Consequences of a Primary Elective Cesarean Delivery Across the Reproductive Life

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OBJECTIVE: To estimate cumulative risks of morbidity associated with the choice of elective cesarean delivery for a first delivery.

METHODS: A decision analytic model was designed to compare major adverse outcomes across a woman's reproductive life associated with the choice of elective cesarean delivery compared with a trial of labor at a first delivery. Maternal outcomes assessed included maternal transfusion, hysterectomy, thromboembolism, operative injury, and death. Neonatal outcomes assessed included cerebral palsy and permanent brachial plexus palsy in the offspring.

RESULTS: Choosing an initial cesarean delivery resulted in a 0.3% increased risk of a major adverse maternal outcome in the first pregnancy. In each subsequent pregnancy, the difference in composite maternal morbidity increased such that by the fourth pregnancy, the cumulative risk of a major adverse maternal outcome was nearly 10% in the elective primary cesarean delivery group, three times higher than women who initially underwent a trial of labor. Although the choice of an initial cesarean delivery resulted in 2.4 and 0.41 fewer cases of cerebral palsy and brachial plexus palsy, respectively, per 10,000 women in the first pregnancy, by a fourth pregnancy, the risk of a adverse neonatal outcome was higher among offspring of women who had chosen the initial elective cesarean delivery (0.368% compared with 0.363%).

CONCLUSION: Maternal morbidity associated with the choice of primary elective cesarean delivery increases in each subsequent pregnancy and is greater in magnitude than that associated with the choice of a trial of labor. These increased risks are not offset by a substantive reduction in the risk of neonatal morbidity.

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Over the past decades, the frequency of cesarean delivery has risen dramatically.[1] This increase is multifactorial and the result of trends in the frequency of both repeat and primary cesarean deliveries. The most rapidly increasing indication for primary cesarean delivery is maternal request, which has doubled over the past decade.[2]

There is a paucity of data regarding the reasons a woman may request a primary cesarean delivery. Fear of childbirth and its associated morbidity have been cited as prominent contributing factors toward such a request.[3] These concerns have been supported by some experts, who have suggested that a planned cesarean delivery is less morbid than a trial of labor when weighing in the rates of an unplanned cesarean delivery.[4–6] In contrast, others believe that the morbidity related to a trial of labor is unfounded, and in some health care systems, programs have been developed to mitigate this concern and support the choice of a trial of labor.[7] A recent National Institutes of Health consensus conference could not determine that one route was clearly more preferred based on available evidence.[8] The lack of consensus has translated to a shifting attitude toward the approach to delivery with more patients having cesarean delivery for maternal request.[9]

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One of the limitations of the available data is its focus on short-term outcomes related only to the initial pregnancy. However, the decision about route of delivery in one pregnancy has ramifications through subsequent pregnancies given the increased morbidity associated with multiple abdominal surgeries and uterine scars. Yet the comparative morbidity across multiple pregnancies related to the initial approach to delivery remains uncertain. A properly powered observational study that would provide such data would require many thousands of women given the relatively low frequency of adverse events that occur with either delivery approach. The logistic difficulty of this makes such an observational study unlikely to be performed. Thus, we designed a decision analysis to provide a framework for understanding the risks over the reproductive lifespan associated with either trial of labor or elective cesarean delivery for an initial delivery.

MATERIALS AND METHODS

A decision analytic model was designed to compare maternal and neonatal morbidity incurred as a consequence of the two different approaches a nulliparous woman could use at her first delivery: trial of labor or elective cesarean delivery. This model included women at term with a singleton gestation in the vertex presentation and no contraindication (eg, placenta previa) to a trial of labor. This model evaluated five maternal obstetric complications that can be ascertained at or near the time of delivery (transfusion, operative injury to the bowel or bladder, deep venous thrombosis, hysterectomy, and death) as well as the neonatal outcomes of cerebral palsy and permanent brachial plexus palsy.

When estimating the morbidity related to a woman's approach to her first delivery, it is important to consider the entirety of her reproductive life given that the initial approach to delivery has ramifications for health outcomes over time. For example, a woman who has chosen an elective cesarean delivery in her first pregnancy likely will forego a trial of labor after a cesarean delivery and continue to have additional cesarean deliveries in subsequent pregnancies. Such a choice, then, affects the probabilities of placenta previa, placenta accrete, or both, which themselves affect the probability of other major complications.[10–12] The majority (67%) of American women will experience at least two deliveries and up to 15% will have four or more pregnancies.[13,14] Thus, this model incorporated not only the index pregnancy, but subsequent pregnancies, and predicated probabilities of events based on prior obstetric history.

In this model, all women who chose a cesarean delivery initially or who had a cesarean delivery after attempting a trial of labor chose to have repeat cesarean deliveries in future pregnancies. This modeling decision was made to avoid confounding of the initial approach-to-delivery decision with consequences related to a trial of labor after cesarean delivery and also because it is likely that a woman who chooses an elective cesarean delivery for a first delivery will not choose a trial of labor after cesarean delivery. Conversely, women who chose a trial of labor initially and had a vaginal delivery continued to choose a trial of labor in subsequent pregnancies unless a contraindication to labor (such as a malpresentation or a placenta previa) occurred. In such a case, they underwent an indicated cesarean delivery.

Probabilities of events, stratified by route of delivery and by parity, were determined from available literature (Table 1). If multiple estimates were available for a particular parameter, a mean was derived weighted by the sample size that served as the basis for the estimate and then used as a baseline result for the model. Ranges used in sensitivity analyses were determined by the lowest and highest values for a given estimate found in the literature. If only one source for an estimate was available, the range was determined according to the 95% confidence interval determined with the binomial proportions method.

In addition to estimation of the individual maternal morbidities, a composite maternal morbidity outcome, which included the occurrence of one of the five individual maternal morbidities, was determined. A woman was considered to have this composite outcome if she experienced any one of the individual morbidities. Also, to determine the frequency of each individual morbidity, a hierarchy was used such that the categorization of the complication was determined by the morbidity considered most significant. In this hierarchy, complications were ranked from least to most morbid as follows: transfusion, operative injury, deep venous thrombosis, hysterectomy, and death.

The probability of cerebral palsy, related to a trial of labor, was predicated on the estimate that cerebral palsy occurs in approximately one per 1,000 births with 4–30% of these cases related to an intrapartum event.[48] Thus, cesarean delivery would reduce this risk. However, having a placenta previa is associated with an earlier gestational age at delivery.[20] Insofar as cesarean delivery increases the risk of a placenta previa, women with one or more cesarean deliveries are more likely to deliver prematurely as a result of vaginal bleeding with the attendant increased probability

Table 1. Probability Estimates

Variable	Base-Case Estimate	Range	Reference
Probability of cesarean delivery after trial of labor in 1st pregnancy	22	10–35	15, 16
Probability of vaginal delivery in subsequent pregnancies	96.7	92–98	17, 18
Probability of placenta previa			
Prior vaginal delivery	0.25	0.1–0.4	10, 11
Prior cesarean deliveries			
1	0.80	0.6–1.3	10–12
2	1.00	0.7–1.8	10–12
3	2.30	2.0–3.0	10, 12
Probability of accreta with no previa			
Prior vaginal delivery	0.0015	0.001–0.005	19
Prior cesarean deliveries			
1	0.300	0.2–0.4	12
2	0.600	0.4–0.8	12
3	2.100	1.8–2.4	12
Probability of accreta with previa			
Prior vaginal delivery	3.00	1–5	19, 20
Prior cesarean deliveries			
1	11.70	11–24	10, 12, 20
2	40.50	39–47	10, 12, 20
3	58.90	40–61	10, 12, 20
Probability of delivery without a previa (wk)			
RR of deep vein thrombosis before 28 wk of gestation	0.60	—	21
28–31 6/7	0.99	—	21
32–36 6/7	8.86	—	21
37–41 6/7	83.87	—	21
42 or more	5.69	—	21
Probability of delivery with a previa (wk)			
RR of deep vein thrombosis before 28 wk of gestation	0.98	—	20
28–31 6/7	14.88	—	20
32–36 6/7	47.19	—	20
37–41 6/7	34.67	—	20
42 or more	0.98	—	20
Maternal morbidity			
At vaginal delivery (no previa, no accreta)			
Probability of transfusion	0.22	0.15–1.0	22, 23
Probability of deep vein thrombosis	0.03	0.03–0.10	22, 24, 25
Probability of hysterectomy	0.03	0.01–0.09	26–29
Probability of maternal death	0.004	0.003–0.005	30
At elective cesarean delivery (compared with vaginal delivery)			
RR of transfusion	2.6	1–4	22, 23
RR of deep vein thrombosis	3	2–5	22, 24, 25
RR of operative injury	0.10	0.06–0.34	12
RR of hysterectomy	2	1.5–5	26, 27, 29
RR of maternal death	2	1–3	30, 31
At cesarean delivery in labor (compared with elective cesarean delivery)			
RR of transfusion	2	1–3	22, 24
RR of deep vein thrombosis	1.5	1–1.7	22, 32
RR of operative injury	1	1–1.5	18, 22
RR of hysterectomy	3	2–5	26, 27
RR of maternal death	1.5	1–3	31, 33

(*continued*)

Table 1. Probability Estimates (*continued*)

Variable	Base-Case Estimate	Range	Reference
At cesarean delivery, with previa, no accreta (compared with elective cesarean delivery if prior cesarean delivery or cesarean delivery in labor if prior vaginal delivery)			
RR of transfusion	13	10–16	20
RR of deep vein thrombosis	2	1–3.6	34, 35
RR of operating room injury	1	1–1.5	20
RR of hysterectomy	28	11–33	36, 37
RR of maternal death	2	1–3	20, 38
With an accreta (relative to previa)			
RR of transfusion	4.6	1.5–6.6	39–41
RR of deep vein thrombosis	1	1–1.5	20
RR of operating room injury	33	18–45	42, 43
RR of hysterectomy	15	10–19	37, 44
RR of maternal death	40	20–100	45–47
Neonatal morbidity			
Probability of cerebral palsy related to intrapartum even	16.0	4.0–30.0	48
Probability of cerebral palsy by gestational age (wk)			
RR of deep vein thrombosis before 28 wk of gestation	7.572	5.129–10.693	49
28–31 6/7	6.677	5.177–8.442	49
32–36 6/7	0.920	0.718–1.162	49
37–41 6/7	0.149	0.129–0.171	49
42 or more	0.447	0.295–0.649	49
Probability of brachial plexus palsy by route of delivery			
Vaginal delivery	0.0517	0.047–0.120	50–52
Cesarean delivery	0.095	0.060–0.130	50–52
Probability of permanent neurologic injury if brachial plexus palsy occurs	11.3	6.8–22.2	53–55

RR, relative risk.
Data are % unless otherwise specified.

of cerebral palsy than women without a prior cesarean delivery. Using published distributions of gestational age at delivery with and without a previa as well as gestational age-based risks of cerebral palsy, the risk of cerebral palsy attributed to prematurity was calculated.[20,21,49] Similarly, the frequency of brachial plexus palsy at vaginal delivery and of subsequent permanent palsy were obtained from the existing literature.[50–55] These probabilities were assumed to be independent of parity.

Maternal and perinatal morbidity were compared per pregnancy as well as over a woman's reproductive life based on the initial choice of approach to delivery. One-way sensitivity analyses were performed to determine which, if any, variables altered the results. Best and worst case scenarios also were determined by varying all probabilities simultaneously to the values that favored either the trial of labor or elective cesarean delivery approach. This decision tree model was constructed using Tree Plan 1.61. This study was exempt from institutional review board approval.

RESULTS

Under baseline estimates, individual maternal morbidities and the composite outcome in the first pregnancy are more frequent in women who undergo an elective primary cesarean delivery (Table 2). However, this difference in the frequency of either an individual or composite adverse outcome is small. Table 2 also illustrates the frequency of individual and composite complications for women in each pregnancy successive to the first. As more pregnancies are undertaken, the difference in risk of maternal morbidity between those who chose an elective primary cesarean delivery and those who chose a trial of labor widens.

Table 3 summarizes the risk in each pregnancy of composite maternal morbidity associated with the choice of elective primary cesarean delivery as well as the cumulative risk according to the total number of pregnancies a woman has had. By the time a woman has had four pregnancies, her cumulative chance of obstetric morbidity has increased to nearly 10% as compared with 3.5% if she initially had chosen a trial of labor.

Table 2. Probability of Maternal Morbidity in Each Pregnancy Based on Initial Approach to Delivery

	Elective Cesarean Delivery in First Pregnancy				Trial of Labor in First Pregnancy			
	1st Pregnancy	2nd Pregnancy	3rd Pregnancy	4th Pregnancy	1st Pregnancy	2nd Pregnancy	3rd Pregnancy	4th Pregnancy
Transfusion	0.572	0.756	1.129	2.886	0.405	0.397	0.497	0.888
Hysterectomy	0.060	0.187	0.615	2.551	0.060	0.083	0.181	0.599
Deep vein thrombosis	0.090	0.091	0.092	0.097	0.051	0.047	0.049	0.053
Operative injury	0.100	0.104	0.122	0.204	0.020	0.025	0.033	0.054
Death	0.008	0.009	0.015	0.039	0.006	0.005	0.007	0.012
Composite	0.830	1.148	1.973	5.777	0.541	0.558	0.768	1.606

Data are %.

With regard to neonatal outcomes, cerebral palsy and brachial plexus palsy were less common with an elective cesarean delivery in the first pregnancy compared with a trial of labor (Table 4) and the cumulative composite neonatal morbidity remains smaller in women undergoing a primary elective cesarean delivery (Table 5). However, the differences in individual pregnancy risk are progressively attenuated as additional pregnancies occur, and by the fourth pregnancy, there is actually a marginal increase in the frequency of cerebral palsy and the composite neonatal morbidity outcome among women who chose an elective primary cesarean delivery in their first pregnancy (Table 5).

The trend in the frequency of the maternal outcomes remains throughout univariable sensitivity analysis. In addition, even when estimates are simultaneously varied to values that favor trial of labor or elective cesarean delivery, the results remain similar (Table 6). For example, when estimates are varied to values that favor elective cesarean delivery, the composite maternal risks remain greater among women who had an elective primary cesarean delivery, but the difference between the two approaches to delivery narrows. Conversely, when model inputs are changed to the probabilities that favor a trial of labor, the difference in composite maternal complication rates between the elective primary cesarean delivery and the trial of labor approach widens. For neonatal outcomes, when estimates are simultaneously varied to values that minimize the risks associated with vaginal delivery, cumulative adverse neonatal outcomes are more frequent with elective cesarean delivery by the third pregnancy. Conversely, when estimates of neonatal morbidity are simultaneously varied to values that favor elective cesarean delivery, the maximum absolute risk increase for either cerebral palsy or permanent brachial plexus palsy in any one pregnancy associated with a trial of labor strategy is 0.095%.

DISCUSSION

This decision analysis reveals the extent to which the initial choice of approach to delivery has consequences throughout a woman's reproductive life. Specifically, women who choose to undergo primary elective cesarean delivery incur greater risks of maternal morbidity and mortality. The difference in attributable risk is small in an initial pregnancy but widens in each pregnancy such that by the fourth pregnancy, the cumulative risk of the composite adverse outcome is nearly 10% in the baseline model and as high as 37% using

Table 3. Probability of Composite Maternal Morbidity per Pregnancy Based on Initial Approach to Delivery

	1st Pregnancy	2nd Pregnancy	3rd Pregnancy	4th Pregnancy	Cumulative Risk
If 2 pregnancies					
Elective cesarean delivery	0.830	1.148			1.978
Trial of labor	0.541	0.558			1.099
If 3 pregnancies					
Elective cesarean delivery	0.830	1.148	1.973		3.951
Trial of labor	0.541	0.558	0.768		1.867
If 4 pregnancies					
Elective cesarean delivery	0.830	1.148	1.973	5.777	9.728
Trial of labor	0.541	0.558	0.768	1.606	3.473

Data are %.

Table 4. Probability of Neonatal Morbidity in Each Pregnancy Based on Initial Approach to Delivery

	Elective Cesarean Delivery in First Pregnancy				Trial of Labor in First Pregnancy			
	1st Pregnancy	2nd Pregnancy	3rd Pregnancy	4th Pregnancy	1st Pregnancy	2nd Pregnancy	3rd Pregnancy	4th Pregnancy
Cerebral palsy	0.1250	0.3060	0.3110	0.3670	0.1490	0.3500%	0.3500	0.3570
Permanent brachial palsy	0.0006	0.0006	0.0006	0.0006	0.0047	0.0057	0.0057	0.0057
Composite	0.1256	0.3066	0.3116	0.3676	0.1537	0.3537	0.3557	0.3627

Data are %.

the input estimates that favor trial of labor. This risk increase is not only the result of the greater risks of operative complications, but also the consequences of placenta previa and accreta. The probability of these placentation disorders not only increases with each additional cesarean delivery, but when they do occur, the probability of a complication increases markedly. Moreover, this model demonstrates that elective first cesarean delivery may allow one to avoid the infrequent intrapartum neonatal events that occur during trials of labor and that may be associated with long-term neurodevelopmental impairment. However, the initial choice of cesarean delivery results in additional placenta previas. The associated emergent deliveries and preterm births are associated with perinatal risks. Thus, although the cumulative neonatal risks are marginally decreased in the primary elective cesarean delivery group, for an individual pregnancy, the marginal benefit is progressively attenuated and ultimately negated by the time of the fourth pregnancy.

One outcome of this study was maternal morbidity experienced at the time of a delivery. This outcome was chosen both because of its importance as well as the availability of reasonable estimates for the probability of its occurrence. However, there may be other maternal factors that women incorporate into the decision-making process. For example, some women may wish to avoid vaginal birth given the concern about future pelvic floor disorders. Although a potentially important consideration, good data with regard to the marginal difference in long-term incontinence from route of delivery are lacking.[8,56,57] Nevertheless, even if all maternal outcomes cannot be quantified, those that can be derived from the data that do exist should be available to women and their health care providers.

Neonatal outcomes chosen included those known to be affected by route of delivery. Insofar as elective cesarean delivery is often scheduled at 39 weeks of gestation, some have suggested that stillbirth rates could be reduced by using a strategy of elective cesarean delivery.[58] Elective cesarean delivery at 39 weeks at gestation would, indeed, reduce the incremental increase in stillbirth associated with expectant management of pregnancy after this point. However, elective induction of labor at 39 weeks of gestation offers a similar reduction in rates of stillbirth. Thus, stillbirth is not intrinsically related to route of delivery

Table 5. Probability of Composite Neonatal Morbidity per Pregnancy and Cumulative Morbidity Based on Initial Approach to Delivery and Number of Pregnancies

	1st Pregnancy	2nd Pregnancy	3rd Pregnancy	4th Pregnancy	Cumulative Risk
If 1 pregnancy					
Elective cesarean delivery	0.126				0.126
Trial of labor	0.154				0.154
If 2 pregnancies					
Elective cesarean delivery	0.126	0.307			0.433
Trial of labor	0.154	0.354			0.843
If 3 pregnancies					
Elective cesarean delivery	0.126	0.307	0.312		0.745
Trial of labor	0.154	0.354	0.356		1.365
If 4 pregnancies					
Elective cesarean delivery	0.126	0.307	0.312	0.368	1.113
Trial of labor	0.154	0.354	0.356	0.363	1.894

Data are %.

Table 6. Results of Best-Case and Worst-Case Sensitivity Analysis

	1st Pregnancy	2nd Pregnancy	3rd Pregnancy	4th Pregnancy	Cumulative Risk
Composite maternal morbidity					
Minimized risks of cesarean delivery					
Elective cesarean delivery	5.300	6.980	8.005	16.939	37.224
Trial of labor	2.640	2.030	2.312	3.275	10.257
Maximized risks of cesarean delivery					
Elective cesarean delivery	0.563	0.568	0.705	2.007	3.843
Trial of labor	0.329	0.341	0.414	0.909	1.993
Composite neonatal morbidity					
Minimized neonatal risks associated with labor					
Elective cesarean delivery	0.164	0.439	0.446	0.527	1.577
Trial of labor	0.171	0.442	0.443	0.451	1.507
Maximized neonatal risks associated with labor					
Elective cesarean delivery	0.098	0.209	0.212	0.248	0.766
Trial of labor	0.150	0.304	0.304	0.310	1.068

Data are %.

but rather timing of delivery, and as such, it was not included as an outcome in this decision analysis. Given its infrequency, even if it were included, the general trends and conclusions would be unlikely to be affected.

Limitations of this study are those inherent in any decision analysis. The majority of published data regarding complications at the time of delivery is from referral centers. These referral centers may have higher-risk parturients or may have different complication frequencies even for patients with similar risk. The estimates used, therefore, may not be generalizable to all centers. To compensate for uncertainties in the estimates available in the literature, wide ranges of probabilities were used in sensitivity analysis to assess whether our results were dependent on our initial assumptions. Our confidence in our conclusions is buttressed by the results from this sensitivity analysis, which revealed a robust model with relatively stable results.

As the National Institute of Child Health and Human Development has stated, there has not been sufficient information from clinical studies to counsel women about which approach to the first delivery is clearly better. One piece of data that is lacking is the cumulative ramifications of the initial choice. Decision analytic models are one method to provide insight when observational studies or randomized trials have not been or cannot be done. Our analysis cannot determine that one approach is "better" than another, particularly because some outcomes (eg, incontinence) remain poorly characterized and because such a determination would need to include preferences accorded to different routes of delivery by women. Nevertheless, this analysis can provide information that may be helpful in counseling and emphasizes that although an initial cesarean delivery may result in only a marginally increased risk of maternal morbidity and a marginally decreased neonatal risk compared with a trial of labor, the difference in maternal morbidity throughout reproductive life become increasingly larger, whereas the difference in perinatal outcomes becomes increasingly smaller.

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