ORIGINAL RESEARCH

Remote prognosis after primary cesarean delivery: the association of VBACs and recurrent cesarean deliveries with maternal morbidity

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Purpose: To determine the effects of vaginal birth after cesarean (VBAC) versus repeated cesarean sections (RCS) after a primary cesarean section (CS), on the rate of intraoperative and postpartum maternal morbidity.

Patients and methods: This is a retrospective population-based cohort study. During the study period (1988–2005) there were 200,012 deliveries by 76,985 women at our medical center; 16,365 of them had a primary CS, of which 7429 women delivered a singleton infant after the primary CS, met the inclusion criteria, were included in our study, and were followed for four consecutive deliveries. Patients were divided into three study groups according to the outcome of their consecutive delivery after the primary CS: VBAC (n = 3622), elective CS (n = 1910), or an urgent CS (n = 1897). Survival analysis models were used to investigate the effect of the urgency of CS and the numbers of pregnancy predating the primary CS on peripartum complications.

Results: Women who failed a trial of labor had a higher rate of uterine rupture than those who had a VBAC. Patients who delivered by CS had a higher rate of endometritis than those giving birth vaginally. The rate of cesarean hysterectomy and transfer to other departments increased significantly at the fourth consecutive surgery ($P = 0.02$ and $P = 0.003$, respectively). VBAC was associated with a 55% reduction in the risk of intrapartum complications in comparison to a planned CS (hazard ratio [HR] 0.45; 95% confidence interval [CI]: 0.22–0.89. A greater maternal parity at the time of primary CS was associated with lower intrapartum and postpartum morbidities (HR 0.44; 95% CI: 0.24–0.79; HR 0.54; 95% CI: 0.47–0.62, respectively).

Conclusions: (1) A successful VBAC is associated with a reduction in the intrapartum complications; and (2) maternal morbidity increases substantially from the fourth consecutive cesarean delivery.

Keywords: trial of labor, uterine rupture, hysterectomy, blood transfusion, parity

Introduction

Cesarean section (CS) is the most common surgery performed in the US and its rate is progressively rising throughout the world.[1] The major increase in the CS rate in western societies was recorded between the 1970s and early 1980s. A transient decrease in primary CS, along with an increase in vaginal birth after cesarean (VBAC), was observed between 1989 and 1996;[2] however, since 1996, the total cesarean rate has been annually increasing reaching 27.6% in 2003[3] and 30.1% in 2006.[4]

Maternal morbidity associated with a CS is substantially higher than that of a vaginal delivery.[5–7] Therefore, VBAC had been regarded as an effective method to reduce the rate of recurrent cesarean deliveries. However, recent studies demonstrated higher maternal and fetal complications in patients undergoing a trial of labor after

CS than in those electively delivered by an elective repeated CS.[8–10] Indeed, a symptomatic uterine rupture occurred in 0.5%–0.7% of women who underwent a trial of labor[11] and the rate of hypoxic–ischemic encephalopathy increases among patients who attempt a trial of labor especially in cases of uterine rupture during this process.[11–14] Because of that, the American College of Obstetrics and Gynecology (ACOG), has recommended that a trial of labor after cesarean delivery is to be done only in hospitals that have facilities for emergency CS. The new guidelines say that hospitals ill-equipped for immediate surgery should help women find care elsewhere and have a plan to manage uterine ruptures.[15]

Thus far, the data regarding maternal complications of deliveries following a CS (either by VBAC or elective repetitive CS), has mainly focused on the first birth after the primary CS. In contrast, there is a paucity of information concerning maternal morbidity associated with either repeated VBAC or repeated CS (RCS). The aims of this large population cohort study including women with a prior CS were to: (1) compare the maternal morbidity associated with elective repetitive CSs and repeated VBACs; and (2) compare the maternal morbidity of an elective repetitive CS with that of an emergency CS due to failed trial of labor.

Materials and methods
Study population and selection of patients

This retrospective population-based cohort study included 7429 women with a singleton pregnancy who delivered subsequently to a primary CS at the Soroka University Medical Center, a regional tertiary medical center in Beer Sheva, Israel, where all the births in the region take place. Cases were identified by searching a computerized birth records database. Women included in the study were followed up to a maximum of four consecutive deliveries after their primary CS in the univariate analyses.

Outcome variables

Data concerning demographic characteristics, medical and obstetric history, as well as pregnancy, delivery, and perinatal outcome, were obtained from the computerized database. The primary outcomes were the rate of intrapartum and postpartum maternal complications during consecutive trials of labor and the intraoperative and postoperative complications of patients with repetitive CS. The data were analyzed

by two methods: (1) the effect of recurrent CSs versus repeated VBACs on intrapartum, operative, and postpartum complications; and (2) the effect of a failure in trial of labor on maternal morbidity.

For patients who attempted a VBAC, intrapartum complications included failure to progress during the first and second stages of labor, placental abruption, uterine rupture, uterine scar dehiscence, instrumental delivery, blood product transfusion, and the need for urgent CS. Postpartum complications included postpartum fever, endometritis, urinary tract infection, anemia, uterine rupture, blood product transfusion, and transfer to other departments (ie, intensive care unit).

For patients who underwent a CS, either elective or urgent, intraoperative complications included infection, trauma to adjacent organs, hysterectomy, blood products transfusion, and transfer to another department after CS. Post-operative complications included: reopening of cesarean scar, disruption of cesarean scar, and wound infection.

Statistical analysis

Maternal demographic characteristics, peripartum complications, and perinatal outcomes were compared with a two-step analysis. First, we compared the rate of complications between patients who underwent repeated VBAC and those who had RCSs. Subsequently, we compared the rate of complications of elective and urgent CS in patients with RCS and in those who failed a trial of VBAC. Student's t-test was used to compare means for normally distributed variables. Chi-square and Fisher exact tests were used to compare categorical variables. Cox proportional hazard regression was performed to investigate the association between repeated VBAC, maternal parity at primary CS, and urgent versus planned CS, to peripartum and postpartum complications. A P value of <0.05 was considered significant. Analysis was done using SAS packages (version 9.1; SAS Institute, Cary, NC).

Results

During the study period (1988–2005) there were 200,012 deliveries by 76,985 women at our medical center; 16,365 of them had a primary CS, of which 7429 women delivered a singleton infant after the primary CS, met the inclusion criteria, and were included in our study (the indication and perinatal complication leading to the primary CS are presented in Supplementary Table 1). The study population was further divided according to the outcome of the subsequent

delivery after the primary CS: 48.8% (3622/7429) had a successful trial of labor and were included in the VBAC group; 25.5% (1897/7429) had an urgent CS due to maternal or fetal indication and comprised the urgent CS group; and 25.7% (1910/7429) who had an elective CS and were included in that group.

The rate of trial of labor after a primary CS was 74.3% (5519/7429); of these 65.6% (3622/5516) succeeded and had a VBAC. The distribution of repeated VBACs, elective and urgent cesarean deliveries up to four consecutive deliveries after the primary CS, are presented in Figure 1A–C. The proportion of VBAC out of all the deliveries increases with each additional consecutive birth, and women in the VBAC group had a higher chance of having four consecutive deliveries after the primary CS than women in the urgent CS (odds ratio [OR], 2.13; 95%; confidence interval [CI]: 2.43–3.54) or the elective CS (OR, 13; 95% CI: 9.16–18.55) groups. Of interest is the finding that women included in the urgent CS group had a higher chance of having four consecutive deliveries after the primary CS than those included in the elective CS group (OR, 4.44; 95% CI: 3.03–6.53) (Figure 2). Demographic characteristics of the study groups are presented in Table 1.

The rate of pregnancy and peripartum complications of the consecutive deliveries after the primary CS is presented in Supplementary Table 2. Patients with RCS, compared to those who had repeated VBACs, had a higher rate of pregnancy complications. A leading indication for repeated urgent CS after the primary CS was labor dystocia; this was the indication for 39.3% of the urgent CSs in the delivery following the primary CS. Of interest, the rate of labor dystocia declined to about 15% of the subsequent deliveries (Supplementary Tables 3–5).

Patients with RCS were more likely to require blood products transfusion than patients in the VBAC group. There was no difference in the rate of uterine rupture between those with RCS and those with consecutive VBACs. The rate of these complications did not differ between urgent and elective CS (Table 2). In the first three subsequent deliveries after the primary CS, patients with RCS had higher rates of postpartum fever and endometritis than those with consecutive VBACs (Table 3).

In patients undergoing repeated cesarean deliveries, the rate of blood products transfusion, trauma to adjacent organs, endometritis, postpartum fever, and urinary tract infections did not significantly change with the increase in the number of recurrent cesarean deliveries. However, the rate of cesarean

hysterectomy and transfer to other departments increased significantly at the fourth consecutive surgery ($P = 0.02$ and $P = 0.003$, respectively) (Figure 3). The major indications for cesarean hysterectomy were uterine rupture and hemorrhage. The rate of placenta accrete differed among the study group and was highest among the elective CS group 0.73% (14/1910), followed by the urgent CS group 0.16% (3/1897), and lowest among those who had VBAC 0.08% (3/3622; $P < 0.001$).

The neonatal outcome of the study groups is presented in Supplementary Tables 6–8. The rate of 1-minute Apgar score <5 was higher among patients with recurrent CS than in those with consecutive VBACs in all subsequent pregnancies following the primary CS. However, the rate of 5-minute Apgar score <7 did not differ significantly between the study groups in all the subsequent deliveries after the primary CS. The total perinatal mortality rate was higher among women who had a VBAC in the first delivery after the primary CS than in those with recurrent CS, mainly due to a higher rate of antepartum death in the VBAC group. However, in the fourth delivery after the primary CS, women with recurrent CS had a higher rate of total perinatal mortality than those with repeated VBACs, mainly due to a higher rate of postpartum death (Supplementary Tables 7 and 8).

The contribution of a failure in a trial of labor to maternal morbidity is a key question. In order to address it we further analyzed our data including patients who had an urgent cesarean delivery due to labor dystocia. In comparison to women undergoing a nonurgent CS, those who failed a trial of labor had a higher rate of CS complications in general ($P < 0.001$), infections, and the need to transfer to another department in the second and third delivery after the primary CS (Table 4).

In comparison to those who had a successful VBAC, those who failed in a trial of labor had a higher rate of uterine rupture ($P < 0.001$). Of interest, the rate of uterine rupture did not differ between those who had a nonurgent CS and those who failed a trial of labor (Table 5).

To study the additive effect of RCS versus subsequent VBACs we constructed a Cox proportional hazard model separately for intrapartum and postpartum maternal morbidity, in which the outcome of nonurgent repeated morning CS served as the reference point and was compared to the outcome of VBAC and urgent CS at each consecutive delivery. The number of deliveries after the primary CS served as the time parameter. In the model for intrapartum complications, a protective effect was given by any additional VBAC (HR,
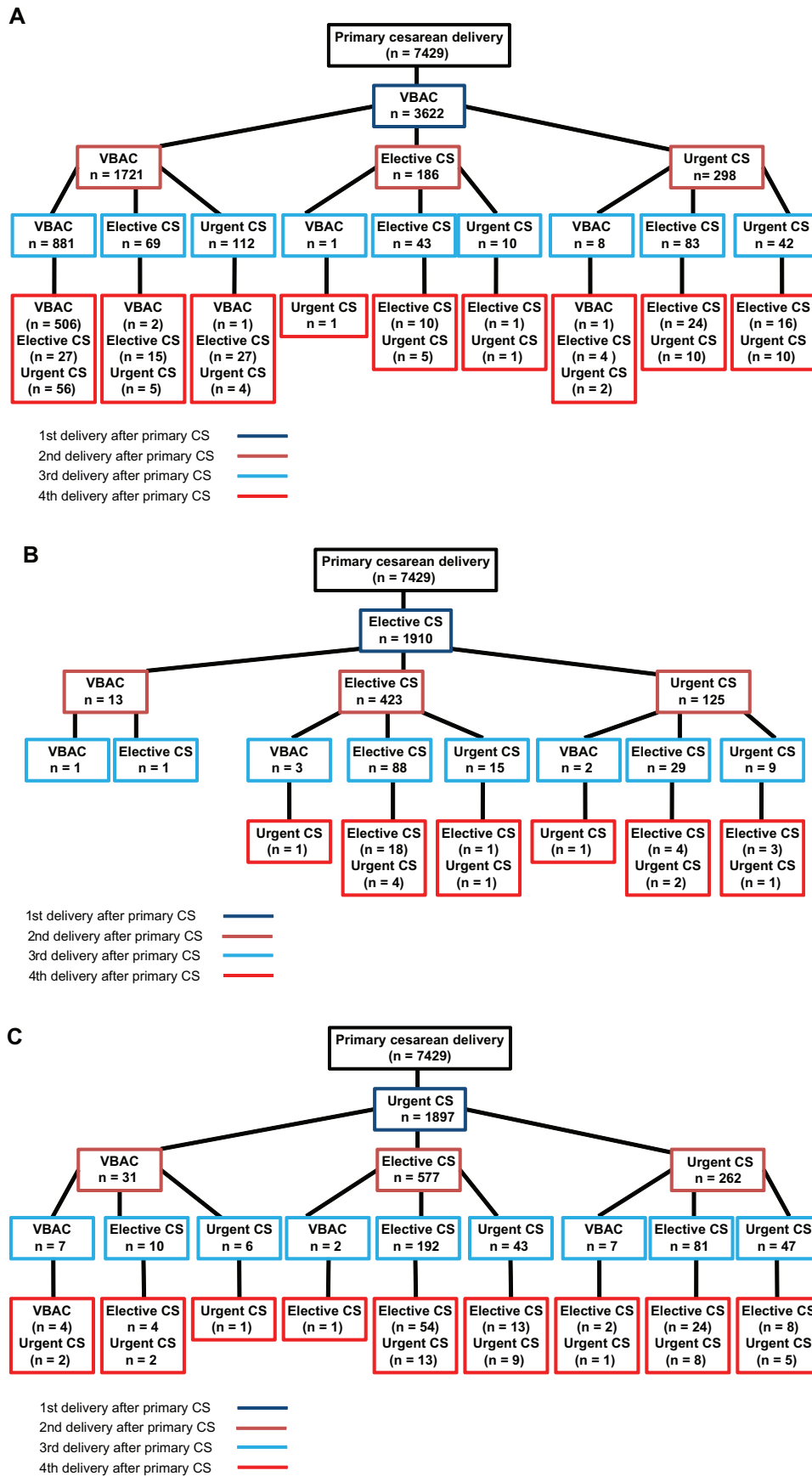
A

Primary cesarean delivery
(n = 7429)

VBAC
n = 3622

VBAC
n = 1721

Elective CS
n = 186

Urgent CS
n= 298

VBAC
n = 881

Elective CS
n = 69

Urgent CS
n = 112

VBAC
n = 1

Elective CS
n = 43

Urgent CS
n = 10

VBAC
n = 8

Elective CS
n = 83

Urgent CS
n = 42

VBAC
(n = 506)
Elective CS
(n = 27)
Urgent CS
(n = 56)

VBAC
(n = 2)
Elective CS
(n = 15)
Urgent CS
(n = 5)

VBAC
(n = 1)
Elective CS
(n = 27)
Urgent CS
(n = 4)

Urgent CS
n = 1

Elective CS
(n = 10)
Urgent CS
(n = 5)

Elective CS
(n = 1)
Urgent CS
(n = 1)

VBAC
(n = 1)
Elective CS
(n = 4)
Urgent CS
(n = 2)

Elective CS
(n = 24)
Urgent CS
(n = 10)

Elective CS
(n = 16)
Urgent CS
(n = 10)

1st delivery after primary CS
2nd delivery after primary CS
3rd delivery after primary CS
4th delivery after primary CS

B

Primary cesarean delivery
(n = 7429)

Elective CS
n = 1910

VBAC
n = 13

Elective CS
n = 423

Urgent CS
n = 125

VBAC
n = 1

Elective CS
n = 1

VBAC
n = 3

Elective CS
n = 88

Urgent CS
n = 15

VBAC
n = 2

Elective CS
n = 29

Urgent CS
n = 9

Urgent CS
(n = 1)

Elective CS
(n = 18)
Urgent CS
(n = 4)

Elective CS
(n = 1)
Urgent CS
(n = 1)

Urgent CS
(n = 1)

Elective CS
(n = 4)
Urgent CS
(n = 2)

Elective CS
(n = 3)
Urgent CS
(n = 1)

1st delivery after primary CS
2nd delivery after primary CS
3rd delivery after primary CS
4th delivery after primary CS

C

Primary cesarean delivery
(n = 7429)

Urgent CS
n = 1897

VBAC
n = 31

Elective CS
n = 577

Urgent CS
n = 262

VBAC
n = 7

Elective CS
n = 10

Urgent CS
n = 6

VBAC
n = 2

Elective CS
n = 192

Urgent CS
n = 43

VBAC
n = 7

Elective CS
n = 81

Urgent CS
n = 47

VBAC
(n = 4)
Urgent CS
(n = 2)

Elective CS
n = 4
Urgent CS
(n = 2)

Urgent CS
(n = 1)

Elective CS
(n = 1)

Elective CS
(n = 54)
Urgent CS
(n = 13)

Elective CS
(n = 13)
Urgent CS
(n = 9)

Elective CS
(n = 2)
Urgent CS
(n = 1)

Elective CS
(n = 24)
Urgent CS
(n = 8)

Elective CS
(n = 8)
Urgent CS
(n = 5)

1st delivery after primary CS
2nd delivery after primary CS
3rd delivery after primary CS
4th delivery after primary CS

Figure 1 Mode of delivery in consecutive deliveries after the primary CS of patients who had a (**A**) VABC, (**B**) urgent CS, or (**C**) elective CS.
Abbreviations: CS, cesarean section; VBAC, vaginal birth after cesarean.

96

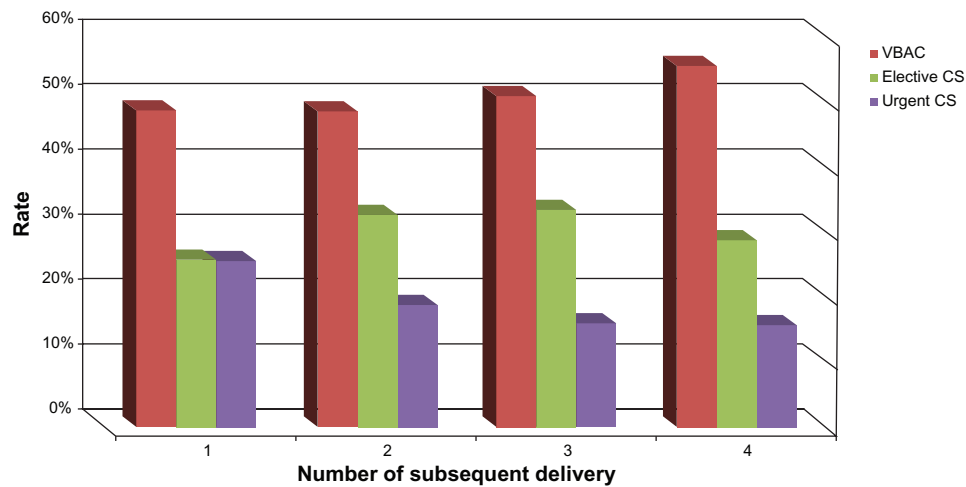International Journal of Women's Health 2012:4

Figure 2 The rate of VBAC, urgent CS and elective CS in the subsequent deliveries after the primary CS.
Abbreviations: CS, cesarean section; VBAC, vaginal birth after cesarean.

0.45; 95% CI: 0.22–0.9) and by maternal parity at primary CS (HR, 0.44; 95% CI: 0.24–0.79) (Table 6a). Urgent CS was not associated with a significant change in the risk of intrapartum complications versus nonurgent repeated morning CS. In the model for maternal postpartum morbidity, only maternal parity at primary CS had a significant protective effect (HR, 0.54; 95% CI: 0.47–0.62) (Table 6a). The introduction of maternal age and labor dystocia to the model did not affect its results (Table 6b).

Discussion
Principal findings of the study
A successful trial of labor after a primary CS is associated with a higher future parity. In comparison to those who delivered by RCS in all subsequent pregnancies, patients who delivered consecutively by repeated VBACs had a lower maternal morbidity, and a 51.9% reduction in the risk of intrapartum complications for each successful trial of labor. A failure in a trial of labor is a major cause of

maternal morbidity, mainly in the first delivery after the primary CS.

What is the effect of repeated VBACs versus recurrent CS
The finding that repeated trials of labor ending in successful VBACs are associated with lower maternal morbidity than RCS is novel. This study is the first to compare the outcome of consecutive VBAC to RCSs. Indeed, women who underwent repeated vaginal deliveries after the primary CS had lower rate of blood products transfusion and postpartum infections than women who had repeated cesareans. The finding that each additional VBAC, when compared to elective RCS, was associated with a 55% reduction in the risk for intrapartumand postpartum complication in comparison to elective CS, is novel and further emphasizes the safety and the benefit of a successful trial of labor.

Repeated VBACs were associated with an overall reduction in intrapartum and postpartum maternal morbidity with

Table I Demographic characteristics of patients at subsequent pregnancy after primary cesarean delivery according to the route of delivery

Measure	VBAC (n = 3622)	Elective CS (n = 1910)	Urgent CS (1897)	*P*-value
Jewish origin	43.4% (1572/3622)	70.6% (1348/1910)	48.2% (914/1897)	<0.001
Age (years)				
Mean ± SD (n)	28.15 ± 5.42(3621)	31.34 ± 5.21(1906)	29.70 ± 5.56(1895)	<0.001
Gravidity				
2–5	76.4% (2764/3616)	74.1% (1416/1910)	74.5% (1413/1896)	0.1046
6+	23.6% (852/3616)	25.9% (494/1910)	25.5% (483/1896)	
Parity				
2–5	86.4% (2928/3387)	87.1% (1565/1796)	85.1% (1525/1793)	0.1760
6+	13.6% (459/3387)	12.9% (231/1796)	14.9% (268/1793)	
Infertility treatments	6.9% (251/3622)	7.5% (143/1910)	7.2% (136/1897)	0.7444

Note: Data is presented in percentage (number).
Abbreviations: VBAC, vaginal birth after cesarean; CS, cesarean section.

Table 2 Delivery related complications of patients with consecutive VBAC without CS or consecutive CS without VBAC

Complications	1st delivery after index CS			2nd delivery after index CS			3rd delivery after index CS			4th delivery after index CS		
	Urgent CS (n = 1897)	nonurgent CS (n = 1910)	VBAC (n = 3622)	Urgent CS (n = 387)	nonurgent CS (n = 1000)	VBAC (n = 1721)	Urgent CS (n = 114)	Nonurgent CS (n = 390)	VBAC (n = 881)	Urgent CS (n = 43)	Nonurgent CS (n = 125)	VBAC (n = 506)
Any Delivery complications	3.1 (58)	3.6 (68)	0.4 (13)**	2.8 (11)	3.5 (35)	0.1 (1)**	6.1 (7)	4.6 (18)	0.1 (1)	9.3 (4)	3.2 (4)	0**
Uterine scar dehisence	2.1 (40)	3.0 (57)	0.2 (6)**	1.8 (7)	3.2 (32)	0**	3.5 (1)	3.6 (14)	1 (0.1)**	7.0 (3)	1.6 (2)	0**
Uterine rupture	0.3 (5)	0.3 (5)	0.1 (3)	0.3 (1)	0.2 (2)	0.1 (1)	0	0.3 (1)	0	0	1.6 (2)	0
Blood products transfusion	0.8 (15)	0.4 (8)	0.1 (5)**	0.8 (3)	0.2 (2)	0**	2.6 (3)	1.0 (4)	0	4.7 (2)	0.8 (1)	0**

Notes: Data is presented in percentage (n). *<0.05, **<0.001.
Abbreviations: CS, cesarean section; VBAC, vaginal birth after cesarean section.

every additional delivery. This is in accord with the findings of Mercer et al,[16] who reported that among 13,532 women from 19 medical centers across the US, VBAC success increased with increasing number of prior VBACs. The rate of uterine rupture decreased after the first successful VBAC and did not increase thereafter. The risk of uterine dehiscence and other peripartum complications also declined substantially after the first successful VBAC. In comparison to the findings of this group, we had a lower rate of uterine rupture in every additional VBAC, and a somewhat lower rate of successful VBAC in each consecutive delivery. The main explanation for this observation is that some of the centers included in the study of Mercer et al[16] allowed patients with more than one CS to go into a trial of labor, while in our center more than one CS is a contraindication for a trial of labor. Collectively, our findings and those of others support the protective and positive effect of recurrent VBAC on maternal morbidity.

In contrast to the beneficial effect of recurrent VBAC, repeated cesarean deliveries are associated with increased maternal morbidity. We report herein that the rate of uterine rupture, hysterectomy, blood and blood product transfusion, and the need for transferring the patient to other departments rises with the increasing number of cesarean deliveries, especially after the fourth consecutive CS. This is in accord with previous reports: Makoha et al[17] noted similar elevation maternal morbidity, including placenta previa, placenta accreta, hysterectomy, adhesions, bladder injury, postoperative hemoglobin deficit, and need for blood transfusion with an increasing number of cesarean deliveries; and Silver et al,[18] for the National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network, reported that the risks of placenta accreta, cystotomy, bowel injury, ureteral injury, and ileus, the need for postoperative ventilation, intensive care unit admission, hysterectomy, and blood transfusion requiring four or more units, and the duration of operative time and hospital stay, significantly increased with an increasing number of cesarean deliveries. Similarly to our findings, Silver et al[18] reported that there was a substantial increase in the risk for several morbidities, including placenta accreta, cystotomy, and need for hysterectomy or intensive care unit admission with the fourth or greater cesarean delivery. Thus, although there is no strict cut off regarding the number of consecutive CSs, it seems that the maternal risk for serious intraoperative complications increases substantially from the fourth RCS. This information should

Table 3 Post-partum related complications of patients with consecutive VBAC without CS or consecutive CS without VBAC

Complications	1st delivery after index CS			2nd delivery after index CS			3rd delivery after index CS			4th delivery after index CS		
	Urgent CS (n = 1897)	Nonurgent CS (n = 1910)	VBAC (n = 3622)	Urgent CS (n = 387)	Nonurgent CS (n = 1000)	VBAC (n = 1721)	Urgent CS (n = 114)	Nonurgent CS (n = 390)	VBAC (n = 881)	Urgent CS (n = 43)	Nonurgent CS (n = 125)	VBAC (n = 506)
Endometritis	2.1 (40)	1.1 (20)	0.2 (7)**	3.4 (13)	1.1 (11)	0.3 (5)**	0.9 (1)	2.3 (9)	0**	0	2.9 (3)	0*
Post-partum fever	2.5 (47)	1.7 (33)	0.6 (20)**	2.1 (8)	1.9 (19)	0.1 (6)**	4.4 (5)	1.3 (5)	0.1 (1)**	0	0.8 (1)	0
Urinary tract infection	1.0 (19)	0.7 (13)	0.3 (11)*	1.6 (6)	0.7 (7)	0.1 (2)**	0	0.5 (2)	0	0	1.6 (2)	0
Transfer to other department	0.8 (15)	0.5 (10)	0.6 (20)	2.3 (9)	0.4 (4)	0.5 (8)*	2.6 (3)	1.0 (4)	0.7 (6)	4.7 (2)	2.4 (3)	0.2 (1)*

Notes: Data is presented in percentage (n). *<0.01, **<0.001.
Abbreviations: CS, cesarean section; VBAC, vaginal birth after cesarean section.

be included while counseling patients regarding repeated cesarean births.

An additional effect of repeated VBACs is the higher number of subsequent deliveries after the primary CS in comparison to those of women who had an elective or urgent RCS. Of interest is the fact that a higher proportion of those who underwent an urgent CS, immediately after the primary CS, had four subsequent pregnancies in comparison to those who had an elective CS. This finding is novel, and it may reflect the differences in the study population; meaning that a higher proportion of patients who choose to have an elective cesarean after the primary CS have a tendency to smaller families than those who attempt a trial of labor after the primary CS. Indeed, the sharp decline in the number of deliveries in this group is after the third cesarean. Guise et al[19] proposed that a woman's decision to undergo a trial of labor after a primary CS is a complex process that is affected by medical, cultural, behavioral, and legal factors. The retrospective nature of our study does not allow us a deeper and more thorough investigation into these factors in relation to our population. A specially designed prospective study will need to be conducted in order to address the effect of these factors on the patient's decision to undergo a trial of labor versus elective CS; nevertheless, educating women about their options early enough in pregnancy for them to make an informed choice is a key factor in this process.

What is the effect of labor dystocia on the success of a trial of labor?

The success of a trial of labor is an end point of many variables. Some of these parameters have been included in different prediction models[20–23] aiming to assess the probability of a given patient to deliver vaginally after a primary CS. According to our findings, labor dystocia is a significant contributor to a failure of a trial of labor mainly in the first delivery after a primary CS. Dystocia was the indication for almost 40% of the urgent CS in the delivery following the primary CS, yet in the subsequent deliveries, its rate declined to about 15% of the urgent CS. This finding further emphasizes previously published data that women with a history of a labor dystocia which led to their primary CS have a lower chance to succeed in a trial of labor in the subsequent birth.[24–27] In addition, our finding that the rate of dystocia as an indication for urgent CS declines in the following deliveries suggests that women who twice failed a trial of labor probably deliver by elective CS in
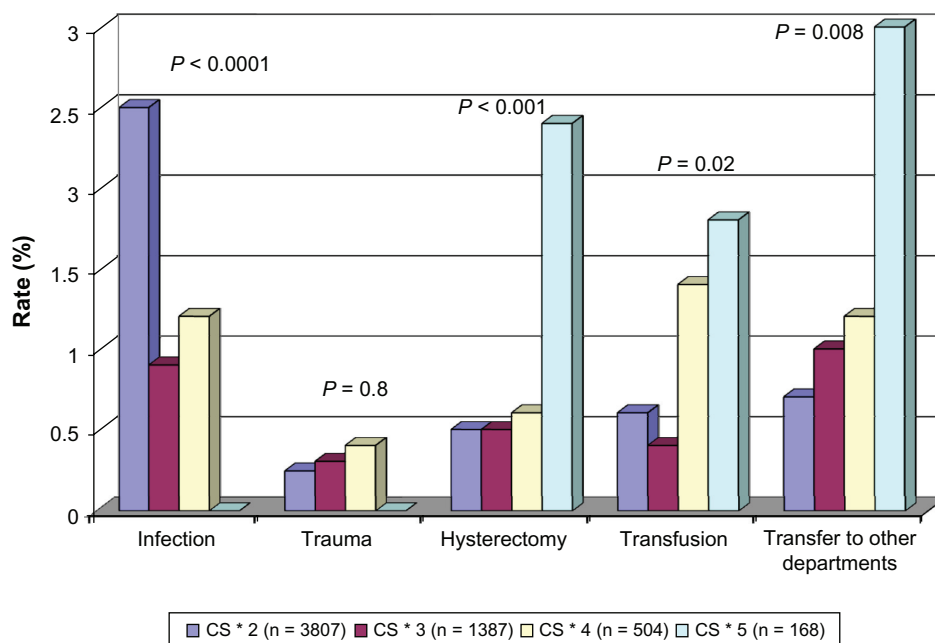
Figure 3 Intraoperative complications of patients with recurrent CS.
Abbreviation: CS, cesarean section.

their subsequent pregnancies or stop delivering. Indeed, in our cohort, only 45.9% of women who had an urgent CS during the subsequent birth after the primary cesarean had additional deliveries, mostly by elective CS. In contrast to this group, 60.9% of women who had a successful VBAC after the primary CS continued to deliver and only 8.4% of them had an elective CS. Collectively the data presented herein suggest that the success in vaginal delivery at the subsequent birth after the primary CS has important implication for maternals health and reproductive future. Those who prevail in the trial of labor and have a VBAC will have overall higher pregnancy rate and lower maternal morbidity than those who failed a trial of labor and women who chooses elective RCS.

Strength and limitation of the study

The limitation of this study is its retrospective nature and the fact that the data are derived from a database which has inherited limitations. Moreover, in the analysis of the data it seems that the inclination of the medical team is to go for a RCS whenever the patient has an additional pregnancy complication aside from the previous CS, which may lead to a bias towards allowing a trial of labor only for the healthier women. We could not ascertain this bias; nevertheless, the large number of deliveries included in our study over such a long period, as well as the fact that all the deliveries of our region take place at our medical center, assure us that the data presented herein is a representative sample of our obstetric population.

Table 4 Intraoperative complications of patients who failed a trial of labor and those who had a nonurgent CS

Complications	2nd delivery after index CS			3rd delivery after index CS		
	Failed TOL (n = 105)	Nonurgent CS (n = 1186)	P-value	Failed TOL (n = 46)	Nonurgent CS (n = 596)	P-value
Any CS complications	3.8 (4)	1.8 (21)	0.139	6.5 (3)	2.4 (14)	0.115
Infection	1.9 (2)	0.7 (8)	0.192	2.2 (1)	0.8 (5)	0.361
Trauma to adjacent organs	0	0.3 (3)	1.000	2.2 (1)	0.3 (2)	0.200
Hysterectomy	1.0 (1)	0.5 (6)	0.449	4.4 (2)	0.7 (4)	0.063
Blood products transfusion	1.0 (1)	0.3 (4)	0.346	2.2 (1)	0.7 (4)	0.311
Transfer to other department	0	0.5 (6)	1.000	2.2 (1)	0.5 (3)	0.258

Notes: Data is presented in percentage (n). Failed TOL was defined as not-planned CS with labor dystocia. Nonurgent CS was defined as CS without indication for urgent CS when section is performed between 8am–3pm.
Abbreviations: CS, cesarean section; TOL, trial of labor.

Table 5 Delivery-related complications of patients who failed a trial of labor, those who had a nonurgent CS and those who had a VBAC

Complications	2nd delivery after index CS				3rd delivery after index CS			
	Failed TOL (n = 105)	Nonurgent CS (n = 1186)	VBAC (n = 1765)	P-value	Failed TOL (n = 46)	Nonurgent CS (n = 596)	VBAC (n = 912)	P-value
Any delivery complications	4.8 (5)	3.6 (43)	0.1 (1)	<0.001	2.2 (1)	4.2 (25)	0.2 (2)	<0.001
Dehiscence	1.9 (2)	3.2 (38)	0	<0.001	0	3.4 (20)	0.2 (2)	<0.001
Blood products transfusion	1.0 (1)	0.3 (4)	0	0.010	2.2 (1)	0.7 (4)	0	0.008
Uterine rupture	2.9 (3)	0.2 (2)	0.1 (1)	<0.001	2.2 (1)	0.3 (2)	0	0.016

Notes: Data is presented in percentage. Failed TOL was defined as not-planned CS with labor dystocia; Nonurgent CS was defined as CS without indication for urgent CS when section is performed between 8am–3pm.
Abbreviations: CS, cesarean section; TOL, trial of labor.

Conclusion

In summary, repeated VBACS are associated with a lower intrapartum maternal morbidity than planned recurrent cesarean deliveries. The recently published National Institute of Child Health and Human Development (Bethesda, MD) consensus regarding VBAC, states that about 30% of maternal fetal medicine fellows do not consult patients with a previous CS regarding the possibility of a trial of labor.[2] The findings of the current study and others may be used to reduce this trend among obstetricians and increase the rate of trial of labor. Moreover, the findings of this study further emphasize the point that a woman who desires large families should be offered a trial of labor after her primary cesarean delivery, especially if she had vaginal deliveries prior to her CS.

Supplementary clinical definitions

Parity groups were defined as follows: multipara (two to five deliveries) and grand-multipara (six or more deliveries). Hypertension was defined in the presence of blood pressure $\geq$140/90 mmHg recorded in two separate measurements at least 4 hours apart. Mild hypertension was defined as a diastolic blood pressure $\geq$90 mmHg and <110 mmHg and/or systolic blood pressure $\geq$140 mmHg and <160 mmHg. Severe hypertension was defined in the presence of

diastolic blood pressure $\geq$110 mmHg and systolic blood pressure $\geq$160 mmHg. Gestational hypertension was defined in the presence of hypertension developed after 20 weeks of gestation without proteinuria. Preeclampsia was diagnosed in the presence of elevated blood pressure and proteinuria of at least + 1 in dipstick; its severity was defined according to the severity of hypertension and/or one of the following + 3 proteinuria by dipstick, thrombocytopenia $\leq$100,000, elevated liver enzymes, persistent headache and/or blurred vision.[28] Gestational diabetes was diagnosed according to oral glucose tolerance test and was classified according to White's classification.[29] Hydramnios (amniotic fluid index [AFI]) > 25 cm or when a vertical pocket of at least 8 cm was measured or as a subjective estimation of increased amniotic fluid volume. Oligohydramnios (AFI) <5 cm, a real-time scanner equipped with a 3.5/5 MHz transducer of appropriate focal length estimated amniotic fluid volume. Preterm delivery was defined as delivery before completion of 37 weeks of gestation.

Newborns were classified according to their weight as: small for gestational age (SGA), birthweight less than the 10th percentile; adequate for gestational age (AGA), birthweight from 10th–90th percentile; and large for gestational age (LGA), birthweight >90th percentile according to regional growth curves.[30] Prelabor rupture of membranes

Table 6a Cox proportional hazard ratio for factors associated with intra-partum and post-partum complications

Variable	Intra-partum complications			Post-partum complications		
	Parameter Estimate	Hazard Ratio	95% Confidence interval	Parameter Estimate	Hazard Ratio	95% Confidence interval
VBAC	−0.807	0.45	0.22; 0.90	−0.044	0.96	0.78; 1.18
Unplanned cesarean delivery	−0.110	0.90	0.44; 1.83	0.117	1.12	0.88; 1.43
First CS	0.829	0.44	0.24; 0.79	−0.622	0.54	0.47; 0.62

Note: VBAC and unplanned cesarean delivery are compared to planned cesarean delivery.
Abbreviations: First CS, the pregnancy number in which the patient undergoes cesarean delivery; CS, cesarean section; VBAC, vaginal birth after cesarean section.

Table 6b Cox proportional hazard ratio for factors associated with intra-partum and post-partum complications

Variable	Intra-partum complications			Post-partum complications		
	Parameter Estimate	Hazard Ratio	95% Confidence interval	Parameter Estimate	Hazard Ratio	95% Confidence interval
VBAC	−0.85	0.43	0.21; 0.86	−0.07	0.93	0.75; 1.15
Unplanned cesarean delivery	0.02	1.02	0.48; 2.17	0.07	1.07	0.82; 1.40
First CS	−0.77	0.46	0.25; 0.83	−0.60	0.55	0.48; 0.63
Labor dystocia	−0.63	0.33	0.15; 1.89	−0.11	1.11	0.81; 1.54
Maternal age	−0.05	0.95	0.89; 1.01	−0.02	0.98	0.96; 0.996

Note: VBAC and unplanned cesarean delivery are compared to planned cesarean delivery
Abbreviations: CS, cesarean section; VBAC, vaginal birth after cesarean section; First CS, the pregnancy number in which the patient undergoes cesarean delivery.

(PROM) was defined as rupture of the chorioamniotic membranes before the onset of labor. Uterine rupture was defined as a complete tear of the uterine wall, including the visceral peritoneum with establishment of a direct communication between the uterine and abdominal cavities. Dehiscence was defined as an opening of the previous cesarean scar with intact visceral peritoneum and no direct communication between the uterine and abdominal cavities. Postpartum fever was defined as maternal temperature ≥38°C, which developed at least 24 hours after delivery recorded in two different measurements at least 4 hours apart or one measurement of maternal temperature of ≥38.5°C regardless of the time after delivery. Endometritis was defined as postpartum maternal fever with clinical signs of tenderness above the uterine fundus or during cervical manipulation, foul vaginal discharge and positive endometrial culture. Wound infection was defined according to either clinical signs of infection or positive wound culture. Wound dehiscence was defined as spontaneous opening of CS wound including the abdominal fascia.

Disclosure

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Supplementary Table

Table S1 Indications and perinatal complications for primary CS

Measure	Rate
Preeclampsia	10.8% (802/7429)
GDM class A	6.4% (474/7429)
GDM class B-R	2.3% (169/7429)
Hydramnios	7.2% (536/7429)
Olihydramnios	6.0% (536/7429)
PROM	9.3% (689/3622)
Mal presentation	33.2% (2467/7429)
Preterm delivery	17.5% (1299/7429)
PPROM	2.5% (183/7429)
Arrest of 1st stage of labor	18.8% (1393/7429)
Arrest of 2nd stage of labor	5.6% (415/7429)
NRFHR	21.2% (1571/7429)
Prolapse of cord	3.6% (269/7429)
Placenta previa	3.1% (229/7429)
Uterine rupture	0.2% (12/7429)

Abbreviations: GDM, gestational diabetes; PROM, prelabor rupture of membranes; PPROM, preterm prelabor rupture of membranes; NRFHR, non reassuring fetal heart rate.

Table S2 Peri-partum complications in the first delivery after primary CS

Measure	VBAC (N = 3622)	Elective CS (N = 1910)	Urgent CS (N = 1897)	P-value
Mild PET	3.0% (108/3622)	3.7% (70/1910)	5.2% (98/1897)	0.0002
Severe PET	0.8% (28/3622)	0.0% (0/1910)	5.6% (107/1897)	<0.0001
Chronic hypertension	1.8% (66/3622)	4.5% (86/1910)	5.2% (99/1897)	<0.0001
GDM class A	4.9% (179/3622)	10.4% (198/1910)	8.9% (168/1897)	<0.0001
GDM class B-R	1.3% (46/3622)	4.8% (92/1910)	4.0% (75/1897)	<0.0001
Hydramnios	3.7% (135/3622)	8.8% (168/1910)	8.9% (169/1897)	<0.0001
Olihydramnios	2.3% (83/3622)	3.0% (58/1910)	4.2% (80/1897)	0.0003
PROM	7.2% (262/3622)	4.5% (85/1910)	9.8% (186/1897)	<0.0001
Mal presentation	1.4% (49/3622)	18.1% (345/1910)	12.4% (235/1897)	<0.0001
Preterm delivery	8.3% (300/3622)	10.1% (192/1910)	14.1% (268/1896)	<0.0001
PPROM	1.2% (45/3622)	0.8% (16/1910)	1.6% (30/1897)	0.1125
Arrest of 1st stage of labor	0.4% (14/3622)	0.0% (0/1910)	33.2% (630/1897)	<0.0001
Arrest of 2nd stage of labor	3.6% (129/3622)	0.0% (0/1910)	6.1% (116/1897)	<0.0001
Arrest of 1st or 2nd stage of labor	3.9% (143/3622)	0.0% (0/1910)	39.3% (746/1897)	<0.0001
NRFHR	2.2% (80/3622)	0.0% (0/1910)	12.1% (229/1897)	<0.0001
Prolapse of cord	0.2% (6/3622)	0.0% (0/1910)	2.2% (42/1897)	<0.0001
Placenta previa	0.1% (4/3622)	2.6% (50/1910)	1.2% (22/1897)	<0.0001
Uterine rupture	0.1% (3/3622)	0.3% (5/1910)	0.3% (5/1897)	0.1793

Abbreviations: PET, preeclampsia; GDM, gestational diabetes; PROM, prelabor rupture of membranes; PPROM, preterm prelabor rupture of membranes; NRFHR, non reassuring fetal heart rate.

Table S3 Peri-partum complications in the second delivery after primary CS

Measure	VBAC (N = 1765)	Elective CS (N = 1186)	Urgent CS (N = 685)	P-value
Mild PET	2.4% (42/1765)	1.9% (23/1186)	2.8% (19/685)	0.4934
Severe PET	0.6% (10/1765)	0.0% (0/1186)	7.2% (49/685)	<0.0001
Chronic hypertension	1.8% (32/1765)	4.5% (53/1186)	5.7% (39/685)	<0.0001
GDM class A	4.1% (72/1765)	8.9% (105/1186)	9.1% (62/685)	<0.0001
GDM class B-R	1.2% (21/1765)	4.0% (48/1186)	3.6% (25/685)	<0.0001
Hydramnios	3.6% (64/1765)	8.3% (99/1186)	7.9% (54/685)	<0.0001
Olihydramnios	2.2% (39/1765)	2.2% (26/1186)	3.5% (24/685)	0.1393
PROM	6.7% (118/1765)	1.5% (18/1186)	9.5% (65/685)	<0.0001
Mal presentation	1.3% (23/1765)	11.8% (140/1186)	14.6% (100/685)	<0.0001
Preterm delivery	7.6% (135/1765)	14.1% (167/1186)	26.0% (178/685)	<0.0001
PPROM	1.1% (20/1765)	0.6% (7/1186)	3.2% (22/685)	<0.0001
Arrest of 1st stage of labor	0.1% (2/1765)	0.0% (0/1186)	11.5% (79/685)	<0.0001
Arrest of 2nd stage of labor	1.2% (21/1765)	0.0% (0/1186)	3.1% (21/685)	<0.0001
Arrest of 1st or 2nd stage of labor	1.3% (23/1765)	0.0% (0/1186)	14.6% (100/685)	<0.0001
NRFHR	1.4% (25/1765)	0.0% (0/1186)	8.5% (58/685)	<0.0001
Prolapse of cord	0.2% (3/1765)	0.0% (0/1186)	2.2% (15/685)	<0.0001
Placenta previa	0.0% (0/1765)	2.3% (27/1186)	1.3% (9/685)	<0.0001
Uterine rupture	0.1% (1/1765)	0.2% (2/1186)	0.6% (4/685)	0.0274

Abbreviations: PET, preeclampsia; GDM, gestational diabetes; PROM, prelabor rupture of membranes; PPROM, preterm prelabor rupture of membranes; NRFHR, non reassuring fetal heart rate.

Table S4 Peri-partum complications in the third delivery after primary CS

Measure	VBAC (N = 912)	Elective CS (N = 596)	Urgent CS (N = 284)	P-value
Mild PET	2.5% (23/912)	1.7% (10/596)	1.8% (5/284)	0.4848
Severe PET	0.7% (6/912)	0.0% (0/596)	9.2% (26/284)	<0.0001
Chronic hypertension	1.3% (12/912)	4.2% (25/596)	5.3% (15/284)	0.0002
GDM class A	5.3% (48/912)	9.2% (55/596)	8.8% (25/284)	0.0069
GDM class B-R	1.3% (12/912)	3.7% (22/596)	4.2% (12/284)	0.0027
Hydramnios	4.4% (40/912)	7.6% (45/596)	8.8% (25/284)	0.0055
Olihydramnios	2.4% (22/912)	2.0% (12/596)	3.5% (10/284)	0.3985
PROM	4.2% (38/912)	2.9% (17/596)	4.9% (14/284)	0.2537
Mal presentation	1.4% (13/912)	13.3% (79/596)	18.0% (51/284)	<0.0001
Preterm delivery	5.0% (46/912)	18.5% (110/596)	30.3% (86/284)	<0.0001
PPROM	0.2% (2/912)	0.8% (5/596)	1.4% (4/284)	0.0561
Arrest of 1st stage of labor	0.0% (0/912)	0.0% (0/596)	14.1% (40/284)	<0.0001
Arrest of 2nd stage of labor	0.8% (7/912)	0.0% (0/596)	1.1% (3/284)	0.0694
Arrest of 1st or 2nd stage of labor	0.8% (7/912)	0.0% (0/596)	15.1% (43/284)	<0.0001
NRFHR	1.2% (11/912)	0.0% (0/596)	4.2% (12/284)	<0.0001
Prolapse of cord	0.0% (0/912)	0.0% (0/596)	1.8% (5/284)	<0.0001
Placenta previa	0.1% (1/912)	1.7% (10/596)	0.4% (1/284)	0.0010
Uterine rupture	0.0% (0/912)	0.3% (2/596)	0.7% (2/284)	0.0697

Abbreviations: PET, preeclampsia; GDM, gestational diabetes; PROM, prelabor rupture of membranes; PPROM, preterm prelabor rupture of membranes; NRFHR, non reassuring fetal heart rate.

Table S5 Peri-partum complications in the fourth delivery after primary CS

Measure	VBAC (N = 514)	Elective CS (N = 256)	Urgent CS (N = 156)	P-value
Mild PET	3.3% (17/514)	0.4% (1/256)	1.9% (3/156)	0.0358
Severe PET	0.6% (3/514)	0.0% (0/256)	6.4% (10/156)	<0.0001
Chronic hypertension	1.6% (8/514)	3.1% (8/256)	5.8% (9/156)	0.0155
GDM class A	5.1% (26/514)	6.6% (17/256)	5.8% (9/156)	0.6651
GDM class B-R	1.4% (7/514)	4.7% (12/256)	3.2% (5/156)	0.0206
Hydramnios	2.1% (11/514)	5.1% (13/256)	7.7% (12/156)	0.0037
Olihydramnios	1.4% (7/514)	0.4% (1/256)	1.9% (3/156)	0.3267
PROM	6.8% (35/514)	2.3% (6/256)	6.4% (10/156)	0.0327
Mal presentation	1.4% (7/514)	11.3% (29/256)	13.5% (21/156)	<0.0001
Preterm delivery	7.6% (39/514)	27.0% (69/256)	24.4% (38/156)	<0.0001
PPROM	1.8% (9/514)	0.8% (2/256)	1.9% (3/156)	0.5241
Arrest of 1st stage of labor	0.0% (0/514)	0.0% (0/256)	13.5% (21/156)	<0.0001
Arrest of 2nd stage of labor	0.6% (3/514)	0.0% (0/256)	1.9% (3/156)	0.0595
Arrest of 1st or 2nd stage of labor	0.6% (3/514)	0.0% (0/256)	15.4% (24/156)	<0.0001
NRFHR	1.6% (8/514)	0.0% (0/256)	8.3% (13/156)	<0.0001
Prolapse of cord	0.2% (1/514)	0.0% (0/256)	2.6% (4/156)	0.0007
Placenta previa	0.0% (0/514)	2.3% (6/256)	1.3% (2/156)	0.0034
Uterine rupture	0.0% (0/514)	1.6% (4/256)	0.6% (1/156)	0.0202

Abbreviations: PET, preeclampsia; GDM, gestational diabetes; PROM, prelabor rupture of membranes; PPROM, preterm prelabor rupture of membranes; NRFHR, non reassuring fetal heart rate.

Table S6 Perinatal outcome of first delivery after primary cesarean delivery according to the route of delivery

Measure	VBAC N = 3622	CS N = 3807	P-value
Male fetus	49.9% (1806/3622)	53.0% (2019/3807)	0.007
SGA	7.4% (267/3622)	6.1% (231/3807)	0.026
LGA	8.3% (301/3622)	17.7% (674/3807)	<0.001
APD	2.0% (73/3622)	0.4% (15/3807)	<0.001
IPD	0.1% (5/3622)	0.0% (1/3807)	0.116
PPD	0.6% (21/3622)	0.8% (32/3807)	0.215
1 minutes Apgar score <5	5.1% (186/3622)	13.2% (502/3807)	<0.001
5 minutes Apgar score <7	3.7% (135/3622)	3.7% (142/3807)	1.000
Birth weight(grams) mean ± SD	3129.2 ± 569.0	3176.7 ± 641.3	<0.001
Birth weight (grams)			
<1500	2.3% (82/3622)	1.9% (74/3807)	<0.001
1500–2500	6.7% (243/3622)	9.7% (368/3807)	
>2500	91.0% (3297/3622)	88.4% (3365/3807)	
Gestational age at delivery (weeks)			
<28	1.0% (38/3622)	0.5% (19/3807)	<0.001
28–32	1.0% (37/3622)	1.5% (59/3807)	
32–37	6.1% (220/3622)	9.7% (369/3807)	
>37	91.9% (3327/3622)	88.3% (3360/3807)	

Abbreviations: SGA, small for gestational age; LGA, large for gestational age; APD, ante partum death; IPD, intrapartum death; PPD, postpartum death.

Table S7 Neonatal complications in patients with consecutive CS

Complications	CS*2 (n = 3807)	CS*3 (n = 1387)	CS*4 (n = 504)	CS*5 (n = 168)
APD	15 (0.4%)	18 (1.1%)	0	2 (1.2%)
PPD	32 (0.8%)	1 (0.6%)	4 (0.8%)	6 (3.6%)
IPD	1 (0.03%)	1 (0.1%)	0	0
All mortality	48 (1.3%)	27 (2.0%)	4 (0.8%)	8 (4.8%)
Apgar score at 1 minute <5	502 (13.2%)	140 (10.1%)	43 (8.5%)	26 (15.5%)
Apgar score at 5 minutes <7	142 (3.7%)	51 (3.7%)	12 (2.4%)	14 (8.3%)
Birthweight	3176.7 ± 641.3	3021.4 ± 596.0	2952.5 ± 538.9	2903.4 ± 510.4
SGA	231 (6.1%)	81 (5.8%)	28 (5.6%)	11 (6.6%)
LGA	674 (17.7%)	210 (15.1%)	58 (11.5%)	19 (11.3%)
Gestational age at delivery (mean ± S.D.)	38.5 ± 2.5	37.5 ± 2.1	37.2 ± 2.1	36.8 ± 3.1

Abbreviations: SGA, small for gestational age; LGA, large for gestational age; APD, ante partum death; IPD, intrapartum death; PPD, postpartum death; S.D., standard deviation.

Table S8 Neonatal complications in patients with consecutive VBAC

Complications	VBAC*2 (n = 3622)	VBAC *3 (n = 1721)	VBAC *4 (n = 881)	VBAC *5 (n = 506)
APD	73 (2.0%)	9 (0.7%)	9 (1.0%)	5 (1.0%)
PPD	21 (0.8%)	11 (0.6%)	4 (0.5%)	0
IPD	5 (0.1%)	1 (0.1%)	1 (0.1%)	0
All mortality	99 (2.7%)	31 (1.8%)	14 (1.6%)	5 (1.0%)
Apgar score at 1 minute <5	186 (5.4%)	70 (4.1%)	36 (4.1%)	27 (5.3%)
Apgar score at 5 minutes <7	135 (3.7%)	61 (3.5%)	30 (3.4%)	24 (4.7%)
Birthweight	3129.2 ± 569.0	3187.0 ± 541.0	3215.9 ± 510.2	3224.0 ± 518.0
SGA	267 (7.4%)	114 (6.6%)	61 (6.9%)	39 (7.7%)
LGA	301 (8.3%)	189 (11.0%)	92 (10.4%)	72 (14.2%)
Gestational age at delivery (mean ± S.D.)	39.1 ± 2.5	39.3 ± 2.3	39.5 ± 2.0	39.4 ± 2.1

Abbreviations: SGA, small for gestational age; LGA, large for gestational age; APD, ante partum death; IPD, intrapartum death; PPD, postpartum death; S.D., standard deviation.