Delivery strategies for women with a previous classic cesarean delivery: A decision analysis

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OBJECTIVE: The purpose of this study was to compare four strategies for treating patients with a previous classic cesarean delivery by medical outcomes and quality-adjusted life years.

STUDY DESIGN: A decision tree was designed that compared four strategies for a hypothetical cohort of 10,000 women with a previous classic cesarean delivery: (1) delivery at 39 weeks of gestation, (2) delivery at 36 weeks of gestation without amniocentesis, (3) amniocentesis at 36 weeks of gestation with delivery if the fetus was mature and antenatal corticosteroids if the fetus was immature, and (4) weekly amniocentesis starting at 36 weeks of gestation with delivery when mature.

RESULTS: Strategy 2 provided the greatest maternal quality-adjusted life years. Comparing strategy 1 with strategy 2, it was determined that 27 cesarean deliveries must be performed at 36 weeks of gestation with one associated case of respiratory distress syndrome to prevent one case of uterine rupture. Sensitivity analysis revealed that the uterine rupture rate must be below 0.36% for any strategy to surpass strategy 2 (elective cesarean delivery at 36 weeks of gestation without amniocentesis).

CONCLUSION: A 36-week delivery may be preferable because it provides a lower risk of severe adverse outcomes and higher maternal quality of life. (Am J Obstet Gynecol 2002;187:1203-8.)

Key words: Classic cesarean delivery, uterine rupture, decision analysis

Classic cesarean delivery, in which the active segment of the uterus is vertically incised, is performed for a variety of indications. Women with a previous classic cesarean delivery scar have a higher risk of uterine rupture compared with women with low transverse incisions in subsequent pregnancies.[1] Even if elective repeat cesarean delivery is planned, uterine rupture can occur before the onset of labor and lead to perinatal and maternal morbidity and death.

Obstetricians generally agree that women with a previous classic cesarean delivery should not be offered a trial of labor.[2] Many clinicians choose to deliver such patients (by elective repeat cesarean delivery) before 39 weeks of gestation to reduce the risk of spontaneous uterine rupture. However, early delivery may lead to complications of prematurity for the neonate, including a small risk of respiratory distress syndrome (RDS). Clinicians disagree over whether to perform amniocentesis if early delivery is planned and whether to give corticosteroids if lung maturity is negative. A prospective, randomized trial is unlikely to be feasible, given the relatively small number of patients with a classic uterine scar and the low rates of associated complications. In this setting, a decision analysis can aid clinical decision making and can enhance our understanding of the relationship between the competing risks of uterine rupture versus RDS in the neonate.

Decision analysis begins with the development of a model, the decision tree, which is a representation of the clinical question at hand. The tree captures the various clinical strategies and their associated outcomes. The outcomes can be considered simply as clinical outcomes and reported as a number needed to treat or a ratio between one outcome and another. The outcomes can be compared more easily if each outcome is converted into a preference score (utility). The utilities are multiplied by the amount of time expected in the given state and summed along with the rest of the years of life that are expected in a discounted fashion to give quality-adjusted life years (QALYs).[3] The model is then applied to a theoretic population with the probabilities that are found in the existing literature. The probabilities that are used in the tree can then be varied with sensitivity analysis to test the validity or robustness of the model. Even if solid data do not exist for a given probability (for example, the risk of uterine rupture before labor), sensitivity analysis allows the model to test probabilities over a wide range of possible values. Threshold analysis can be used to determine

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Presented at the Twenty-second Annual Meeting of the Society for Maternal-Fetal Medicine, New Orleans, La, January 14-19, 2002.

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0002-9378/2002 $35.00 + 0 ***6/6/127123***

doi:10.1067/mob.2002.127123

Table I. Probabilities used in the model

Outcome	*P value*	*Reference*
RDS rate at 36 wk	.033	10
RDS rate at 37 wk	.004	10
RDS rate at 38 wk	.004	10
RDS rate at 39 wk	.003	10
Uterine rupture at 36-39 wk	.037	1, 4
Maternal death after uterine rupture	.01	11
Hysterectomy after uterine rupture	.044	4
Infant death after uterine rupture	.31	11
Infant CP after uterine rupture	.05	11
FLM+ at 36 wk	.817	12
FLM– at 36 wk	.183	12
RDS at 36 wk with FLM–	.15	10, 12
Infant RDS after corticosteroids	.075	13
UR during 48 h	.0035	2/7 of weekly rupture rate
Infant RDS, if FLM+ at 36 wk	.006	10, 12
UR at >1 wk	.0123	1/3 of rate over 36-39 wk
FLM+ at 37 wk	.8366	10, 12
FLM- at 37 wk	.1634	10, 12
Infant RDS, if FLM+ at 37 wk	.0007	10, 12
Infant no RDS, if FLM+ at 37 wk	.9993	10, 12
Infant RDS, if FLM-	.0208	10, 12
FLM+ at 38 wk	.8366	10, 12
FLM– at 38 wk	.1634	10, 12
Infant RDS, if FLM+ at 38 wk	.0007	10, 12
Infant no RDS, if FLM+ at 38 wk	.9993	10, 12
RDS at 37 wk and FLM–	.0208	10, 12
Sensitivity of FLM testing	.85	12
Specificity of FLM testing	.84	12

+, positive; –, negative. *FLM,* Fetal lung maturity.

Table II. Utilities used in the model

Outcome	*Utility*	*Duration of effect*	*Reference*
Maternal death	0	NA	NA
Hysterectomy	0.96	1 y	14
Infant death	0.00-0.86	1 y	5, 8, 15
Infant CP	0.21-0.81	50 y	5, 8
Infant RDS at 36 wk	0.81-0.99	4 wk	5, 8
Infant RDS at 37 wk	0.81-0.99	3 wk	5, 8
Infant RDS at 38 wk	0.81-0.99	2 wk	5, 8
Infant RDS at 39 wk	0.81-0.99	1 wk	5, 8

NA, Not applicable.

Table III. Total QALYs by strategy

Strategy	*Description*	*Total QALYs*
1	39-Wk delivery	26.0925
2	36-Wk delivery, no amniocentesis	26.1128
3	36-Wk amniocentesis, corticosteroids	26.1129
4	Serial amniocentesis	26.1114

the rates of complications at which two different strategies become equal. The purpose of our study was to use decision analysis to examine the question of how best to treat a patient with a previous classic cesarean delivery.

Material and methods

Using DATA 3.5 software (TreeAge Software, Inc, Williamstown, Mass), we designed a model that compares four delivery strategies for women with a previous classic cesarean delivery scar (Figs 1 and 2). Strategy 1 is elective cesarean delivery at 39 weeks of gestation. Strategy 2 is elective cesarean delivery at 36 weeks of gestation, without assessment of fetal lung maturity. Strategy 3 is amniocentesis at 36 weeks of gestation, with steroids given if lung maturity is negative and delivery within 48 hours. Strategy 4 is amniocentesis at 36 weeks of gestation, with amniocentesis repeated weekly and cesarean delivery performed when lung maturity is positive or when 39 weeks of gestation is achieved, whichever comes first.

The perspective of the analysis was that of the pregnant woman. A hypothetic cohort of 10,000 women at 36 weeks of gestation was examined to determine maternal and infant outcomes from the four strategies. Outcomes that were considered in the model were death, hysterectomy, and no major morbidity for the mother and death, cerebral palsy (CP), RDS, and no major morbidity for the infant. We assumed that all women were delivered by cesarean delivery. We did not consider the baseline risks that are associated with elective cesarean delivery because these are equal regardless of strategy. Rather, we compared the risks that are associated with each of the four strategies and beyond baseline risks. For the same reason, we did not consider the risk of uterine rupture before 36 weeks of gestation.

MEDLINE and EMBASE searches were performed to obtain probability estimates for each of the outcomes in the decision tree (Table I). The search was restricted to English-language articles. For risks of uterine rupture, we used the keywords *uterine rupture, cesarean delivery, classic cesarean delivery,* and *repeat cesarean delivery.* The reference lists of the retrieved articles and textbook chapters were also hand searched. The base case estimates were chosen on the basis of the quality of the studies and the applicability of the data to our hypothetic patient cohort. When a range of values was found, the ranges were tested in sensitivity analyses. When no published value was found for a given probability, the value was modeled on the basis of other data. For example, we could not find a value in the literature for the risk of uterine rupture before labor, with a previous classic hysterotomy. The uterine rupture rate in the literature (12%)[1] was for patients who underwent a trial of labor. We took this value and risk adjusted it with the ratio between the risk of uterine rupture before labor to that in labor for patients with a previous low transverse cesarean delivery.[4] When 12% is multiplied by this ratio, the result is 3.7%, which was our base case estimate for the uterine rupture rate. We assumed a uniform weekly rupture rate between 36 and 39 weeks of gestation.

Table IV. Perinatal outcomes per 10,000 women

Strategy	*Description*	*RDS*	*CP*	*Fetal/infant death*	*Hysterectomy*	*Maternal death*
1	39-Wk delivery	32	19	115	16	4
2	36-Wk delivery	330	0*	0*	0*	0*
3	Lung maturity testing with corticosteroids	229	<1	2	<1	<1
4	Serial lung maturity testing	53	1	8	1	<1

*The difference above the background rate of these complications, not that we would expect zero rates.

Table V. Sensitivity analyses: range

Outcome	*P value (range)*	*Source*
Uterine rupture (before labor)	.037 (.0016-.18)	Lower rate: rate with low transverse cesarean section not in labor[4]; upper rate[16]
Maternal death after uterine rupture	.01 (0-.042)	Lower rate[4]; upper rate[17]
Hysterectomy after uterine rupture	.044 (0-.19)	Lower rate: authors' estimate; upper rate[11]
Infant death after uterine rupture	.31 (.055-.6)	Lower rate[4]; upper rate: double the base rate
Infant CP after uterine rupture	.05 (.01-.16)	Lower rate: Authors' estimate; upper rate[18]
Infant RDS after corticosteroids	.075 (.015-.15)	Lower rate: assumes 90% efficacy; upper rate: assumes zero efficacy

The ranges of values that are shown were all tested in the model; strategy 2 produced the highest number of QALYs over the full range for all probabilities listed above.

Maternal utilities for the various outcomes were determined on the basis of the literature (Table II). Base-case estimates for utilities were based on a study of maternal preferences for prenatal diagnosis.[5] The utilities combined maternal preferences for both maternal and fetal/infant outcomes. QALYs were calculated for each terminal branch based on the life expectancy of a 30-year-old woman in labor[6]; a discount rate of 3% was applied (Table III).

Results

Strategy 1, elective cesarean delivery at 39 weeks of gestation, leads to the highest number of fetal deaths and CP cases and to the lowest number of RDS cases. Strategy 2, elective cesarean delivery at 36 weeks of gestation without amniocentesis, has the highest number of RDS cases but no other associated adverse outcomes (Table IV). In a comparison of strategy 1 with strategy 2, it was determined that 27 cesarean deliveries must be performed at 36 weeks of gestation with one associated case of RDS to prevent one case of uterine rupture. The strategy that provides the highest quality-adjusted life expectancy was determined by "rolling back" the tree. Using the base case estimates, strategy 2, or elective cesarean delivery at 36 weeks of gestation without amniocentesis is the optimal strategy.

One-way sensitivity analysis was performed for key probabilities (Table V). Whether considering quality-adjusted life expectancy or the occurrence of major complications, strategy 2 remained the optimal strategy. Threshold analysis was performed to determine how low the uterine rupture rate would have to be for any strategy to surpass strategy 2. The incidence of uterine rupture over the 3-week period between 36 and 39 weeks of gestation would have to be <0.36% for strategy 3 (amniocentesis with antenatal steroids if fetal lung maturity is negative) to surpass strategy 2. This is more than a 10-fold reduction compared with our base case estimate of 3.7%. We also performed a threshold analysis for the efficacy of antenatal corticosteroids, and strategy 2 remained the optimal strategy over a wide range of values.

Comment

Our model suggests that early delivery (at 36 weeks of gestation) is preferable to strategies that delay delivery to ensure fetal lung maturity. Although rare, the catastrophic outcomes that are associated with uterine rupture tip the balance toward favoring early delivery. Complications of prematurity after 36 weeks of gestation are generally thought to be minor and transient; therefore, although complications of prematurity are more frequent than uterine rupture, they are not nearly as detrimental to maternal quality of life. Thus, in our model, we saw no benefit of offering fetal lung maturity testing because it would lead, in cases of negative results, to further expectant management in a risky situation.

The gold standard to address a clinical controversy is a randomized, controlled trial. Because of the small number of patients with a classic uterine scar and the even smaller number of uterine ruptures, tens of thousands of patients would have to be randomized to have adequate power to determine the best strategy. Decision analysis is not intended to replace randomized controlled trials; however, when none are available, it can provide insight to clinical conundrums. Our model is intended to aid clinicians in understanding the relative risks and benefits

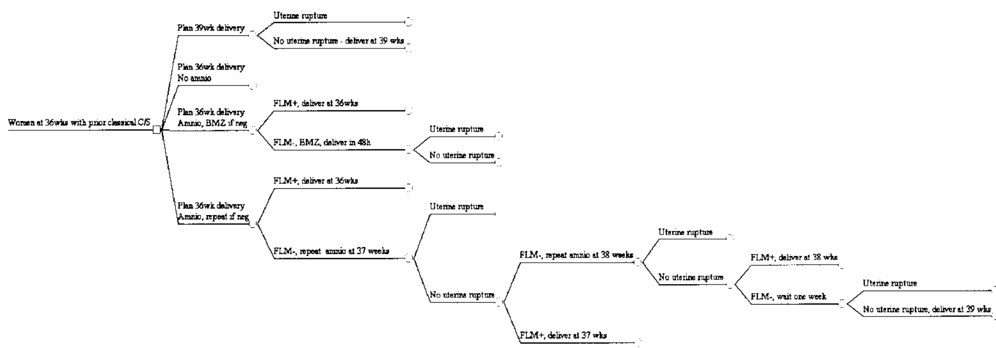

Fig 1. Decision tree: delivery strategies for women with a previous classic cesarean delivery. Please see Fig 2 for outcomes that are related to uterine rupture. *Amnio,* Amniocentesis; *wk,* gestational age in weeks; *C/S,* cesarean delivery; *BMZ,* betamethasone; *FLM,* fetal lung maturity.

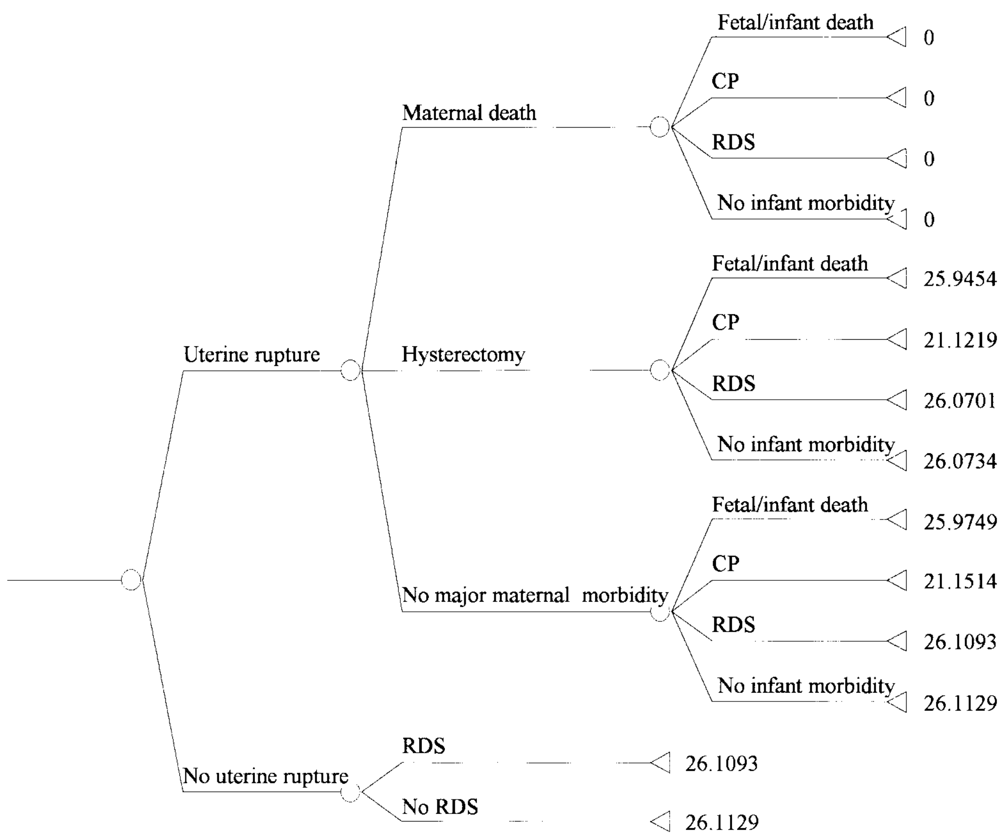

Fig 2. Decision tree: outcomes from uterine rupture. The numbers at the end of each branch are the QALYs that were calculated for each outcome.

of the various strategies. Although there is uncertainty associated with the results of any decision analysis, this model strongly suggests that a strategy of elective delivery at 39 weeks of gestation (strategy 1) for women with a previous classic cesarean delivery is not optimal with regard to maternal and fetal outcomes.

In our model, the "optimal" strategy is determined on the basis of maternal QALYs. Some readers may be dubious about the validity of such a measure. The difference in QALYs between the four strategies is extremely small, and one might also question whether it is significant, given the uncertainty in our data input. However, another test of a decision model is its "robustness," how much the best strategy varies when different probabilities are tested by sensitivity analysis. Our model was "robust" over a wide range of possible values for our key data input, with strategy 2 remaining optimal throughout. Also, Table IV allows comparison of the four strategies by clinical outcomes for a hypothetic cohort of 10,000 women, regardless of maternal QALYs. Strategy 2 actually leads to the highest number of RDS cases but has the least number of major adverse outcomes in each category, because this strategy carries no risk of uterine rupture (after 36 weeks of gestation). Strategy 1, waiting until 39 weeks of gestation to deliver, leads to the lowest number of RDS cases, but this strategy also has the highest number of CP cases, infant deaths, and maternal deaths. Outcomes from RDS vary by region and type of hospital.[7] If RDS at 36 weeks of gestation at a given institution is known to be associated with serious morbidity and/or mortality rates, clinicians and patients may be willing to take on the risks of uterine rupture to avoid RDS-related sequelae. If, however, RDS at 36 weeks of gestation is felt to be a minor and transient morbidity, then it is difficult to argue the benefit of delaying delivery beyond 36 weeks of gestation, with the associated risk of catastrophic uterine rupture.

We found no data for maternal utilities in the United States for outcomes such as infant death, CP, and RDS. Therefore, we used data from a study on maternal preferences for prenatal diagnosis.[5] This study was performed in a racially diverse group of women in California. The preferences that were measured were for second-trimester losses and for infants with Down syndrome, not for infant death at term and CP. Although we used the Down syndrome utility value for CP and RDS as a general value for having a "sick infant," we modified the length of time that this utility is applied to the mother's life. The decreased quality of life from having an infant with RDS was only applied for a few weeks, whereas the affects of having a child with CP lasted for the mother's entire future life span. We found only one study, from the Netherlands, that actually measured maternal utilities for perinatal outcomes, such as infant death at term.[8] As a sensitivity analysis, we reanalyzed the model with the Dutch data on maternal preferences; strategy 2 remained the optimal strategy. More research is needed on maternal preferences for perinatal outcomes in the United States.

We did not examine all of the possible delivery strategies for patients with a previous classic cesarean delivery. We did not include strategies such as elective cesarean delivery before 36 weeks of gestation or trial of labor because we found no recommendations in the literature that discussed such options. We did not include strategies for delivery at 37 or 38 weeks of gestation. However, even the 48-hour delay in delivery in strategy 3 with the few associated uterine ruptures was enough to make it marginally less favorable than strategy 2. Therefore, it is likely that a strategy of 37-week delivery would also be less favorable by leading to a higher rate of uterine rupture compared with 36-week delivery (strategy 2). Also, for simplicity, we did not account for the small risks that were associated with amniocentesis, which include the need for emergency delivery, and consequent RDS if lung maturity has not been achieved.[9] Accounting for these risks would only bolster our conclusion, which supports a strategy of no amniocentesis. We also did not consider a strategy of expectant management in the hospital on continuous monitoring. Although this would avoid much of the risk of uterine rupture before labor, it may not be a cost-effective alternative.

Another limitation is the poor quality and quantity of data for the risk of uterine rupture in patients with a previous classic cesarean delivery. The uterine rupture rate for such women who did not undergo a trial of labor has been studied poorly. However, our threshold analysis revealed that the uterine rupture rate (between 36 and 39 weeks of gestation) would have to be as low as 0.4% for any strategy to surpass strategy 2. If a clinician believes that the risk of uterine rupture between 36 and 39 weeks of gestation in a patient with a classic scar is less than approximately one half of a percent, then the optimal treatment scheme is strategy 3 (amniocentesis at 36 weeks of gestation, with antenatal steroids if fetal lung maturity is negative).

It is important to note that the differences (in both outcomes and QALYs) between strategies 2, 3, and 4 are slight. Patient preference becomes especially important when little medical evidence exists to support one strategy over another. Although our study incorporated some data on maternal preferences, there are no data on patient preferences for these specific strategies. Patients with a previous classic cesarean delivery frequently had a difficult experience with their first delivery, having had either an emergency or preterm cesarean delivery, and the anxiety that is associated with waiting for amniocentesis results can be substantial. Ultimately, the clinician should consider the preferences of the individual patient when choosing a strategy.

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