ORIGINAL ARTICLE

Neonatal outcomes following elective caesarean delivery at term: a hospital-based cohort study

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Abstract

Objective: To assess neonatal outcomes following elective caesarean delivery (CD) at term (≥37 + 0 weeks gestation).

Methods: A retrospective cohort study was conducted in a single Irish maternity hospital. Elective CDs at term between August 2008 and July 2012 were reviewed. Outcome measures were admission to the neonatal intensive care unit (NICU), length of stay, respiratory complications, hypoglycaemia, jaundice, newborn sepsis and medical interventions.

Results: A total of 4242 women had an elective CD at term, accounting for approximately 15% of all term deliveries. Admission rate to the NICU at 37 weeks gestation was 21.8% versus 10% at 39 weeks (p for trend <0.0001). Similar trends of decreasing risk with later gestational age were noted for the other outcomes. An increased odds of admission to the NICU at 37 weeks [adjusted odds ratio (OR) 2.48 (95% CI 1.28, 4.79)] and at 38 weeks [OR 1.34, 95% CI 1.02, 1.77] compared to the reference of 39 weeks gestation was found.

Conclusions: This study supports evidence that, with regard to neonatal outcome, 39 weeks gestational age is the optimal delivery time. Heightened awareness of the increased risk of neonatal morbidity, when delivery is performed electively before 39 weeks, is warranted among healthcare workers.

Keywords

Admission, intensive care, morbidity, newborn, respiratory

Introduction

Rates of elective caesarean delivery (CD) have increased in recent decades, despite their association with increased neonatal respiratory complications when compared with vaginal delivery [1–5]. The international gold standard for timing of elective CD is at 39 weeks gestational age [6,7]. This is based primarily on observational studies that have shown that delivery at earlier term gestational ages (37 + 0 to 38 + 6 weeks) is associated with increased infant mortality and morbidity, in particular respiratory morbidity and neonatal intensive care unit (NICU) admissions [8–14].

Respiratory complications secondary to transient tachypnoea of the newborn (TTN) or surfactant deficiency, accounts for the majority of NICU admissions in early term infants following elective CD [4,9]. Although respiratory distress is generally considered to be transient with full recovery without any long-term consequences, a small, but significant number of infants will progress to severe respiratory failure [15].

Increased rates of NICU admission result in increased financial costs and also, infant and mother separation within the first days of life. Elective CD at earlier term gestational age is associated with increased neonatal interventions, which may further increase both cost and parental anxiety [16]. Despite the increased risk of neonatal respiratory morbidity, NICU admissions, and the consequences associated with each, rates of elective CDs prior to 39 weeks have been shown to be as high as 50% [17]. The Royal College of Obstetricians and Gynaecologists (RCOG) advise maternal treatment with antenatal betamethasone for planned CDs prior to 39 weeks gestation, but this practice is not widespread [18].

The primary study objective was to assess neonatal outcome following elective CD at term (≥37 weeks gestation) within our population. In particular, rates of admission to the NICU, reasons for admission and medical interventions at each gestational age from 37 weeks onwards were studied.

Methods

Study design, data source and study population

A retrospective cohort analysis according to the Strengthening the reporting of observational studies in epidemiology (STROBE) guidelines of elective CD at term, and subsequent
neonatal admission in a tertiary maternity hospital in Ireland was conducted [19]. Approximately 8800 deliveries occur each year in Cork University Maternity Hospital (CUMH), with approximately 1200 admissions annually to the NICU. Two physicians reviewed all elective CDs over a 4-year period (August 2008–July 2012 inclusive), using theatre logbooks (which include indications for CD, and demographics for both mother and infant), and cross-checking with maternal medical files where necessary.

**Mode of delivery**

All planned CDs that took place at or greater than 37 + 0 weeks gestational age and in the absence of labour, were considered eligible for inclusion. Pregnancies that warranted early or immediate delivery due to maternal medical or obstetric complications were excluded. We also excluded multiple deliveries (twins or more) and all pregnancies that were complicated by foetal congenital abnormalities, or where delivery took place at an earlier date than planned due to foetal concerns, small for gestational age (SGA, <10th centile) or large for gestational age (LGA, >90th centile) on ultrasound, or abnormal umbilical artery flow on Doppler studies. A total of 4242 women with singleton elective CDs were eligible for inclusion in the analyses (Figure 1).

**Outcome definitions**

The following neonatal outcomes were studied: admission to NICU (ICU or high dependency admissions only); length of stay in NICU greater than 2 d; respiratory outcomes including TTN and respiratory distress syndrome (RDS); mechanical ventilation or continuous positive airway pressure (CPAP); hypoglycaemia; jaundice, newborn sepsis and an Apgar score <7 at 1 min. The primary outcome was a composite that included any of the above outcomes.

Newborn details were obtained from the NICU electronic record system where applicable. Two authors (D. F., A. C.) performed the data entry. TTN criteria were tachypnea within 2 h after birth and typical radiological findings. RDS was defined as typical radiological findings and oxygen therapy with a fraction of inspired oxygen (FI\textsubscript{O\textsubscript{2}}) of 0.4 or greater. Hypoglycaemia was defined as a blood glucose value less than 2.6 mmol per litre, and treatment with intravenous dextrose. Both clinically suspected sepsis (clinical signs and a raised CRP at 18 h), and blood culture positive sepsis were included in the definition for sepsis. Jaundice was defined as having a serum bilirubin requiring phototherapy treatment as per the NICE guidelines [20]. Medical interventions that took place within the neonatal unit (administration of antibiotics, intravenous fluids) were also recorded.

![Figure 1. Flow diagram of study participants.](image-url)
Covariate definitions

Details such as maternal age, public or private status, gestational age at delivery, indication for CD, birthweight and APGAR scores were extracted from the theatre logbooks. Gestational age within our hospital is determined based on standard criteria that take clinical history and findings from the first ultrasound examination at 11–14 weeks into account. If ultrasound findings are consistent with expected gestational age based on last menstrual period, gestational age is based on last menstrual period. If the date of the last menstrual period is unknown, or ultrasound findings are inconsistent with a gestational age based on last menstrual period, gestational age is calculated based on ultrasound findings.

Statistical analyses

First, baseline characteristics of the entire study cohort were analysed and presented as numbers (n) and percentages (%) or mean ± standard deviation (SD). Next, the risk of each adverse outcome was calculated using the Cochran–Armitage test for trend for the entire study cohort (N = 4242). Multiple logistic regression models which adjusted for previous CD, maternal age, gravidity, parity, history of placenta praevia, prior obstetric complications and private health insurance were performed to investigate the association between neonatal outcome and gestational age at delivery, relative to delivery at 39 completed weeks (reference group). All covariates were included in the logistic models as presented in Table 1.

Additional analyses

Sub-group analyses including only infants admitted to the NICU (N = 423) were repeated, and reported the risk as outlined previously. We also performed a sub-group analysis by infant sex (male, female). Data were analysed using SAS software©, version 9.2 (SAS Institute Inc., Cary, NC).

Results

Summary of study characteristics

Baseline characteristics of the 4242 women who had an elective CD at term are presented in Table 1. Among the women undergoing elective CD in this cohort, 1.3% were performed at 37 weeks gestation; 13.6% at 38 weeks gestation; 67.7% at 39 weeks and 17.4% at 40 weeks or later.
Thus, 14.9% of elective CDs were performed before 39 weeks of gestation. Characteristics varied according to gestational age at delivery. The most frequent indication for delivery across the different gestational ages was a prior CD (75.2%). Mean birthweight increased with later gestational age at delivery. A higher percentage of women who delivered at 37 or 38 weeks gestational age were over 35, had private health insurance, or were delivered for maternal health conditions even after adjustment for potential confounders, including previous CD, maternal age, gravidity, parity, placenta praevia, prior obstetric complications and private health insurance.

**Admission to NICU and length of stay**

Infants delivered at 37 weeks gestation were twice as likely to be admitted to the NICU [OR 2.48, 95% CI 1.28–4.79] and to have a length of stay greater than 2 d [OR 2.90, 95% CI 1.38–6.07], compared to infants delivered at 39 weeks (Table 3). Equally, infants born at 38 weeks gestation were at an increased risk of admission to the NICU [OR 1.34, 95% CI 1.02–1.77] and to a longer length of stay [OR 1.52, 95% CI 1.10–2.10].

**Respiratory outcomes, other outcomes and interventions received**

Infants born at 37 weeks were over three times more likely to experience any respiratory outcome [OR 3.27, 95% CI 1.55–6.93], and over twice as likely to suffer from other outcomes such as jaundice or sepsis [OR 2.83, 95% CI 1.17–6.85]. Infants born at 37 weeks were also at increased odds of receiving a medical intervention such as antibiotics [OR 2.96, 95% CI 1.22–7.94]. An increased odds of each outcome was over twice as likely in infants delivered at 38 weeks (Table 3). Infants delivered at 38 weeks were also at increased odds of each outcome was over twice as likely to suffer from other outcomes such as jaundice or sepsis [OR 2.83, 95% CI 1.17–6.85].

**Additional analyses**

**Risk of adverse neonatal outcome in NICU infants only (N = 423)**

The risk of each adverse outcome in the sub-group of infants admitted to the NICU (N = 423) followed a similar trend, with higher rates of each outcome in the earlier gestational ages (37 and 38 weeks), and declining at the later gestational ages. However, apart from the combined respiratory outcome measure which affected 75% of infants at 37 weeks gestation...
Sub-group analysis by infant sex, males only (N = 2134), females only (N = 2108)

In sub-group analyses, both males and females had a significantly increased risk of any adverse outcomes at 37 weeks gestation. However, this increased risk only persisted at 38 weeks for the male group (Tables S2 and S3).

Comment

Our retrospective cohort study reviewed the neonatal outcomes in 4242 elective CDs at term. Our main findings were that a high number of CDs occurred prior to 39 weeks gestational age, and admissions to the NICU were more frequent among those deliveries. Respiratory morbidity was the most common indication for admission, and a high proportion of admissions received medical treatment in the form of intravenous antibiotics or intravenous fluids.

Strengths and limitations

Our study further corroborates growing evidence that significantly increased neonatal morbidities are associated with delivery at earlier term gestational ages. While this finding is not new, it is important. High rates of CDs at early term gestational ages result in higher neonatal admissions, an increased burden on neonatology units and increased healthcare costs. A recent study emphasised the importance in evaluating local prevalence data in this area, to assist in the implementation of specific preventive measures and plans, as well as in prioritising limited health care resources [13]. Within the limitations of a cohort study, we adhered to the STROBE guidelines, and were strict with our inclusion/exclusion criteria. Therefore, our findings are generalisable to other neonatal units of our size and highlights the influence of gestational age on neonatal outcomes at term.

Limitations to the study include being reliant on the data input in theatre records. While these stated the cause for elective CD, they may not have always indicated when maternal or foetal factors led to delivery prior to the planned date. Second, our study design did not allow us to assess whether delaying delivery until 39 weeks resulted in increased rates of stillborn births. Also, we are unable to comment on non-elective CDs delayed until 39 weeks, and whether they resulted in increased neonatal morbidity when compared with elective CDs at earlier term gestational ages. Finally, as maternal chart reviews were not routinely included as part of our study, we are unable to comment on maternal outcomes, or adjust for race, smoking, or body mass index.

Interpretation

Timing of elective CD should take both maternal and infant outcomes into account. No reduction in maternal morbidity has been shown when elective CDs are performed at less than 37 weeks gestation [14]. The increased neonatal morbidity associated with elective CDs at 38 weeks gestation, suggests that this is a significant interval.

Grace et al. [15] compared the outcomes of elective CDs at 38, 39, 40, and 41 weeks, and found that elective CDs at 38 weeks resulted in the highest rates of NICU admissions, and also had a significant adverse impact on neonatal outcomes, compared to 39, 40, and 41 weeks.

In summary, our study adds to the growing body of evidence suggesting that elective CDs at 38 weeks gestation should be delayed until 39 weeks, to reduce the risk of adverse neonatal outcomes. Further research is required to determine the optimal timing for elective CDs, to achieve the best possible outcomes for both mother and infant.
39 weeks [16]. Furthermore, we know that infants born at these gestations are more likely to receive neonatal resuscitation, require admission to a neonatal unit, have respiratory distress syndrome, transient tachypnea, or pneumothorax [9,21–23]. Despite this, almost 15% of our elective sections took place prior to 39 weeks gestation. Among our cohort, we identified two groups who could be targeted to reduce this number. First, a higher number of women aged over 35 or who had private health insurance were delivered prior to 39 weeks, compared with other demographic groups. Second, repeat elective CDs accounted for a large proportion of our deliveries, which could be reduced by increasing vaginal births after CD (VBAC), as they have been shown to be a safe alternative to elective repeat CD [24,25].

Within our study, a significantly decreasing rate of NICU admissions was observed from 39 weeks gestation at CD. The risks of individual adverse neonatal outcomes were higher for deliveries at 37 weeks (by a factor of 1.33 to 4.64), and also at 38 weeks (by a factor of 1.11 to 1.84), relative to delivery at 39 weeks gestation. Tita et al. found similarly higher rates of adverse events at 37 weeks (1.8 to 4.2) and 38 weeks (1.3 to 2.1), when compared with delivery at 39 weeks in elective repeat CDs [9]. Similar to prior studies, respiratory morbidity accounted for the majority of NICU admissions. Unlike other studies our decreasing rates persisted at 40 weeks gestation, and then began to increase once 40 weeks gestation was completed. Incidences of secondary outcomes such as length of stay >2 d, hypoglycaemia and jaundice were also more common at lower gestational ages. A recent randomised control trial (RCT) by Glavind et al. displayed no significant difference in NICU admissions for infants delivered by elective CD at 38 weeks compared with those delivered at 39 weeks gestational age [26]. However, the authors have stated that elective CDs should continue to be scheduled at 39+ weeks of gestation, until further studies evaluate both the short term, and possibly long-term adverse effects of scheduling CDs at earlier term gestational ages [27].

A recent trial has highlighted how a single course of betamethasone prior to elective CD has shown to significantly decrease NICU admissions due to respiratory distress in term gestation CDs [28]. This practice has been advocated by the RCOG, if delivery cannot be delayed until after 39 weeks gestation [18]. However, the numbers that required treatment within this study were low, which is a probable confounder. Also, although the initial follow-up of the cohort displayed no side effects, the long-term adverse effects of antenatal steroids within this population have not been adequately researched [29]. It is not current practise within our maternity hospital to prescribe antenatal steroids prior to elective CD at term, and no such cases were documented in our cohort.

Among our cohort, significantly higher rates of intervention, with both intravenous antibiotics and intravenous fluids, were found in infants delivered at lower gestational ages. We found that among those infants admitted to the NICU, use of intravenous antibiotics was high among all infants. Of infants delivered at 39 weeks gestation, 40% who were admitted to NICU received intravenous antibiotics, despite known low rates of neonatal sepsis among infants delivered prior to the onset of spontaneous labour [30,31].

Conclusion
Our study supports evidence that 39 weeks gestational age is the optimal time for elective CDs with regard to neonatal outcomes. Efforts should be made to reduce rates of planned CDs at lower gestational ages. We would welcome further RCTs in this area, including the possible role of antenatal betamethasone for planned CDs at term.

Declaration of interest
E. M. D. and D. F. conceived and designed the study. D. F. and A. C. acquired the data. SMON analysed the data. D. F., S. M. O. N., A. S. K., K. O. D. and E. M. D. interpreted the data. D. F. drafted the article. D. F., S. M. O. N., A. C., A. S. K., K. O. D. and E. M. D. critically revised the article for important intellectual content. All authors agreed on the final article and approved its submission for publication. D. F. will act as guarantor for the article. The Corresponding Author has the right to grant on behalf of all authors and does grant on behalf of all authors, a worldwide licence to the Publishers and its licensees in perpetuity, in all forms, formats and media (whether known now or created in the future), to (i) publish, reproduce, distribute, display and store the Contribution, (ii) translate the Contribution into other languages, create adaptations, reprints, include within collections and create summaries, extracts and/or, abstracts of the Contribution, (iii) create any other derivative work(s) based on the Contribution, (iv) to exploit all subsidiary rights in the Contribution, (v) the inclusion of electronic links from the Contribution to third party material, where-ever it may be located; and (vi) licence any third party to do any or all of the above. This study was granted ethical approval by both Cork University Maternity Hospital and University College Cork Research Ethics Committees in November 2012. Eugene Dempsey is supported by Science Foundation Ireland. The authors declare no conflicts of interest.

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Supplementary material available online
Supplementary Tables S1–S3