adverse neonatal outcomes at different gestational ages, with 39 weeks' gestation as the reference**

Neonatal outcome	37 weeks' gestation		38 weeks' gestation		40 weeks' gestation	
	Odds ratio (95% confidence interval)	p Value	Odds ratio (95% confidence interval)	p Value	Odds ratio (95% confidence interval)	p Value
Respiratory distress syndrome	5.348 (1.245-22.965)	0.024	2.372 (0.567-9.921)	0.237	2.25 (0.193-26.183)	0.517
Transient tachypnoea	2.475 (0.841-7.289)	0.1	1.548 (0.552-4.339)	0.406	3.703 (0.755-18.168)	0.107
Persistent pulmonary hypertension	-	-	-	-	-	-
Sepsis	1.659 (0.465-5.925)	0.436	1.485 (0.455-4.846)	0.512	5 (0.925-27.041)	0.062
Neonatal intensive care unit admission	3.938 (1.173-13.225)	0.027	1.704 (0.523-5.55)	0.377	1.481 (0.146-15.078)	0.74
Composite respiratory outcomes	3.402 (1.406-8.233)	0.007	1.845 (0.789-4.316)	0.158	3.422 (0.86-13.614)	0.081
Overall composite outcomes	3.397 (1.56-7.383)	0.002	1.94 (0.923-4.077)	0.08	4.327 (1.289-14.529)	0.018

babies born at 38 or 40 weeks' gestation, compared with 39 weeks. The non-significance may be due to the small sample size for babies delivered at 39 weeks ( $n=97$ ) and 40 weeks ( $n=22$ ), compared 38 weeks ( $n=1177$ ). In a retrospective cohort study in Shanghai, babies born at 38 or  $\geq 40$  weeks also had an increased risk of neonatal respiratory disease<sup>15</sup>. However, in a randomised control study in Denmark, no significant reduction in the neonatal admission rate was reported for babies delivered by elective Caesarean section at 39 weeks gestation, compared with 38 weeks' gestation<sup>16</sup>.

The use of antenatal corticosteroids to induce maturation of the surfactant system has been reported to reduce the incidence of respiratory morbidities in babies<sup>8</sup>. However, a Cochrane systemic review concluded that there is insufficient evidence to draw any definite conclusions regarding antenatal corticosteroid administration before elective Caesarean section at term, and that higher-quality studies with large sample sizes are needed<sup>17</sup>. In addition, antenatal corticosteroids may increase the risk of neonatal hypoglycaemia<sup>18</sup> in term neonates and the risk of mental and behavioural disorders in children<sup>19</sup>.

When counselling patients on the gestational week of delivery, obstetricians should consider the risk of stillbirth and the risk of emergency Caesarean section when patients go into labour before the scheduled date. The rate of stillbirth after 24 weeks' gestation is around 1 in 200<sup>20</sup>. In a 10-year retrospective cohort study in California, the risk of stillbirth at term was found to increase with gestational age from 2.1 per 10 000 pregnancies at 37 weeks' gestation to 10.8 per 10 000 pregnancies at 42 weeks' gestation<sup>21</sup>. Similarly, at each later gestational week after 38 weeks, the mortality risk of expectant management was higher than the risk of delivery; thus, delivery at 39 weeks may reduce the risk of stillbirth. Therefore, it is not advised to delay delivery after 39 weeks.

As for the risk of going into labour before the scheduled date of an elective Caesarean section, emergency Caesarean sections have higher maternal and fetal complication rates. In a cross-sectional study in Nepal, emergency Caesarean section increased the risks of adverse maternal outcomes (wound infection, postpartum haemorrhage, fever, and maternal intensive care unit admission) and fetal outcomes (birth asphyxia, meconium-stained liquor, and neonatal intensive care unit admission)<sup>22</sup>. A systemic review and meta-analysis also reported a higher risk of maternal complications (infection, fever, and wound dehiscence) and fetal complications after emergency Caesarean section<sup>23</sup>.

When counselling patients on the timing of delivery for elective Caesarean section, the risks of adverse maternal and fetal outcomes should be balanced with those of stillbirth, going into spontaneous onset of labour, and neonatal morbidities.

Limitations of the present study include the small sample size for babies born at 39 weeks' gestation, which was used as the reference. A larger sample size may reveal any associations of neonatal outcomes in babies born at 39 weeks. In addition, records from only a single hospital were reviewed; there are eight public hospitals in Hong Kong providing obstetric care. A territory-wide study of all hospitals is warranted to obtain a more representative picture of the risks associated with the timing of elective Caesarean section.

## Conclusion

Elective Caesarean delivery at 37 weeks' gestation is associated with higher risks of respiratory distress syndrome and neonatal intensive care unit admission, compared with elective Caesarean delivery at 39 weeks' gestation.

## Contributors

All authors designed the study, acquired the data, analysed the data, drafted the manuscript, and critically revised the manuscript for important intellectual content. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

## Conflicts of interest

As an editor of the journal, KYL was not involved in the peer review process of this article. All other authors have disclosed no conflicts of interest.

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## Data availability

All data generated or analysed during the present study are available from the corresponding author upon reasonable request.

## Ethics approval

The study was approved by the Kowloon Central Cluster Research Ethics Committee (reference: KC/KE-22-0149/ER-1). The patients were treated in accordance with the tenets of the Declaration of Helsinki. The patients provided written informed consent for all treatments and procedures and for publication.

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