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Neonatal Morbidity and Mortality After Elective Cesarean Delivery

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Abstract

As overall cesarean delivery rates have continued to rise, there has been growing interest in the rates of elective cesarean delivery (ECD), and its relative benefits and harms for the mother and neonate. This article explores the effects of elective cesarean delivery at term on neonatal morbidity and mortality. Available data are subject to a number of limitations, and do not provide conclusive evidence regarding the safety of planned elective cesarean versus planned vaginal delivery. Nevertheless, some data suggest an association between ECD and increased neonatal respiratory morbidity and lacerations, and possibly decreased central and peripheral nervous system injury. Potentially increased risks of neonatal mortality with ECD at term may be counterbalanced by risks of fetal demise in ongoing pregnancies. Patients and physicians considering ECD should carefully review competing risks and benefits; further research is needed to inform these discussions.

Keywords

cesarean delivery; elective; neonatal; morbidity; mortality; respiratory morbidity; injury

The cesarean delivery (CD) rate in the United States reached 30.2% in 2005, an all-time high¹. A number of factors are contributing to this rise: an increase in the rates of first-time, or primary CD, coupled with a decrease in rates of vaginal birth after cesarean, are felt to be major components. In addition to the growing numbers of elective repeat cesarean deliveries, there has been increasing attention given to elective cesarean delivery without medical or obstetric indications, which may be performed on maternal request. Clinicians and patients considering elective cesarean delivery (ECD) should undertake a thorough discussion of the risks and benefits of planned ECD versus planned vaginal delivery, related to both maternal and infant outcomes.

In this article, we will explore the effects of elective cesarean delivery on neonatal morbidity and mortality. Available data are subject to a number of limitations. There are no randomized trial data comparing outcomes among births from planned elective cesarean versus planned vaginal delivery in otherwise uncomplicated pregnancies; it's possible that such a trial can never be accomplished. Furthermore, it has been difficult to identify and report rates of elective cesarean deliveries in many observational studies because this procedure option may not be

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included in hospital coding systems, or among payers' reimbursable insurance claims. Thus, we focus primarily on available data on neonatal outcomes associated with cesarean delivery without labor, most commonly in the context of elective repeat cesarean and cesarean for breech, recognizing that data from these patient groups may not be fully generalizable to other types of elective CD, e.g. cesarean delivery on maternal request.

Perinatal and infant mortality

For more than 15 years, United States vital statistics data have indicated a 1.5-fold increased risk of neonatal mortality after cesarean delivery (both planned and unplanned) compared to vaginal delivery, though this has been assumed to be due to the greater proportion of high-risk pregnancies that are delivered operatively². Data more specific to elective cesarean delivery in uncomplicated pregnancies are conflicting. In a meta-analysis of 9 studies including more than 33,000 women, Mozurkewich and colleagues reported a significant increase in intrapartum and neonatal deaths among term, non-malformed infants who underwent a trial of labor, compared to those who underwent elective repeat cesarean delivery (OR 2.05, 95% CI 1.17 – 3.57)³. A recent U.S. population-based study of neonatal and infant mortality by mode of delivery among women with “no indicated risk,” however, showed that neonatal mortality was increased more than two-fold after birth by cesarean, even after excluding infants with congenital anomalies and presumed intrapartum hypoxic events (Apgar score < 4) and adjusting for demographic and medical covariates². In these studies and others, the reported rates of neonatal death after elective repeat or “no indicated risk” cesareans are low, ranging from 0.01 – 0.17%^{2–5}.

When considering the risk of neonatal death after elective cesarean delivery, one should also give consideration to the competing risk of fetal demise in an ongoing pregnancy. Multiple investigators have reported an increase in unexplained intrauterine fetal demise rates that begins near term and continues with advancing gestation^{6–8}. Smith⁹ calculated the cumulative probability of antepartum stillbirth as 0.08% at 38 weeks gestation, rising to 0.34% at 41 weeks' gestation.

In an attempt to reconcile the competing risks of neonatal death after elective cesarean at term and antepartum stillbirth in ongoing term pregnancies, we¹⁰ conducted a decision analysis, modeling the probability of perinatal death among a hypothetical cohort of 2,000,000 women with uncomplicated pregnancies at 39 weeks, half of whom underwent elective cesarean delivery, and half who were managed expectantly. After taking multiple chance probabilities into account, the model estimated that while neonatal deaths were increased among women delivered by elective cesarean, overall perinatal mortality was increased among women managed expectantly, because of the ongoing risk of fetal death in pregnancies that continue beyond 39 weeks. Of note, it was estimated that 1,441 elective cesarean deliveries would need to be performed to prevent one perinatal death (Table 1). In a separate analysis, Hankins and colleagues reached a similar conclusion⁷.

Though this type of modeling is subject to limitations^{10–13}, it is clear that elective delivery —by cesarean or induction of labor, for that matter—of a healthy fetus at 39 weeks by accurate dating essentially eliminates the risk of future *in utero* fetal demise. Three important caveats should be stated, however. First, the results of these analyses should not be taken as an impetus for elective delivery before 39 weeks. Neonatal deaths increase with each week of decreasing gestational age, such that by 37 weeks, the association between elective cesarean delivery and reduced perinatal mortality appears to be lost¹⁰, and perinatal deaths may be expected to increase with surgical intervention (Figure 1). Thus, clinicians should adhere to American College of Obstetricians and Gynecologists' (ACOG) practice guidelines for confirming gestational age (or lung maturity) before elective delivery¹⁴.

Second, these analyses assume that a liveborn infant whose impending stillbirth was prevented by ECD at 39 weeks would have the same risk of neonatal mortality as an infant who would not have died *in utero* if managed expectantly. This assumption may not hold in reality, as a fetal condition that may predispose to stillbirth at 40 weeks may similarly predispose to neonatal death after a “rescue” delivery at 39 weeks.

Third, calculation of a “number needed to treat” as above, assumes a causal relationship between exposure—in this case, mode of delivery—and outcome. This assumption may also be contested; existing observational data do not warrant the conclusion that the association between ECD and perinatal death (or other outcomes considered here) is causal. Similarly, one should keep in mind that it is *delivery* of an infant that prevents future stillbirth, not *elective cesarean delivery* per se.

Respiratory morbidity

Though characterized by varying definitions and methodologies, a consistent body of evidence indicates that infants delivered by elective cesarean experience higher rates of respiratory morbidity than infants delivered vaginally^{15,16}. In term infants, respiratory difficulty is most often manifested as transient tachypnea of the newborn (TTN), though more serious disorders, such as respiratory distress syndrome (RDS) and persistent pulmonary hypertension (PPH) do occur^{17,18}. In a cohort study of more than 33,000 births between 37 and 42 weeks, infants delivered by prelabor cesarean (N=2341) were nearly 7 times more likely to develop respiratory morbidity (RDS or TTN) than infants delivered vaginally (3.6% versus 0.5%, OR 6.8, 95% CI 5.2 – 8.9)¹⁹. In this and other studies^{20–22}, the risk of respiratory morbidity in term infants is decreased with advancing gestational age. Hansen, et al.²⁰ recently showed that infants delivered by elective cesarean at 37 weeks had a 10% incidence of respiratory morbidity (defined as TTN, RDS, or PPH), compared to 2.8% among infants delivered vaginally (OR 3.7, 95% CI 2.2 – 6.1). By 40 weeks, the rate of respiratory morbidity with elective cesarean decreased to 1.5%, and was no longer significantly different from the rate seen with vaginal deliveries. Of note, even among term infants, respiratory difficulty associated with elective cesarean can be serious. In the Hansen study, 1.9% of infants delivered by ECD at 37 weeks experienced serious respiratory morbidity, defined as that requiring treatment for ≥ 3 days with continuous oxygen, nasal continuous positive airway pressure, or any period of mechanical ventilation²⁰.

Proposed mechanisms for the association between cesarean delivery and respiratory morbidity include iatrogenic prematurity with surfactant deficiency^{18,23}, and an attenuation of the fetal catecholamine surge during labor^{24,25}. Some^{19,26}, but not all^{27,28} authors report a decrease in respiratory morbidity if cesarean delivery is performed after the onset of labor. This has prompted some authors to recommend deferral of elective cesarean delivery until after the onset of spontaneous labor²⁹.

As mentioned earlier, ACOG practice guidelines specify that without biochemical assessment of fetal lung maturity, elective delivery should not be undertaken prior to 39 weeks gestation by strict criteria¹⁴. This recommendation was affirmed by an expert panel conducting the recent NICHD State of the Science Conference on Cesarean Delivery on Maternal Request³⁰. Of interest, a recent British randomized trial showed that a single course of antenatal corticosteroids prior to elective cesarean delivery at 37 weeks or later significantly decreased special care nursery admissions for respiratory distress (2.4% versus 5.1%, $P=0.021$, RR 0.46, 95% CI 0.23 – 0.93)³¹. The treatment effect was particularly pronounced at 37 – 38 weeks, but even with treatment, respiratory distress was substantially more common at these gestational ages than at ≥ 39 weeks. Again, delaying elective cesarean delivery until 39 weeks or later decreases rates of newborn respiratory distress, but steroids may be helpful in

preventing respiratory complications in the fetus at 37 or 38 weeks who has a non-immediate indication for prelabor cesarean delivery.

Neonatal asphyxia or encephalopathy and permanent neurologic injury

Early advocates for elective cesarean delivery proposed that these “atraumatic” deliveries would decrease the risk for intrapartum neurologic injury and cerebral palsy³². Neonatal encephalopathy is a clinical syndrome of abnormal neurologic function in late preterm and term infants characterized by altered level of consciousness, abnormal muscular tone and reflexes, respiratory difficulty, and/or seizure activity³³. An infant with neonatal encephalopathy may or may not develop permanent neurologic impairment, such as cerebral palsy. Despite consistently rising cesarean delivery rates over the last three decades, cerebral palsy rates in term (≥ 2500 gram) infants have not decreased³⁴, supporting the now widely-held premise that a small minority of cases (approximately 10%) of encephalopathy and cerebral palsy in these infants are related to intrapartum hypoxic events and are thus amenable to prevention by altering route of delivery^{35,36}. On the other hand, in at least some cases, ECD at 39 weeks would be expected to preempt an unpredictable catastrophic obstetric event (e.g. acute placental abruption at 40 weeks) that might result in permanent neurological injury.

Data addressing the impact of route of delivery on immediate and long-term neurological outcome are sparse and conflicting. Badawi and colleagues³⁷ conducted a case-control study of 164 term infants with moderate to severe newborn encephalopathy and 400 randomly selected control infants and found a lower risk of encephalopathy in infants delivered by elective cesarean (defined as cesarean planned at least 24 hours prior to surgery) than in those delivered via spontaneous vaginal delivery (OR 0.17, 95% CI 0.05 – 0.56). On the other hand, Towner, et al.³⁸ found higher rates of convulsions and central nervous system (CNS) depression among infants weighing 2500 – 4000 grams delivered by cesarean without labor than in infants delivered spontaneously, though the difference was only significant for CNS depression (OR 2.2). A limitation of this study is that the “cesarean without labor” group likely included pregnancies with precarious maternal or fetal status, which would confound the relationship between mode of delivery and neonatal neurological outcome¹⁶. Another consideration is that the vaginal delivery comparison groups in both studies consisted of *actual* spontaneous births, not all births from *planned* vaginal delivery, some of which would have been vacuum, forceps, and cesarean deliveries during labor. In both the Badawi and Towner papers, rates of neonatal neurologic abnormalities were significantly higher in those delivered by operative vaginal delivery (OR 2.3 – 6.9) and cesarean during labor (OR 2.2 – 10.8) as compared to spontaneous vaginal delivery^{37,38}. If elective cesarean prevents cerebral palsy, given that the U.S. rate of cerebral palsy is 2 to 3 per thousand, and that 10% of cases arise intrapartum, approximately 3000 to 5000 elective cesarean deliveries would need to be performed to prevent 1 case of cerebral palsy related to labor events^{10,32,39}.

Intracranial Hemorrhage

Mode of delivery may be expected to influence rates of intracranial bleeding in neonates, i.e. subdural or cerebral, intraventricular, and subarachnoid hemorrhage. Towner and colleagues³⁸ conducted a large, population based retrospective review of more than 583,000 births of 2500 – 4000 gram infants to nulliparous women in California, and found a combined rate of intracranial hemorrhage of 0.4% among operative vaginal deliveries, 0.1% in cesarean with labor, 0.05% in spontaneous vaginal deliveries, and 0.05% in cesarean deliveries without labor. While risk was significantly increased for operative vaginal delivery and cesarean during labor, there was no significant difference in the risk of intracranial hemorrhage between women who underwent prelabor cesarean and those who had a spontaneous vaginal delivery. These data suggest that intracranial hemorrhage may be related to underlying abnormalities of labor, as

operative vaginal deliveries and labored cesarean deliveries are often undertaken because of dysfunctional labor.

Suspected and confirmed neonatal sepsis

Suspected neonatal infection is a major reason for admissions to neonatal intensive care units and invasive procedures in infants. Infection and inflammation have been linked to higher rates of cerebral palsy^{40,41}. There are scant data comparing rates of suspected and confirmed neonatal sepsis in infants delivered by elective cesarean and by planned vaginal delivery. Hook and colleagues⁴² compared infectious outcomes among 497 women undergoing elective repeat cesarean delivery and 492 who attempted vaginal birth after cesarean (VBAC). Rates of both suspected and confirmed neonatal sepsis were significantly lower in the elective repeat cesarean group (2% versus 5%, $P < 0.05$ for suspected sepsis, and 0% versus 1% $P < 0.05$ for proven sepsis). The rate of suspected sepsis was 12% in neonates born after a failed trial of labor, compared to 2% after a successful VBAC ($P < 0.0001$). Based on these data, a decision analytic model estimated that evaluations for suspected neonatal sepsis would be decreased with a policy of elective cesarean delivery at term, but that 76 elective cesarean deliveries would need to be performed to prevent 1 confirmed case of neonatal sepsis¹⁰.

Brachial plexus injury

Shoulder dystocia leading to brachial plexus injury remains a feared complication of attempted vaginal delivery. Shoulder dystocia remains notoriously difficult to predict, despite identification of risk factors such as maternal diabetes, maternal obesity, and fetal macrosomia. A number of studies have examined the potential benefit of prophylactic cesarean delivery for preventing brachial plexus injury to the suspected macrosomic fetus^{43–46}, but there is little data regarding the impact of elective cesarean delivery on the rate of brachial plexus injury in non-macrosomic infants. One large population-based study in California examined rates of brachial plexus injuries by mode of delivery in infants weighing 2500 – 4000g and found that, compared to spontaneous vaginal deliveries, brachial plexus injuries were significantly less common in cesarean deliveries (0.03% vs. 0.08%, OR 0.4, 95% CI 0.3 – 0.5) and significantly more common in operative vaginal deliveries (0.5% vs. 0.08%, OR 6.0, 95% CI 3.3 – 10.7)³⁸. Brachial plexus injury occurred in 0.04% of cesarean deliveries without labor; this rate was not significantly different from that of spontaneous vaginal deliveries (0.08%, OR 0.5, 95% CI 0.3 – 1.0)³⁸.

Fetal lacerations

That infants delivered by cesarean would be at risk for laceration from sharp instruments is intuitive, and has been borne out in published reports. Fetal laceration occurs in 0.1 – 3.1% of cesarean deliveries^{47,47–52}. The risk of fetal laceration is greater during emergent (5.3%) and unscheduled labored cesarean deliveries (1.8%) than in elective cesareans without labor (1.0%)^{47,52}. Other risk factors for fetal laceration at cesarean are abnormal presentation^{49,50} and rupture of membranes⁵². Though moderate to severe injuries requiring plastic surgical repair have been reported, lacerations that occur during elective cesarean are usually mild and rarely require treatment beyond application of sterile strips^{47,52}.

Other outcomes

There are limited data examining other outcomes that may be influenced by elective cesarean delivery. A number of authors have expressed concern that cesarean delivery, by separating mother and infant after birth, may negatively impact bonding and early initiation of breastfeeding⁵³. In the Term Breech Trial, 77% of women randomized to planned vaginal delivery and 73% randomized to planned cesarean initiated breastfeeding “within a few hours”

of delivery ($P=0.05$)⁵⁴. The median duration of breastfeeding was 8 months in both groups⁵⁵.

Another area of interest has been the “hygiene hypothesis,” i.e. an alteration in microbial colonization of neonates who are not exposed to vaginal flora during delivery, which may affect postnatal maturation of T cells and predispose to illnesses later in childhood⁵⁶. A number of investigators have reported associations between cesarean delivery and childhood asthma^{57–59}, but these findings have not been replicated in other studies^{60–62}.

Summary

Increasing cesarean delivery rates in the U.S. and worldwide are of intense interest and public health importance. Elective repeat cesarean delivery rates have been increasing steadily since the late 1990's, and there may be a growing trend in cesarean delivery on maternal request. There are insufficient data on which to base conclusions regarding rates of neonatal morbidity and mortality between planned elective cesarean and planned vaginal delivery. Nevertheless, existing data suggests that elective cesarean delivery is associated with greater risk of neonatal respiratory morbidity and fetal laceration, and potentially decreased risk of brachial plexus injury, neonatal sepsis, intracranial hemorrhage, intrapartum asphyxia, and neonatal encephalopathy. Though neonatal deaths may be increased among infants delivered via elective cesarean, overall perinatal mortality may be reduced due to prevention of antepartum stillbirths. To minimize potential neonatal risks of elective cesarean, these deliveries should not be undertaken prior to 39 weeks gestation. Patients considering elective cesarean delivery should be made aware of available data on potential risks and benefits to the fetus and neonate. Further research is needed to inform these discussions.

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Figure 1. Estimated perinatal deaths associated with elective cesarean delivery versus expectant management, by gestational age

Perinatal mortality increases for both modes of delivery as gestational age decreases below 39 weeks. At 37 weeks' gestation, more perinatal deaths would be expected with elective cesarean delivery than with expectant management.

Adapted from Signore C, Hemachandra A, Klebanoff M. Neonatal mortality and morbidity after elective cesarean delivery versus routine expectant management: a decision analysis. *Semin Perinatol.* 2006;30:288–295, with permission.

Table 1

Results of decision analyses comparing outcomes among 1 million elective cesarean deliveries and 1 million planned vaginal deliveries: Estimated neonatal morbidity and mortality by management strategy

	Elective Cesarean Delivery at 39w	Expectant Management	# of Cesarean Deliveries Needed to Prevent One Case*
Perinatal Deaths	804	1496	1441
Stillbirths	0	1118	
Neonatal Deaths	804	378	
Respiratory Morbidity (TTN and RDS)	11,000	2524	
Intracranial Hemorrhage	490	1007	1934
Brachial Plexus Injury	410	787	2653
PPH	3700	1488	
Suspected Sepsis	20,000	33,211	76
Confirmed Sepsis	0	2635	380
Laceration	8000	2464	

Numbers shown are number of cases per million deliveries. TTN, transient tachypnea of the newborn; RDS, respiratory distress syndrome; PPH, persistent pulmonary hypertension

* Results shown only for those outcomes estimated to occur more frequently with expectant management.

Adapted from Signore C, Hemachandra A, Klebanoff M. Neonatal mortality and morbidity after elective cesarean delivery versus routine expectant management: a decision analysis. *Semin Perinatol.* 2006;30:288–295.