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Vaginal birth after caesarean section *versus* elective repeat caesarean section: assessment of maternal downstream health outcomes

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Objective To compare the maternal implications of strategies of vaginal birth after caesarean section (VBAC) attempt *versus* elective repeat caesarean section in women with one previous lower segment caesarean section.

Design Decision model.

Population Women with one prior low transverse caesarean section who are eligible for trial of labour.

Methods Two decision models were built: the first one applying to women planning only one more pregnancy, the second one applying to women planning two more pregnancies. Probability estimates for VBAC success rate and risks of uterine rupture, placenta praevia, placenta accreta and hysterectomy were extracted from the available literature.

Main outcome measures Hysterectomy for uterine rupture, placenta accreta or other indications.

Results In the first model VBAC attempt led to a higher hysterectomy rate (267/100,000) compared with repeat caesarean section (187/100,000). However, in the second model a policy of elective repeat caesarean section led to higher cumulative hysterectomy rate: 1465/100,000 *versus* 907/100,000 for VBAC. The first model was robust to all but one variable in sensitivity analyses. The second model was robust to all variables in sensitivity analyses.

Conclusions These results indicate that long term reproductive consequences of multiple caesarean sections should be considered when making policy decisions regarding the risk–benefit ratio of VBAC.

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Introduction

Concerns about immediate maternal and neonatal complications associated with uterine rupture[1–3] have contributed to a decrease in vaginal birth after caesarean section (VBAC) rates and the recent rise of caesarean deliveries in developed countries.[4–7] The decline of VBAC rates, with its subsequent rise in caesarean section rates, is not without clinical implications. Caesarean sections have been associated with downstream perinatal complications such as placenta accreta[8–10] and placenta praevia.[11–17] The relationship between the number of previous caesarean sections and the increased risk of placenta praevia–accreta has been well described.[9–11,18] The frequency of placenta accreta has increased tenfold over the last 50 years, which is thought to be related to the increasing caesarean section rate.[19] Placenta accreta is associated with significant maternal morbidity, including postpartum haemorrhage and peripartum hysterectomy.[8,20–26]

Considering the immediate risk of uterine rupture with VBAC and the later risk of placenta accreta with multiple repeat caesarean sections, what is the best decision for women who have undergone a single low transverse caesarean section? Randomised controlled trials are not available and are unlikely to be conducted. Moreover, previously published observational studies do not specifically address the downstream consequences of a strategy of multiple repeat caesarean sections for women with a prior caesarean section delivery. Therefore, a decision analysis was designed to evaluate and compare the immediate and downstream maternal morbidity of both a trial of labour and an elective repeat caesarean section for women with one prior low transverse caesarean section.

Methods

We used decision model analysis to compare delivery strategies (i.e. VBAC attempt *versus* elective repeat caesarean

section) for the subsequent pregnancy in women who have had a single, prior low transverse caesarean section. The clinical dilemma captured in this study is weighing the immediate risks of a VBAC attempt, mostly driven by the rate of uterine rupture, against the downstream risks of multiple repeat caesarean sections, mostly driven by the rate of placenta accreta. The implications of this clinical decision, whether to attempt a VBAC or have an elective repeat caesarean section after one caesarean section, will differ for a woman who is planning only one additional pregnancy compared with a woman considering multiple additional pregnancies. As such, we constructed two separate decision models: the first model for women who plan only a single additional pregnancy (in addition to the prior low transverse caesarean section), and the second model for women who plan two additional pregnancies.

The decision models were created and analysed with DATA 4.0-Healthcare Version (Treeage Software, Williamstown, MA). These models are illustrated in Figs 1 and 2 and are available on request. Both models begin with the decision of a VBAC attempt *versus* an elective repeat caesarean section after one prior low transverse caesarean section. In the first model (one additional desired pregnancy), the following clinical situations and complications are then represented: successful/failed VBAC, placenta accreta (yes/no), uterine rupture (yes/no) and peripartum hysterectomy (yes/no) (Fig. 1).

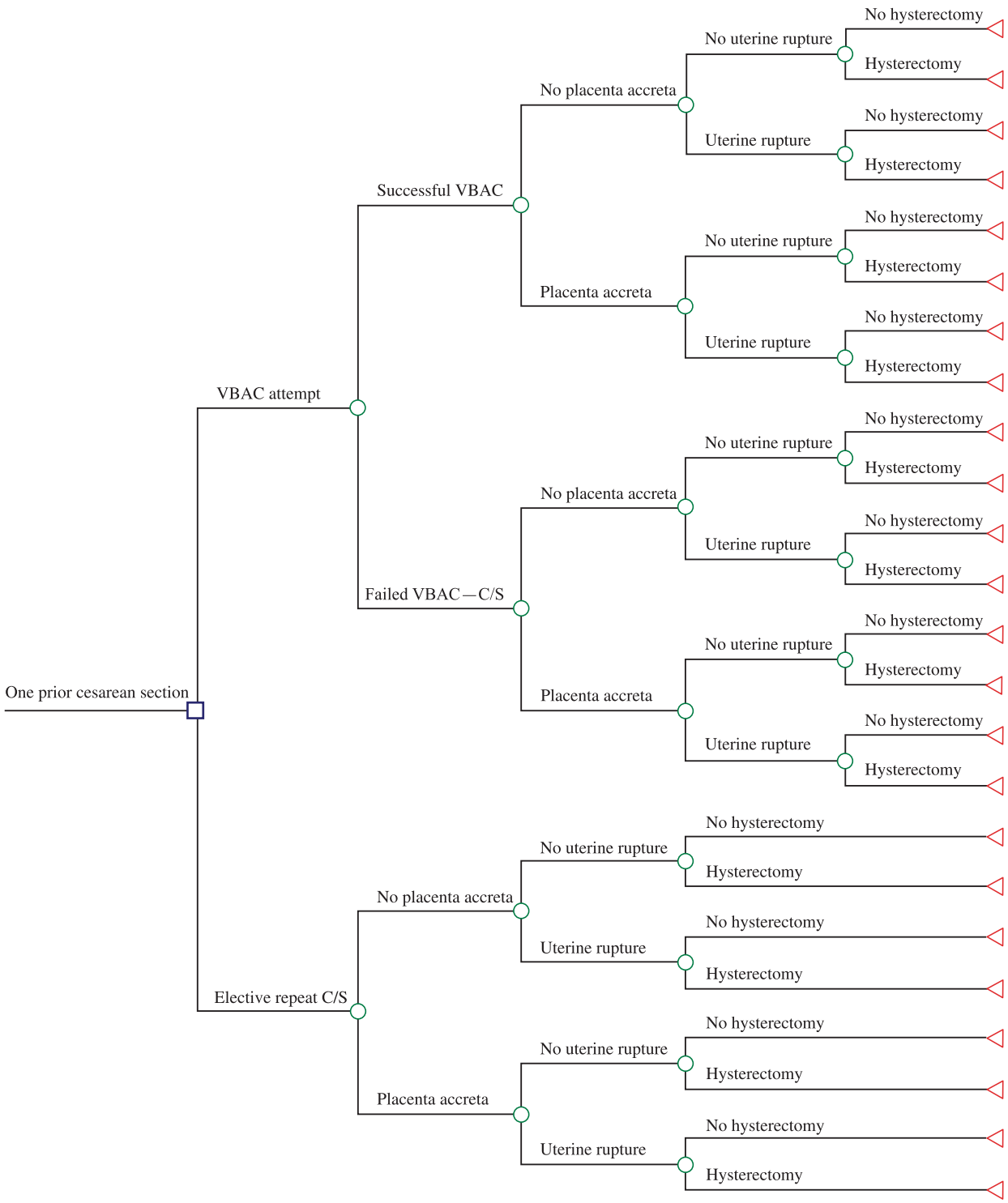
In the second model (two additional desired pregnancies), the first pregnancy is modeled as in the first model. Then for women who did not have a hysterectomy, the second pregnancy is modeled to include the following clinical situations and complications: placenta praevia (yes/no), second VBAC attempt (yes/no), successful/failed VBAC, elective repeat caesarean section (third caesarean section), placenta accreta (yes/no), uterine rupture (yes/no) and peripartum hysterectomy (yes/no). This second model is too large to be shown in its entirety. Figure 2 illustrates the subtree of the second pregnancy for women who had a successful VBAC, without uterine rupture, placenta accreta or hysterectomy with their first pregnancy in the model and who do not have a placenta praevia with their second pregnancy in the model.

Because hysterectomy is a marker for significant maternal morbidity and obviously puts an end to a woman's reproductive potential, it was chosen as the primary outcome in the models. The second model evaluates the cumulative rate of hysterectomy after the second delivery after the primary caesarean section. We did not consider costs or patient preferences in these models. Other adverse maternal outcomes, such as operative injury, blood transfusions or infertility, were not included in the models; we assumed that hysterectomy would capture most of the serious maternal morbidity, as there is a correlation between these outcomes and peripartum hysterectomy. As we decided to focus on maternal outcomes, neonatal outcomes were not considered in these models.

There are several notable assumptions in these models. First, we assumed that the target population was comprised of women with one prior low transverse caesarean section who are eligible for a VBAC attempt. Second, we assumed that women 'declare' their intent for mode of delivery before labour. As such, in the 'elective repeat caesarean section' strategy, we assumed that all women had their caesarean sections performed prior to the onset of labour. Third, we assumed that the risks of uterine rupture and placenta accreta were independent of each other.

In the second model, we conservatively assumed that the only additional maternal risk with multiple prior caesarean sections was the increased risk of placenta praevia and placenta accreta. We did not include other potential risks surrounding multiple caesarean sections, including the potential for an increase in bleeding, transfusion and operative injury. We assumed that all women who had a successful VBAC would attempt a second VBAC (unless they had had a uterine rupture, or had a placenta praevia), and that all women who had an elective repeat caesarean section would have a third caesarean section. Women who had a prior uterine rupture (and who did not require a hysterectomy) were assumed to be having a caesarean section as soon as fetal lung maturity was documented.

To obtain the probability estimates used in the two models, we performed a MEDLINE search using the key words: VBAC, trial of labour, repeat caesarean section, uterine rupture, placenta accreta, placenta praevia, hysterectomy and pregnancy. We reviewed the identified articles to assess the quality of the data and extract the relevant information for the probability estimates. Table 1 lists the probability estimates used for the base-case analysis, as well as the ranges used in the sensitivity analyses. When possible, the ranges were based on reported or calculated 95% confidence intervals for the probability estimate. These ranges represent either the uncertainty around the probability estimate (for example, the probability of placenta accreta after one prior caesarean section) or the different values that these baseline estimates would take in different populations (for example, the VBAC success rate). The number and the quality of the studies available to obtain the probability estimates for the variables used in the models varied according to the variables. For example, more quality studies were available on VBAC success rate than on probability of hysterectomy after various clinical scenarios. For some probabilities (for example, recurrence risks of placenta accreta), published data were not available and expert opinion was used; to address the uncertainty around these probability estimates, we used broad ranges in sensitivity analyses. When assessing probabilities of uterine rupture, we aimed to include only true uterine ruptures and exclude asymptomatic uterine dehiscences, as these are not associated with significant maternal morbidity; however, in a few studies, it was impossible to separate these two entities. For uterine rupture and hysterectomy probabilities, we focussed as



Schematic representation of the model: Model 1 (one additional desired pregnancy)

Figure 1. The tree begins with a decision node (square), which represents the decision to attempt a VBAC *versus* to undergo an elective repeat caesarean section after one prior caesarean section. Circles represent chance nodes, from which emanate events with specified probabilities. In this model, the VBAC attempt can succeed or fail. After a successful VBAC, a failed VBAC and an elective caesarean section: placenta accreta and uterine rupture can occur or not. Finally, the triangular nodes represent the final outcome; in this case, hysterectomy or no hysterectomy.

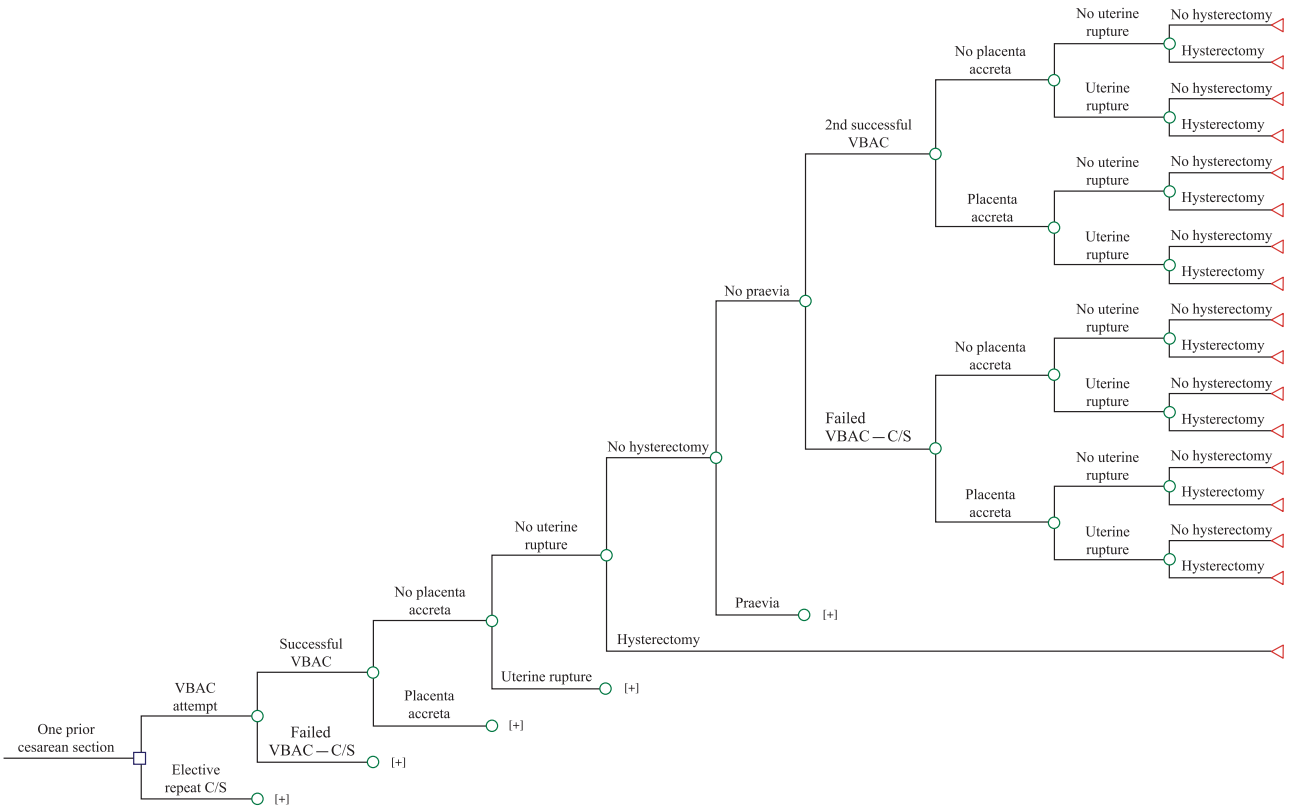


Figure 2. The tree begins with a decision node (square), which represents the decision to attempt a VBAC *versus* to undergo an elective repeat caesarean section after one prior caesarean section. Circles represent chance nodes, from which emanate events with specified probabilities. Finally, the triangular nodes represent the final outcome; in this case, hysterectomy or no hysterectomy. The subtree illustrated applies to women who attempted a VBAC and had a successful VBAC, no uterine rupture, no placenta accreta and no hysterectomy with their first pregnancy in the model. In their second pregnancy in the model, if they have a placenta praevia, they are delivered by caesarean section (not shown). If there is no placenta praevia, a second VBAC attempt is modeled. This second VBAC attempt can succeed or fail. Then placenta accreta and uterine rupture are modeled as possible events, and hysterectomy/no hysterectomy as the final outcome. The [+] signs represent all the other subtrees, which are collapsed and could not be illustrated in this figure.

much as possible on studies providing differential data for these risks after either a successful VBAC or a failed VBAC, as these risks are different.

In the base-case analysis, we used a 70% rate of successful VBAC. For the sensitivity analyses, we varied the plausible range from 50% to 90% to account for the different clinical scenarios that affect the likelihood of VBAC success: for example, the VBAC success rate is higher for women who had a caesarean section for breech presentation than for women who had a caesarean section for dystocia. In the second model (two additional desired pregnancies) although not a real 'probability', we modeled the possibility of attempting a second VBAC after a failed one. We acknowledge that the practice of offering a VBAC attempt after two caesarean sections is becoming less common. Thus, to account for the clinical practice of not offering a VBAC attempt after two caesarean sections, the range used in sensitivity analysis included 0% for this 'probability'.

For each strategy, we calculated the number of caesarean sections, successful and failed VBACs, uterine ruptures, placenta accreta and hysterectomies (Models 1 and 2), and the number of placenta praevia (Model 2 only) for a hypothetical cohort of 100,000 women entering the models. Cumulative rates are reported for the second model. As we chose hysterectomy as our primary outcome, the more favourable strategy was the one that resulted in the lower rate of hysterectomy.

To assess the degree of uncertainty around our results, we performed univariate and multivariate sensitivity analyses. Univariate sensitivity analyses are done by varying one probability estimate through its plausible range, while holding all others constant. Multivariate sensitivity analyses are done by varying more than one probability estimate, while holding the others constant. Finally, we performed a 'bias to' analysis for each model, where all the probability estimates are set at the extreme of their plausible range favouring one strategy.[65–68]

Results

The results of the base-case analysis for Model 1, comparing a strategy of VBAC attempt to a strategy of elective repeat caesarean section for women who desire only one additional pregnancy, are presented in Table 2. The risk of hysterectomy with a strategy of VBAC attempt (267/100,000) is higher than the risk of hysterectomy with a strategy of elective repeat

Table 1. Probabilities and ranges used in base-case and sensitivity analyses

Variable	Base-case analysis	Range	References
Probability of successful VBAC	0.7	0.5–0.9	27–39
Probability of placenta accreta after one prior C/S	0.002	0.0004–0.01	10,19,24,40
Probability of uterine rupture after successful VBAC after one prior C/S	0.001	0.0005–0.005	27,28,34,35,41–46
Probability of uterine rupture after failed VBAC after one prior C/S	0.02	0.005–0.05	27,28,34,35,41–46
Probability of uterine rupture at elective C/S	0.0005	0–0.005	27–29,41,42,44–49
Probability of hysterectomy after a successful VBAC—no rupture, no accreta	0.0001	0.00005–0.002	20–23,27,28,36,38,40,50,51
Probability of hysterectomy after a failed VBAC after one prior C/S—no rupture, no accreta	0.001	0.0005–0.005	20,22,27,28,36,38,40,50,51
Probability of hysterectomy at elective C/S after one prior C/S—no rupture, no accreta	0.0005	0.0001–0.003	20,22,27,28,36,38,40,50,51
Probability of hysterectomy after uterine rupture—no accreta	0.15	0.025–0.3	27,28,30,35,36,38,44,47,48,52–54
Probability of hysterectomy if placenta accreta—no rupture	0.65	0.3–1.0	8,11,13,24,55
Probability of hysterectomy when uterine rupture and placenta accreta	0.8	0.5–1.0	Expert opinion
Probability of placenta praevia after one prior C/S	0.008	0.002–0.02	9–14,16
Probability of successful VBAC after one successful VBAC	0.9	0.85–0.95	36,37,56,57
Probability of placenta accreta if placenta praevia after one prior C/S	0.2	0.05–0.3	9–11,13
Probability of hysterectomy at C/S for placenta praevia—no rupture, no accreta	0.05	0.005–0.2	11,13,16,21,22
Probability of second uterine rupture—with elective C/S when positive fetal lung maturity	0.05	0.01–0.1	33,58–60
Probability of second placenta accreta after one prior C/S and one accreta	0.2	0.1–0.5	Expert opinion
Probability of second placenta accreta when praevia after one C/S	0.7	0.5–0.9	Expert opinion
Probability of placenta praevia after two C/S	0.02	0.01–0.04	9–13
'Probability' of second VBAC attempt after a first failed VBAC attempt	0.2	0.0–1.0	*
Probability of successful VBAC after a failed VBAC attempt	0.5	0.3–0.7	29,30,34,36,39,61–63
Probability of uterine rupture after successful VBAC after two prior C/S	0.0025	0.001–0.01	29,30,34,39,62,64
Probability of uterine rupture at failed VBAC after two prior C/S	0.05	0.01–0.1	29,30,34,39,62,64
Probability of hysterectomy when VBAC failure after one failed VBAC (at third C/S)—no rupture, no accreta	0.001	0.0005–0.01	62
Probability of hysterectomy at elective C/S after two prior C/S	0.001	0.0001–0.005	62
Probability of placenta accreta after two C/S (assuming no placenta praevia)	0.01	0.001–0.05	Expert opinion
Probability of placenta accreta if placenta praevia after two prior C/S	0.35	0.2–0.6	9–11,13
Probability of a second placenta accreta if placenta praevia after two C/S (prior accreta, two prior C/S, praevia the current pregnancy)	0.9	0.7–1.0	Expert opinion
Probability of a second placenta accreta after one prior accreta and two prior C/S	0.4	0.1–0.5	Expert opinion

VBAC = vaginal birth after caesarean section; C/S = caesarean section.
*Represents clinical scenario: the range covers all possibilities.

Table 2. Base-case analysis (per 100,000 women): Model 1 (one additional desired pregnancy)

Strategy	Caesarean section	Successful VBAC	Failed VBAC	Uterine rupture	Placenta accreta	Hysterectomy
Elective repeat C/S	100,000	0	0	50	200	187
VBAC attempt	30,000	70,000	30,000	670	200	267

VBAC = vaginal birth after caesarean section; C/S = caesarean section.

caesarean section (187/100,000). Thus, under baseline probability estimates, an elective repeat caesarean section is the preferred strategy for women who desire only a single additional pregnancy. For every hysterectomy prevented, 1250 elective repeat caesarean sections have to be performed.

Table 3 shows the results of the univariate sensitivity analyses for Model 1. The 'threshold value' is the value of the variable at which the alternative strategy, VBAC attempt for the first model, becomes the preferred strategy. The model is sensitive to the variable if the threshold value falls within the plausible range used in sensitivity analysis. This first model (one additional desired pregnancy) was robust to all but one variable in sensitivity analyses, which means that elective repeat caesarean section remained the preferred strategy when the probability value for most variables was varied in sensitivity analyses. However, Model 1 was sensitive to the probability of hysterectomy at elective repeat caesarean section (no uterine rupture, no placenta accreta). A VBAC attempt became the preferred strategy when the probability of hysterectomy at elective repeat caesarean section (for other indications than uterine rupture or placenta accreta) was higher than 1.3/1000, which is in the reported range.[27]

The results of the base-case analysis for Model 2, comparing a strategy of VBAC attempt to a strategy of elective repeat caesarean section for women who desire two additional pregnancies, are presented in Table 4. The rates reported are the *cumulative* rate of events for both the first and the second pregnancies (after the index caesarean section) illustrated in Model 2. The cumulative risk of hysterectomy is *lower* with a strategy of VBAC attempt (907/100,000) than with a strategy of elective repeat caesarean section (1465/100,000). Thus, under baseline probability estimates, a VBAC attempt is the preferred strategy for women who desire at least two additional pregnancies. For every hysterectomy prevented, 179 women have to initially attempt a VBAC.

These findings were highly robust over substantial variations in assumptions. The second model (two additional desired pregnancies) was robust to all variables in univariate sensitivity analyses (Table 5). Only when all the probabilities were set at the extremes of their plausible range that would favour the elective repeat caesarean section strategy, the 'bias toward elective repeat caesarean section' analysis, did the elective repeat caesarean section become the preferred strategy.

Table 3. Univariate sensitivity analyses: Model 1 (one additional desired pregnancy)

Variable	Plausible range	Threshold value*	Sensitive?†
Probability of successful VBAC	0.5–0.9	0.913	No
Probability of placenta accreta after one prior C/S	0.0004–0.01	None	No
Probability of uterine rupture after successful VBAC after one prior C/S	0.0005–0.005	None	No
Probability of uterine rupture after failed VBAC after one prior C/S	0.005–0.05	0.002	No
Probability of uterine rupture at elective C/S	0–0.005	0.006	No
Probability of hysterectomy after a successful VBAC—no rupture, no accreta	0.00005–0.002	None	No
Probability of hysterectomy after a failed VBAC after one prior C/S—no rupture, no accreta	0.0005–0.005	None	No
Probability of hysterectomy at elective C/S after one prior C/S—no rupture, no accreta	0.0001–0.003	0.0013	Yes
Probability of hysterectomy after uterine rupture—no placenta accreta	0.025–0.30	0.022	No
Probability of hysterectomy if placenta accreta—no rupture	0.3–1.0	None	No
Probability of hysterectomy when uterine rupture and placenta accreta	0.5–1.0	None	No
Bias to VBAC‡			Yes

VBAC = vaginal birth after caesarean section; C/S = caesarean section.
*Threshold value: the value of the variable at which the VBAC attempt becomes the preferred strategy.
†The model is sensitive to the variable if its plausible range contains the threshold value.
‡All probabilities set at the extremes of their plausible ranges favouring the VBAC attempt strategy.

Table 4. Base-case analysis (cumulative rate of events per 100,000 women): Model 2 (two additional desired pregnancies)

Strategy	Caesarean section	Successful VBAC	Failed VBAC	Placenta praevia	Uterine rupture	Placenta accreta	Hysterectomy
Elective repeat C/S	199,813*	0	0	1996	102	1904	1465
VBAC attempt	64,513**	135,221**	39,802	1156	1062	970	907

VBAC = vaginal birth after caesarean section; C/S = caesarean section.
*Not exactly 200,000 as some women had a hysterectomy with their first delivery in the model.
**These numbers do not add up to 200,000 as some women had a hysterectomy with their first delivery in the model.

Table 5. Univariate sensitivity analyses: Model 2 (two additional desired pregnancies)

Variable	Plausible range	Threshold value*	Sensitive?†
Probability of successful VBAC	0.5–0.9	0.3	No
Probability of placenta accreta after one prior C/S	0.0004–0.01	0.02	No
Probability of uterine rupture after successful VBAC after one prior C/S	0.0005–0.005	0.03	No
Probability of uterine rupture after failed VBAC after one prior C/S	0.005–0.05	0.12	No
Probability of uterine rupture at elective C/S	0–0.005	None	No
Probability of hysterectomy after a successful VBAC—no rupture, no accreta	0.00005–0.002	0.004	No
Probability of hysterectomy after a failed VBAC after one prior C/S—no rupture, no accreta	0.0005–0.005	0.02	No
Probability of hysterectomy at elective C/S after one prior C/S—no rupture, no accreta	0.0001–0.003	None	No
Probability of hysterectomy after uterine rupture—no accreta	0.025–0.3	0.75	No
Probability of hysterectomy if placenta accreta—no rupture	0.3–1.0	0.05	No
Probability of hysterectomy when uterine rupture and placenta accreta	0.5–1.0	None	No
Probability of placenta praevia after one prior C/S	0.002–0.02	0.06	No
Probability of successful VBAC after one successful VBAC	0.85–0.95	None	No
Probability of placenta accreta if placenta praevia after one prior C/S	0.05–0.3	None	No
Probability of hysterectomy at C/S for placenta praevia—no rupture, no accreta	0.005–0.2	None	No
Probability of second uterine rupture—with elective C/S when positive fetal lung maturity	0.01–0.1	None	No
Probability of second placenta accreta after one prior C/S and one accreta	0.1–0.5	None	No
Probability of second placenta accreta when praevia after one C/S	0.5–0.9	None	No
Probability of placenta praevia after two C/S	0.01–0.04	None	No
'Probability' of second VBAC attempt after a first failed VBAC attempt	0.0–1.0	None	No
Probability of successful VBAC after a failed VBAC attempt	0.3–0.7	None	No
Probability of uterine rupture after successful VBAC after two prior C/S	0.001–0.01	None	No
Probability of uterine rupture at failed VBAC after two prior C/S	0.01–0.1	None	No
Probability of hysterectomy when VBAC failure after one failed VBAC (at third C/S)—no rupture, no accreta	0.0005–0.01	0.21	No
Probability of hysterectomy at elective C/S after two prior C/S	0.0001–0.005	None	No
Probability of placenta accreta after two C/S (assuming no placenta praevia)	0.001–0.05	None	No
Probability of placenta accreta if placenta praevia after two prior C/S	0.2–0.6	None	No
Probability of a second placenta accreta if placenta praevia after two C/S (prior accreta, two prior C/S, praevia the current pregnancy)	0.7–1.0	None	No
Probability of a second placenta accreta after one prior accreta and two prior C/S	0.1–0.5	None	No
Bias to elective repeat caesarean section‡			Yes

VBAC = vaginal birth after caesarean section; C/S = caesarean section.
*Threshold value: the value of the variable at which the elective repeat C/S becomes the preferred strategy.
†The model is sensitive to the variable if its plausible range contains the threshold value.
‡All probabilities set at the extremes of their plausible ranges favouring the VBAC attempt strategy.

The VBAC success rate is influenced by many clinical factors (prior vaginal delivery, indication for prior caesarean section) and varies from woman to woman. Therefore, we were specifically interested in the results of the multivariate sensitivity analyses that included VBAC success rate. These results for Model 1 (one additional desired pregnancy) are shown in Table 6; threshold values for six probabilities at different baseline VBAC success rates (50%, 60%, 70%, 80% and 90%) are listed. For all the other probabilities, the results were unaffected in multivariate sensitivity analyses: an elective repeat caesarean section remained the preferred strategy.

Model 2 (two additional desired pregnancies) was robust in all multivariate sensitivity analyses that included VBAC success rate. A VBAC attempt remained the preferred strategy, even when the baseline VBAC success rate was 50% and the other variables were varied across their plausible range.

Discussion

The implications of a woman's decision to undergo a VBAC attempt or elective repeat caesarean section in subsequent pregnancies after a single low transverse caesarean section are multiple and complex. In the past several years, researchers and clinicians have focussed on the immediate safety concerns of VBAC-specifically the risk of uterine rupture with its associated risks of maternal morbidity and potential neonatal morbidities. Because of this safety concern, the pendulum regarding VBAC has begun to swing more towards elective repeat caesarean sections. This is evidenced by recent statistics from the U.S. National Center for Health Statistics, which suggests that, after reaching a maximum of 28.3% in 1996, the VBAC rate has declined precipitously since, and was only 12.7% in 2002.[5] We believe, however, that recent arguments about the safety of VBAC have ignored the potential downstream consequences of a strategy of multiple elective repeat caesarean sections. Elective repeat caesarean sections likely consume more resources than VBAC attempts, including an average increase in hospital days for a mother post-caesarean. More importantly, multiple repeat caesareans increase the risk of placenta praevia and placenta accreta in future pregnancies (with their related risks). Thus, the purpose of our decision model was to incorporate both immediate and downstream risks in the delivery decision for a woman with a single low transverse caesarean section.

Our study suggests that for a woman with a single prior caesarean section who plans only one additional pregnancy, a strategy of elective repeat caesarean section is preferred because it results in fewer hysterectomies than a VBAC attempt. This conclusion was stable and mostly unaffected by our sensitivity analyses.

The implications of this decision are different for a woman who desires two or more additional children. In this case, the downstream risks of multiple caesarean sections appear to outweigh the immediate risks of a VBAC attempt. Thus, for a woman who desires two or more additional children, a strategy of VBAC attempts *decreases* the total number of hysterectomies performed (compared with the elective repeat caesarean section strategy). In this case, the increase in hysterectomies performed due to placenta accreta with the repeat caesarean section strategy outweighs the increase in hysterectomies performed due to uterine ruptures with the VBAC attempt strategy. This finding was also very stable across plausible ranges of probabilities in the sensitivity analyses. This is somewhat tempered by the fact that in the VBAC strategy, a small number of women (those who have a uterine rupture followed by a hysterectomy in the first pregnancy) obviously lose the option of having additional children.

We did not build a third model for women who are planning three additional pregnancies after their caesarean

Table 6. Multivariate sensitivity analysis: Model 1 (one additional desired pregnancy). Results for different baseline VBAC success rates

VBAC success rate (%)	Threshold values*at various baseline VBAC success rates					
	Uterine rupture after successful VBAC	Uterine rupture after failed VBAC	Uterine rupture at elective C/S	Hysterectomy after failed VBAC (no rupture, no accreta)	Hysterectomy at elective C/S (no rupture, no accreta)	Hysterectomy after uterine rupture (no accreta)
90	0.00064	0.0167	0.0008	0.0005	0.00055	0.13
80	None	0.0059	0.0033	None	0.00092	0.05
70**	None	Not in range	Not in range	None	0.0013	Not in range
60	None	Not in range	Not in range	None	0.00167	Not in range
50	None	None	Not in range	None	0.00204	None

VBAC = vaginal birth after caesarean section; C/S = caesarean section; not in range = not in plausible range.
*Threshold value: the value of the variable at which the VBAC attempt becomes the preferred strategy.
**Base-case analysis.

section. This model would apply only to a minority of women. Moreover, the data to extract probabilities applying to a third pregnancy after caesarean section are almost non-existent; we would have had to estimate most of these probabilities, leading to substantial uncertainty in the model results. However, if we extrapolate from the second model (two additional desired pregnancies), knowing that the risks of placenta praevia and placenta accreta increase with greater number of previous caesarean sections, we can postulate that a VBAC attempt would be even more favourable in such a model.

The strength of a decision analysis lies in its ability to break down a complex clinical decision into its component parts. In this case, we believe decision analysis was an appropriate research tool to aid clinical decision making. Still, our analysis has the following limitations. First, we chose *a priori* not to include costs in the models. In this case, we do not believe that costs are or should be the driving factor in this clinical decision. Cost and cost-effectiveness studies on trial of labour after a prior low transverse caesarean section have reached divergent conclusions when looking at the costs and the outcomes after only one delivery.[69–71] Interestingly, the only cost-effectiveness study that modeled more than one pregnancy after the first caesarean section demonstrated that a policy of allowing a trial of labour leads to decreased maternal morbidity and decreased costs (even when incorporating long term neonatal outcomes).[72]

Second, we did not include patient preferences in these models but suggest that physicians continue to incorporate preferences into decision making on an individual level. Other adverse maternal outcomes, such as operative injury and blood transfusion, were not included in our models either; the addition of these complications would likely make the VBAC attempt strategy more favourable.

Finally, even though we believe that our study answers important questions about the risk of serious maternal morbidity after one prior caesarean section, we realise and acknowledge that its direct application to clinical practice is limited by the exclusion of neonatal outcomes in our models. Maternal outcomes are only one element of the discussion. Neonatal outcomes should be included in the discussion and decision making as well. The recent literature on VBAC attempt has focussed on increased risks of neonatal mortality and morbidity associated with uterine rupture.[3,27,64] However, the downstream consequences of multiple caesarean sections (i.e. placenta praevia) have also been associated with neonatal mortality and morbidity, mostly due to pre-term delivery.[73,74] The question remains: Will it ultimately be possible to incorporate and balance maternal and neonatal outcomes in a single study to definitely close the debate on the optimal management of women with one prior caesarean section? Even if a randomised controlled trial occurs, we doubt that it would definitely close the debate. It would most likely provide answers only about immediate maternal and neonatal outcomes, as to be able to compare downstream consequences of both options (VBAC attempt and elective repeat caesarean section), one would have to enroll and follow women throughout their whole reproductive life. We suggest that a more comprehensive decision model incorporating multiple maternal and neonatal outcomes should be the next step to address this question. However, before this can be accomplished in a meaningful way, better information is needed on the incidence of outcomes such as operative injury, urinary incontinence and stillbirth. There is also a need for validated utilities applying to the outcomes to be included in such a comprehensive decision model, as such a model will require the use of utilities to balance the different maternal and neonatal outcomes.

Conclusion

The results of our analysis suggest that the downstream consequences of multiple caesarean sections must be incorporated into patient counseling regarding VBAC, especially in women who are considering multiple additional children. Specifically, for women who desire multiple children after a single caesarean, a strategy encouraging VBAC will result in fewer cumulative hysterectomies than an elective repeat caesarean section strategy. Our results should also be taken into consideration when making policies about the mode of delivery after one prior caesarean section: they suggest that if the 'pendulum' continues to swing away from VBAC, the incidence of placenta praevia and placenta accreta, and their associated morbidities, will continue to rise sharply. ■

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