Immediate and late respiratory morbidity in children after elective cesarean section: comparison of early-term cesarean section (week 37–38+6) and full-term cesarean section

**Objective:**

Increasing reports show the impact of cesarean sections on infant morbidity, especially respiratory, 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,[3] but studies have not yet shown if there is a significant difference between children born by elective cesarean section in early term (weeks 37–38+6) and full term (weeks 39– 40+6).[4] This study compared immediate and late respiratory morbidity in children born by elective cesarean section during gestational weeks 37–38+6 versus weeks 39–40+6.

**Study Design:**

We conducted a retrospective cohort study on data collected from pediatric patients born in the French hospital of Nazareth whose ages at the time of the study were between 5 and 8 years. We then invited a random selection of those children and their parents to fill out questionnaires and asked the children to perform a pulmonary function test (spirometry).

**Results:**

A significant correlation was observed between the gestational week of birth and the APGAR score value in the first minute. A clear correlation also was observed between gestational week of birth and respiratory function test values at age 5 to 8 years.

**Conclusions:**

We concluded that there is a definite relationship between gestational week of birth and early and late respiratory morbidity. Better values were evident ​​in the 1-minute APGAR score and respiratory function in full-term births compared to early-term births.

**Abbreviations**

Cesarean section (CS), FVC (forced vital capacity), FEV1 (forced expiratory volume in one second), FEF (Forced expiratory flow)

## **What is known**

It is known that premature birth involves many newborn complications, including in the respiratory system, especially in late, very, and extremely preterm infants.

## **What is new**

One of the unique advantages in this study that it tested the late effect of early (37-38+6) elective CS in the respiratory function later in life at 6-8 years using a spirometry test which is considered gold standard method to assess respiratory function in this age, something which have not been tested in all the studies that we reviewed.

**Introduction:**

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%.[5,6] In Israel (the country in which this study was conducted), the percentage of births by CS in 2012 was 20.6% (9.5%-28.7%), a 6% increase compared to the previous year. These figures were reported at an annual meeting of the Israeli society for mother and fetus and relied on data from 26 centers in Israel.[7]

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 due to increased risk of neonatal brain injury, uterine rupture, or other complications.[6] 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.[8–11]

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.[12]

There are many contradictory reports in the literature about increasing 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.[13] It is also important to note recent reports 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).[14]

To reduce the mainly respiratory complications in neonates born by elective CS, the American College of Obstetrics and Gynecology recommended in 2007 to postpone CS until 39 weeks of pregnancy.[4] Despite this recommendation, there is not enough evidence in the literature to show a significant difference in respiratory complications between infants born at early term (weeks 37–38+6) and at full term (weeks 39–40+6). In 2009, Tita et al. found 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.[15] In 2012, Nir et al. compared in retrospective study the differences between these two groups and showed that there is more morbidity in the early-term group compared to full term. [16]

**Study Population and Methods:**

**Study population:**

Our study 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 (study group) included children born in weeks 37–38+6, and the second group (control group) included children born at 39–40+6 weeks.

**Methods:**

The study was conducted in two parts.

In the first part, we reviewed the birth files for both groups, collecting relative information including APGAR score, neonatal respiratory complications after delivery, mother’s age at birth, birth week, gender, pregnancy type (spontaneous or IVF), birth season, and place of residence.

In the second part, we invited a randomly selected group of the parents to fill out a questionnaire and have their children pass a spirometry test checking FVC, FEV1, and FEV1/FVC.

Later, the data were summarized, and we compared the variables between the two groups. A chi-square test was used to assess categorical variables between groups, and a *t* test was applied for continuous variables; *P* < 0.05 was considered significant. Statistical analyses were performed using IBM SPSS statistics 22.0 for Windows.

**Results:**

The results also have been divided into two parts. The first part describes the results following birth, and the second part describes the results at 5 to 8 years of age.

First part:

This part included 118 participants. The information was collected from the files at the French hospital database. 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).

*N*=118

 Group 1 Group 2

 Group 1 Group2

*n*=62

*n*=56

Statistical analysis showed a significant difference (*P* = 0.022) in APGAR 1 between the two groups, which showed that the first subgroup was lower than the second subgroup. 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 according to the chi-square test. Results of the correlation tests between the two groups are described in Table 4; 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.

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

Second part:

This part describes the group of children aged 6 to 8 years who performed the breath function test (spirometry) administered by an experienced respiratory technician. A total of 41 children participated, and we divided them into two groups by week of birth. Group 1 (birth week 37–38+6) included 24 children, and Group 2 (birth week 39–40+6) included 17 children.

N= 41

 Group 1 Group 2

N=24

N=17

The respiratory function test results demonstrated a statistically significant difference between the two groups, as described in Table 6. The children in the first group (early term) demonstrated lower values mainly in these three parameters: FEV1 (*P* = 0.02), FVC (*P* = 0.001), and FEF (*P* =0.035). The other respiratory function test parameters were not statistically significantly different.

**Discussion:**

In this study, we examined differences between neonates born by elective CS in weeks 37–38+6 and neonates born by elective CS in weeks 39–40+6. We compared the APGAR values between the two groups following birth according to data from medical records, and later we invited the children to take a respiratory function test and the parents to fill out questionnaires.

The first part of the study included 118 newborns, 62 in the first group (37–38+6) and 56 in the second group (39–40+6). The data showed that there was a statistically significant difference in the first-minute APGAR score in favor of the second group (those born after week 39). It also has been shown that there is a higher percentage of neonates in the early-term group who needed oxygen support after delivery. Those who suffered from respiratory distress were compared to the second group, but this difference did not reach statistical significance.

The second part of the study included 41 children ages 6 to 8 years, 24 in the first group (born during gestational weeks 37–38+6) and 17 in the second group (born during gestational weeks 39–40+6). It was evident that respiratory function values, ​​mainly 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 and other data collected in questionnaires did not show a statistically significant difference.

By looking at the results of the first part of the research, we can see that the significant difference was mainly in APGAR minute 1, which is known as a 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. [17–19] This important information highlights the importance to strive for full-term delivery. Another issue we examined in the first part of our study was immediate respiratory distress and the need for oxygen support; in this part of the study, the results analysis was very borderline (*P* = 0.051) in the first group. To prove this statistically, perhaps we need a larger sample size.

After a broad and wide scan in the literature, we found that this research is the first to test the late morbidity in respiratory function according to week of birth in *term* children. Spirometry is considered the gold standard technique to measure lung function in children ≥6 years,[20] and this fact is further strengthened by the results we observed in the second part of our study, which showed a statistically significant difference between the two groups in the FEV1, FVC, and FEF values. The values favored group 2 (full term) compared to group 1 (early term), reflecting better 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.[21] Therefore, according to this fact, it is recommended to follow the recent guidelines and to schedule elective cesarean sections at week 39 and later.[15, 22]

One limitation of this study is the relatively small number of participants in the second part of our study. It also was not possible to perform this study with a blinded placebo control group.

In conclusion, it is known that a premature birth involves many newborn complications, both respiratory and other morbidities. Looking at the results of our study, we can show that even early-term children born during gestational weeks 37–38+6 had a higher risk for respiratory morbidity expressed in lower APGAR 1-minute scores, the need for primary resuscitation immediately after birth, and later on, a worse pulmonary function test compared to full-term children. Accordingly, we recommend that elective CSs be performed after 39 weeks’ gestation if there are no compelling medical reasons to perform them earlier.

Table 1- APGAR Score

|  |  |  |  |
| --- | --- | --- | --- |
| *P* value | Group 1 | Group 2 |  |
| 0.022 | 8.82±0.64 | 9.02±1.34 | APGAR 1 |
| 0.22 | 0.65±9.87 | 0.134±9.98 | APGAR 5 |
| 0.60 | 1.4±5.87 | 0.64±5.76 | Admission days |

Table 2

|  |  |  |  |
| --- | --- | --- | --- |
| *P* value | Group 1 | Group 2 |  |
| 0.358 | 30.69±5.99 | 29.63±5.7 | Mother’s age |
| 0.167 | 37.86±0.54 | 39.88±0.9 | Birth week |
| 0.000 | 3104.92±441.9 | 3502.45±463.7 | Birth weight |
| 0.175 | 2 3.2% | 0 0.0% | Need for intubation |
| 0.609 | 5.87±1.396 | 5.76±0.637 | Admission days |
| 0.027 | 8.8226±0.64 | 9.0179±0.133 | APGAR 1 |
| 0.222 | 9.8710±0.660 | 9.9821±0.133 | APGAR 5 |
| 0.051 | 4 6.6% | 0 0.0% | Need for oxygen  |
| 0.046 | 6 11.3% | 11 27.5% | Congenital anomaly |

Table 3

|  |  |  |  |
| --- | --- | --- | --- |
|  | Group 2 | Group 1 | *P* value |
| Mother’s age at birth | 5.7±29.6 | 5.9±30.69 | 0.358 |

|  |  |  |  |
| --- | --- | --- | --- |
| Birth Season | Group 2 | Group 1 | 0.63 |
| 1 (winter) | 18 | 22 |
| 2 (spring) | 15 | 11 |
| 3 (summer) | 16 | 17 |
| 4 (autumn) | 14 | 2 |

|  |  |  |  |
| --- | --- | --- | --- |
| Newborn Sex | Group 2 | Group 1 | 0.398 |
| 1 (male) | 31 | 29 |
| 2 (female) | 25 | 32 |

|  |  |  |  |
| --- | --- | --- | --- |
| Spontaneous Pregnancy/IVF | Group 2 | Group 1 | 0.835 |
| 1 (spontaneous) | 54 | 58 |
| 2 (IVF) | 1 | 3 |

Table 4

|  |  |  |
| --- | --- | --- |
|  | Pierson | *P* value |
| Respiratory distress | 1.838 | 0.5 |
| Oxygen need | 3.80 | 0.12 |

Table 5 - Respiratory Function Test Results

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

Table 6

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Group 2 | Group 1 | P0.067= |
| Passive smoking | (Yes) 1  | 11 | 9 |
| (No) 2 | 6 | 16 |
| Pets at home | (Yes) 1  | 3(17.6%) | 2(7.7%) | P0.39= |
| (No) 2 | 14(82%) | 24 (92%) |
| Chronic disease | (No) 1 | 41(74%) | 39(66%) | P0.325= |
| (Yes) 2  | 14(25.5%) | 20(33.9%) |
| Birth season | Winter | 18(34%) | 22(42%) | P0.631= |
|  | Spring | 15(28%) | 11(21.2%) |
|  | Summer | 16(30.2%) | 17(32.7%) |
|  | Autumn | 4(7.5%) | 2(3.8%) |
| Place of residence  | Urban  | 32(58.2%) | 35(57.4%) | P0.93= |
|  | Not Urban | 23(41.8%) | 26(42.6%) |

**References:**

1. Kamath BD et al. Neonatal outcomes after elective cesarean delivery. *Obstet Gynecol* 2009; **113**(6): 1231-1238.

2. Levine EM et al. Mode of delivery and risk of respiratory diseases in newborns*.* *Obstet Gynecol* 2001; **97**(3): 439-442.

3. Hibbard JU et al. Respiratory morbidity in late preterm births*.* *JAMA* 2010; **304**(4): 419-425.

4. ACOG Practice Bulletin No. 97: fetal lung maturity. *Obstet Gynecol* 2008; **112**(3): 717-726.

5. Boyle A, Reddy UM. Epidemiology of cesarean delivery: the scope of the problem. *Semin Perinatol* 2012; **36**(5): 308-314.

6. Nakashima J et al. Elective cesarean section at 37 weeks is associated with the higher risk of neonatal complications. *Tohoku J Exp Med* 2014; **233**(4): 243-248.

7. Kubi bar MK. *The annual meeting of the Israeli Society of Maternal Fetal Medicine, the international meeting in fetal medicine.* November 2011.

8. Branch DW, Silver RM. Managing the primary cesarean delivery rate. *Clin Obstet Gynecol* 2012; **55**(4): 946-960.

9. D'Souza R, Arulkumaran S. To 'C' or not to 'C'? Caesarean delivery upon maternal request: a review of facts, figures and guidelines. *J Perinat Med* 2013; **41**(1): 5-15.

10. Stjernholm YV, Petersson K, Eneroth E. Changed indications for cesarean sections. *Acta Obstet Gynecol Scand* 2010; **89**(1): 49-53.

11. Gregory KD et al. Changes in indications for cesarean delivery: United States, 1985 and 1994. *Am J Public Health* 1998; **88**(9): 1384-1387.

12. Souza JP et al. Caesarean section without medical indications is associated with an increased risk of adverse short-term maternal outcomes: the 2004-2008 WHO Global Survey on Maternal and Perinatal Health. *BMC Med* 2010; **8**: 71.

13. Wood NS et al. Neurologic and developmental disability after extremely preterm birth. EPICure Study Group. *N Engl J Med* 2000; **343**(6): 378-384.

14. Sengupta S et al. Adverse neonatal outcomes associated with early-term birth. *JAMA Pediatr* 2013; **167**(11): 1053-1059.

15. Tita AT et al. Timing of elective repeat cesarean delivery at term and maternal perioperative outcomes. *Obstet Gynecol* 2011; **117**(2 Pt 1): 280-286.

16. Nir V, Nadir E, Feldman M. Late better than early elective term cesarean section. *Acta Paediatr* 2012; **101**(10): 1054-1057.

17. The APGAR score. *Pediatrics* 2006; **117**(4): 1444-1447.

18. Ellis M et al. An APGAR score of three or less at one minute is not diagnostic of birth asphyxia but is a useful screening test for neonatal encephalopathy. *Indian Pediatr* 1998; **35**(5): 415-421.

19. Modabbernia A et al. APGAR score and risk of autism. *Eur J Epidemiol* 2019; **34**(2): 105-114.

20. Fainardi V, Lombardi E. Lung function tests to monitor respiratory disease in preschool children. *Acta Biomed* 2018; **89**(2): 148-156.

21. Schittny JC. Development of the lung. *Cell Tissue Res* 2017; **367**(3): 427-444.

22. ACOG Committee Opinion No. 386 November 2007: cesarean delivery on maternal request. *Obstet Gynecol* 2007; **110**(5): 1209-1212.