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Can a prediction model for vaginal birth after cesarean also predict the probabililty of morbidity related to a trial of labor?

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Abstract

Objective—To determine if a model for predicting vaginal birth after cesarean (VBAC) can also predict the probabilty of morbidity associated with a trial of labor (TOL).

Study Design—Using a previously published prediction model, we categorized women with one prior cesarean by chance of VBAC. Prevalence of maternal and neonatal morbidity was stratfied by probability of VBAC success and delivery approach.

Results—Morbidity became less frequent as the predicted chance of VBAC increased among women who underwent TOL (P<.001), but not elective repeat cesarean section (ERCS) (P >.05). When the predicted chance of VBAC was less than 70%, women undergoing a TOL were more likely to have maternal morbidity (RR 2.2, 95% CI [1.5, 3.1]) than those who underwent an ERCS; when the predicted chance of VBAC was at least 70%, total maternal morbidity was not different between the two groups (RR 0.8, 95% CI [0.5, 1.2]). The results were similar for neonatal morbidity..

Conclusion—A prediction model for VBAC provides information regarding the chance of TOL-related morbidity, and suggests that maternal morbidity is not greater for those women who undergo TOL than those who undergo ERCS if the chance of VBAC is at least 70%.

Keywords

VBAC; prediction; morbidity

The decision to undergo a trial of labor (TOL) after cesarean is based on several factors, including the probability of maternal and neonatal morbidity. McMahon et al, based on their analysis of Canadian data, suggested that women undergoing a TOL after cesarean were almost twice as likely as those undergoing an elective repeat cesarean to have major maternal complications.[1] This increase in morbidity after a TOL after cesarean was primarily due to the rate of complications in women who had a but ultimately required a cesarean. El-Sayed et al have demonstrated that neonatal morbidity also accrues more commonly to those women who undertake a TOL after cesarean but require a cesarean.[2]

Given the contribution to morbidity from these repeat cesareans that occur during a TOL, the probability that a woman who is undergoing a TOL after cesarean will incur morbidity is dependent upon her probability of achieving a vaginal birth after cesarean (VBAC). Yet, women typically have been counseled about their chance of vaginal delivery, and by extension their chance of morbidity, based on population-based measures such as means or ranges.[3] Cahill et al demonstrated how such an approach can obscure potentially important information.[4] In their analysis of women with a prior cesarean, Cahill et al demonstrated that women who have had a prior vaginal delivery, a factor that has been repeatedly shown to increase the chance of subsequent VBAC once a TOL is undertaken, were actually less likely to incur maternal morbidity than those women who had an elective cesarean. [4–6] However, the majority of women who have had a cesarean have not had a prior vaginal delivery, and even the women who have had a prior vaginal delivery are a heterogeneous group, thus limiting the generalizability of that analysis.

We have recently reported on a predictive nomogram that allows the estimation of the probability of vaginal delivery for women with one prior cesarean undergoing a TOL.[7] The present study was designed to assess whether the nomogram, in addition to predicting vaginal

delivery, also could predict the frequency of maternal and neonatal morbidity with a TOL and identify those women for whom a TOL is no more morbid than an elective repeat cesarean.

Materials and Methods

Between 1999 and 2002, investigators at 19 academic medical centers, belonging to the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network, created a registry that included pregnancy outcomes of women who delivered at their institutions. Using data from this registry, a model was developed that provides individual-specific prediction of the probability of VBAC for women with one prior cesarean and a singleton gestation in the cephalic presentation at term who undergo a trial of labor.[8] This model included maternal age, body mass index, ethnicity, history of vaginal delivery, timing of the vaginal delivery in relation to the cesarean, and indication for the prior cesarean. Full details of the technique of data collection for the registry and of the prediction model development have been previously described, and the results for the model can be obtained at www.bsc.gwu.edu/mfmu/vagbirth.html.[7,8]

For the present analysis, all women who had one prior low-transverse cesarean and a cephalic singleton gestation at term in the current pregnancy were identified. Those who had a placenta previa, an absolute contraindication to trial of labor, were excluded from further analysis. The remaining population of women, all of whom were eligible for a trial of labor, had their predicted probability of VBAC calculated. Women were then categorized by deciles of the predicted probability of VBAC. Women with a predicted probability of VBAC if a TOL were to be undertaken of less than 60% were placed into a single group.

Maternal morbidity was calculated for all women who were eligible for a TOL after cesarean. This morbidity was defined as either “major” or “minor”, adhering to the scheme previously utilized by McMahon et al.[1] Specifically, a woman was considered to have minor morbidity if she experienced a puerperal fever, a blood transfusion, or an abdominal wound infection. A woman was considered to have major morbidity if she had either a hysterectomy or an operative injury. Operative injury was defined as a laceration of the bowel, bladder, or ureter. Women with multiple complications were counted only once within one category of morbidity. For example, if they had multiple major complications, or a major and a minor complication, they were coded as having had a major complication; if they had multiple minor complications, they were coded as having had a minor complication. This scheme was identical to that used by McMahon et al with two exceptions.[1] We did not consider a uterine artery laceration without any other consequences to be a major complication, as we did not consider its ramifications to be equivalent to a hysterectomy or visceral organ injury. Also, a uterine rupture was only coded as morbidity if associated with one of the major or minor morbidities enumerated above. In an effort to ensure that this latter decision did not materially affect the conclusions of the study, uterine rupture without other major or minor morbidity was included in selected analyses. A woman was considered to have neonatal morbidity if her newborn experienced any one of the following: Apgar score < 4 at 5 minutes, umbilical cord arterial pH < 7.0, admission to the neonatal intensive care unit, hypoxic-ischemic encephalopathy, or death.

The frequency of major, minor, and total (either major or minor) maternal morbidity, as well as neonatal morbidity, was determined for each decile of predicted probability of VBAC success and stratified by delivery approach (whether an eligible woman attempted a TOL or chose an elective repeat cesarean). Of note, even those women in the study sample who underwent an elective repeat cesarean were categorized by their predicted probability of VBAC success, as they were all eligible for a TOL. Within each strata of the predicted chance of VBAC success, the morbidity of women who underwent TOL was compared to that of women who underwent elective repeat cesarean. The comparisons were performed either with Fisher’s

Exact or Chi-Square analyses based on cell size. Also, within each "delivery approach" group, the Cochran-Armitage test of trend was used to analyze whether the frequency of morbidity changed as the predicted probability of VBAC success changed.[9] Separate analyses were performed for minor morbidity, major morbidity, and total morbidity. As indicated by the data from the initial comparative morbidity analyses, the probability strata were further grouped to assess whether women who achieve a specified probability of VBAC success were no more likely to experience maternal morbidity than their counterparts undergoing an elective repeat cesarean. Relative risks and 95% confidence intervals were calculated for these selected comparisons.

For all statistical tests, nominal two-sided P-values are reported with statistical significance defined as a P-value < 0.05. SAS version 8.2 (SAS Institute, Cary, North Carolina) was used for analysis. Approval for the study was obtained at the Institutional Review Board of each participating institution.

Results

13,541 women with one prior cesarean were identified who were eligible for a TOL after cesarean and who had a singleton gestation in the cephalic presentation at term. Of these women, 7660 (56.6%) underwent a TOL and 5881 (43.4%) underwent an elective repeat cesarean. Overall, 0.3% had major morbidity, 1.26% had minor morbidity, 1.56% had either major or minor maternal morbidity, and 8.7% had neonatal morbidity.

Table 1 illustrates the comparison of women who did and did not experience any maternal or neonatal morbidity. As noted, women with morbidity were more likely to have a greater BMI, be of African-American ethnicity, and not have had a prior vaginal delivery. Tables 2, 3, 4 and 5 demonstrate the frequency of the minor, major, and total maternal morbidity, and neonatal morbidity, respectively, stratified by the deciles of predicted probability of VBAC success and delivery approach. For those women who underwent a TOL, all types of composite morbidity became less likely as the probability of VBAC success increased. This trend is in contrast to the frequency of morbidity associated with elective repeat cesareans. For women who delivered via an elective repeat cesarean, all categories of morbidity remained similar regardless of their predicted chance of VBAC success.

Also, the probability of minor, major, neonatal, and total morbidity was greater for women who underwent a TOL than for those who underwent an elective repeat cesarean when the probability of VBAC success was less than the 60–70% range. Above a VBAC success probability of 70%, no type of morbidity was no more likely among women who underwent a TOL. Women with a probability of VBAC success greater than 90% actually had lower neonatal morbidity if they underwent a TOL rather than an elective repeat cesarean.

Based on these data, women were further grouped according to whether their probability of VBAC success was 70% or greater. Table 6 presents relative risks and 95% confidence intervals for the associations of major, minor, and total maternal morbidity, as well as neonatal morbidity, with delivery approach, for these dichotomized groups. When the predicted chance of VBAC success was less than 70%, women who underwent a trial of labor were significantly more likely to have all types of morbidity than those who underwent an elective cesarean. However, when the predicted chance of VBAC success was at least 70%, the risks of these morbidities were not different between the two groups. The results were not different if uterine rupture, not associated with other morbidity, was included in the maternal morbidity analysis. In that case, women undergoing a TOL after cesarean with a probability of VBAC success less than 70% had an increased chance of minor morbidity, major morbidity, or uterine rupture (relative risk 2.6, 95% confidence interval [1.8, 3.6]); those with a probability of VBAC success

of at least 70% did not have an increased relative risk of these morbidities (relative risk 1.1, 95% confidence interval [0.7, 1.7]).

Comment

The rate of VBAC has markedly declined after reaching its apex in 1998.[10] Part of this decline may be attributed to changing perceptions regarding the morbidity associated with TOL after cesarean. McMahon et al published a manuscript in 1996 that suggested that women who underwent a TOL after cesarean had higher rates of morbidity than those who had elective repeat cesareans.[1] This conclusion, however, was derived in a population that had a vaginal delivery rate after a TOL after cesarean of only 60.4%. This summary rate, which was lower than the 70–80% success rates that many investigators had previously reported, materially affected the central conclusion regarding morbidity, as morbidity was most likely to occur among women who required a repeat cesarean after a failed TOL after cesarean. Indeed, in the data presented by McMahon et al, 92.5% of major complications occurred among the group of women with a failed TOL.[1]

The relationship between failed TOL after cesarean and morbidity, in concert with the particularly high frequency of failed TOL in the population analyzed by McMahon et al,[1] raises the possibility that the conclusions of these authors are not generalizable to other populations of women who may have higher TOL success rates. Indeed, Cahill et al have recently demonstrated that a population of women with a higher probability of a successful TOL after cesarean actually do not have decreased morbidity after choosing an elective cesarean.[3] Studying women with a prior vaginal birth, these authors found the frequency of successful TOL to be nearly 90%, and the composite morbidity to be lower after a TOL than after an elective repeat cesarean.

Yet, most women who are candidates for a TOL after cesarean have not had a prior vaginal delivery, and even if they have, they may have other characteristics that make their probability of vaginal delivery less than 90%.[5–8,11] Thus, it is desirable to be able to assess morbidity for patients based on their own individual chance of achieving a VBAC if they were to undertake a TOL. Recently, we have reported a model that can accurately and precisely predict the probability of successful VBAC based on several characteristics easily ascertainable at a first prenatal visit.[7] The additional ability of this model to predict maternal morbidity has not been evaluated.

In the present analysis, we have demonstrated that the nomogram for prediction of VBAC success also is predictive of the probability that a women undertaking a TOL experiences minor, major, neonatal, or total morbidity. As a woman's individual chance of vaginal delivery increases, her chance of morbidity decreases. Also, as her chance of vaginal delivery increases beyond 70%, there is no longer evidence that her choice of TOL incurs a greater risk of maternal morbidity. Of women who are eligible for a trial of labor, many will fall into this "lower risk of morbidity" subgroup; in our population, nearly 50% (6400/13,541) of women who were eligible for a trial of labor had a predicted probability of vaginal delivery that was greater than 70%.

Not surprisingly, the inverse relationship between the predicted chance of VBAC success and maternal morbidity is not seen in the group of women who underwent elective cesarean. Even though these women had an elective cesarean, their characteristics can be utilized to gain insight into their chance of VBAC if they had chosen TOL. Analyzing their risk of morbidity by this predicted chance, and comparing their morbidity to women of similar chance who did choose TOL, is a necessary technique, as it limits the potential for confounding bias.

The limitations of this analysis should be noted. The results are derived from a population of women at term with a singleton gestation who have had one prior low-transverse cesarean, and therefore cannot be generalized to women who do not have these characteristics. Nevertheless, we chose this population for analysis as it represents the vast majority of women who are undergoing a TOL after cesarean. Another issue with regard to generalizability is that the data for the prediction model were generated from women at institutions associated with the MFMU, and the extent to which this model is valid for women in community hospitals without the resources of larger centers remains unknown. Lastly, this anaylsis does not account for morbidity that accrues as women continue to have children; if that morbidity were accounted for it may lower the probability of TOL success at which the total morbidity from a TOL is no greater than from an ERCS, as a successful VBAC markedly increases the chance of subsequent successful VBAC and corresponding obstetric morbidity. This analysis could not be performed, as the cesarean registry does not continue to track women through their reproductive life.

Women with a prior cesarean need to weigh multiple factors in their decision to proceed with a TOL. Two probabilities that are relevant to their decision making process are that of achieving a vaginal delivery and that of avoiding additional maternal morbidity. The nomogram that has been developed for prediction of VBAC success provides insight into both these factors for women with a singleton gestation at term and a history of one prior low-transverse cesarean, and can be used to refine counseling by health providers and choices of the pregnant women in their care.

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Appendix

Appendix

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Table 1

Characteristics of study population stratified by the presence of either maternal or neonatal morbidity

	Morbidity N = 1365	No morbidity N = 12,176	P
Age (years)	29.3 ± 5.8	29.5 ± 5.6	0.22
Body mass index (kg/m^2)	28.6 ± 7.4	26.8 ± 6.5	<.001
Race			<.001
Caucasian	631 (46.2)	6965 (57.2)	
African-American	418 (30.6)	2446 (20.1)	
Hispanic	250 (18.3)	2194 (18.0)	
Other	66 (4.8)	571 (4.7)	
Prior vaginal birth	367 (26.9)	3926 (32.2)	<.001
Prior vaginal birth after prior cesarean	224 (16.4)	2473 (20.3)	<.001
Prior cesarean secondary to arrest of dilation or descent	642 (47.0)	5393 (44.3)	.05

Table 2

Probability of minor morbidity stratified by probability of VBAC and delivery intent

	Trial of labor		Elective repeat cesarean		P*
	N	%	N	%	
<60%	42/1904	2.2	32/2611	1.2	.01
60–69%	22/1187	1.9	8/1439	0.56	<.01
70–79%	20/1413	1.4	19/1111	1.7	0.63
80–89%	11/1462	0.75	4/536	0.75	1.00
• 90%	11/1694	0.65	1/184	0.54	1.00
	P <.0001**		P = 0.71**		

*Chi-square or Fisher's exact

**Cochran-Armitage test of trend

Table 3

Probability of major morbidity stratified by probability of VBAC and delivery intent

	Trial of labor		Elective repeat cesarean		P*
	N	%	N	%	
<60%	17/1904	0.89	6/2611	0.23	<.01
60–69%	2/1187	0.17	4/1439	0.28	0.70
70–79%	4/1413	0.28	2/1111	0.18	0.70
80–89%	5/1462	0.34	0/536	0.0	0.33
• 90%	0/1694	0.0	1/184	0.54	0.10
	P<.0001**		P = 0.75**		

*Chi-square or Fisher's exact

**Cochran-Armitage test of trend

Table 4

Probability of total morbidity stratified by probability of VBAC and delivery intent

	Trial of labor		Elective repeat cesarean		P*
	N	%	N	%	
<60%	59/1904	3.1	38/2611	1.5	<.001
60–69%	24/1187	2.0	12/1439	0.83	0.01
70–79%	24/1413	1.7	21/1111	1.9	0.76
80–89%	16/1462	1.1	4/536	0.75	0.62
• 90%	11/1694	0.65	2/184	1.1	0.37
	P <.0001**		P = 0.64**		

*Chi-square or Fisher's exact

**Cochran-Armitage test of trend

Table 5

Probability of neonatal morbidity stratified by probability of VBAC and delivery intent

	Trial of labor		Elective repeat cesarean		P*
	N	%	N	%	
<60%	259/1904	13.6	224/2611	8.6	<.001
60–69%	104/1187	8.8	121/1439	8.4	0.78
70–79%	123/1413	8.7	88/1111	7.9	0.51
80–89%	113/1462	7.7	44/536	8.2	0.71
• 90%	79/1694	4.7	20/184	10.9	0.001
	P <.001**		P = 0.95**		

*Chi-square or Fisher's exact

**Cochran-Armitage test of trend

Table 6

Relative risks and 95% confidence intervals for maternal morbidity associated with trial of labor versus elective repeat cesarean, stratified by probability of VBAC

	< 70%		≥ 70%	
	RR	**95% CI**	**RR**	**95% CI**
Minor maternal morbidity	2.1	1.4 – 3.1	0.7	0.4 – 1.2
Major maternal morbidity	2.5	1.2 – 5.3	1.2	0.3 – 4.4
Total maternal morbidity	2.2	1.5 – 3.1	0.8	0.5 – 1.2
Neonatal morbidity	1.4	1.2 – 1.6	0.8	0.7 – 1.0

RR= relative risk; CI = confidence interval