Immediate and late respiratory morbidity in children after elective cesarean section: comparison of early-term and full-term cesarean section

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**Conflict of Interest**

The authors declare that they have no conflict of interest.

I declare that the material in this statement is original and has not been previously published and has not been submitted for publication elsewhere while under consideration.

**Abstract**

**Objective:**

To compare the association between early- and full-term elective cesarean section and neonatal and late (age 5-8 years) respiratory morbidity.

This retrospective cohort study included patients 5 to 8 years old whose neonatal data were collected from medical records before they underwent pulmonary function tests.

The study included 118 children delivered by elective cesarean section: 62 early-term and 56 full-term. The early-term group had significantly lower 1-minute Apgar scores, 8.82±0.64, versus 9.02±1.34 for the full-term group (*P* = .022).

Of the study group, 24 early-term and 17 full-term children underwent pulmonary function tests at ages 5 to 8 years. The early-term group had lower values: FEV1 1.22±0.24 versus 1.62±0.53 (*P* = .02), FVC 1.39±0.27 versus 1.92±0.6 (*P* = .001), and FEF 1.68±0.5 versus 2.04±0.57 (*P* = .035).

We concluded that both early and late respiratory morbidities are more common in preterm versus full-term children born by elective cesarean section.

CS (cesarean section), FVC (forced vital capacity), FEV1 (forced expiratory volume in 1 second), FEF (forced expiratory flow)

Increasing reports show the impact of cesarean sections on infant morbidity, especially the respiratory impact, which is reflected in the need for more specialized care and prolonged hospital stays.(1,2) There is an inverse relationship between birth week and neonatal complications including respiratory morbidity and mortality, but studies have not yet shown if there is a significant difference between children born by elective cesarean section (CS) at early term (weeks 37–38+6) and those who are born by elective CS at full term (weeks 39–40+6).

In the past decade, there has been a global tendency toward an increase in the rate of CS, despite the increased risk for neonatal respiratory complications when compared with vaginal delivery. In the Netherlands, the percentage of births by CS is 14.3%; in the United Kingdom and Canada, it is between 22.8% and 26.8%; and in the United States, the percentage reaches 32.3%. The highest percentage is in Mexico at 43.9%.(3,4) In Israel (the country in which this study was conducted), the percentage of births by CS in 2017 was 14.8%, as reported by the Organisation for Economic Co-operation and Development (OECD).

Cesarean section is indicated for maternal and fetal reasons and is divided into elective and emergency procedures. Maternal indications include obstetric and maternal complications such as multiple pregnancy, placenta previa, and history of cardiac disease, while fetal indications include intrauterine growth retardation and nonreassuring fetal status. Elective CS may be indicated in cases of breech presentation and prior history of CS or uterine surgery, owing to increased risk of neonatal brain injury, uterine rupture, or other complications.(4) Notably, it can be seen globally that the most common cause of CS has changed from uterine or embryonic to psychosocial factors, defined as maternal fear of giving birth or maternal demand without the presence of medical reasons. There has also been a decline in the rate of attempted vaginal birth after single cesarean delivery.(5-8)

In 2010, the World Health Organization published a review about the risks associated with cesarean delivery during the years 2004 to 2008 in 24 countries. The conclusion of this review was that CS involves an increase in significant maternal and neonatal risk and should be performed only when there is an expectation of a particular benefit that exceeds the maternal and neonatal risks associated with the procedure.(9)

There are many contradictory reports in the literature about increasing neonatal morbidity and mortality as a result of CS. This is owing to different reviews and to the mixing of elective and emergent CS. In addition, there are increasing reports about the association between CS and neonatal morbidity, primarily in the respiratory system, which is reflected in a prolonged hospital stay after delivery and higher rates of hospital admissions.(1,2)

There is an inverse relationship between the gestational week of birth and newborn complications and morbidity. The closer to full term a baby is born, the more the chance for complications decreases.(10) It is also important to note recent studies reporting that newborns born in weeks 37 to 38+6 (early term) have more developmental disorders and learning difficulties than those born in weeks 39 to 40+6 (full term).(11,12)

In 2009, Tita et al. reported that the rates of adverse respiratory outcomes, mechanical ventilation, newborn sepsis, hypoglycemia, admission to the neonatal intensive care unit, and hospitalization for 5 days or more were increased by a factor of 1.8 to 4.2 for births at 37 weeks and 1.3 to 2.1 for births at 38 weeks compared to full-term births.(13) In 2018, Tita et al. reported that even with confirmed pulmonary maturity, early-term birth in the absence of medical or obstetric indications is associated with worse neonatal respiratory and hepatic outcomes compared with full-term birth.(14) In a retrospective study published in 2012, Nir et al. compared the differences between elective early and elective late CS groups and showed that there is greater morbidity in the early-term group compared to full term, but these findings were not statistically significant.(15) A recent retrospective study published in 2019 by Weiniger et al. showed increased neonatal respiratory morbidity after early-term CS.(16)

It is worth noting that some of the results mentioned above are based on data collected from infants born by both elective and urgent CS. None of the aforementioned studies showed a significant difference in 1-minute Apgar scores or tested late respiratory morbidity in children born by early-term CS.

In 2013, the American College of Obstetricians and Gynecologists (ACOG) recommended avoiding elective early-term CS and postponing elective CS until 39 weeks of pregnancy except when fetal lung maturity has been demonstrated, in order to assuage neonatal respiratory morbidity through delayed elective planned CS at 39 weeks and later.(17)

Despite these recommendations, there is not enough evidence in the literature to show a significant difference in respiratory complications between infants born by elective CS at early term (weeks 37–38+6) and elective CS at full term (weeks 39–40+6).

Full-term elective CS increases the incidence of intrapartum CS (a scheduled CS turns out to be an urgent CS) owing to maternal and neonatal reasons, and in turn, it increases the risk of further maternal and neonatal complications.(18,19) Therefore, we decided to conduct this study to determine if it is worth scheduling an elective CS at full term instead of early term, despite the increased risk for intrapartum CS at full term.

Furthermore, the association between early-term versus full-term CS and pulmonary functions at age 5 to 8 years has not yet been studied sufficiently.

We hypothesized that early elective CS increases the risk of immediate neonatal and later childhood respiratory morbidity.

Hopefully, this study can increase knowledge and evidence about the importance of full-term elective CS and help obstetricians to plan their surgeries accordingly.

**Study Population and Methods**

**Study population:**

Our study, conducted from 2018 to 2019, included children who were born by elective CS between 2003 and 2007 in the French Hospital of Nazareth. They were divided into 2 groups: the first group (early-term group) included children born in weeks 37 to 38+6, and the second group (full-term group) included children born at 39 to 40+6 weeks.

**Methods:**

The study was conducted in 2 parts.

Part 1—Immediate respiratory morbidity:

In the first part of the study, we reviewed the birth files for both groups. Information was collected from the files in the French Hospital database. The information collected included Apgar scores, neonatal respiratory complications after delivery, mother’s age at birth, gestational week of birth, gender, pregnancy type (spontaneous or in vitro fertilization), birth season, and place of residence.

The aim of this part of the study was to examine the association between early- and full-term elective CS and other perinatal characteristics and the Apgar score and immediate respiratory morbidity.

Part 2—Late respiratory morbidity:

In the second part of the study, we invited a randomly selected group of the parents to complete a questionnaire and have their children take a spirometry test checking forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), and forced expiratory flow (FEF).

Spirometry was performed in accordance with the American Thoracic Society/European Respiratory Society (ATS/ERS) task force guidelines, using a KoKo® spirometer. A respiratory technician experienced with testing children aged 5 to 8 years performed the spirometry.

The aim of this part of the study was to test the association between early- versus full-term elective CS and environmental characteristics and late respiratory morbidity at 5 to 8 years of age.

Statistical Methods

Statistical description and analyses were performed using IBM SPSS Statistics 25.0 for Windows. A chi-square test and *t* test were used to compare the groups for categorical variables and continuous variables, respectively. *P* < .05 was considered significant.

**Results**

Part 1 describes the early results following birth, and Part 2 describes the results at 5 to 8 years of age.

Part 1—Immediate respiratory morbidity:

This part of the study included 118 participants. These participants were divided into 2 groups, the first including 62 neonates born by elective CS at early term (37–38+6 weeks) and the second including 56 neonates born at full term (39–40+6 weeks).

Statistical analysis showed a significant difference in the 1-minute Apgar score between the groups. The score was lower in the first group than in the second group: 8.82 (±0.64) versus 9.02 (±1.34), respectively (*P* = .022). In contrast, no statistically significant difference was observed between the groups in the Apgar score at 5 minutes (*P* = .22) (Table 1). Regarding respiratory distress and the need for oxygen support after birth, no statistically significant difference was observed between the groups. It is worth noting that 4 newborns from the first group (early term) needed oxygen support after delivery, but this number was too small to demonstrate any statistically significant difference (Table 1).

When other data were examined, including the mother’s age at birth, spontaneous pregnancy versus pregnancy after fertility treatments, birth season, and gender, no significant difference was found between the groups (Table 3).

Part 2—Late respiratory morbidity:

These results describe the group of children aged 5 to 8 years who performed the breath function test (spirometry) administered by an experienced respiratory technician. A total of 41 children participated. We divided them into 2 groups by week of birth. The early-term group (birth week 37–38+6) included 24 children, and the full-term group (birth week 39–40+6) included 17 children.

The pulmonary function test results showed a statistically significant difference between the groups, as described in Table 4. The children in the early-term group had lower values, mainly in these 3 parameters: FEV1 (*P* = .02), FVC (*P* = .001), and FEF (*P* = .035). The other pulmonary function test parameters showed no significant difference.

When other data were examined, including passive smoking, pets at home, chronic disease, birth season, and place of residence, no significant difference was found between the groups (Table 5).

**Discussion**

This study examined differences between children born by elective CS at weeks 37 to 38+6 (early term)and at weeks 39 to 40+6 (full term) at 2 periods of time: immediately after birth and at 5 to 8 years of age. In the neonatal period, Apgar scores along with other respiratory parameters were collected from medical records and compared between the 2 groups, whereas pulmonary function tests were conducted at 5 to 8 years of age, at which time parents were also asked to complete questionnaires.

Data collected during the neonatal period from 118 newborns (62 early term, 56 full term) showed a statistically significant difference in the first-minute Apgar score in favor of the full-term group. The data also showed that a higher percentage of neonates in the early-term group needed oxygen support after delivery. Those who experienced respiratory distress were compared to the full-term group, but the difference did not reach statistical significance.

Studies published in the last decade, including a recent study published in 2018, showed increased neonatal respiratory morbidity following early-term CS at 37 to 38 weeks of gestation. However, most of those studies included urgent CSs, whereas our study only included elective CSs.(16,20,21) We think our comparison of 2 homogeneous groups that both had elective CSs, neutralizing the emergency factor and all other complications related to urgent CSs, makes our study more clinically powerful.

Salemi et al. compared early-term deliveries, including electively induced and electively performed CS deliveries, with full-term deliveries. They investigated neonatal morbidities including respiratory complications, neonatal sepsis, and feeding difficulties as well as admission to the neonatal intensive care unit. They found no significant differences between the early-induced group and the full-term group, but when comparing the early elective CS group with the full-term group, the early elective CS group had higher rates of morbidities. However, the mode of delivery of the full-term group was not reported in this study.(22)

Nir et al.’s (2012) study was very similar to our study and compared neonates born by early elective and late elective CS. It showed higher neonatal morbidity including more ill infants, more infants with dyspnea, and lower 1-minute and 5-minute Apgar scores among the early-term group, but these differences did not reach a level of significance.(15)

Our study showed that immediately after birth, the only significant difference between early-term babies and full-term babies was a low 1-minute Apgar score. Notably, there was no significant difference in the 5-minute Apgar score between the groups. The Apgar score is a known measure for assessing the general status of the neonate in the immediate postpartum period and is a useful screening test for clinically significant birth asphyxia and the risk of later developing several neurological and psychiatric disorders, including cerebral palsy and intellectual disability. (23-25) In 2018, Leinonen et al. reported a strong and statistically significant association between a low 1-minute Apgar score and cerebral palsy, epilepsy, and intellectual disability.(26) This important information and our result of lower 1-minute Apgar scores in early-term neonates further highlight the importance to strive for full-term delivery.

However, less is known about the long-term effects when the 1-minute Apgar score is low but the 5-minute Apgar score is normal.

The statistically significant finding of lower 1-minute Apgar scores in the early-term group was not reported previously in any of the above-mentioned studies, which makes this result and its association with early and late child development and well-being more valuable and worthy of study. Moreover, our results showed that immediate respiratory distress and the need for oxygen support were more common in the early-term group compared to the full-term group, although the level of significance was borderline (*P* = .051). More studies with a larger sample size are needed to thoroughly investigate this relationship.

Our data regarding pulmonary function tests collected from 41 children ages 5 to 8 years (24 early-term and 17 full-term children) showed that FEV1, FVC, and FEF were statistically significantly lower among children in the early-term group compared to children in the full-term group. The remaining parameters of respiratory function tests and data collected from questionnaires did not show a statistically significant difference.

A comprehensive and complete literature search looking for a relationship between early-term deliveries and pulmonary function in school-aged children yielded minimal published studies. Three studies have reported that children born at early term have increased respiratory symptoms and hospital admissions for respiratory illnesses during childhood. The first of these studies, published by Boyle et al. in 2012, showed that children at 3 and 5 years of age had a poorer outcome of general health (growth, wheezing, asthma, use of medication, and parental rating of children’s health), more hospital admissions, and more longstanding illness with decreasing gestational age even at early-term births.(27) The second study, published in 2013 by Paranjothy et al., showed that the risk of any emergency respiratory admission up to age 5 years increased as gestational age decreased from 40 weeks. Even for infants born at 39 weeks’ gestation, there was an increased risk of emergency hospital admissions for respiratory conditions compared with infants born at 40 to 42 weeks.(28) The third study, published by Edwards et al. in 2015, reported that children born at early term had higher rates of admission to the hospital during their first year of life and reported more wheezing at younger than 5 years and at older than 5 years compared to full-term control subjects.(29)

Importantly, these 3 studies did not compare lung-function tests or children who were born by elective CS.

A more recent study published in 2016 by Kotecha et al. performed pulmonary function tests at 2 periods: the first at 8 to 9 years of age and the second at 14 to 17 years of age. They found that at 8 to 9 years of age, the standardized spirometry measures, although within the normal range, were lower in the group born at early term compared to the full-term controls. Delivery by caesarean section did not influence later spirometry, and the effect of early-term birth was not modified by delivery by caesarean section. At 14 to 17 years, the spirometry measures in the early-term group were similar to the full-term group, and the rates of asthma and respiratory symptoms were also similar between the 2 groups.(30)

Spirometry is considered the gold standard technique to measure lung function in children aged 6 years or older,(31) which makes our results clinically important. Our results showed a statistically significant difference in FEV1, FVC, and FEF values in favor of the full-term group compared to the early-term group. This difference could possibly reflect better clinical lung function in the full-term group. One possible explanation for this result is that the lungs continue to grow even after 38+6 weeks of pregnancy, and birth at week 39 or later results in better maturation of the lungs.(32) This result supports the recommendation to follow the recent guidelines for scheduling elective cesarean sections at week 39 or later.(13,17)

Limitations of this study include the relatively small number of participants in the second part of the study. Most of the participants were also of the Arab population in Israel; thus, the sample also was not necessarily representative in terms of geographic distribution or cultural demographics. In addition, because it was not possible to perform this study with a blinded placebo control group, data were cross-sectional, and this limits the ability to draw causal inferences.

In conclusion, our study showed that early-term children born during gestational weeks 37 to 38+6 had a higher risk for respiratory morbidity expressed as lower 1-minute Apgar scores and the need for primary resuscitation immediately after birth. Moreover, later on, at 5 to 8 years of age, their pulmonary function test results were lower than those of children who were born at full-term. Accordingly, we support the ACOG recommendation that elective CSs should be performed after 39 weeks’ gestation if there are no compelling medical reasons to perform them earlier.

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None.

**Conflict of interest**

The authors declare that they have no conflict of interest.

I declare that the material in this statement is original and has not been previously published and has not been submitted for publication elsewhere while under consideration.

**Ethical Standard**

The study was approved by the Ethics Committee of the Saint Vincent De Paul Hospital and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Parents gave their informed consent prior to inclusion of their children in the study and could opt out if they disagreed with their child’s participation. Participation in the study was fully voluntary and with no explicit incentives provided for participation.

**Authors’ Contributions**

RSH conceived and designed the study. EN analyzed, interpreted, and drafted the article. NE carried out the initial analyses, revised the manuscript, and approved the final manuscript as submitted. BM and IJ revised the article. All authors approved the final version.

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**Tables:**

Table 1. Apgar Scores and Participant Characteristics

|  |  |  |  |
| --- | --- | --- | --- |
|  | Group 1 | Group 2 | *P* value |
| Mother’s age |  |  | .358 |
| Birth week | 37.86±0.54 | 39.88±0.9 | .167 |
| Birth weight |  |  | .000 |
| Need for intubation | 23.2% | 0% | .175 |
| Admission days |  |  | .609 |
| Apgar 1 | 8.8226±0.64 | 9.0179±0.133 | .0227 |
| Apgar 5 | 9.8710±0.660 | 9.9821±0.133 | .222 |
|  | 46.6% | 0% | .051 |

Table 2. Respiratory Distress and Need for Oxygen Support

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Pearson | | *P* value | | |  | |
| 1.838 | | .5 | | | Respiratory distress | |
| 3.80 | | .12 | | | Oxygen need | |



















3. Characteristics of Early Respiratory Morbidity Group

|  |  |  |  |
| --- | --- | --- | --- |
|  | Group 2 | Group 1 |  |
| .358 | 5.7±29.6 | 5.9±30.69 | Mother’s age at birth |
| .63 |  |  |  |
| 18 | 22 | Winter |
| 15 | 11 | Spring |
| 16 | 17 | Summer |
| 14 | 2 | Autumn |
| .398 |  |  |  |
| 31 | 29 | Male |
| 25 | 32 | Female |
| .835 |  |  | Spontaneous pregnancy/IVF |
| 54 | 58 | Spontaneous |
| 1 | 3 | IVF |

IVF, in vitro fertilization

4. Respiratory Function Test Results

|  |  |  |  |
| --- | --- | --- | --- |
|  | Group 1 | Group 2 |  |
| FEV1 | 1.22±0.24 | 1.62±0.53 | .02 |
| FVC | 1.39±0.27 | 1.92±0.6 | .001 |



|  |  |  |  |
| --- | --- | --- | --- |
| FEF | 1.68±0.5 | 2.04±0.57 | .035 |

FEV1, forced expiratory volume in 1 second; FVC, forced vital capacity; FEF, forced expiratory flow

5. Characteristics of Late Respiratory Morbidity Group

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *P* value | Group 2 | Group 1 |  | Passive smoking | |
| .067 | 11 | 9 | Yes |
|  | 6 | 16 | No |
| .39 | 3(17.6%) | 2(7.7%) | Yes | Pets at home |  |
| 14(82%) | 24(92%) | No |  | |
| .325 | 14(25.5%) | 20(33.9%) | Yes | Chronic disease | |
| 41(74%) | 39(66%) | No |
| .631 | 18(34%) | 22(42%) | Winter | Birth season | |
| 15(28%) | 11(21.2%) | Spring |
| 16(30.2%) | 17(32.7%) | Summer |
| 4(7.5%) | 2(3.8%) | Autumn |
| .93 | 32(58.2%) | 35(57.4%) | Urban | Place of residence | |
| 23(41.8%) | 26(42.6%) | Not Urban |