



Labor progression of women attempting vaginal birth after previous cesarean delivery with or without epidural analgesia

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Abstract

Purpose Normal labor curves have not been assessed for women undergoing a trial of labor after cesarean delivery (TOLAC). This study examined labor patterns during TOLAC in relation to epidural analgesia use.

Methods Retrospective cohort study of deliveries of women undergoing TOLAC at a single, academic, tertiary medical center. Length of first, second and third stages of labor was compared between 424 women undergoing TOLAC in the current labor with no previous vaginal delivery (VD) and 357 women with at least one previous VD and current TOLAC.

Results Women in the TOLAC only group had significantly longer labors compared to women in the previous VD and TOLAC group. In both groups, women who underwent epidural analgesia had longer first and second stages of labor. In the TOLAC only group, more women who had epidural analgesia tended to deliver vaginally as compared to those who did not ($P=0.09$). For women who delivered vaginally, the 95th percentile for the second stage duration with epidural was 3.40 h in the TOLAC only group and 2.3 h in the previous VD and TOLAC group. The 95th percentile for the second stage duration without epidural was 1.4 h in the TOLAC only group and 0.9 h in the previous VD and TOLAC group.

Conclusions Operative intervention (instrumental delivery/cesarean delivery (CD)) might be considered for women attempting TOLAC after a 2-h duration of second stage without epidural and 3-h duration with epidural, with an hour less for women who also had previous VD.

Keywords TOLAC · Labor progression · VBAC · Epidural analgesia · Labor curve

Introduction

Evaluation of normal and abnormal labor processes is critical for the safety of the parturient and the fetus. The first attempt to assess the duration of normal labor was conducted by Friedman in the 1950s, who evaluated 500 nulliparous women in labor. According to Friedman's labor curve, active phase of labor was defined as cervical dilation of 3–4 cm [1, 2]. Zhang et al. investigated 62,415 women during vaginal delivery and defined active phase as 6 cm cervical dilation [3, 4]. The definitions of “normal labor” and “labor arrest” or dystocia, affect labor management and clinical interventions. Dystocia is commonly defined as the 95th percentile of labor duration and is derived from the curves mentioned above. Dystocia for women attempting trial of labor after cesarean delivery (TOLAC) has not been addressed. The incidence of TOLAC is about 18% [5]. TOLAC requires well-experienced medical staff and constant evaluation during labor, to avoid uterine rupture. Women undergoing TOLAC have 0.5% chance of uterine rupture, with

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0.1% chance of fetal neurologic damage or mortality as sequela [6, 7].

A recent study evaluated labor patterns among women attempting TOLAC by comparing them to nulliparous women [8]. That study found that labor duration for TOLAC was longer as compared to that of nulliparous women, particularly after induced labors. Yet, only women who had one prior CD without previous vaginal deliveries were included.

Creating a valid curve for TOLAC might contribute to the evaluation of normal and abnormal patterns during these labors and increase the base of knowledge for developing guidelines for correct clinical management of TOLAC. Therefore, the purpose of this study was to document the progress of cervical dilation and labor progression during TOLAC in women with and without a previous VD, and with and without the use of epidural analgesia.

Materials and methods

Study design

A retrospective, cohort study of all 781 TOLAC deliveries performed from 2007 through 2016 at a single academic tertiary medical center was conducted. Data were collected from electronic medical records and included information on maternal demographics; medical, obstetric and prenatal history; and information about the labor and delivery (including vaginal examinations and use of epidural analgesia). Data regarding early neonatal outcomes were also collected. Information on labor progression, including time of cervical examinations was extracted. Of these, 424 women had a previous cesarean delivery with no prior vaginal delivery. The remaining 357 women had a previous cesarean delivery and at least one vaginal delivery.

Inclusion criteria were women with one previous cesarean delivery in any previous delivery, singleton pregnancy, gestational age from 37 weeks 0 days to 41 weeks 6 days and vertex presentation at admission. Pregnancies with fetal malformation, macrosomia, multiple gestations and maternal hypertension or diabetes were excluded. Women undergoing induction of labor were also excluded. The duration of each labor stage, the progression of effacement and dilatation, as well as use of epidural analgesia and its effect on labor progression were evaluated.

Cervical dilation was measured approximately every 2 h and at rupture of membranes, non-reassuring fetal heart rate and pushing.

Ethical approval

The study was approved by the Institutional Ethics Committee. As this was a retrospective study, informed consent was not required.

Statistical analysis

Data are presented as numbers and percentages for nominal variables and as means and standard deviations for continuous parameters. Length of each stage of labor is presented as mean and 95% percentile. We calculated cumulative duration of labor from admission to any given dilation up to the first 10 cm in both groups. Then we plotted the mean labor curve based on these calculations.

Differences between two groups were analyzed using Chi square test for qualitative data and *t* test for quantitative variables. $P < 0.05$ was considered statistically significant. All analyses were done using SPSS® 23 version package for windows (SPSS, Inc.).

Results

The entire cohort

For the entire cohort, the mean maternal age at delivery was 34.6 years (SD 4.8). The mean gestational age at delivery was 39.5 weeks (SD 1.1). Cervical dilatation at admission was 3 cm, with 80% effacement. Among the participants, 640 (76.5%) received epidural analgesia. Vaginal Birth after Cesarean (VBAC) and failed TOLAC rates were 84.1% and 15.9%, respectively. The average newborn weight was 3244 g (SD 408). In the full cohort, the mean duration of the first stage of labor was 8.87 h (SD 5.25) and the mean duration of the second stage was 0.9 h (SD 0.93). No uterine rupture was observed in this cohort.

Comparison between women with TOLAC only and women who had a previous VD

Women in the TOLAC only group were younger than the women in the previous VD and TOLAC group (33.6 ± 4.7 years vs. 35.74 ± 4.7 years, $P < 0.001$) (Table 1). Gestational age at delivery was similar between groups (39.4 weeks vs. 39.5 weeks, $P = 0.191$). Women undergoing TOLAC were also more likely to have smaller cervical dilation upon admission compared to women with a previous VD and TOLAC (2.5 cm vs. 3 cm, $P < 0.001$), but there were no clinical differences in median cervical effacement ($P = 0.803$; Table 1).

Women undergoing first TOLAC had significantly longer first and second stages of labor as compared to women in the previous VD and TOLAC group (10.35 h vs. 7.33 h, $P < 0.0001$ and 1.43 h vs. 0.53 h, $P = 0.0001$) (Table 2). In the TOLAC only group, progression from 4 to 10 cm lasted 5.17 h (SD 3.53), whereas in the previous VD

Table 1 Maternal and obstetrical characteristics of women with TOLAC only compared to women with previous VD and TOLAC

Variable	TOLAC (<i>n</i> =424)	Previous VD and TOLAC (<i>n</i> =357)	<i>P</i> value
Maternal age, year (mean ± SD)	33.6 ± 4.7	35.8 ± 4.7	0.001
BMI at delivery, kg/m ² (mean ± SD)	26.1 ± 4.8	26.5 ± 4.7	0.33
Gestational age at delivery, weeks (mean ± SD)	39.4 ± 1	39.5 ± 1.1	0.191
Cervical dilation at admission, cm (median; 10th, 90th percentiles)	2.5 (0.5, 4.5)	3 (1.5, 6)	0.001
Cervical effacement at admission, % (median; 10th, 90th percentiles)	80 (70, 100)	80 (60, 100)	0.803

Table 2 Obstetrical outcomes of women with TOLAC only compared to women with previous VD and TOLAC

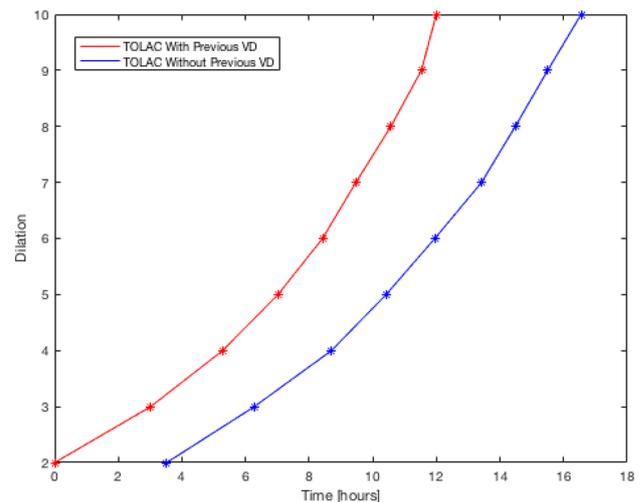
Variable	TOLAC Only (<i>n</i> =424)	Previous VD and TOLAC (<i>n</i> =357)	<i>P</i> value
Epidural, <i>N</i> (%)	372 (82.7)	268 (69.3)	0.001
Vaginal delivery, <i>N</i> (%)	353 (79.5)	345 (89.4)	0.0001
Cesarean delivery, <i>N</i> (%)	91 (20.5)	41 (10.6)	0.0001
First stage of labor duration, h (mean ± SD; median, 95th percentile)	10.35 ± 5.62; 9.78, 20.70	7.33 ± 4.37; 6.5, 16.02	0.0001
Duration of progression from 4 to 10 cm cervical dilatation, h (mean ± SD, median, 95th percentile)	5.17 ± 3.53; 4.37, 12.68	3.88 ± 2.83; 3.10, 8.78	0.0001
The duration of second stage with epidural, h (mean ± SD; median, 95th percentile)	1.43 ± 1; 1.27, 3.30	0.58 ± 0.67; 0.3, 2.12	0.0001
Duration of second stage without epidural, h (mean ± SD; median, 95th percentile)	0.47 ± 0.52; 0.3, 1.7	0.27 ± 0.52; 0.17, 0.8	0.0001
Duration of third stage, h (mean ± SD; median, 95th percentile)	0.17 ± 0.17; 0.16, 0.37	0.18 ± 0.12; 0.16, 0.37	0.771
Neonates with cord pH ≤ 7.1 <i>N</i> (%)	4 (0.9)	4 (1.1)	0.807
Newborns with 5-min Apgar scores ≤ 7, <i>N</i> (%)	2 (0.4)	0 (0)	1

and TOLAC group, it lasted 3.88 h (SD 2.83) ($P=0.001$). No difference was found between groups in the duration of the third stage of labor ($P=0.0771$). Figure 1 shows the duration of labor for each centimeter of cervical dilatation in both groups.

As shown in Fig. 1, the median durations of labor before 6 cm cervical dilation were similar between women with TOLAC only as compared to women with previous VD and TOLAC. After 6 cm dilation, women with previous VD and TOLAC had faster labors than women in the TOLAC only group did, which is consistent with the labor curves.

The effect of epidural analgesia

Women undergoing TOLAC without a previous VD were more likely to receive epidural analgesia ($n=372$, 82.7%) than were women with a previous VD and TOLAC ($n=268$, 69.3%) ($P=0.0001$). In both groups, women who had an epidural analgesia had longer first and second labor stages (Table 2). In the TOLAC only group, the second stage with or without epidural was longer compared to the previous VD and TOLAC group (1.43 ± 1 vs. 0.58 ± 0.67 , $P=0.0001$ and 0.47 ± 0.52 vs. 0.27 ± 0.52 , $P=0.0001$, respectively; Table 2, Fig. 2).

**Fig. 1** Labor progression curve (cervical dilation in cm by hours)—women with and without previous VD attempting TOLAC

Vaginal birth after cesarean (VBAC) rate

More women in the previous VD and TOLAC group delivered vaginally as compared to the TOLAC group (89.4% vs. 79.5% respectively; $P<0.0001$). Within the group of

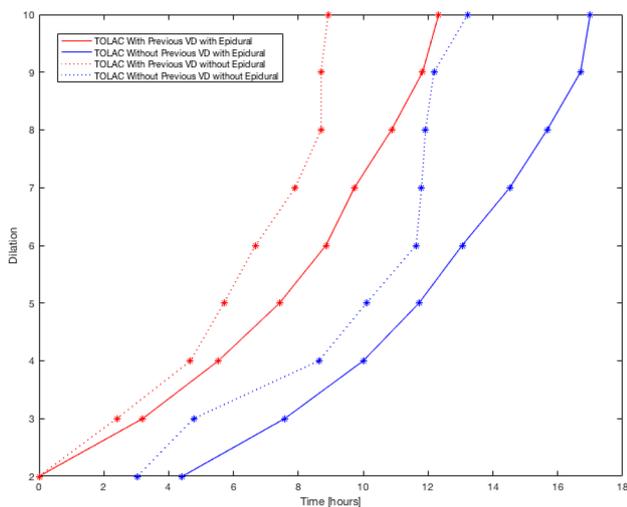


Fig. 2 Labor progression curve (cervical dilation in cm by hours)—women with and without a previous VD with and without epidural analgesia attempting TOLAC

women who delivered vaginally, those in the TOLAC only group were more likely to deliver by vacuum extraction as compared to women in the previous VD and TOLAC group (24.3% vs. 9.8%, $P < 0.0001$). As shown in Table 3, there were no differences in the duration of the first and second stages of labor between those who had VBAC and those who had a failed TOLAC ($P = 0.901$ and $P = 0.6$, respectively). However, the second stage was longer for those who failed TOLAC ($P = 0.0001$; Table 3).

When evaluating the second stage of labor for women who had VBAC, including normal vaginal delivery or instrumental delivery, we found that the 95th percentile of the

intervals of duration of the first stage of labor was 20.70 h in the TOLAC only group and 16.02 h in the previous VD and TOLAC group. The 95th percentile for the duration of the second stage of labor with epidural was 3.40 h in the TOLAC only group and 2.3 h in the previous VD and TOLAC group. The 95th percentile for the second stage duration without epidural was 1.4 h in the TOLAC only group and 0.9 h in the previous VD and TOLAC (Table 4; Fig. 3).

Neonatal outcomes

Cord pH < 7.1 ($P = 0.807$) and 5-min Apgar scores ($P = 1$) were similar between the TOLAC only and the previous VD and TOLAC groups.

Discussion

Our study included a comparison of labor curve between 424 women attempting TOLAC without a previous VD and 357 women with a previous VD. We chose these groups for comparison to evaluate the difference between “nulliparas” women without prior VD to “multiparas” women with previous VD. Based on this cohort, we found that women undergoing TOLAC compared to women with a previous VD and TOLAC had longer first and second stages of labor. These observations are in agreement with previous studies. The duration of the first and second stages of labor was shorter for multiparous as compared to nulliparous women [1–4] Women in the TOLAC group were younger than those with a previous CD. Although this difference was statistically significant, its clinical meaning was of little importance, as is reasonable to expect that higher parity is related to older

Table 3 Duration of labor stages for VBAC and failed TOLAC

Labor stages	VBAC N=660 (85%)	Failed TOLAC N=121 (15%)	P value
First stage of labor, h (mean ± SD; median, 95th percentile)	9 ± 5.3 8.15 (19.8)	8.7 ± 8.8 6.9 (NA)	0.901
Progression from 4 to 10 cm cervical dilatation, h (mean ± SD, median, 95th percentile)	4.62 ± 3.15 4 (9.8)	4.9 ± 4.15 3.5 (NA)	0.6
Second stage of labor average h (mean ± SD, median, 95th percentile)	0.9 ± 0.92 0.47 (3)	2.17 ± 1.15 2.32 (NA)	0.0001

Table 4 Duration of labor second stage for VBAC only in relation to parity and epidural anesthesia

Variable	TOLAC only		Previous VD and TOLAC	
	With epidural N=372	Without epidural N=52	With epidural N=268	Without epidural N=89
Second stage of labor	1.4 ± 1	0.5 ± 0.5	0.7 ± 0.97	0.3 ± 0.65
Average h (mean ± SD, median, 95th percentile)	1.25, 3.4	0.3, 1.4	0.3, 2.3	0.17, 0.9

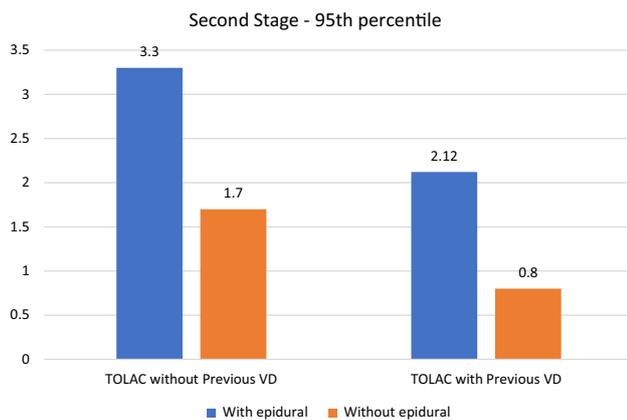


Fig. 3 95th percentile of duration (hours) of second stage of labor for women with and without a previous VD with and without epidural analgesia attempting TOLAC

age. As shown in Fig. 1, women who had a previous spontaneous vaginal delivery were more likely to progress faster to > 6 cm cervical dilation as compared to women without previous VD. These findings are consistent with Zhang's curve that showed that multiparous women progress faster than do nulliparous women after 6 cm cervical dilation [4]. This suggests that the active phase for these women begins after 6 cm and that labor protraction or arrest should not be determined before 6 cm.

The novelty of the data presented here is represented by the findings regarding epidural analgesia. The rate of epidural analgesia use in our cohort was high (76.5%). The main reason for this is that in our medical center we advise women with TOLAC to use epidural analgesia to allow fast surgical intervention if necessary; thus, avoiding general anesthesia in case an emergency CS is required. Since women with previous CS are more prone to subsequent emergency CS, we prefer these women to have epidural analgesia during labor.

Women in the TOLAC group were more likely to have epidural analgesia than women with previous VD and TOLAC. Nulliparous women are more likely to have epidural than are multiparous women [9]. We also found that all women in our cohort who received epidural analgesia had longer first and second stages of labor. Other studies also demonstrated that epidural analgesia was associated with a longer second stage of labor [10, 11]. A Cochrane review also found that epidural analgesia was associated with longer second stage of labor [12]. In addition, a recent retrospective study reported a 60-min increase in the median duration of second stage labor among nulliparous women who received epidural analgesia as compared to those without. In this study, the 95th percentile duration of second stage of labor was 95 min longer for nulliparas and 101 min longer for multiparas who received epidural analgesia as compared to those without [13].

We found that women attempting TOLAC who had previously delivered vaginally had higher VBAC rates of 89.4% as compared to 79.5% for women who had a previous CD only. This finding is supported by a previous study in which a history of vaginal delivery increased the likelihood of VBAC by approximately threefold [14].

We found no differences in the duration of first stage labor between those who had VBAC and those who had failed TOLAC. However, the second stage was longer for those who had failed TOLAC. This finding is reasonable because prolonged second stage is an indication for intervention (instrumental or CD) and might explain the higher incidence of CD for women who had longer second stage durations.

An interesting finding in our study was that epidural use correlated with an increased chance for VBAC in the TOLAC group who did not have a previous VD. These results differed from several previous reports that claimed epidural analgesia increased the risk for CD [15, 16]. One possible explanation for these differences may be related to different study timelines and populations. While the studies mentioned above were conducted 10–20 years ago, our study is more current. Comparison to the older results does not consider changes that have occurred over the past few decades, including the trend of reducing the number of cesarean deliveries [17]. Therefore, our results better reflect the contemporary maternal profile. Moreover, a recent study evaluated the effect of epidural on 7260 nulliparous and 2987 multiparous women receiving epidural analgesia and found that for nulliparous women, epidural was a protective factor against cesarean delivery [18]. For the multiparous women, epidural analgesia did not affect the risk for cesarean delivery. The finding that epidural use correlates with an increased chance for VD in TOLAC women/nulliparous women should be addressed in future studies. No uterine rupture was observed in our cohort, although the incidence of uterine rupture ranges from 0.5 to 1.3% [19, 20]. One possible explanation is that since it is known that induction of labor for TOLAC can increase the risk of uterine rupture [21], in our medical center we do not use oxytocin for induction of labor and rarely use it for augmentation of labor, thus reducing the risk of uterine rupture.

Since VBAC can help reduce the rate of cesarean deliveries, as well as reduce each patient's individual risk for operative morbidity and future pregnancy complications, it is important to evaluate when is the best time to determine dystocia; usually defined as labor duration beyond the 95th percentile.

Our results suggest that an operative intervention (instrumental delivery or CD) that is based on the 95th percentile may be considered for women attempting TOLAC, after a 2-h second stage duration without epidural, and 3 h duration with epidural and an hour less for women who had previous VD.

The strengths of this study include the relatively large sample size and the analysis of epidural use and gravidity. One limitation to this study is that it is retrospective, although we believe our data provide sufficient support for our findings. Another limitation is that women who had induction of labor were not included. Women undergoing induction have been shown to be at greater risk for uterine rupture and require increased surveillance when attempting TOLAC. Also, their labor curves might need to be evaluated differently [22, 23]. Moreover, there is a concern regarding the low number of women who did not use epidural analgesia as compared to women who did. Despite this relatively low number, our large cohort size may allow us to reach the conclusion regarding the best time for intervention during TOLAC, as mentioned. Nonetheless, our conclusions should be considered with caution and additional larger studies, preferably prospective, should be conducted to support our findings. In Addition, A future study comparing between women with previous cesarean section and nulliparas can also add to the understanding of TOLAC labor curve.

To conclude, women attempting TOLAC who had a previous CD and no VD are more likely to have longer labors and less likely to have VD as compared to women with a previous VD. Epidural analgesia might increase the chance for VD in the TOLAC group who did not have a previous VD. For women attempting TOLAC, an operative intervention might be considered after a 2-h duration of the second stage of labor without epidural, 3-h duration with epidural and 1 h less for women who had a previous VD.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

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