

# Predicting Uterine Rupture in Women Undergoing Trial of Labor After Prior Cesarean Delivery

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Uterine rupture is the most serious complication for women undergoing trial of labor (TOL) after prior cesarean delivery. While rates of uterine rupture vary significantly according to a variety of clinically associated risk factors, the absolute risk for this complication ranges between 0.5 and 4 percent. Previous vaginal delivery and prior successful vaginal birth after cesarean delivery confer the lowest risk of rupture on women attempting TOL. In contrast, multiple prior cesareans, short interpregnancy interval, single layer uterine closure, prior preterm cesarean, labor induction and augmentation have all been suggested in some studies as factors which may increase the rate of uterine rupture. While considering these risk factors is important in counseling women regarding childbirth following cesarean delivery, the infrequency of uterine rupture coupled with relatively weak associations for most risk factors has prevented the development of an accurate prediction tool for uterine rupture. Preliminary studies suggest that sonographic evaluation of the uterine scar may hold some promise for identifying women at risk.

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Catastrophic uterine rupture is the most dreaded complication for women attempting vaginal delivery after previous cesarean section (VBAC). It is important to distinguish uterine rupture from uterine scar dehiscence. Dehiscence most often represents an occult scar separation with intact uterine serosa and thus does not represent a risk for fetal or maternal sequelae. In contrast, uterine rupture is a complete separation of all uterine layers with potential consequences of hemorrhage and umbilical cord compression leading to fetal and maternal compromise. Varying terminology and definitions used as well as ascertainment bias all have contributed to difficulty estimating risks of uterine rupture from the VBAC literature.<sup>1</sup> A review of 10 observational studies providing the best evidence on the rate of symptomatic rupture in women undergoing trial of labor (TOL) revealed rates ranging from 0/1000 in a small study to 7.8/1000 in the largest study cited.<sup>1</sup> The Maternal Fetal Medicine Units (MFMU) Network Study reported a 0.69% incidence with 124 symptomatic ruptures occurring in nearly 18,000

women undergoing TOL.<sup>2</sup> In this study, all cases of uterine rupture underwent central review to assure accuracy of the diagnosis.

## Risk Factors for Uterine Rupture

Rates of uterine rupture have been reported to vary significantly according to a variety of associated risk factors.<sup>3</sup> Understanding that previous classical and T incisions significantly increase the risk for uterine rupture, this review will consider reported risks as well as prediction of uterine rupture in women undergoing TOL with a previous low transverse incision. Characteristics of the obstetrical history, including number of previous Cesareans, previous vaginal delivery, including previous VBAC, previous preterm cesarean, interdelivery interval, and uterine closure technique, have all been reported to affect the risk of uterine rupture. Factors related to labor management, including induction and the use of oxytocin augmentation, have been studied as well.

## Previous Vaginal Delivery

Previous vaginal delivery has been consistently reported to be protective against uterine rupture in women undergoing TOL. Zelop and colleagues<sup>4</sup> reported a rupture rate of 0.2%

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(2/1021) in women with a previous vaginal birth attempting VBAC compared with 1.1% (30/2762) among women with no previous vaginal deliveries. Controlling for demographic differences and labor characteristics revealed that women with previous vaginal delivery had a rate of uterine rupture that was one-fifth that of women without previous vaginal birth (odds ratio [OR] 0.2%, 95% confidence interval [95% CI] 0.04-0.8). Both the large multicenter studies of Macones (OR 0.38%, 95% CI 0.23-0.62) and Landon (OR 0.66%, 95% CI 0.45-0.95) have confirmed the protective effect of previous vaginal birth on the risk for subsequent uterine rupture.<sup>2,5</sup>

## Number of Previous Cesarean Deliveries

A large single-center study of more than 1000 women undergoing TOL after multiple previous cesareans revealed a uterine rupture rate of 1.7% in women with 2 or more previous cesareans compared with 0.6% in those with a single previous operation (OR 3.06, 95% CI 1.95-4.79).<sup>6</sup> In this report, women with 3 or more previous cesareans did not have an increased risk for rupture compared with women with only 2 previous cesareans. A smaller study encompassing 12 years of 134 women with 2 previous cesareans which controlled for labor characteristics reported a uterine rupture rate of 3.7% in these women compared with 0.8% in women with a single previous cesarean (OR 4.5%, 95% CI 1.18-11.5).<sup>7</sup> These data led ACOG in 2004 to recommend that a TOL of women with 2 previous cesarean deliveries be limited to those with a history of a successful VBAC or previous vaginal delivery.<sup>8</sup> Following these recommendations, Macones and colleagues<sup>9</sup> reported a uterine rupture rate of 20/1082 (1.8%) in women with 2 previous cesareans compared with 113/12,535 (0.9%) in women with 1 previous operation (adjusted OR 2.3%, 95% CI 1.37-3.85). In a subsequent case-control analysis, these authors<sup>5</sup> reported that 2 previous cesareans was not associated with an increased risk for uterine rupture (OR 1.46%, 95% CI 0.87-2.44). The MFMU Cesarean Registry also found no difference in rupture rates in women with multiple previous cesarean (9/975%, 0.9%) compared with women with a single previous cesarean (115/16,916%, 0.7%).<sup>3</sup> In this study, the rate of uterine rupture 5/497 (1%) in women with multiple previous cesarean and a history of successful previous vaginal birth was not significantly different from the rate of 4/470 (0.85%) in those with no previous vaginal delivery. It follows that if multiple previous cesarean is associated with an increased risk for uterine rupture, the magnitude of additional risk is small enough to allow TOL as an option for informed women.

## Interpregnancy Interval

A short interpregnancy interval has been hypothesized to be associated with incomplete healing of the uterine scar and thus an increased risk for uterine rupture. Shipp and co-workers<sup>10</sup> reported a rupture rate of 2.3% (7/311) in women

with an interdelivery interval of less than 18 months compared with 1.1% (22/2098) with a longer interdelivery interval. In contrast, Huang and colleagues<sup>11</sup> found no increased rate of uterine rupture in women attempting VBAC with a less than 18 month interdelivery interval. Controlling for possible confounders, Bujold and colleagues<sup>12</sup> noted an interdelivery interval of less than 24 months to be associated with a 2.8% rupture rate compared with 0.9% in women undergoing TOL more than 24 months since their previous cesarean section. In the MFMU report, the risk for rupture was 1.1% in those women attempting TOL less than 24 months from their previous cesarean, which represented a 2-fold increased risk. Stamilio and colleagues<sup>13</sup> have also confirmed an increased rupture rate when the interpregnancy interval is less than 6 months. In their study, the rupture rate was 2.7% in such cases compared with 0.9% with a longer interpregnancy interval.

## Uterine Closure Technique

In recent years, a single-layer uterine closure technique has gained popularity because it is associated with a shorter operating time with similar short-term complications compared with the traditional 2-layer myometrial closure. In a retrospective study of 292 women undergoing TOL, similar rates of uterine rupture were found for women regardless of the previous uterine closure technique used.<sup>14</sup> A small randomized trial of 145 women who received 1- or 2-layer closure at the time of primary cesarean revealed no cases of rupture in the subsequent delivery.<sup>15</sup> However, this trial was clearly underpowered to detect potential differences in uterine rupture. In a large observational cohort study of nearly 3000 women in which detailed operative report review was accomplished, a nearly 4-fold increased risk for uterine rupture after single-layer closure was evident compared with a double-layer closure.<sup>16</sup> The rate of rupture was 15/1489 (3.1%) with single layer closure versus 8/1491 (0.5%) with previous double layer closure. Durnwald and Mercer<sup>17</sup> found that 182 women with single-layer closure did not have an increased rate of uterine rupture; however, the rate of dehiscence at subsequent delivery was increased. In the absence of an adequately sized prospective trial concerning this issue, it remains unclear whether single-layer closure increases the risk for uterine rupture.

## Previous Preterm Cesarean Delivery

Because preterm cesarean delivery may involve an incision that is more likely to extend into the upper contractile portion of the uterus, it has been suggested that previous preterm cesarean may increase the risk for subsequent uterine rupture. Sciscione and colleagues<sup>18</sup> from the MFMU Network reported a risk of rupture of 1.0% in women undergoing TOL with a previous preterm cesarean compared with 0.68% in those with previous term cesarean delivery. In a multivariable analysis, the OR for uterine rupture was 1.6 (95% CI 1.01-

2.50) in women with previous preterm cesarean delivery. These authors also noted that uterine ruptures occurred earlier in the previous preterm group than in women with previous cesarean delivery at term (37.2 vs 39 weeks). In contrast to the MFMU report, Harper et al's<sup>19</sup> analysis revealed similar risks of uterine rupture when patients were stratified according to previous cesarean before or after 34-week gestation. The risk for uterine rupture was 6/508 (1.2%) in those with previous preterm cesarean compared with 103/12,027 (0.9%) in women with previous term operations. Post hoc analysis revealed the study to have sufficient power to detect a 2.3-fold increased risk for rupture in the previous preterm group. Thus, it appears that any increased risk for rupture in those women with a previous preterm cesarean is fairly small.

## Labor Induction

Induction of labor appears to be associated with an increased risk of uterine rupture in women undergoing TOL. In the MFMU Network analysis, a nearly 3-fold (OR 2.86%, 95% CI 1.75-4.67) risk was evident as rupture occurred in 48/4708 (1.0%) women undergoing induction and TOL compared with 24/6685 (0.4%) accompanying spontaneous labor.<sup>2</sup> It remains unclear whether induction causes uterine rupture or whether an associated factor, such as cervical status conveys a risk for rupture. Grobman and colleagues<sup>20</sup> failed to detect a difference in rupture rates according to Bishop Score in women undergoing induction and TOL. In this analysis, the authors found the risk for uterine rupture in women with no previous vaginal delivery undergoing induction with oxytocin to be 1.8%, which was more than 2-fold greater than in comparable cases in spontaneous labor (OR 2.19%, 95% CI 1.28-3.76).

Although a systematic review<sup>21</sup> that did not include the MFMU report failed to find a greater rate of uterine scar disruption with labor induction, several additional analyses suggest that oxytocin should be used with caution in women undergoing induction attempting VBAC. Cahill and colleagues<sup>22</sup> have reported that a dose-response relationship exists between maximal oxytocin dose and the risk for rupture compared with women who attempt VBAC with no oxytocin exposure. A limitation of this report is that it includes both women undergoing induction as well as those receiving oxytocin augmentation. At the maximal dose of oxytocin (>20 mU/min), these authors noted the risk of uterine rupture to be only 2.07%. In a follow-up study, these authors considered the association of maximum oxytocin exposure and risk for uterine rupture by estimating time to event in their analysis.<sup>23</sup> Their previous analysis suggested an approximate 1% attributable risk for rupture at higher oxytocin doses; however, the more recent report estimates the attributable risk to be 2.9% and 3.6% for doses greater than 20 and 30 mU/min. From these data, greater doses of oxytocin should be used with caution in women undergoing TOL and an upper limit of 20 mU/min seems reasonable.<sup>23</sup>

Conflicting data has emerged regarding whether other induction methods significantly increase the risk for uterine

ine rupture. Following the report of Lydon-Rochelle and colleagues suggesting an increased risk for uterine rupture with prostaglandin use for induction, 2 reports using improved methodology have failed to confirm these findings.<sup>2,24,25</sup> Macones and colleagues reported an increased risk for rupture only in women receiving a combination of oxytocin and prostaglandins, whereas the MFMU Network study revealed no cases of uterine rupture when prostaglandins alone were used for induction, including 52 cases of misoprostol alone.<sup>2,25</sup> The safety of this medication, which is popular for cervical ripening and labor induction, has been challenged in women undergoing TOL. A randomized trial comparing misoprostol use in women attempting VBAC to other medications was discontinued due to concerns of an unacceptable risk for uterine rupture in the misoprostol group.<sup>26</sup> As a result, ACOG has advised against the use of misoprostol (prostaglandin E<sub>1</sub>) for labor induction in women with previous cesarean delivery.<sup>27</sup>

Unfortunately, many VBAC studies fail to specify the prostaglandin used for labor induction. In the largest report of women receiving prostaglandins for labor induction attempting VBAC, Smith and colleagues<sup>28</sup> reported a 0.87% risk for uterine rupture among 4475 women receiving unspecified prostaglandins compared with 0.29% in 4429 cases not receiving this class of medication. Although the relative risk associated with prostaglandin use was elevated, clearly the absolute risk for rupture was impressively low in this series. At present, based on limited data, ACOG suggests avoiding sequential use of prostaglandin E<sub>2</sub> and oxytocin in women undergoing TOL. This recommendation has thus limited options for induction in women undergoing TOL to primarily oxytocin or mechanical methods with or without oxytocin. At present, the use of mechanical methods, such as Foley catheters indicate relative safety.<sup>29</sup>

## Oxytocin Augmentation

As previously discussed, excessive oxytocin use may be associated with uterine rupture such that careful labor augmentation should be practiced in women with a scarred uterus. Leung, and colleagues reported a 2.7-fold increased risk for uterine rupture with labor augmentation.<sup>30</sup> In contrast, a meta-analysis failed to demonstrate an increased risk.<sup>31</sup> Dysfunctional labor, including arrest disorders, may increase the risk for uterine rupture and may actually be the primary factor responsible in some cases. The MFMU Network study documented a risk for rupture of 52/6009 (0.9%) in women receiving oxytocin for augmentation compared with 24/6685 (0.4%) in spontaneous labor which was confirmed in multivariable analysis.<sup>2,3</sup> In contrast, Macones, and colleagues<sup>25</sup> found that labor augmentation was not associated with uterine rupture. In summary, oxytocin augmentation may marginally increase uterine rupture risk and should be used judiciously.

## Uterine Rupture Prediction Models

It is apparent that several risk factors associated with uterine rupture can be identified that may aid in counseling women regarding their relative risk for this event. Until recently, investigators had not attempted to combine risk factors in an effort to develop predictive models for clinical use. Macones, and colleagues used multivariable methods to develop 2 separate predictive models relying on antepartum and intrapartum factors and then constructed a combined model.<sup>5</sup> The models were then assessed with the use of receiver operating characteristic curves. The 2 clinical predictive indexes were neither sufficiently sensitive nor specific for clinical use. For example, the optimal cut-off yielded a sensitivity of 75% with a false-positive rate of approximately 40%.

Grobman and colleagues<sup>32</sup> also attempted to develop a model that would estimate individual specific risk for uterine rupture during an attempted VBAC. These authors relied on factors that were available before or at admission to labor and delivery. The optimal final prediction model, based on logistic regression, included 2 variables: previous vaginal delivery (OR 0.44) and induction of labor (OR 1.73). Unfortunately, the model did not allow a clinically useful estimate of the probability of uterine rupture for an individual woman. For example, an empiric probability risk of rupture of 1.3% derived from the model carried a 95% CI ranging from 0.6% to 1.8%. With the wide CI about the point estimate, the model was thus neither accurate nor discriminating.

## Sonographic Evaluation of the Uterine Scar

To better identify women at risk for uterine rupture undergoing TOL, the thickness of the lower uterine segment (LUS) has been scheduled with ultrasound. Bujold, and colleagues<sup>33</sup> conducted a prospective cohort study of 125 women with previous cesarean undergoing TOL who received sonographic measurement of the LUS before labor. There were only 3 cases of uterine rupture; however, receiver operating curve analysis showed that full thickness of <2.3 mm was the optimal cutoff for the prediction of uterine rupture (3/33 vs 0/92;  $P = 0.02$ ). The rate of uterine rupture (9.1%) reported is significantly greater than previously cited risk factors and thus, if confirmed in additional studies, may identify a subgroup of women at sufficiently high risk to advise against TOL. Limitations of Bujold's study include the small number of ruptures as well as the fact that most women with a LUS < 2.0 mm did not undergo TOL. This later fact suggests that practice patterns have been established that may limit further investigation concerning the utility of ultrasound to predict uterine rupture.

## Conclusions

A pregnant woman with previous cesarean delivery is at risk for maternal and perinatal complications whether she elects to undergo TOL or repeat cesarean section. Counseling such women should ideally include an individualized discussion of the risk of uterine rupture and the likelihood of successful VBAC. Future childbearing plans and the potential risks of repeated cesarean deliveries should also be considered.

In contrast to the introduction of a useful nomogram to predict the likelihood of successful VBAC for a given

**Table 1 Risk Factors for Uterine Rupture**

	Odds Ratio (95% CI)	Absolute Risk, %	Reference(s)
Prior vaginal delivery	0.2 (0.04-0.8)	0.2	4
	0.38 (0.23-0.62)	—	5
	0.66 (0.45-0.95)	0.5	3
Multiple previous cesareans	3.06 (1.95-4.79)	1.7	6
	4.5 (1.18-11.5)	3.7	7
	2.3 (1.37-3.85)	1.8	9
	1.46 (0.87-2.44)	—	5
	1.36 (0.69-2.69)	0.9	3
Short interpregnancy interval	3.0 (1.2-7.2)	2.25	10
	—	0	11
	2.65 (1.08-6.46)	2.7	12
	2.05 (1.41-2.96)	1.1	3
	2.66 (1.21-5.82)	2.7	13
One-layer closure	—	0	14,15
	3.95 (1.35-11.49)	3.1	16
Previous preterm cesarean	1.6 (1.01-2.50)	0.79	18
	1.5 (0.7-3.5)	1.2	19
Labor induction	2.86 (1.75-4.67)	1.0	3
	1.01 (0.43-2.34)	—	5
Oxytocin augmentation	2.40 (1.45-4.07)	0.9	3
	1.72 (0.80-3.64)	—	5

woman, 2 well-conducted analyses in which the authors used somewhat-different methodologies have failed to develop a clinically useful individual prediction model for uterine rupture.<sup>5,32</sup> Neither study considered previous operative technique (single vs double uterine closure), however both analyses were derived from large well conducted multicenter studies that are unlikely to be accomplished again. Although multiple factors have been demonstrated to be associated with uterine rupture, such associations even in combination may not allow accurate prediction of an uncommon outcome. The fact that some risk factors are only weakly associated with uterine rupture further limits development of an individual specific risk model. Given these considerations, obstetrical care providers will continue to be expected to provide information to women regarding the risk of uterine rupture. It is fair to say that this event clearly cannot be predicted on an individual basis. Known risk factors representing population averages can be discussed with women considering their options following previous cesarean delivery. This information should include absolute and relative risks to provide a basis for objective counseling regarding risk for uterine rupture accompanying TOL (Table 1).

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