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Original Article

Optimal timing of elective repeat cesarean deliveries of term singleton pregnancies: A multicenter cross-sectional study

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ABSTRACT

Objective: Cesarean deliveries must be optimally timed to minimize their effects on mothers and neonates. This study aimed to determine the optimal timing of elective repeat cesarean deliveries to reduce the incidence of neonatal respiratory disorders and of emergent cesarean deliveries.
Materials and methods: This multi-center, cross-sectional, retrospective analysis evaluated data on the maternal and neonatal outcomes of 856 singleton pregnancies scheduled for elective repeat cesarean deliveries at 37–39 weeks' gestation. The emergent cesarean delivery and neonatal respiratory disorder risks were analyzed according to the scheduled cesarean delivery times.
Results: The elective cesarean delivery rates were 91.0% during the first and 92.6% during the second half of the 37th week of gestation, 88.7% during the first and 82.9% during the second half of the 38th week of gestation, and 62.5% during the first and 33.3% during the second half of the 39th week of gestation. The neonatal respiratory disorder rates were 21.8% for elective cesarean deliveries during the first half of the 37th week of gestation and approximately 8% for elective cesarean deliveries during the second half of the 37th week until the first half of the 38th week of gestation. No neonatal respiratory disorders occurred among the babies delivered by elective cesarean deliveries during the 39th week of gestation.
Conclusion: For improved maternal and neonatal outcomes in the Asian population, it may be better to perform scheduled elective repeat cesarean deliveries from the second half of the 37th week of gestation until the 38th week of gestation following confirmation of gestational age by early first trimester ultrasonography.

Introduction

Cesarean delivery (CD) is a common surgical procedure in modern obstetrics. In 2013, 190,361 CDs were performed in Japan, and the overall CD rate was 18.5% [1].

Determining the optimal timing of elective CD is important for neonatal [2–10] and maternal [5] health; hence, CDs should be considered from the perspectives of maternal and neonatal health. The timing of CD affects newborns' prognoses. The American College of Obstetricians and Gynecologists (ACOG) and the National Institutes of Health recommend that nonmedically indicated elective CDs should be performed after 39 weeks' gestation to reduce neonatal respiratory morbidity and mortality rates [11]. A study on Asian women showed that CDs performed at 38 weeks' gestation were associated with the lowest prevalence of neonatal respiratory complications [7]. A Japanese study recommended that elective CDs should be performed during the first half of the 38th week of gestation rather than after the 39th week of gestation to reduce incidences of spontaneous labor and emergent CDs [12]. CDs must be optimally timed to minimize maternal and neonatal complications. A systematic review and meta-analysis showed that the maternal and fetal complication rates were higher during emergent CDs than during elective CDs [9]. Studies from Australia and Thailand found that a history of CD predicted spontaneous labor before the scheduled CD date among patients who requested elective CDs [7,13].

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This multicenter retrospective study was conducted to determine the optimal timing of elective repeat CDs to reduce the incidence of neonatal respiratory disorders and emergent CDs.

Materials and Methods

Data sources

This multicenter retrospective study evaluated the optimal timing of repeat elective CDs based on associations between weeks of gestation, neonatal respiratory outcomes, and the prevalence of emergent CDs. Twenty-six of the 40 birthing facilities in the Gunma prefecture were involved in this study. Data from women who were scheduled for elective repeat CDs at 37–39 weeks' gestation from January 1, 2014 to December 31, 2014 were collected.

Inclusion and exclusion criteria

The inclusion criteria were all pregnant women who were scheduled to undergo elective repeat CDs, women whose delivery dates were confirmed by early ultrasound, and women whose elective CDs were scheduled to occur at 37–39 weeks' gestation. We excluded women with severe complications during pregnancy, with placental positioning disorders, with fetal anomalies, and those who elected to undergo vaginal deliveries after CDs (Fig. 1).

Definitions

Emergent CD was defined as CD in a patient whose delivery schedule was advanced by labor, rupture of the membranes, bleeding, or maternal deterioration including hypertensive disorders of pregnancy, and fetal dysfunction. A neonate with a respiratory disorder was defined as one who received oxygen additional to that administered for initial resuscitation and routinely.

Data collection

The maternal demographic and clinical data included the number of previous CDs; the anticipated mode of delivery of the current pregnancy, for example, CD and trial of labor after CD; gestational week on which the CD was planned; actual mode of

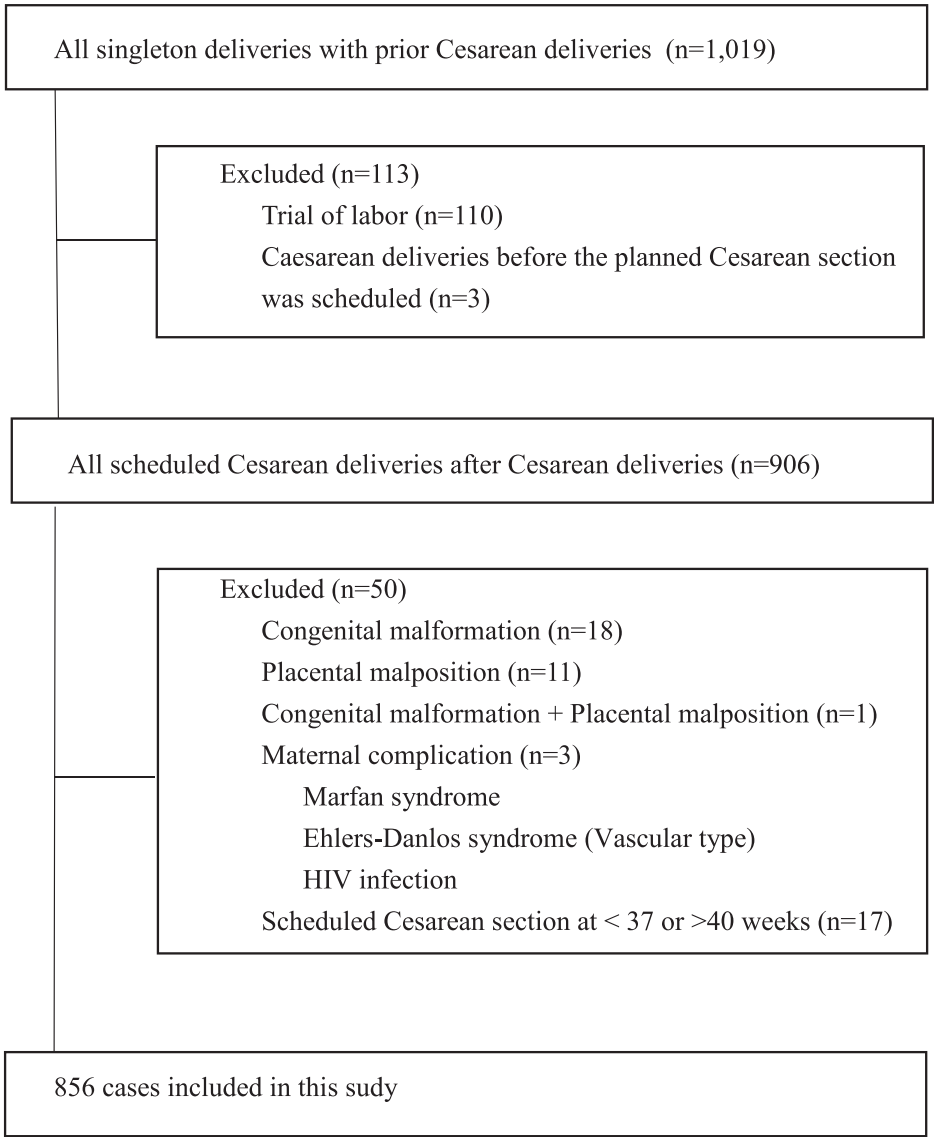

Fig. 1. Flow chart of participant enrollment.

delivery, namely, elective CD, emergent CD, or vaginal delivery; reason for an emergent CD and vaginal delivery if required; reason for a vaginal delivery, if implemented; complications during the current pregnancy; and complications during the current labor.

Data were extracted that described neonates' birth characteristics; including the sex; birth weight; gestational age; one- and five-minute Apgar scores; umbilical artery blood pH; presence or absence of morphological abnormalities; presence or absence of chromosomal abnormalities; neonatal birth care requirements, namely, routine care, bag and mask, or intubation; and requirements for oxygen after initial neonatal birth care.

Study ethics and consent to participate

The study's protocol was approved by the local epidemiologic ethics committee. Permission to undertake the study was obtained from the directors of each participating clinic and hospital. Study approval was obtained from the local obstetrics and gynecology society. The requirement for informed consent was waived, because the study was retrospective and the data were anonymized.

Statistical analyses

The statistical analyses were performed using IBM® SPSS® software, version 25 (IBM Corporation, Armonk, NY, USA) and R version 3.6.1. The Kruskal–Wallis test was used to analyze the continuous variables, and Fisher's exact test was used to analyze the categorical variables.

Results

During the study period,1,019 singleton deliveries had a prior CD, 906 of whom were scheduled to undergo an elective repeat CD (Fig. 1). After excluding women who had fetal abnormalities, placental malposition, maternal complications, or CDs scheduled for 35, 36, or 40 weeks of gestation, the data from 856 pregnant women were analyzed.

Timing of elective cesarean deliveries

Table 1 shows the distribution of the gestational weeks on which the elective CDs were scheduled. The elective CDs were most frequently scheduled for the first half of the 38th week of gestation (372/856; 43.5%). Elective CDs were scheduled for 13.0% (111/856) and 20.6% (176/856) of the patients during the first and the second halves of the 37th week of gestation, respectively, and for 2.8% (24/856) and 0.4% (3/856) of the patients during the first and the second halves of the 39th week of gestation, respectively. Table 1 also shows the elective CD rates according to the numbers of previous CDs. Elective CD rates did not differ by gestational week in the patients with one or with two or more previous CDs.

Implementation of elective cesarean deliveries according to schedule

Table 2 shows the rates at which the elective CDs were implemented according to the gestational weeks in which they were scheduled. The elective CD rates were 91.0% during the first half and 92.6% during the second half of the 37th week of gestation, and 88.7% during the first half and 82.9% during the second half of the 38th week of gestation. The elective CD rates during the first and second halves of the 39th week of gestation were 62.5% and 33.3%, respectively. The elective CD

Table 1
Elective cesarean deliveries according the gestational week of scheduled cesarean deliveries and the number of previous cesarean deliveries.

Gestational week during the scheduled cesarean section	Number of previous CDs: One						Two or more							Subtotal
	Scheduled CDs, *n*	Elective CDs, *n*	Emergent CDs, *n*	Vaginal deliveries, *n*	Nonelective CDs[a], *n*	Elective CD rate, %	Scheduled CDs, *n*	Elective CDs, *n*	Emergent CDs, *n*	Vaginal deliveries, *n*	Nonelective CDs[a], *n*	Elective CD rate, %	[b]*P*-value	Scheduled CDs, *n*
First half of 37th week (37 weeks 0 days–37 weeks 3 days)	84	75	9	0	9	89.3	27	26	1	0	1	96.3	0.446	111
Second half of 37th week (37 weeks 4 days–37 weeks 6 days)	130	118	12	0	12	90.8	46	45	1	0	1	97.8	0.188	176
First half of 38th week (38 weeks 0 days–38 weeks 3 days)	290	253	35	2	37	87.2	82	77	5	0	5	93.9	0.114	372
Second half of 38th week (38 weeks 4 days–38 weeks 6 days)	138	116	22	0	22	84.1	32	25	7	0	7	78.1	0.438	170
39th week (39 weeks 0 days –39 weeks 6 days)	17	10	7	0	7	58.8	10	6	4	0	4	60	1.000	27
Total (37 weeks 0 days–39 weeks 6 days)	659	572	85	2	87	86.8	197	179	18	0	18	90.9	0.373	856

CD, cesarean delivery.
[a] Number of nonelective cesarean deliveries = number of emergent cesarean deliveries and vaginal deliveries.
[b] Fisher's exact test compared patients who had undergone one cesarean delivery previously with those who had undergone ≥2 cesarean deliveries regarding the numbers of elective cesarean deliveries and nonelective cesarean deliveries.

nonperformance rates at the 37th, 38th, and 39th weeks of gestation were 8.0% (23/287), 13.1% (71/542), and 40.7% (11/27), respectively.

Prevalence of respiratory disorders according to the gestational age at implementation of elective cesarean delivery

Except for the birth weight, the neonatal outcomes did not differ in relation to the gestational age at birth (Table 3). Table 4 shows the prevalence of respiratory disorders according to the gestational age at elective CD. The neonatal respiratory disorder rates were 21.8% during the first half of the 37th week of gestation and approximately 8% during the second half of the 37th week until the first half of the 38th week of gestation. No respiratory disorders occurred among the babies delivered by elective CD during the 39th week of gestation.

Discussion

The study's key findings showed that the emergent CD rate was higher among women whose CDs were planned for 39 weeks' gestation than those whose CDs were planned for 37–38 weeks' gestation. Furthermore, the respiratory distress rate did not differ between the neonates born during the second half of the 38th week and the 39th week of gestation and those born during the first half of the 38th week of gestation by elective CD.

We found that the elective CD rate was lower at 39 weeks' gestation than at 37 and 38 weeks' gestation. These results concur with the findings from previous studies [4,7,13]. In this study, 40.7% of the patients underwent emergent CDs before their scheduled date at 39 weeks' gestation. This number is similar to those from studies of patients in Asia (51.6%) [7], Thailand (51.0%) [14], and Japan (31.8%)

Table 2
Elective cesarean delivery implementation and nonperformance rates according to the gestational week of scheduled cesarean delivery.

Gestational weeks in the scheduled cesarean deliveries	Elective CDs n = 751	Implementation rate of CD (%)	Number of nonelective CDs n = 105	Nonperformance rate of CD (%)	*P*-value[d]
First half of 37th week (37 weeks 0 days–37 weeks 3 days)	101	91.0	10[a]	9.0	0.602
Second half of 37th week (37 weeks 4 days–37 weeks 6 days)	163	92.6	13[a]	7.4	0.173
First half of 38th week (38 weeks 0 days–38 weeks 3 days)	330	88.7	42[b]	11.3	Reference
Second half of 38th week (38 weeks 4 days–38 weeks 6 days)	141	82.9	29[a]	17.1	0.075
First half of 39th week (39 weeks 0 days–39 weeks 3 days)	15	62.5	9[a]	37.5	0.001**
Second half of 39th week (39 weeks 4 days–39 weeks 6 days)	1	33.3	2[a]	66.7	0.037*
Total (37 weeks 0 days–39 weeks 6 days)	751	87.7	105[c]	12.3	–

CD, cesarean delivery.
*$P < 0.05$, **$P < 0.01$.
[a] Number of nonelective cesarean deliveries = number of emergent cesarean sections.
[b] Number of nonelective cesarean deliveries = 40 emergent cesarean deliveries and 2 vaginal deliveries.
[c] Number of nonelective cesarean deliveries = 103 emergent cesarean deliveries and 2 vaginal deliveries.
[d] Fisher's exact test compared the number of elective cesarean deliveries and nonelective cesarean deliveries for each gestational week scheduled for cesarean deliveries and the first half of the 38th week of gestation.

Table 3
Neonatal outcomes according to the gestational week in elective cesarean delivery cases.

		Total	First half of 37 weeks' gestation	Second half of 37 weeks' gestation	First half of 38 weeks' gestation	Second half of 38 weeks' gestation	First half of 39 weeks' gestation	Second half of 39 weeks' gestation	*P*-value[a]
		(37 weeks 0 days–39 weeks 6 days)	(37 weeks 0 days –37 weeks 3 days)	(37 weeks 4 days–37 weeks 6 days)	(38 weeks 0 days –38 weeks 3 days)	(38 weeks 4 days –38 weeks 6 days)	(39 weeks 0 days –39 weeks 3 days)	(39 weeks 4 days –39 weeks 6 days)	
Number, *n*	*n*	751	101	163	330	141	15	1	
Sex									
Male	*n* (%)	386 (51.4)	52 (51.5)	91 (55.8)	166 (50.3)	72 (51.1)	4 (26.7)	1 (100.0)	0.287[b]
Female	*n* (%)	365 (48.6)	49 (48.5)	72 (44.2)	164 (49.7)	69 (48.9)	11 (73.3)	0 (0.00)	
Birth weight									
	Median (IQR)	2920 (2704, 3142)	2836 (2663, 3015)	2888 (2658, 3054)	2916 (2707, 3154.5)	3020 (2872, 3233)	2912 (2510, 3322)	3314 (3314, 3314)	<0.001***
	Mean ± SD	2939.9 ± 333.5	2872.9 ± 341.4	2877.2 ± 318.3	2955.5 ± 342.3	3024.4 ± 288.4	2912.30 ± 451.0	3314	
Apgar score									
1 min	Median (IQR)	9 (8, 9)	9 (9, 9)	9 (8, 9)	9 (8, 9)	9 (8, 9)	9 (8, 9)	9 (9, 9)	0.073
	Mean ± SD	8.58 ± 0.868	8.36 ± 1.188	8.55 ± 0.755	8.63 ± 0.815	8.59 ± 0.837	8.93 ± 0.704	9	
5 min	Median (IQR)	9 (9, 10)	9 (9, 10)	10 (9, 10)	9 (9, 10)	9 (9, 10)	9 (9, 10)	9 (9, 9)	0.218
	Mean ± SD	9.37 ± 0.728	9.18 ± 0.065769	9.44 ± 0.641	9.38 ± 0.731	9.4 ± 0.645	9.6 ± 0.507	9	
Umbilical artery pH									
	Median (IQR)	7.319 (7.285, 7.319)	7.314 (7.286, 7.348)	7.316 (7.285, 7.351)	7.32 (7.2805, 7.348)	7.32 (7.2865, 7.35125)	7.328 (7.3035, 7.3495)	7.329 (7.329, 7.329)	0.906
	Mean ± SD	7.3137 ± 0.0587	7.31016 ± 0.065769	7.31225 ± 0.063355	7.31378 ± 0.056623	7.31565 ± 0.054524	7.332 ± 0.036396	7.329	
Umbilical artery base excess									
	Median (IQR)	−2.3 (−3.9, −0.9)	−2.2 (−3.55, −1.2)	−2.3 (−4.0, −1.0)	−2.4 (−3.9, −1.0)	−2 (−4.0, −0.3)	−1.35 (−3.875, −0.45)	−4.2 (−4.2, −4.2)	0.621
	Mean ± SD	−2.78 ± 2.89	−2.654 ± 2.6778	−2.853 ± 3.0704	−2.862 ± 2.8426	−2.624 ± 3.0354	−1.86 ± 1.7264	−4.2	

SD, standard deviation; IQR, interquartile range.
***$P < 0.001$.
[a] Kruskal-Wallis test.
[b] Fisher's exact test.

Table 4
Prevalence of respiratory disorders according to gestational week in elective cesarean delivery cases.

Gestational week of scheduled cesarean section	Elective CDs, *n*	Respiratory disorders, *n*	Prevalence of respiratory disorders	*P*-value[a]
First half of 37th week (37 weeks 0 days–37 weeks 3 days)	101	22	21.8%	0.001**
Second half of 37th week (37 weeks 4 days–37 weeks 6 days)	163	12	7.4%	0.729
First half of 38th week (38 weeks 0 days–38 weeks 3 days)	330	28	8.5%	Reference
Second half of 38th week (38 weeks 4 days–38 weeks 6 days)	141	12	8.5%	1.000
First half of 39th week (39 weeks 0 days–39 weeks 3 days)	15	0	0.0%	0.621
Second half of 39th week (39 weeks 4 days–39 weeks 6 days)	1	0	0.0%	1.000
Total	751	74	9.9%	–

CD, cesarean delivery.
Prevalence of respiratory disorders (%) = number of respiratory disorders/number of elective cesarean deliveries × 100.
*$P < 0.05$, **$P < 0.01$.
[a] Fisher's exact test.

[15], but higher than those in Denmark (15.2%) [16] and Australia (8.5%) [13]. Previous studies have shown that the normal gestational period is shorter for Asian women than for Caucasian women [17,18]. An Australian study of repeat CD showed that women born in Asia were more likely to enter spontaneous labor before 39 weeks' gestation [13]; hence, ethnic differences may partly explain why many of the women in this study underwent emergent CDs before their scheduled repeat CDs at 39 weeks' gestation.

In this study, the rate of emergent CD was higher among the women whose CDs were planned for 39 weeks' gestation than in women whose CDs were planned for 37–38 weeks' gestation Previous studies have also reported that patients with CDs scheduled at 39 weeks experienced more emergent CDs than those scheduled at 37–38 weeks, and spontaneous labor pain was a major factor that influenced unplanned delivery [7,14–16]. First trimester ultrasonography confirmed the gestational ages. The rate of maternal complications is higher in patients who undergo emergent CDs than in those who undergo elective CDs [9]. Given the rate of elective CDs in our study, it may be appropriate to perform elective repeat CDs before 39 weeks' gestation.

The neonates born by elective CD during the first half of the 37th week of gestation had a significantly higher incidence of respiratory disorders than those born by elective CD during the first half of the 38th week of gestation in this study. The respiratory distress rate did not differ between the neonates born during the second halves of the 38th and the 39th weeks of gestation and those born during the first half of the 38th week of gestation by elective CD. The ACOG and the United Kingdom's National Collaborating Centre for Women's and Children's Health recommend that, given the risk of neonatal morbidity, elective CD for nonmedical purposes should be delayed until 39 weeks' gestation [11,19]. However, previous studies have shown that gestation-specific neonatal respiratory morbidity patterns differ between Caucasian and Asian patients [7], with the lowest rates of neonatal respiratory morbidity found at 39–40 weeks' and 38 weeks' gestation, respectively [4,15,20]. Planned elective repeat CDs should be scheduled after 38 weeks of gestation to reduce neonatal respiratory morbidity.

Our study's strength is that all the participants' gestational ages were confirmed by early first trimester ultrasonography. However, the results should be interpreted in the context of the study's limitations. First, while this was a multicenter study, it was conducted in one prefecture in Japan, and its findings do not reflect the general Japanese population. Nationwide surveys are needed for generalization of the results. Second, this study did not include women undergoing their first CD. Women with histories of CD have reported earlier natural labor pains [7]. Further studies of patients undergoing their first CDs are needed to evaluate the timing of elective CDs. Third, the study population after 39 weeks gestational age was small in this study, which might have affected the results of the elective CD nonperformance rate. Further studies with an increased proportion of 39-week gestation cases are needed to obtain more accurate evidence. Fourth, the impact on the mother at the time of the scheduled CD should be examined according to whether an elective CD has been performed. Although emergent CDs may be more risky than elective CDs [9], it was not possible to determine the differences in the effect of emergent and of elective CDs on maternal prognoses. Lastly, while the timing of the CDs and the effects of the procedures on the neonates were examined in the context of the Apgar score at birth, the influence of cord blood gas analysis and whether additional oxygen was administered after resuscitation on the neonates' prognoses were not evaluated. We investigated the effects of additional oxygen administration on the neonates and the rate of emergent CDs. Investigations into the short- and mid-to long-term prognoses of mothers and children are needed to clarify the effects of the timing of scheduled CDs.

In conclusion, while elective repeat CDs at 39 weeks' gestation may reduce the incidence of neonatal respiratory disorders, given the incidence of emergent CDs, elective repeat CDs undertaken after the second half of the 37th week of pregnancy and preferably before the 39th week of gestation would be more appropriate, specifically in Asian mothers. If the gestational age is confirmed by early ultrasonography, scheduled repeat CDs performed from the second half of the 37th week of gestation until the 38th week of gestation may improve the outcomes of Asian mothers and neonates.

Author contributions

MH, HS, and KH designed the study. MH, HS, TH, and MI collected the data. MH, HS, YK, KH, and SO analyzed and interpreted the data. MH and HS drafted the manuscript. AI was comprehensively involved in all aspects of this study and in the preparation of the manuscript. All authors have read and approved the final version of the manuscript.

Declaration of competing interest

The authors declare that they have no conflicts of interest.

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