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 effect of early and full-term elective Cesarean section on the immediate (neonatal) and late (5-8 years age) respiratory morbidity.

A retrospective cohort study, we first collected data from patients whose ages at the time of the study were between 5 and 8 years. Data was collected from medical records regarding the neonatal period. Thereafter, included children have pulmonary function tests performed at age of 5-8 years and their parents to fill out questionnaires.

Data collected from the neonatal period included 62 early versus 56 full term children who were delivered by elective CS. Early term group had significantly lower APGAR score in the first minute 8.82±0.64 versus 9.02±1.34 (*P* = 0.022) for the full-term group

Pulmonary function tests were performed for 24 early and 17 full term children at ages 5 to 8 years. The results have showed worse values in the early term group FEV1 1.22±0.24 vs 1.62±0.53 (P = 0.02), FVC 1.39±0.27 versus 1.92±0.6 (P = 0.001), FEF 1.68±0.5 versus 2.04±0.57 (P = 0.035).

We concluded that early term babies born by elective cesarean section have both early and late respiratory morbidities compared with full term babies born by elective cesarean section.

Cesarean section (CS), 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 one, which is reflected in 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 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 cesarean sections (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%, this figure was reported by the Organization for Economic Co-operation and Development (OECD) association.

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 non-reassuring fetal status. Elective CS may be indicated in cases of breech presentation and prior history of CS or uterine surgery due 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 (WHO) published a review about the risks associated with cesarean delivery during the years 2004–2008 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 due to different reviews and to the mixing of elective and emergent CS. In addition, there are increasing reports about the effect of CS on 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)

It is also known that 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 that there is recent studies reporting that newborns born in weeks 37–38+6 (early term) have more developmental disorders and learning difficulties than those born in weeks 39–40+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). Again 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) A retrospective study published in 2012, Vered 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 this findings were not significant statically.(15) Recent retrospective study published in 2019 by Weiniger et al. showed increased neonatal respiratory morbidity at early term CS.(16)

Nevertheless, 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 significant difference at 1-minute APGAR score or tested the late respiratory morbidity of the early term CS on these children.

in 2013 The American College of Obstetrics and Gynecology (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 above. (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).

It is known that full term elective CS increases the incidence of intrapartum CS (scheduled which turn to be urgent CS) due to maternal/neonatal reasons and in turn it increases the risk of further maternal and neonatal complications.(18, 19) Therefore, we decided to conduct this study and to check if it is worth scheduling elective CS at full term instead of early term despite the increased risk for intrapartum CS at full term.

Furthermore, the effect of early term versus full term CS on pulmonary functions at age 5-8 years wasn’t yet studied enough.

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

Hopefully, this study can improve the 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 during the years 2018-2019, it included children who were born by elective CS between the years 2003 and 2007 in the French hospital of Nazareth. They were divided into two groups: the first group (early term group) included children born in weeks 37–38+6, and the second group (full term group) included children born at 39–40+6 weeks.

**Methods:**

The study was conducted in two parts.

Immediate respiratory morbidity part:

In this part, we reviewed the birth files for both groups, information was collected from the files at the French hospital database. The information collected included APGAR score, neonatal respiratory complications after delivery, mother’s age at birth, birth week, gender, pregnancy type (spontaneous or in vitro fertilization (IVF)), birth season, and place of residence.

The aim of this part was to test the effect of early and full-term elective CS, and other perinatal characteristics on APGAR score and immediate respiratory morbidity.

Late respiratory morbidity part:

In this part, we invited a randomly selected group of the parents to fill in a questionnaire and have their children pass 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, using a KoKo® spirometer, performed by a respiratory technician experienced with testing children at ages of 5-8 years.

The aim of this part was to test the effect of early, full term elective CS and environmental characteristics on late respiratory morbidity at 5-8 years age.

Statistical Methods

Statistical description and analyses were performed using IBM SPSS Statistics 25.0 for Windows. Chi-square test and t test were used to compare between the groups for categorical variables and continuous variables respectively. *P* < 0.05 was considered significant.

**Results:**

The first part describes the early results following birth, and the second part describes the results at 5 to 8 years of age.

1-Immediate respiratory morbidity part:

This part included 118 participants. These participants were divided into two 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 APGAR score at first minute between the two groups, which showed that the first subgroup was lower than the second subgroup, 8.82 (±0.64) versus 9.02 (±1.34) respectively, (*P* = 0.022). In contrast, no statistically significant difference (*P* = 0.22) was observed between the two groups in the APGAR 5 (Table 1). Regarding the data of respiratory distress and the need for oxygen support after birth, no statistically significant difference was observed between the two 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 two groups (Table 3).

2-Late respiratory morbidity part:

This part describes 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 two groups by week of birth. Early term group (birth week 37–38+6) included 24 children, and full term group (birth week 39–40+6) included 17 children.

The pulmonary function test results demonstrated a statistically significant difference between the two groups, as described in Table 4. The children in the early term group demonstrated lower values mainly in these three parameters: FEV1 (*P* = 0.02), FVC (*P* = 0.001), and FEF (*P* = 0.035). The other pulmonary function test parameters were not statistically significantly different.

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

**Discussion:**

In this study, we examined differences between neonates born by elective CS at weeks 37–38+6 (early term)and neonates born by elective CS at weeks 39–40+6 (full term) at two periods of time, immediately after birth and later at 5-8 years of age. At neonatal period APGAR scores along with other respiratory parameters were collected from medical records and compared between the two groups, while pulmonary function tests were conducted at the age 5-8 years and parents were asked to fill out questionnaires.

Data collected at the neonatal period from 118 newborns (62 early term, 56 e full-term) have shown 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 suffered from respiratory distress were compared to the full-term group, but this difference did not reach statistical significance.

Studies that were published in the last decade including recent study published in 2018 showed increased neonatal respiratory morbidity at early term CS at 37–38 weeks of gestation. However, most of those studies included in the study group urgent CSs, differently from our study where only elective CSs were included. (16, 20, 21) Therefore, we think that the fact that we compared two homogenous groups, which both had elective CSs, neutralizing the emergency factor and all other complications related to urgent CSs, makes our study more clinically powerful.

A study published by Salemi et al. tested early term deliveries including the electively induced and electively performed CS deliveries, and compared these two groups with full term deliveries group.

They have investigated neonatal morbidities including respiratory complications, neonatal sepsis, feeding difficulties and NICU admission. There were 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)

Another study that was published in 2012 by Vered Nir et al which is very similar to our study, compared neonates born by early elective and late elective CS, showed higher neonatal morbidity including more ill infants, more infants with dyspnea, and lower APGAR(at 1 and 5 min) score among the early term group but these differences didn’t reach a level of significance.(15)

We have shown in this study that immediately after birth the only significant difference was low first minute APGAR score in the early term babies compared to full term babies. Notably, there was no significant difference in the five-minute APGAR score between both groups. APGAR score is a known measure for assessing the general status of the fetus 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), at 2018 Elina Leinonen et al. reported strong and statistically significant association between low one-minute APGAR score and cerebral palsy, epilepsy and Intellectual disability.(26) This important information and our result of lower one-minute APGAR score at early term neonates highlights more the importance to strive for full-term delivery.

However, less is known about the long-term effects when the one-minute is low and five-minute APGAR scores is normal.

It should be pointed out that this finding of statically significant lower first-minute APGAR score in the early term group wasn’t reported previously in any of the above-mentioned studies, which make this result more valuable and worth studying it and its effect in the early and the late child development and well-being in the future. Moreover, we have shown that immediate respiratory distress and the need for oxygen support was more common but borderline (*P* = 0.051) in the early term group compared to the full-term group. More studies with bigger sample size are needed to be done to investigate thoroughly 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 other data collected from questionnaires did not show a statistically significant difference.

A comprehensive and complete literature search looking for the relationship between early term deliveries and its effect on pulmonary functions at the school aged children, yield minimal published studies. Three studies have reported that early-term-born children have increased respiratory symptoms and admissions to hospital for respiratory illnesses during childhood. First study published at 2012 by Elaine M Boyle et al. reported that children at 3 and 5 years of age had poorer outcome of general health (growth, wheezing, asthma, use of drugs and parental rating of children’s health), more hospital admissions, and more longstanding illness with decreasing gestation age even at early term births.(27). Second study published at 2013 by Shantini Paranjothy et al. showed that the risk of any emergency respiratory admission up to age 5 years increased as gestational age decreased to 40 weeks. Even 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) And finally third study published by Martin O. Edwards et al. at 2015 reported that Early term–born children had higher rates of admission to the hospital during their first year of life, reported more wheeze at less than 5 years old and at older than 5 years compared to full-term control subjects.

Importantly, all these studies neither compared lung function test nor compared electively born children.

A more recent study published at 2016 by Sarah Kotecha et al. is the only study that performed pulmonary function tests at two periods first group at 8-9 years of age and the second group at 14-17 years of age. They found that at 8-9 years the standardized spirometry measures, although within the normal range, were lower in the early-term-born group, 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 14–17 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 two gestation groups.(29)

Spirometry considered as the gold standard technique to measure lung function in children ≥6 years old,(30) which makes our results highly significant clinically importance. Based on this assumption and on our results showing a statistically significant difference between the two groups in FEV1, FVC, and FEF values in favor of full-term group compared to the early-term group. This difference could possibly reflect better clinically lung function in the full-term group. Perhaps one 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.(31) This result also supports more the recommendation to follow the recent guidelines and to schedule elective cesarean sections at week 39 or later.(13, 17)

Some limitations of this study including:

1. The relatively small number of participants in the second part of our study.
2. It was not possible to perform this study with a blinded placebo control group.
3. Most of the participants were of the Arab population in Israel, thus the sample was also not necessarily representative in terms of geographic distribution, or cultural demographics.
4. Data were cross-sectional, and this limits the ability to draw causal inferences.

In conclusion, our study has shown that even early-term children born during gestational weeks 37–38+6 had a higher risk for respiratory morbidity expressed as lower 1-minute APGAR scores, the need for primary resuscitation immediately after birth, moreover later on at 5-8 years of age, a worse pulmonary function test compared to full-term children. 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 have 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 Score and Participants characteristics

|  |  |  |  |
| --- | --- | --- | --- |
|  | Group 1 | Group 2 | *P* value |
| Mother’s age | 30.69±5.99 | 29.63±5.7 | 0.358 |
| Birth week | 37.86±0.54 | 39.88±0.9 | 0.167 |
| Birth weight | 3104.92±441.9 | 3502.45±463.7 | 0.000 |
| Need for intubation | 2 3.2% | 0 0.0% | 0.175 |
| Admission days | 5.87±1.396 | 5.76±0.637 | 0.609 |
| APGAR 1 | 8.8226±0.64 | 9.0179±0.133 | 0.0227 |
| APGAR 5 | 9.8710±0.660 | 9.9821±0.133 | 0.222 |
| Need for oxygen  | 4 6.6% | 0 0.0% | 0.051 |

Table 2 – Respiratory distress and need for oxygen support

|  |  |  |
| --- | --- | --- |
| Pearson’s | *P* value |  |
| 1.838 | 0.5 | Respiratory distress |
| 3.80 | 0.12 | Oxygen need |

3 Characteristics of early respiratory morbidity group

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| --- | --- | --- | --- |
| *P* value | Group 2 | Group 1 |  |
| 0.358 | 5.7±29.6 | 5.9±30.69 | Mother age at birth |
| 0.63 |  |  | Birth Season |
| 18 | 22 | 1(winter) |
| 15 | 11 | 2(Spring) |
| 16 | 17 | 3(Summer) |
| 14 | 2 | 4(Autumn) |
| 0.398 |  |  | Newborn Sex |
| 31 | 29 | 1(Male) |
| 25 | 32 | 2(Female) |
| 0.835 |  |  | Spontaneous pregnancy/IVF |
| 54 | 58 | 1 (Spontaneous) |
| 1 | 3 | 2 (IVF) |

4 - Respiratory Function Test Results

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| --- | --- | --- | --- |
|  | Group 1  | Group 2  | *P* value |
| FEV1 | 1.22±0.24 | 1.62±0.53 | 0.02 |
| FVC | 1.39±0.27 | 1.92±0.6 | 0.001 |
| FEF | 1.68±0.5 | 2.04±0.57 | 0.035 |

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

5 – Characteristics of Late respiratory morbidity group

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| --- | --- | --- | --- | --- |
| *P* value | Group 2 | Group 1 |  | Passive smoking |
| *P*0.067= | 11 | 9 | Yes  |
| 6 | 16 | No |
| *P*0.39= | 3 (17.6%) | 2 (7.7%) | Yes | Pets at home |
| 14 (82%) | 24 (92%) | No |
| *P*0.325= | 14 (25.5%) | 20 (33.9%) | Yes | Chronic disease |
| 41 (74%) | 39 (66%) | No |
| *P*0.631= | 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 |
| *P*0.93= | 32 (58.2%) | 35 (57.4%)  | Urban  | Place of residence  |
| 23 (41.8%) | 26 (42.6%) | Not Urban |